MODEL 711

SURGE GENERATOR/MONITOR

OPERATING MANUAL AND SCHEMATICS

KeyTek Instrument Corp.

260 Fordham Road
Wilmington, Massachusetts 01887

Specifications Subject To Change Without Notice

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WARNING!

1. AC POWER-LINE VOLTAGE WILL BE PRESENT AT THE MODEL F31* OUTPUT TERMINALS WHEN THE SURGE LINE BREAKER IS ON.

2. WHEN THE SURGE IS GENERATED, TRANSIENT VOLTAGES TO 6KV AND CURRENTS TO 10KA WILL BE PRESENT IN THE EQUIPMENT UNDER TEST.

3. PROPER SAFETY PRECAUTIONS MUST BE TAKEN TO PREVENT INJURY TO PERSONNEL AND DAMAGE TO ASSOCIATED EQUIPMENT.

4. SURGE AND POWERLINE VOLTAGES AND CURRENTS CAN BE LETHAL!

WARNING!

IN PARTICULAR, DISCONNECT OR SURGE FILTER ALL OTHER LINES, INCLUDING GROUND AND OTHER POWER, FROM/TO THE EQUIPMENT UNDER TEST.

WARNING!

SURGE TEST EQUIPMENT IS DESIGNED TO TEST DEVICES AND CIRCUITS FOR PROTECTION AGAINST HIGH-VOLTAGE, HIGH-ENERGY ELECTRICAL SURGES. SUCH SURGES OCCUR IN FIELD USE OF EQUIPMENT, AND RESULT FROM NATURAL PHENOMENA SUCH AS LIGHTNING DISCHARGES AND POWER-LINE DISTURBANCES. THE ONLY SURE WAY TO TEST FOR WITHSTAND AND SUSCEPTIBILITY PROTECTION AGAINST THESE PHENOMENA IS TO SIMULATE SURGE WAVEFORMS KNOWN TO RESULT FROM THEM.

THE PULSES INVOLVED CAN INCLUDE VOLTAGE PEAKS OF OVER 6000 VOLTS AND CURRENT PEAKS TO THOUSANDS OF AMPERES; WITH ENERGY DISCHARGES RANGING FROM TENS TO HUNDREDS OF JOULES.

SURGES AT THE ABOVE LEVELS ARE POTENTIALLY DANGEROUS AND EVEN LETHAL. HENCE EVEN THOUGH ALL REASONABLE DESIGN PRECAUTIONS HAVE BEEN TAKEN VIA INTERLOCKS, DUAL-SWITCH OPERATION AND SO ON, SURGE TEST INSTRUMENTATION SHOULD BE USED ONLY BY OR UNDER THE DIRECT SUPERVISION OF QUALIFIED PERSONNEL, AND ONLY AFTER THOROUGH UNDERSTANDING, VIA THE OPERATING INSTRUCTIONS IN THE MANUAL, OF THE RECOMMENDED CONNECTIONS AND METHODS OF OPERATION.

IN ISOLATED SITUATIONS, COMPONENTS BEING SURGED MAY FRAGMENT IF THEY ARE IMPROPERLY MANUFACTURED, OR ARE MISAPPLIED FOR THE SURGE ENERGIES INVOLVED. FOR THIS REASON, COMPONENTS AND CIRCUITS BEING SURGE-TESTED SHOULD BE COVERED TO PREVENT PERSONNEL HAZARD.

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*Or the F31-50, for units with 50A option.

WARNING

SURGING CIRCUITS

1. THE SURGE TEST LOOP MUST BE ISOLATED FROM ALL OTHER LINES, EQUIPMENT GROUNDS, AND CIRCUITS.

2. MEASUREMENTS WITH AN OSCILLOSCOPE, OR OTHER TEST EQUIPMENT, MUST BE MADE IN A DIFFERNTIAL MODE WITH NO GROUND CONNECTIONS BETWEEN THE TEST EQUIPMENT AND THE CIRCUIT UNDER TEST. DO NOT "FLOAT" THE TEST EQUIPMENT BY REMOVING CHASSIS GROUND.

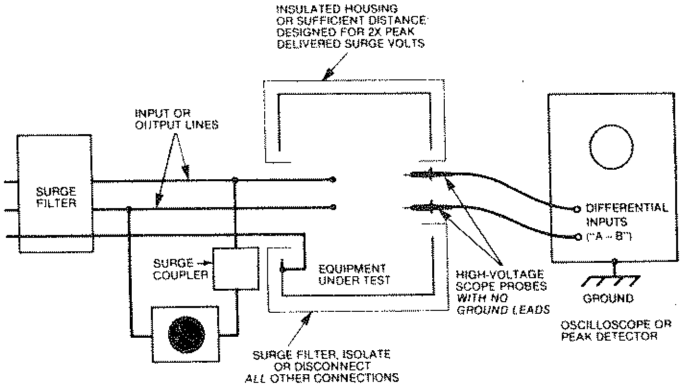

Figure 9.
MONITORING WITHIN SURGED EQUIPMENT

3. FIGURE 9. ABOVE, TAKEN FROM KEYTEK APPLICATION NOTE AN106, SHOWS THE CORRECT METHOD FOR MONITORING WITHIN SURGED EQUIPMENT. REFER TO AN106 (ENCLOSED) FOR FURTHER, DETAILED APPLICATION INFORMATION.

WARRANTY

KeyTek Instrument Corp. warrants each instrument manufactured by it to be free from defects in material and workmanship for a period of one year from the date of delivery to the original purchaser, provided the instrument is used in accordance with the instructions in this manual. KeyTek's obligation under this warranty is limited to servicing or adjusting an instrument returned to the factory, transportation charges prepaid, for that purpose. This is the only warranty offered in connection with the sale of this instrument, no other warranty is implied. KeyTek is not liable for consequential damages.

If a fault in operation occurs, the following steps should be taken:

1. Notify KeyTek Instrument Corp. giving full details of the faulty operation, the model number and serial number of the instrument. On receipt of this information, service data or shipping instructions will be provided.

2. On receipt of the shipping instructions, forward the instrument prepaid and repairs will be made at the factory.

If it is necessary to return this instrument to the factory, it should be shipped in the original packing carton. If it is not available, use any suitable rigid container with adequate packing to protect the unit during transit.

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List of Illustrations

MODEL 711 B/K

Installation and Initial Turn-On of the 711 B/K is as described in the following pages for the 711 A/J, with one exception, the ARU-151A, which takes the place of the CPC-101, must be set for manual operation, via the front panel push-button, during initial turn-on.

NOTE: The 711 B/K is shipped with an ARU-151A keeper plug attached to the rear of the 711 B/K. For alternating polarity/operation, this keeper must be removed and the unit marked "Alternating-Polarity Option for 711 Auto/Remote Unit ARU-151A", connected in its place.

Transit Case TC21

The Model 711 A/J Transit Case is designed to provide a rugged shipping container for the Model 711 A/J, its accessories, and cables. Additionally, it is constructed to allow equipment operation with a minimum of unpacking and setup.

By removing the front and rear covers of the transit case, the main body of the case containing the Model 711 A/J can be set on a workbench and the equipment operated without any further unpacking (see fig. viii-1).

If required by space limitations or operational considerations, the Model 711 A/J can be further disassembled from the transit case by removing the units individually, or by removing the inner rack assembly (see fig. viii-2).

As shipped, the Model 711A is partially connected for operation with the Model F31. To operate the equipment, the following connections must be made:

1. Connect the Voltage Probe Body via its attached cable, to the VIS connector on the rear panel of the Model 711A. Connect the appropriate Probe Head to the Probe Body (see Model 711 Operating Instructions page 5-4). The Probe Body and Probe Heads are shipped as accessories in the Accessory Storage Area of the rear cover of the transit case (see fig. viii-3).

2. Connect the two ac line cords (one from the Model 711, and one from the Model F31) to ac power (see page 1-1 of Model 711 Operating Instructions). These line cords are shipped connected to the rear of the Models 711 and F31.

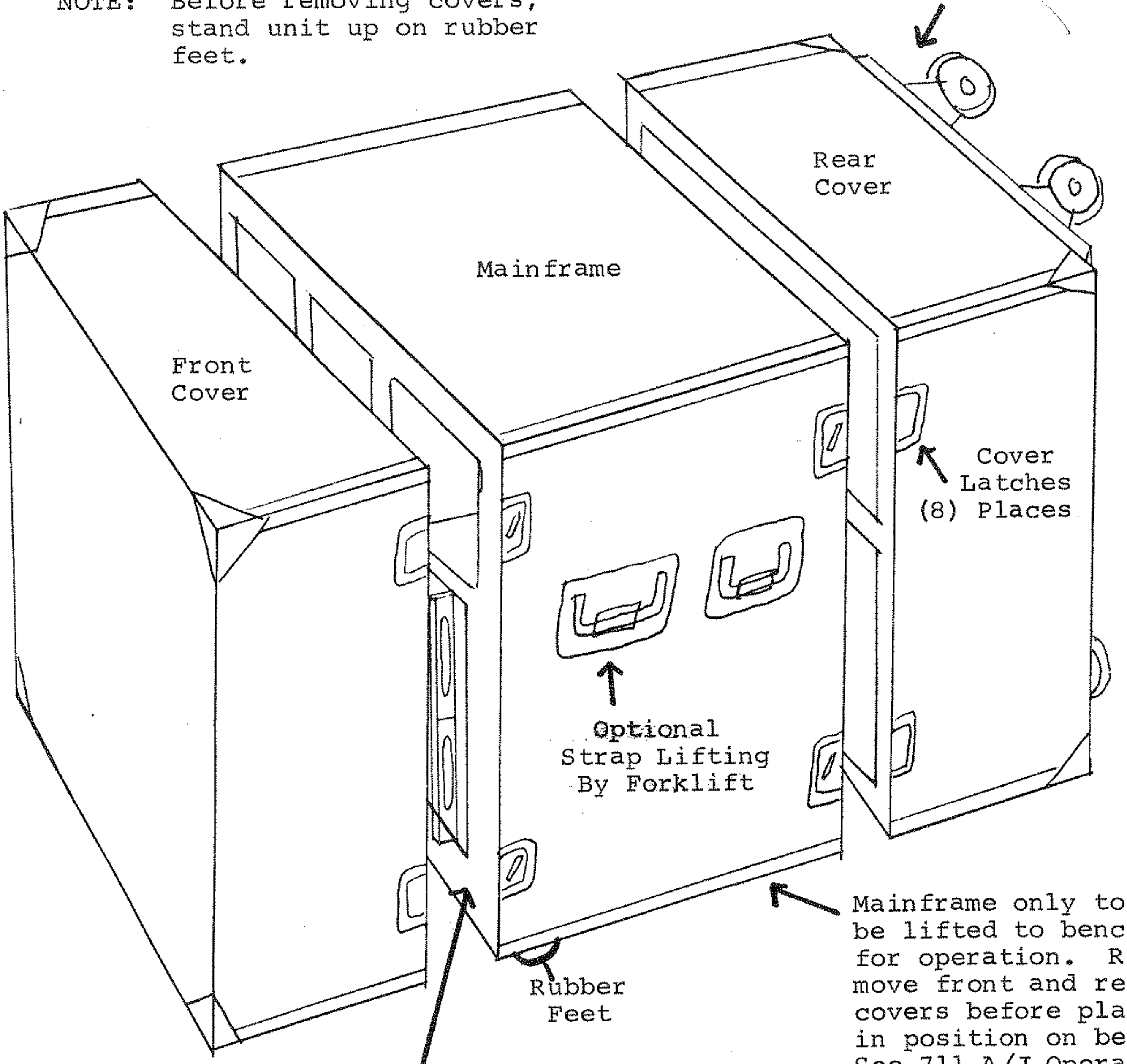
3. Connect the AC Surge Line Input Cable to the rear of the Model F31. This cable is shipped inside the rear cover of the transit case. (See page 4-2 of Model 711 Operating Instructions.)

4. Check to insure the correct output terminal covers are in place on the Model 711 Front Panel, and on the Model F31 front panel. The unit is shipped with a black Model 711 Front Output Cover, and a black Model F31 Front Output Cover in place. The unit to be surged can then be connected to the Front Output Cover of the Model F31.

5. Before attempting to operate the unit, review all Model 711 Operating Instructions.

711 A/J Transit Case

NOTE: Before removing covers, stand unit up on rubber feet.



Unit is shipped with casters down

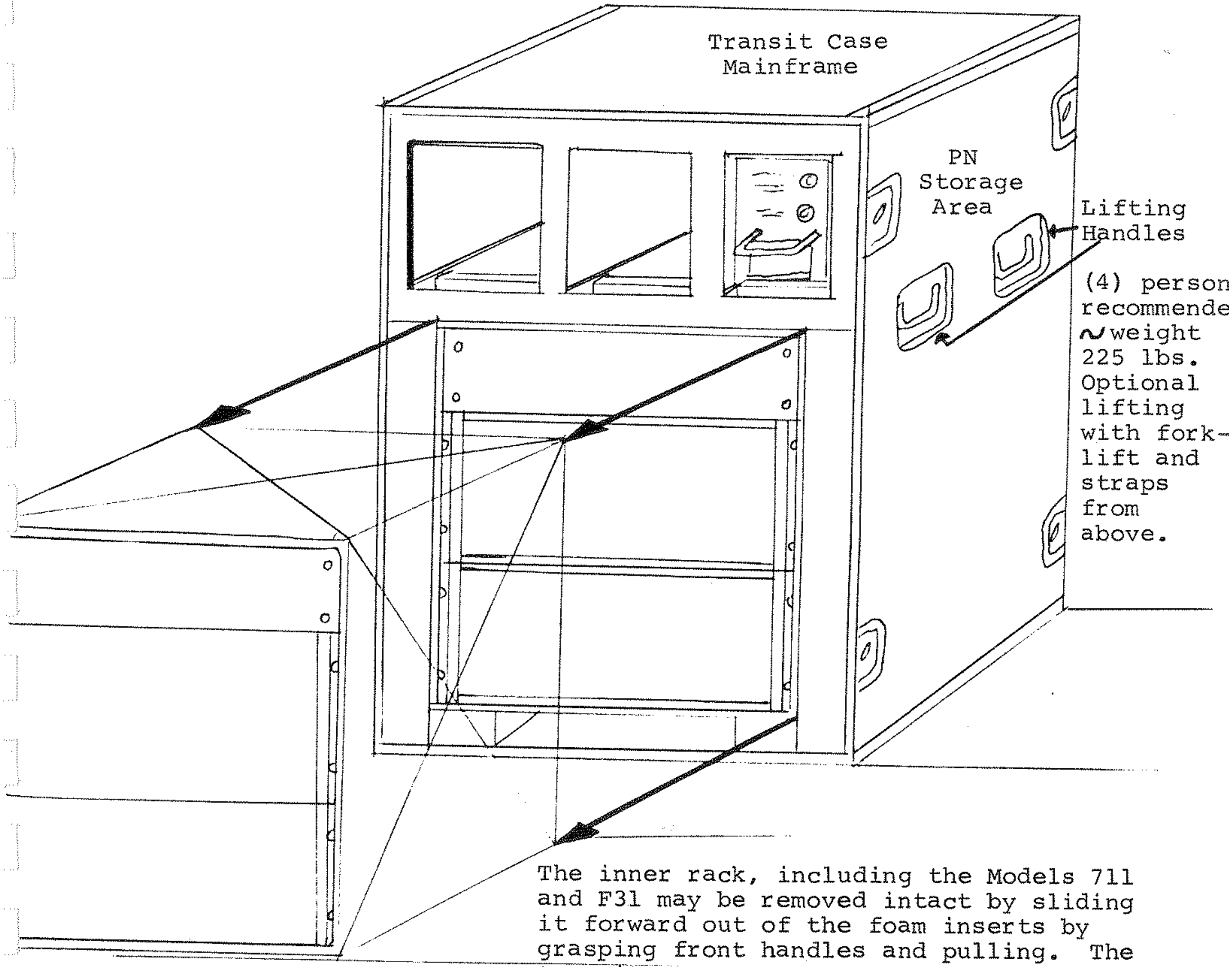
Optional Strap Lifting By Forklift

Unit is shipped with front panels facing upwards.

Mainframe only to be lifted to bench for operation. Remove front and rear covers before placing in position on bench. See 711 A/J Operating Instructions for cabling and installation.

fig. viii-1

711 A/J Transit Case



(4) person recommende
∼weight
225 lbs.
Optional lifting with fork-lift and straps from above.

The inner rack, including the Models 711 and F31 may be removed intact by sliding it forward out of the foam inserts by grasping front handles and pulling. The transit case must be on a firm bench surface. (Not recommended unless bench space is limited.) The individual units may be removed and set on the bench by removing rear cables and front rack mounting screws. Each unit can then be pulled forward out of the inner rack.

fig. viii-2

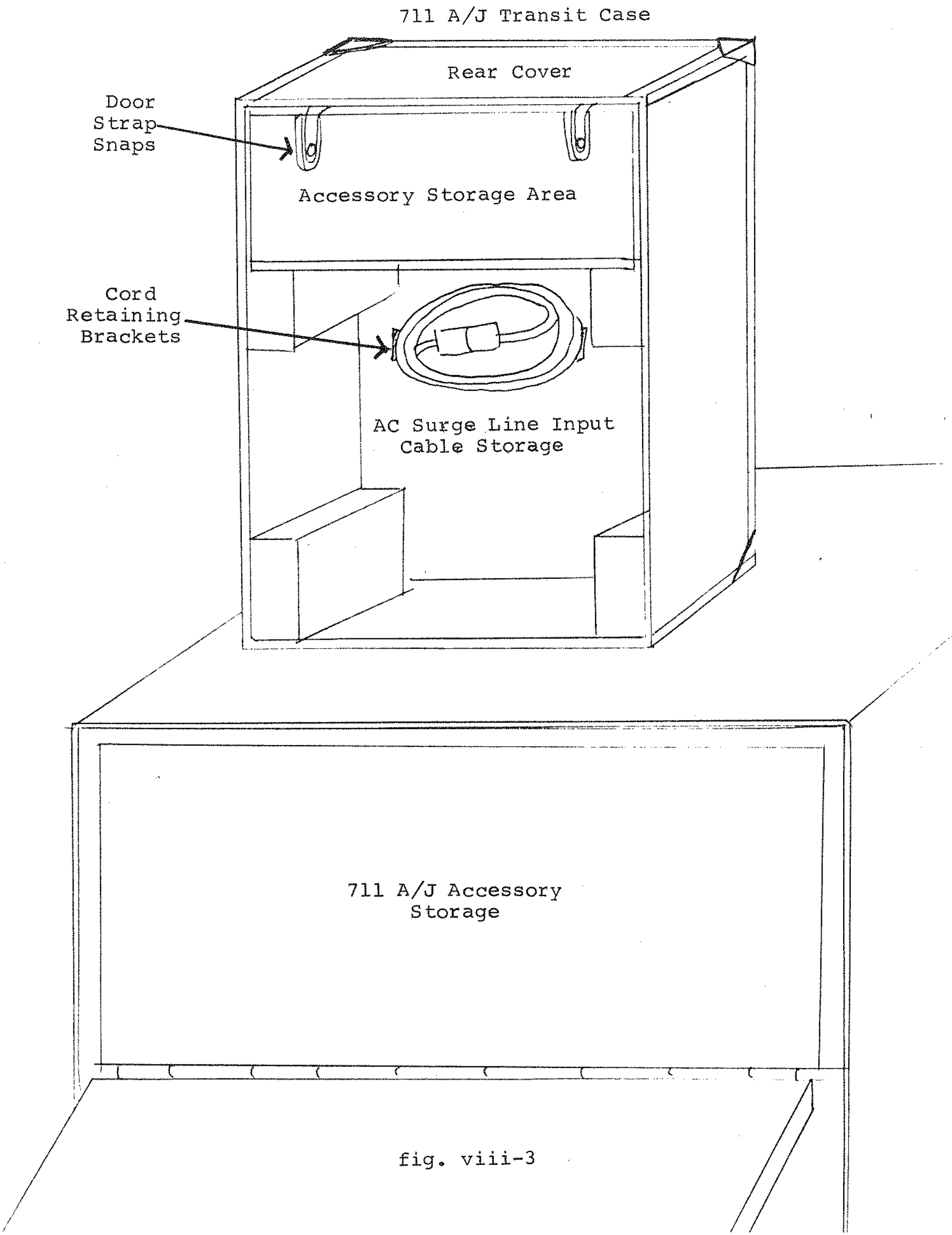

711 A/J Transit Case
Rear Cover
Door Strap Snaps
Accessory Storage Area
Cord Retaining Brackets
AC Surge Line Input Cable Storage
711 A/J Accessory Storage

fig. viii-3

SECTION 1

1. Installation and Initial Turn-On

> NOTE: This procedure does not include installation and turn-on of the Model F31. Before connecting the Model F31, installation and initial turn-on should be accomplished in accordance with Section 1. Once the 711 mainframe has been turned on, installation and initial turn-on of the Model F31 should be done in accordance with the Model F31 Operating Instructions in Section 4. If the unit does not function as described, refer to Section 7, "Initial Trouble-shooting".

1.1 Connections

1. Make sure the Model 711A power ON-OFF switch (Fig 1-1.) is in the OFF position.

2. Insert the desired Surge Network into the Model 711A mainframe and make sure it is locked into place. (See Section 3.1) Cover the Output Terminals of the surge network with the plastic safety cover provided. Note: this plastic cover is interlocked to prevent surge generator operation if it is removed. (See Section 3.1, "To Change Surge Networks".)

3. Connect the Model 711A Keeper Plug to the Rear Output Connector located on the rear panel of the Model 711A. Secure the two captive screws that hold it in place with respect to the rear panel. (See Fig. 1-2.)

4. Connect the ac power line cord from the ac input connector located on the 711A rear panel to an appropriate ac source.*

*The Model 711A Mainframe is normally shipped to operate from 115 Vac (±10%), 60Hz (for units shipped to U.S. or Canadian locations) or 220 Vac (±10%) 50Hz (for units shipped overseas). For operation at other ac line voltages, refer to Appendix A, "Operation at Other AC Line Voltages".

1.2 Initial Turn On

1. Turn the power ON-OFF switch to the ON position. After a several second delay, the READY light (located next to the CHARGE switch), and the CHARGE/READY DELAY light (located on the Charge Pulse Control -- CPC101) will both be ON. In addition, one of the RANGE lights (6kV, 3kV, 1.5kV, or 150V -- determined by the Surge Network selection -- 6kV for both P1 and P3) should be ON. The Open Interlock light should be OFF. (If it is ON, refer to Section 2, "Interlocks".)

2. Select LOCAL control on the CPC101. The LOCAL LED indicator should be ON.

3. Select charge + or - operation by turning the bat-handle lock mechanism counter-clockwise to loosen the CHARGE SELECT PLUG from its socket (the OPEN INTERLOCK light will turn ON as the plug is loosened.) Grasp the outer ring of the CHARGE SELECT PLUG, pull it towards you to allow the tab on the plug to clear the + or - indent. (The plug itself is captive and spring loaded, and cannot be fully removed from its socket.) Turn the plug to select the desired polarity and be sure the plug tab goes into the proper indent. Turn the bat-handle clockwise until the OPEN INTERLOCK light goes out.

   CAUTION: DO NOT OVERTIGHTEN. The bat-handle provides a significant amount of torque to the switch shaft. Overtightening the switch could result in a broken switch shaft.

4. Remove any jumpers or cables from the Output Terminals of the Surge Network.

5. Turn the SET VOLTAGE knob fully counter-clockwise.

6. Depress the CHARGE switch. The CHARGE/READY and CHARGE lights on the CPC101 will turn ON. The CHARGE/PULSE DELAY light on the CPC101 will turn ON slowly as the 711A is charged. While holding the CHARGE switch

depressed, turn the SET VOLTAGE control clockwise. The Analog charge meter will indicate the peak open-circuit output voltage that will be delivered when the Pulse Switch is subsequently depressed. (A range light to the right of the analog meter annunciates the voltage scale to be read.) If the CHARGE switch is released, the charge voltage in the 711A as indicated on the analog meter, will fall quickly to zero.

7. While holding the CHARGE switch depressed, set the analog meter to the desired voltage. After a delay of approximately 5 seconds if the P1 Surge Network is being used, or 10 seconds for the P3, a green pulse READY light (located next to the PULSE switch on the VIS-102P) and the PULSE light on the CPC101, will come on. During charge, the SURGE light on the Surge Network being used will turn on slowly.* The unit can now be fired by depressing the PULSE switch. Note: If the PULSE switch is depressed *before* the pulse READY light turns ON, a pulse *will* be fired simultaneously with the turning on of the READY light, but *not* before. Since the READY light extinguishes as soon as the pulse is fired, the READY light may only flicker briefly as the pulse is fired, or may not be visible at all.

8. When the PULSE switch is depressed, a pulse will appear between the SURGE HIGH and SURGE LOW output terminals located on the Surge Network. The SURGE light in the Surge Network will go OFF, the analog charge meter will drop to zero, and the digital voltage and current monitors will display zeros or approximate zeros.**

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*The surge lights on different networks may vary in brightness. In addition, with higher ac line voltage versions of the F31 Coupler/Filter, such as 480V, the surge light may glow dimly at all times, indicating the normal presence of high ac line voltage in parts of the Surge Network.

**For some Surge Networks, internal shaping circuits may draw currents up to 10 or 20% of rated maximum, hence will show at this time.

WARNING: If the SURGE light on the Surge Network does not go OFF,* High Voltage is still present within and possibly on the output terminals of the Surge Network. The unit is malfunctioning; it should be turned off and the factory contacted immediately.

If the analog meter drops very slowly after pressing the PULSE switch, a pulse did not occur and the high-voltage safety circuitry is working. Contact factory.

This completes the initial installation and turn-on of the Model 711. For output connections, installation of Companion Units (such as the Model F31 or F33 Coupler/Filter), and Option Modules (such as LSU-121 or VIS-102P), see the appropriate Operating Instruction Section.

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*For operation of the Model 711 itself, and for normal, 120/208V ac line operation with the Model F31. With 480V versions of the Model F31, there may be a continuing glow in the SURGE light with the F31 surge-line breaker on. With the breaker off, the SURGE light should be off in all situations except during CHARGE.

1.3 Remote Charge/Pulse Cable (Supplied Only On User Request)

1.3.1 Without Option Module ARU-151 or 151A

If external charge and pulse control is desired for the Model 711, depress the EXTERNAL push button on the front panel of the Charge/Pulse Unit, CPC-101. At this time, charge and pulse control will transfer from the front panel switches of the Model 711, to the Remote charge/pulse connector, located behind the cover plate of the rear of the Model 711. Connector JJ is as follows:

1.	Spare	Grey
2.	Spare	Violet
3.	Charge Switch Arm	Red
4.	Charge External Normally Open	White
5.	Pulse External Normally Open	Brown
6.	Pulse Switch Arm	Orange

To charge, connect wire 3 to wire 4. With that connection remaining in place, to pulse, connect wire 5 to wire 6. After pulsing, open both 3-4 and 5-6.

NOTE: These circuits operate at a 48V dc level. Connections should be made via external relays or switches rated at 48V dc.

An alternative mode of operation is to leave 5-6 permanently connected; in this mode, the unit will pulse automatically when it is ready, after a suitable delay following the connection of 3-4 for charging. This mode is <u>not</u> recommended, however, since the time the pulse occurs is not under external control. This has negative implications for both test control, and for safety Thus, it is preferable to open 5-6 when 3-4 is opened, following the pulse.

In any event, do <u>not</u> connect the 3-4 circuit to the 5-6 circuit; they must be independent.

1.3.2 With Option Module ARU-151 Without B/K (no alternating polarity option)

Connections are as follows:

1.	LG	Grey
2.	$\overline{\text{INH P IN}}$	Violet
3.	SPARE	Red
4.	$\overline{\text{CR+}}$	White
5.	$\overline{\text{REM P IN}}$	Brown
6.	SPARE	Orange

A. To charge remotely and pulse automatically:

1. Connect $\overline{\text{REM P IN}}$ to LG to initiate charge cycle
2. Connect $\overline{\text{CR+}}$ to LG to initiate each charge/ pulse cycle

B. To charge remotely and pulse on command:

1. Open connection $\overline{\text{REM P IN}}$ to LG
2. Connect $\overline{\text{INH P IN}}$ to LG
3. Connect $\overline{\text{CR+}}$ to LG to initiate charge cycle
4. After appropriate charge delay (pulse ready lite turns on in 5 to 30 seconds depending on programmer network installed). Open connection $\overline{\text{INH P IN}}$ to LG to initiate pulse
5. Repeat steps B2 to B4 for additional charge pulse cycles.

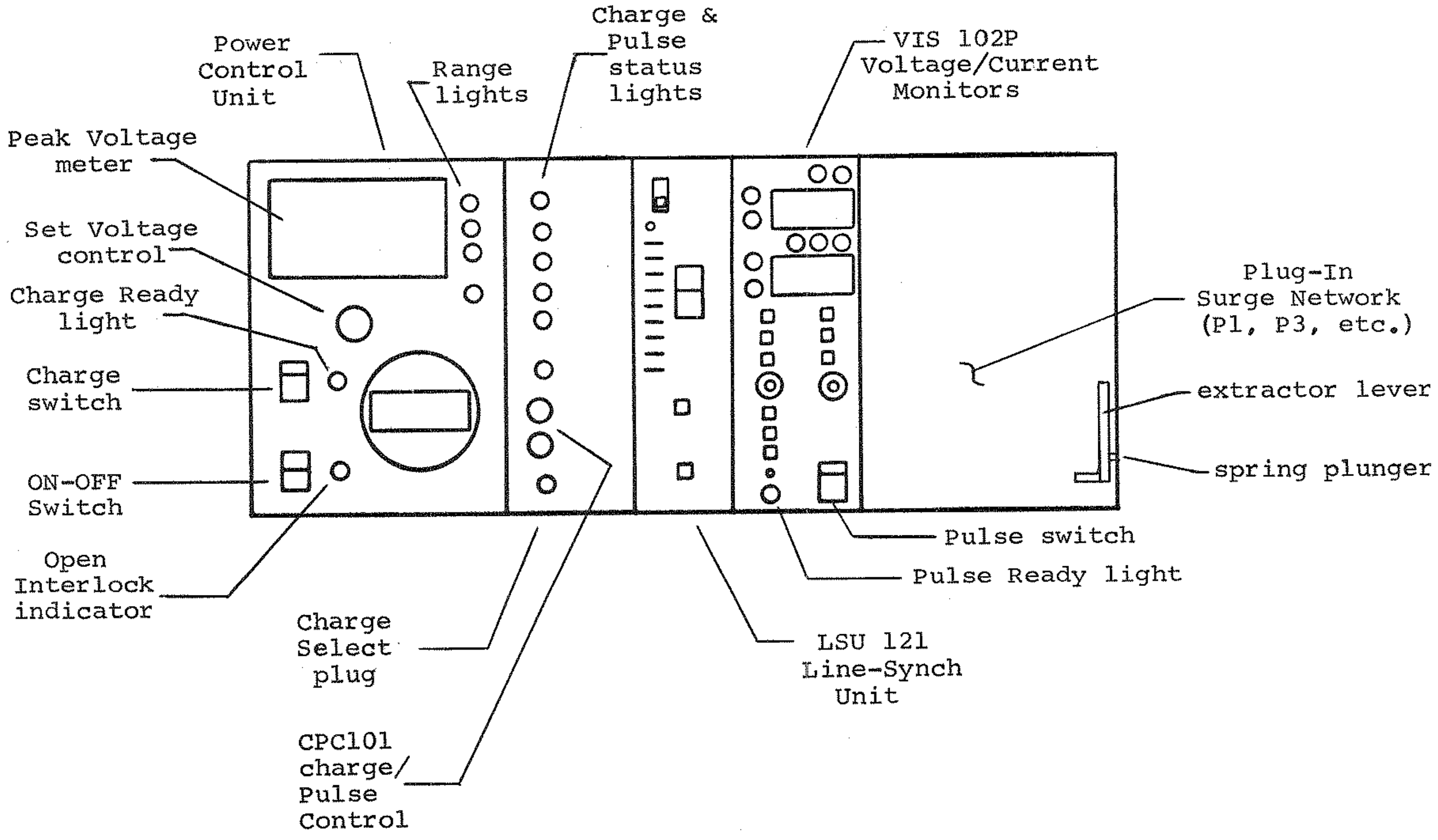

Fig. 1-1

711A/J Front Panel

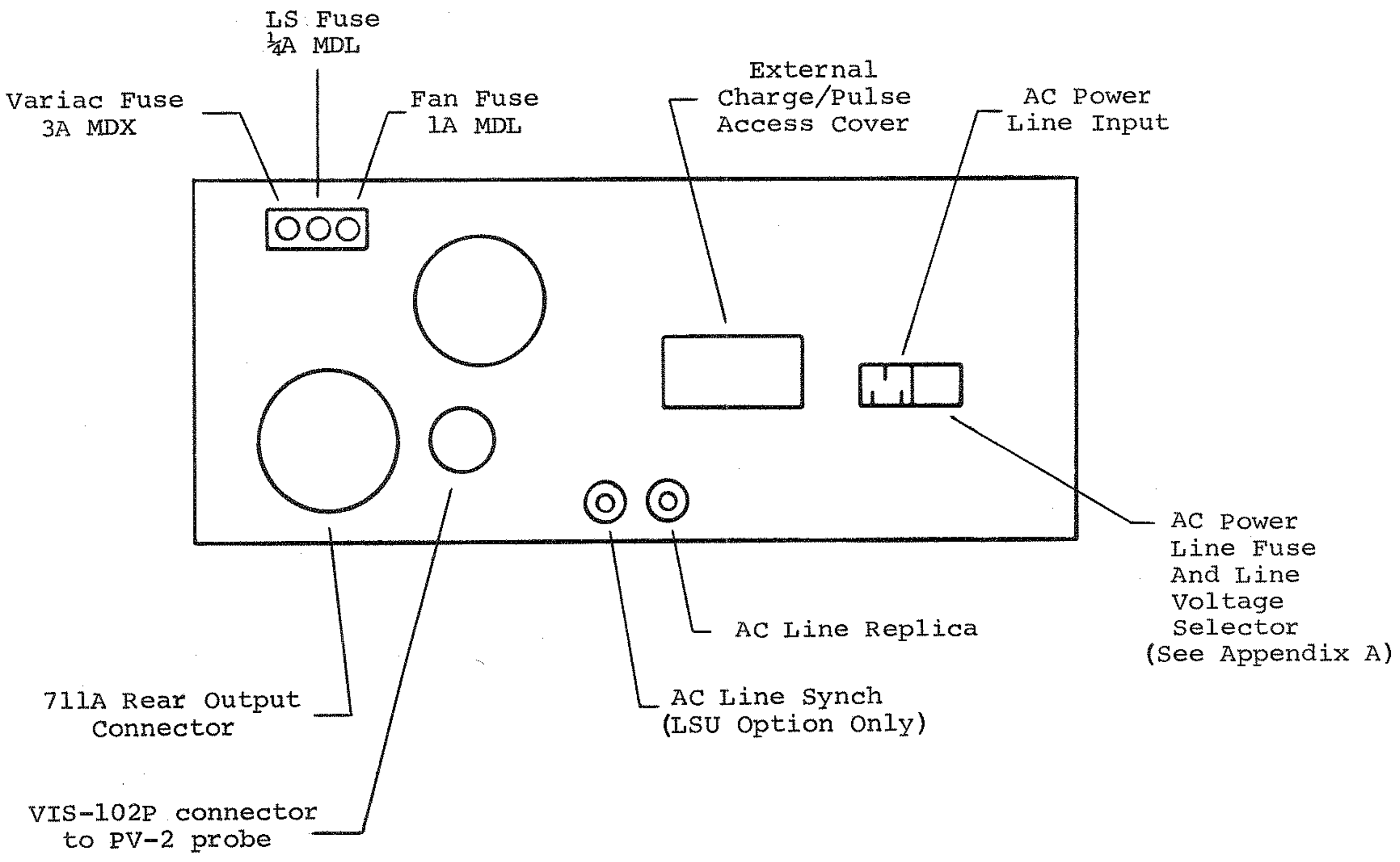

Fig. 1-2

711A/J Rear Panel

2. Interlocks

Interlocks are provided in the 711A mainframe as a safety measure. An open interlock condition will be annunciated by the OPEN INTERLOCK light located just to the right of the 711A POWER ON-OFF switch. If this LED is ON, surge generator operation will be inhibited, and the open interlock in the system must be located and corrected before the unit can be operated.

The following conditions will cause the OPEN INTERLOCK LED to be on, and will prevent operation of the Model 711A:

1. Polarity Selector switch not fully seated.
2. Model 711 Keeper (on the rear of the Model 711A) not fully seated and secured.
3. Surge Network not fully seated in its socket.
4. Surge Network Terminal Cover interlock, or External Interlock in use but open.* (See Section 3C.)
5. Companion Unit or Option Module interlocks open. (See appropriate Operating Instructions for the Option Modules and Companion Units used.)
6. Probe cable disconnected at rear of unit (only with Model F31 connected).
7. With probe head disconnected from probe body (lights VIS "IL" light instead of main OPEN INTERLOCK light).

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*The interlock circuit can be extended from the Surge Network EXT IL socket, to a remote test fixture or enclosure. For interlock plug information, see Section 3, "Surge Networks".

3. Surge Networks

The Model 711 requires a Surge Network, which defines voltage and current waveshapes, peak open-circuit voltage, peak short-circuit current, and surge generator source impedance. The Surge Networks are actually plug-in modules for the 711A mainframe, and can easily be changed when different waves are required.

3.1 To Change Surge Networks

1. Remove the plastic, interlocked Terminal Array Cover from the front of the Surge Network.

2. Pull back the spring plunger on the side of the right handle, and lift the Surge Network extractor lever. (See Fig. 1-1.) This will disengage the Surge Network from its rear connector, and cause it to move forward out of the mainframe by a few inches.

3. Slide the Surge Network forward out of the 711 mainframe. It should slide quite easily. CAUTION: Some Surge Networks weigh as much as 20 lbs.

4. Place the rear of the Surge Network to be used, in the plastic guide located in the center of the Surge Networks opening. This is most easily accomplished by holding the front of the Surge Network at a slight downward angle.

5. Once the Surge Network to be used is properly located in its slide, the network can be inserted straight into its opening until it is approximately three quarters of the way in.

6. Raise the Surge Network extractor until the handle is approximately at the center of the network.

7. Slide the surge network into its opening until some resistance is felt. Pull back on the side spring plunger, lower the extractor handle to seat the Surge Network in its socket, and then release the side spring plunger.

3.2 Output Connections

1. If Companion Units (such as the Model F31 or F33) are used, the surge output is taken from a rear connector to the Companion Unit. Output to the equipment under test is then taken from the Companion Unit and a plastic, interlocked, Terminal Array Cover must be in place on the front of the Surge Network. Refer to the appropriate Operating Instruction for making connections to the equipment under test.

2. If Companion Units (such as the Model F31 or F33) are not used, the surge output is taken directly from the front of the Surge Network on terminals marked SURGE HIGH and SURGE LOW.

3. WARNING!

   Surge Networks are capable of producing voltages in excess of 6kV and currents to 10kA. The energy levels involved can be lethal to personnel and damaging to equipment; therefore, all necessary safety precautions should be taken.

3.3 Interlocks

Each Surge Network is provided with two interlock jacks as follows:

1. KPR IL (Keeper Interlock)

   A plug on each Terminal Cover fits into the KPR IL socket only when the Terminal Cover is in place. This jack is not to be used to extend an interlock condition to an external test fixture or enclosure.

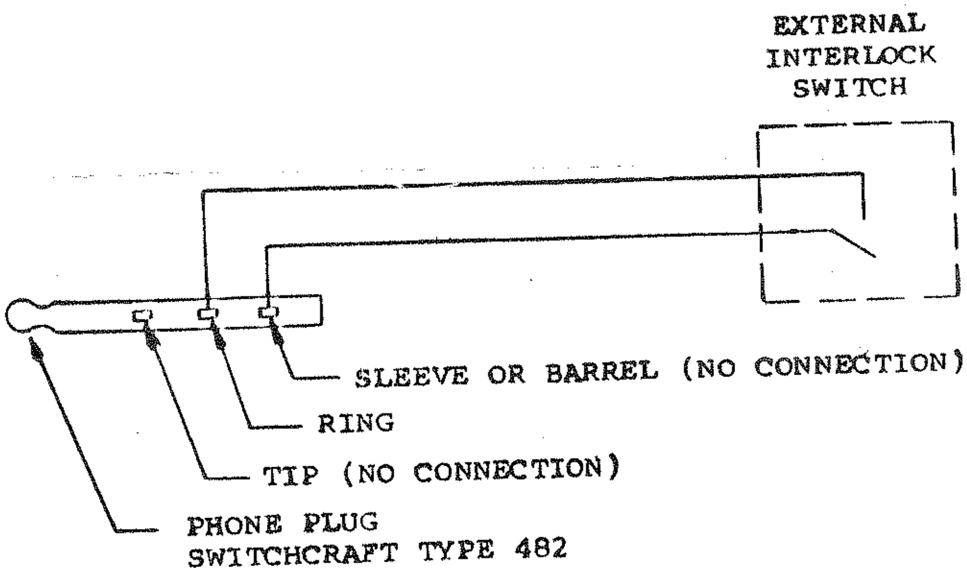
2. EXT IL

   The External Interlock jack (EXT IL) is used when it is desired to extend the Model 711A interlock circuit to include an external test fixture or enclosure. The ring and barrel terminals should be wired to the interlock switch in the fixture or enclosure, such that when the situation is safe, ring is connected to barrel. When a 480V version of the F31 is supplied, the EXT IL jack is "repeated" on the front of the surge network front adapter.

If the EXT IL is in use, the interlock switch must be closed in whatever auxiliary external equipment is connected to it. Note that if the External Jack is not in use, then internal terminals in the Jack automatically short out this interlock, so that normal operation of the instrument will not be inhibited. Only if the Jack is interfaced with an external interlock system -- such as a door on a test chamber or fixture, can the Jack interrupt operation.

The special Type 482 jack is used in order to guarantee that there is no intermediate position for the plug, between fully removed and fully inserted, that will allow the unit to drop back into the "plug removed" situation. The Type 482 has a dead-contact ring that holds the internal telephone jack connections open once they have been opened, unlike standard plugs and jacks.

The Type 482 and its mating jack mounted on the Surge Network front panel are both military-type, heavy-duty units, with high mechanical stability and the connection advantages of gold-plating.



3.4 Instructions Pertinent to Specific Networks

1. P1: Select desired mode: 200A or 500A, at standard IEEE 587 Q, or enhanced Q. The bat-handle selector switch operates like the Model 711 Surge Polarity Switch. (See Fig. 3-1.)

2. P3: For optimum waveform, operate with the Front Output Adapter jumper in place when using the Model 711 without the Model F31. With the Model F31, operate without the P3 Front Output Adapter jumper. (See Fig. 3-2.)

3. P7: Same as item (2) above for the P3.

4. Surge Networks supplied with KeyTek 711 Series equipment are modified for use with systems including Option F31-05 to allow operation on 480V Surge Lines.

   SURGE NETWORKS SUPPLIED WITH SYSTEMS INCLUDING OPTION F31-05 CANNOT BE INTERCHANGED WITH OTHER SURGE NETWORKS, AND SURGE NETWORKS SUPPLIED WITH SYSTEMS NOT INCLUDING OPTION F31-05 CANNOT BE USED IN SYSTEMS THAT DO INCLUDE OPTION F31-05.

3.5 Surge Network P9

Surge Network P9 is designed to produce all three surge waveforms required by FCC Docket 19528 Part 68. The three waves are:

1. < $\overline{10}$ x > 160us, 1500V; 200A short-circuit current (telecom lines).
2. < $\overline{10}$ x > 560us, 1500V; 100A short-circuit current (telecom lines).
3. < $\overline{2}$ x > 10us, 2500V; 1kA short-circuit current (ac lines).

The desired surge wave is selected via a front panel mode switch.

> NOTE: The < $\overline{2}$ x > 10us ac line test can be used to surge live ac lines only if an appropriate Coupler/Filter is used, such as the Model F31. The < $\overline{10}$ x > 160us and < $\overline{10}$ x > 560us waves are not intended to be used for testing ac line input and cannot be filtered with the Model F31 or similar Coupler/Filter.

The output, when either of the two telecom waves are selected, must be taken from the front panel of the Surge Network itself. (NOTE: The 711 keeper plug must be connected at the rear of the Surge Network, and the clear plastic 711 front output fixture must be in place.)

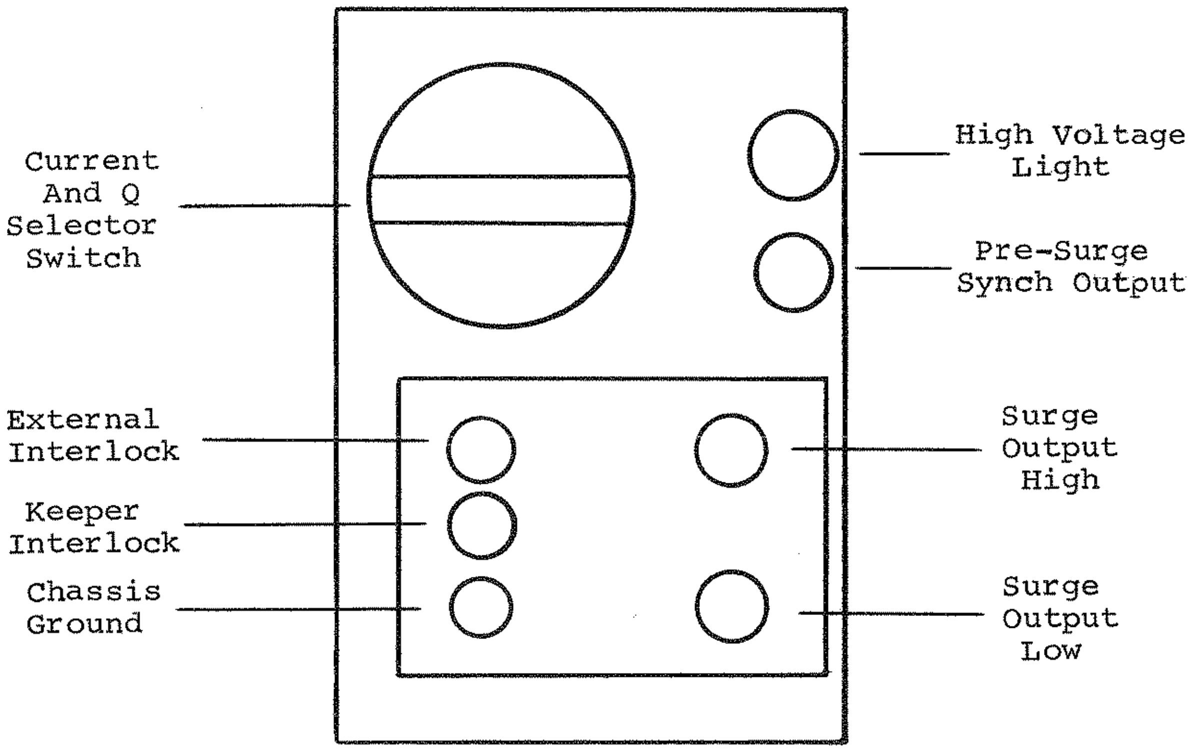


Fig. 3-1

P1 Surge Network

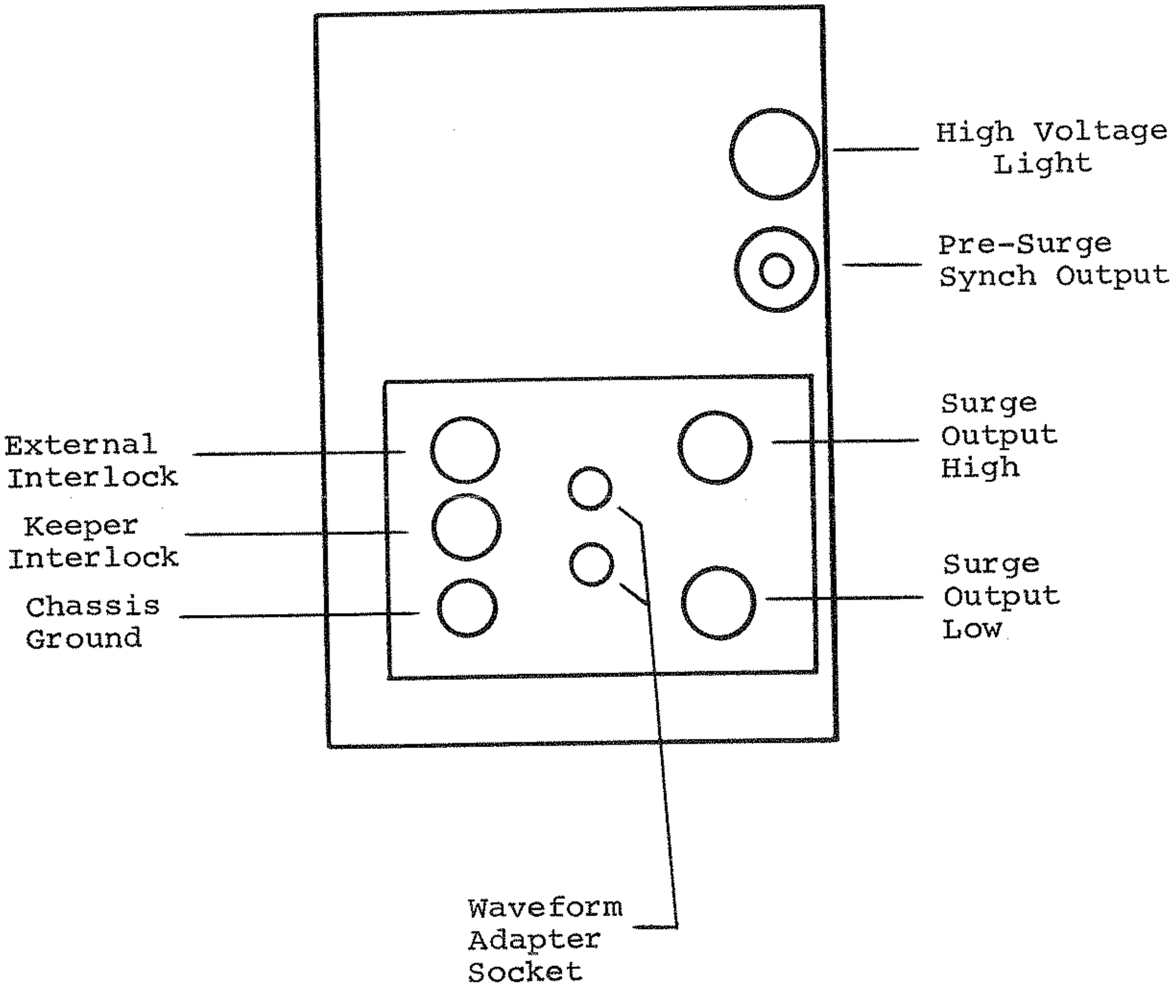


Fig. 3-2

P3 and P7 Surge Networks

3.6 Surge Network P21

3.6.1 Introduction

Surge Network P21 is designed to produce surge waveforms as specified by CCITT, Rec K.17. The three waves are:

1. .5 x 700us open-circuit voltage, 0-6kV; max peak short-circuit current is 400A (when damping R of 0 ohms is selected).

2. 10 x 700us open-circuit voltage, 0-6kV; max peak short-circuit current is 400A (when damping R of 0 ohms is selected).

3. 100 x 700us open-circuit voltage, 0-5kV; max peak short-circuit current is 333A (when damping R of 0 ohms is selected).

Note that the short-circuit currents under (1), (2) and (3) above, are only applicable if the short is applied before the surge is generated. However, so-called "short-circuit" current can be thousands of amperes for gas-tubes or other loads that break down, flash over or crowbar after the capacitor in the surge-generating network that shapes the front of the surge wave is partially charged. This is a function of the circuit defined by CCITT, in which no resistance exists between the shunt capacitor and the load for the 0-ohm damping resistor selection, and is a perfectly normal phenomenon. To reduce this current, use a damping resistor selection of 2.5 ohms or 25 ohms -- which is essentially in series between the front-shaping capacitor and the load.

NOTE: All of the CCITT surge waves are intended for testing equipment connected to telecommunications lines. They are not intended to be used for testing ac line inputs, and cannot be filtered with a Model F31 or similar Coupler/Filter.

3.6.2 Special Waveform Considerations

The P21 plug-in is designed to meet the CCITT specified circuit. This circuit gives results slightly different from the CCITT specs. In particular,

1. The front time for the voltage wave in the 100 x 700 mode is about 70 us;

2. The short-circuit current waves overshoot with even small circuit inductances; 10 to 15% for the 25 ohm damping resistor, 30 to 40% for the 2.5 ohm damping resistor, even higher for the 0 ohm damping resistor.

3. The front time on short-circuit current on the 100 x 700 selection is on the order of 8 to 9 us.

4. The duration of the 100 x 700 selection is on the order of 900 us.

These are the perfectly normal results of the CCITT-specified circuit, which is used in the P21; and will not in any way interfere with the effectiveness of the tests run using this Surge-Forming Network.

3.6.3 Operation

1. The output must be taken from the front panel of the Surge Network itself. The 711/ESU-221 cable must be connected at the rear of the Surge Network, and the clear plastic 711 front output cover must be in place.

2. The desired surge wave, .5 x 700, 10 x 700 or 100 x 700, is selected via front panel mode switches on the P21 Surge Network and the ESU-221 Energy Storage Unit. Both switches must be set to select the same surge wave, otherwise the waveforms will be incorrect. (These switches operate in the same manner as the 711 polarity switch -- see section 1.2, item 3., page 1-2.)

3. It is mandatory that a damping resistor selection be made, or else no output will exist. Therefore, plug in one dual banana jumper (supplied) into the 0 ohms, 2.5 ohms or 25 ohms dual banana receptacles on the P21 front panel (under the output cover).

3.7 Surge Network P41

3.7.1 Introduction

Surge Network P41 is designed to simulate automotive load dump and field decay transients in accordance with SAE J1113a. The two waveforms are specified as follows:

1. Auto dump: 0 to +150V peak, exponential decay, with time constant approximately 230ms; 50A max current.
2. Field decay: 0 to -100V peak, exponential decay, with time constant approximately 8ms; 220A max current.

NOTE: These wave are <u>not</u> intended to be used for testing ac line inputs, and <u>cannot</u> be filtered with a Model F31 or similar Coupler/Filter.

3.7.2 Operation

1. The output of Surge Network P41 must be taken from the front panel of the Surge Network itself. The clear plastic 711 front output fixture must be in place.

2. The desired surge wave, (+) Load Dump or (-) Field Decay, is selected via a front panel push-button switch.
3. The selected wave is superimposed on an (externally-supplied) 14-volt dc source. Terminals are provided inside the interlocked, front-panel cover area for connection of +14 and +14 Return (i.e., the high and low ends of an external battery or power supply, respectively).
4. The front panel 14V supply fuse, as shipped, is 20A MDL (slow-blow). At this value it will blow only for Load Dump, and not in Field Decay, as the latter includes a 3/4 ohm series resistor (as per the SAE specification), which limits the current. An overheat thermostat will eventually

open at excessive currents, however, for <u>either</u> wave; and then the 14-volt supply will disconnect, and its front panel light will go out.

The fuse can be changed to a lower value, of course, to protect either the supply or the circuits to be surged; but a value over 20A should <u>not</u> be used.

5. The I Monitor coax allows oscilloscope monitoring of delivered load current, including the surge. This I monitor output has a scale factor, as indicated, of -10mV per ampere. The minus sign simply means that its polarity is opposite from that of the output current.

4. Model F31

CAUTION: The Model F31 is designed to handle surge waves to 10kA with durations to 50us: Surge Networks P1, P3, P7, P9 (ac surge test). Longer duration waves, such as those produced by Surge Networks P9 (telecom waves), P21, and P41, CANNOT be used with the Model F31.

The KeyTek Model F31 Surge Coupler/Filter permits coupling high voltage, high current spike-surges from a compatible external surge generator, to the ac or dc power line input of a circuit or system under test. Coupling means are provided not only for normal mode or line-to-line, but also for all three key common modes (line 1 to ground, line 2 to ground, and lines 1 and 2 together to ground). In addition, the Model F31 provides surge back-filtering, to prevent surging other equipment connected to the power source; even when surges are applied to points within the test piece other than the power line that drives it.

WARNING: High surge voltages and currents, as well as ac line voltage, will be present at the Model F31 output.

4.1 Connections for Surging the AC or DC Power Line (refer to Fig. 4-1 for connector locations).

1. Connect the F31 Surge Input Cable from the 711 Rear Output Connector, to the Model F31 Surge Input Connector on the F31 rear panel.*

2. Connect the AC Interlock power cable from the rear panel of the F31 to the ac power line. (Note: normally set for 120 Vac, 60Hz line for units shipped within the U.S., and to 220 or 240 Vac 50Hz for units exported. To set for other line voltages, use the procedure given in Appendix A.)

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*First disconnect the Model 711 rear keeper plug if it is in place; the F31 Surge Input Cable replaces it when the F31 is used.

3. Connect the AC or DC line to be surged to the Surge Line Input Connector on the rear of the F31 (up to 277 Vac, 120 Vdc).*

4. Power connections to the Equipment Under Test (EUT) can now be made from the output ac socket adapter that mounts to the Model F31 front panel output connections, <u>or</u> directly to the three front panel Output Connectors: Surged High (high for ac lines), Surged Low (neutral for ac lines)* and Surged Ground ("third wire" ground for ac lines).

4.2 Connections for Surging a Signal Line While Using the F31 to Surge-Filter the Power Line (refer to Fig. 4-1 for connector locations).

Note: See Figure 4 of KeyTek Preliminary Bulletin F31/1 for the recommended method for surge testing a signal line.

1. Connect the F31 Keeper Cable from the rear surge input connector on the Model F31, to the Model 711A Rear Output Connector. This keeper replaces the Surge Input Cable used in A.1, above.

2. Connect the AC Interlock power cable from the rear panel of the F31 to the ac power line. (Note: normally set for 120 Vac, 60Hz line for units shipped within the U.S., and to 220 or 240 Vac, 50Hz for units exported. To set for other line voltages, use the procedure given in the Appendix A.)

3. Connect the AC or DC line that is to power the equipment under test, to the Surge Line Input Connector on the rear of the F31 (up to 277 Vac, 120 Vdc).*

4. Power connections to the Equipment Under Test (EUT) can now be made from the output ac socket adapter that mounts to the Model F31 front panel output connections, <u>or</u> directly to the three front panel Output Connectors: Surged High (High for ac lines), Surged Low (neutral for ac lines)* and Surged Ground ("third wire" ground for ac lines).

*For the 480V version of the F31, connect this connector to the rear of the F48, companion to the F31V used in this application. WARNING: Keep the F48 horizontal when in operation, as the interlock relays it contains are mercury operated.
Also note Surged Low is <u>not</u> neutral in a 480V system, but is generally 277V above ground.

5. The surge output from the Model 711A/J front panel can now be connected directly to the Equipment Under Test (EUT) to a signal line, or some other point in the EUT. (NOTE: use suitable coupler(s).)+

4.3 Interlock Conditions

Any open interlock will inhibit both surge generator operation <u>and</u> surge-line relay operation. For normal operation all interlocks must be closed. The interlocks are as follows for the Model F31:

1. AC Interlock Power must be ON.
2. A. For unit shipped to the U.S. or Canada, if AC interlock power to the F31 is reversed, or if a low resistance path does not exist between ac neutral and third wire ground, surge generator operation will be inhibited. This condition can not be bypassed.

   B. For unit shipped overseas, this interlock condition is permanently bypassed, since most overseas power systems do not have a neutral which is at the same potential as the third wire ground.
3. All High Voltage cables must be properly connected.
4. The Model F31 Output Terminal cover must be installed.
5. For an ac surge line, the Model F31 surge-line relay is inhibited if surge line low is not at ground potential. This can be bypassed by the operator* if neither side of the surge line is at ground potential.** The fact that it has been bypassed will be annunciated on the Model F31 front panel. (This entire function is inoperative for dc surge lines and the 480V unit.)
6. When using the Model F31 EXT IL connector, an external interlock switch must be connected (ring and barrel), and closed at the EUT. (Note: use <u>only</u> a phone plug Switchcraft type 482 for the EXT IL jack.)
7. The Mode Selector switch must be fully engaged in the selected coupling mode.

+See AN105 and AN106. USE WITHOUT COUPLER(S) CAN DAMAGE THE MODEL 711, THE MODEL F31 AND/OR THE EUT.

*Front panel push-push switch. (Not with 480V unit.)

**It can also be bypassed if the ac surge line is reversed; however, this is <u>NOT</u> recommended since high and low are then reversed to the equipment under test.
It is automatically bypassed in the 480V unit, as surge line low is usually 277V from ground.

4.4 Operation

> Note: Before attempting to operate the Model F31, review the Model 711 Operating Instructions, and Application Notes AN105 and 106.

1. To operate the Model F31, the INTERLOCK POWER switch must be on. Failure to turn this switch on will prohibit surge generator operation <u>and</u> surge-line relay operation.

2. Coupling -- The mode of coupling to the ac surge line is selected via the coupling mode selector located on the Model F31 front panel. To select the coupling mode, proceed as follows (see Fig. 4-1):

   a. Turn the selector bat-handle counter-clockwise until the selector plug is completely disengaged from its socket. (Note: The selector plug is captive and cannot be removed from the Model F31 front panel. In addition, the selector plug is being held in position by a detent mechanism).

   b. Grasp the outer edge of the selector plug, pull the selector forward approximately 1/4" to free it from the detent, and turn it to the desired coupling mode.

   c. Under normal conditions, when all other interlock conditions are satisfied, turn the selector mode bat-handle clockwise to 1/8 turn past the point where the interlock light goes out.

   > CAUTION: <u>DO NOT OVERTIGHTEN</u>! If other interlock conditions are not met, the interlock light will <u>not</u> go out.

3. Operating with surge-line low not at ground: for an ac line where neither side of the ground is at ground potential, it is necessary to bypass an interlock condition which would normally prohibit operation. This bypass switch is located on the left side of the Model F31 front panel. (Not with 480V unit.)

4. Applying surge-line power to the EUT: as long as the surge-line circuit breaker is switched off, no power is applied to the equipment under test. To apply power, simply switch on the breaker. (The ac or dc line to be surged must be connected -- see Section A, 3. above.) (Note: any interlock condition noted in Section C above, will prevent the operator from turning the surge-line relays on.) A red LED marked BREAKER ON, near the Model F31 output terminals will be ON when the surge line is live.*

4.5 Waveforms

Surge Networks used with the Model 711 have been calibrated to provide specified waveforms at the Surge Network Output Terminals. When travelling these waves through the Model F31, some minor waveform anomalies may be observed due to the effects of the coupling and filtering components.

Surge Networks used when a 50A F31 is supplied, are optimized at the F31 output in a "balanced" way for all four coupling modes. Waves at the Surge Network front panels may, therefore, have deviations from nominal values.

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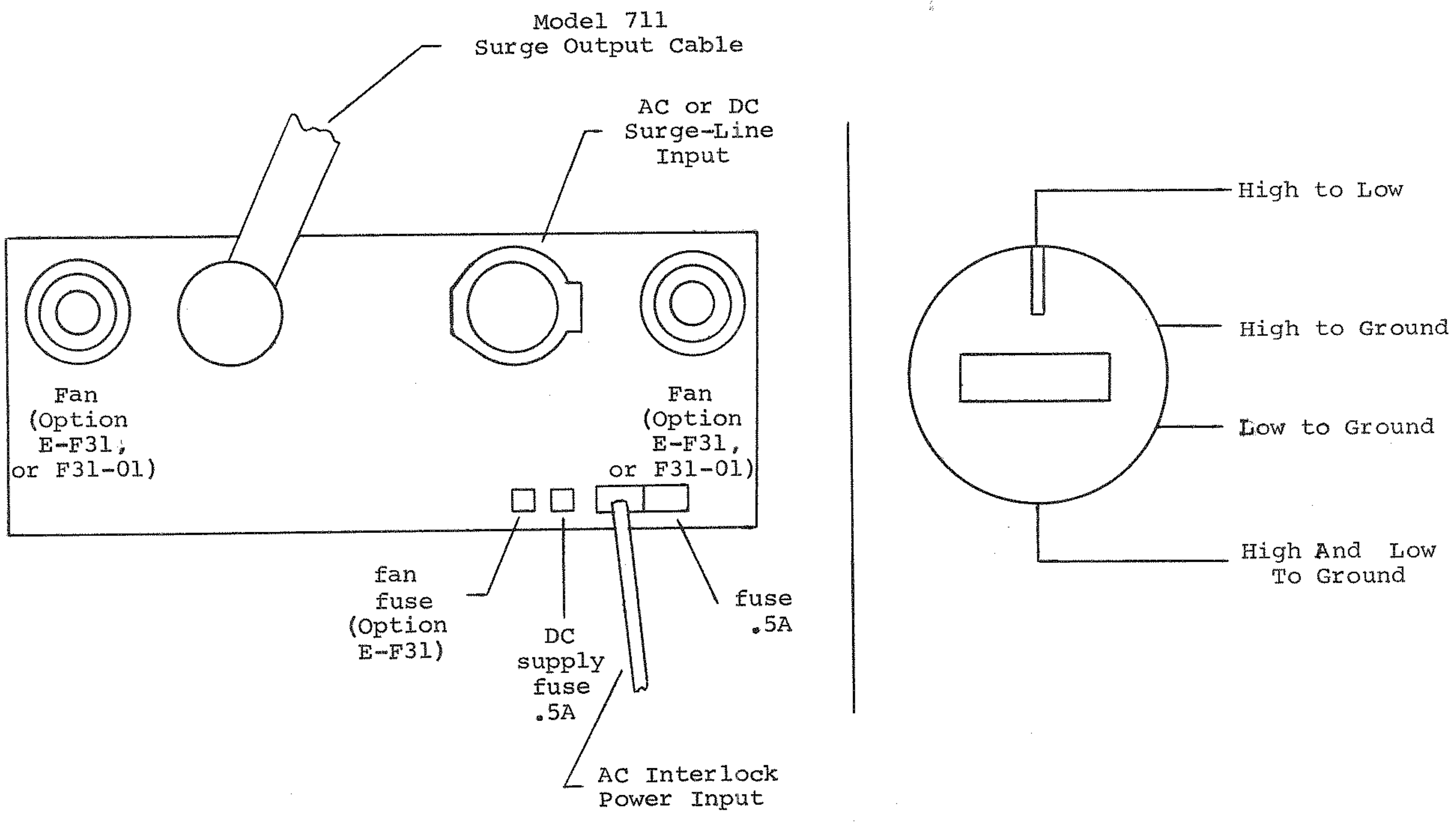
*It is strongly recommended that surging be first accomplished with surge line power <u>off</u>.



MODEL F31 REAR PANEL

MODEL F31
COUPLING MODE
SELECTOR SWITCH

Fig. 4-1

4.6 711 Model A/J Option G

Option G is added to the 711 A/J in order to provide low undershoot waveforms when using the filter outputs with the P3 Surge Network wave. The addition of the Option G significantly reduces both open circuit voltage and short circuit current waveform undershoots. The front panel output of the P3G Surge Network is unchanged. The wave shapes of all other Surge Networks are unaffected or improved (P1G is unchanged, P7G has been improved).

WARNING

Option G provides low undershoot open-circuit voltage and short-circuit current waveforms in HI to LOW, HI to GND and LOW to GND coupling modes, when used with a Model 711 and P3G. However, the HI and LOW to GND coupling mode provides waveforms similar to those obtained when using a standard surge generator and coupler/filter; i.e., undershoots are essentially unchanged in this one mode.

The addition of Option G restricts surge line voltage to 120VAC or less; thus the F31 with Option G surge line input must not be connected to a line whose voltage exceeds 120VAC. Connecting the surge line input to a source greater than 120VAC may result in damage to the unit.

DESCRIPTION AND BACKGROUND

Figs. 4-1.1 and 4-1.2 show typical open-circuit voltage and short-circuit current waveforms respectively, obtained when using a standard 711 A/J, with a P3 Surge Network surging the filter in the HI to LOW coupling mode. The undershoot of the open-circuit voltage wave is approximately 30%. The short-circuit current wave undershoots about 12%. Figs. 4-1.3 and 4-1.4 show the same waves as Figs. 4-1.1 and 4-1.2 respectively, but using a 711 A/J with Option G, including the P3G. Photo 3, with this new configuration, shows an open-circuit voltage undershoot of only about 10%. The short-circuit current wave of Fig. 4 for the same new configuration undershoots only approximately 3%. These represent significant reductions in both voltage and current wave backswings.

In application to clamping protectors, the low-undershoot waves yield dramatically improved results. For a standard coupler/filter configuration with open circuit voltage of 6KV, Fig. 4-1.5 shows the voltage across a clamping protector clamping at 460V, and Fig. 4-1.6 shows the resulting protector current wave. Both waves show that the protector engages in the reverse direction during the undershoot. Figs. 4-1.7 and 4-1.8 show analogous voltage and current waveforms, respectively, with a 711 A/J with Option G for the same clamping protector. It has not engaged in the reverse direction. The small voltage undershoot that takes place after the protector has been driven in the forward direction is not large enough to re-engage the protector. Thus for applications in which undershoot sensitive devices are being tested, Option G can provide significantly enhanced results.

The Option G mainframe, filter and surge networks are not compatible with their non-optioned, standard counterparts and therefore are not interchangeable. The Charge/Pulse and Line Synch units are, however, fully compatible between standard and Option G 711's. The VIS102P from a 711G is backwards-compatible with standard 711 units.

The Option G 711 mainframe is identified by the presence of the Auxiliary Switch Assembly on the rear panel. It also includes an additional interlock condition to detect the failure of this assembly. The Surge Networks are designated P1G, P3G, P7G etc. The VIS102P with Option G is identified by the presence of not one but two LED interlock indicators in the bottom portion of its front panel. The F31 Surge Coupler/Filter with Option G is marked "Surge Coupler/Filter Option G" on the bottom left corner of the front panel.

OPTION G OPERATION

The operation of a 711 A/J with Option G is identical to that of a standard 711 A/J but with the addition of two important considerations:

1. The use of the Option G filter surge line input is restricted to 120VAC.* Connecting the surge line input to higher surge line voltages may result in damage to the unit.

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*Additional modifications needed to restore 240VAC capability.

2. The Option G Auxiliary Switch Assembly, a black box attached to the rear panel of the 711G, must be in place and properly tightened down for all surge testing. Failure to correctly affix the Auxiliary Switch Assembly will result in an open interlock condition. The open interlock will prevent charging or pulsing.

An additional interlock condition has been added to the 711G interlock system. The purpose of this interlock is to detect a failure of the Option G Auxiliary Switch Assembly which will in turn prevent further operation by opening the interlock of both the 711G and the F31G. This condition is indicated by the illumination of both interlock indicators in the bottom portion of the VIS front panel, as well as the open interlock LED's in the 711G mainframe front panel and the F31G front panel. (Normal interlock conditions are indicated by the 711G mainframe, F31G front panel indicators and the VIS front panel LED indicator number 1 in the usual way.)

A failure of the Auxiliary Switch Assembly is thus indicated by the illumination of both indicators on the VIS front panel, plus the indicators on the 711G mainframe and the F31G front panel. In the event that this condition occurs, it can only be reset by turning off both the Model 711G Surge Generator and Model F31G Filter. Turn off the F31G surge line breaker if it was in the on position. Turn off the F31G interlock AC power and turn off the 711G power switch. Wait 10 seconds. Turn power back on and surge again. If the Auxiliary Switch Assembly interlock condition repeats, contact factory for service information. Continued use with a failed Auxiliary Switch Assembly can result in extensive damage to the unit.

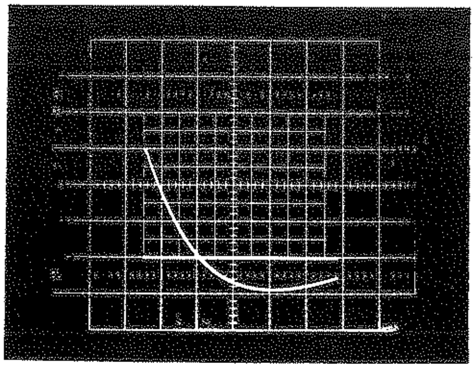


Fig. 4-1.1

Typical Open-Circuit Voltage Wave When Using Back Filter; approximately 1.2/50, 30% Undershoot

OCV 6kV

2kV/cm 100us/cm

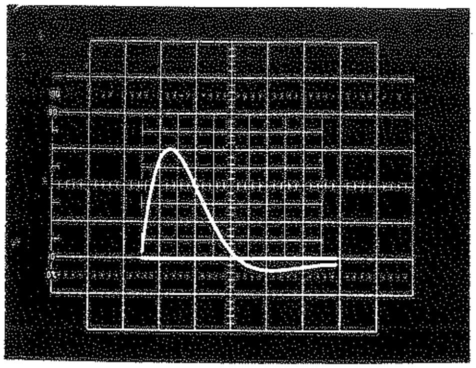


Fig. 4-1.2

Short Circuit Current Resulting from the Wave of Fig. 4-1.1; 12% Undershoot

1kA/cm 10us/cm

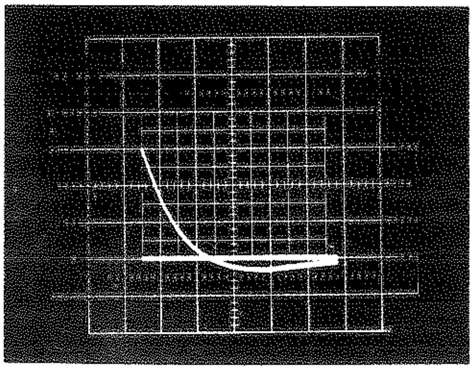


Fig. 4-1.3

Open Circuit Voltage Wave of Fig. 1 Using 711A/J with Option G; Approximately 1.2/50, 10% Undershoot

OCV 6kV

2kV/cm 100us/cm

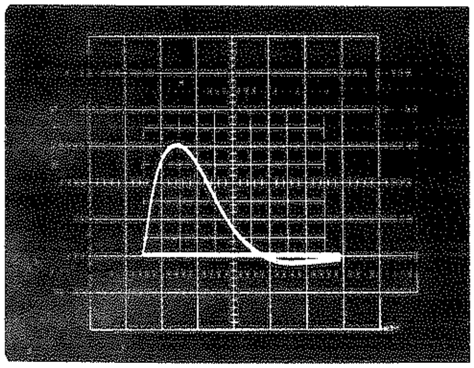


Fig. 4-1.4

Short Circuit Current Resulting from the Wave of Fig. 4-1.3; 5% Undershoot

1kA/cm 10us/cm

Note: "OCV: = open-circuit voltage

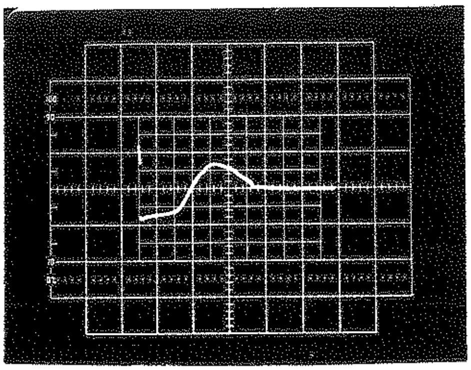


Fig. 4-1.5

Voltage Wave Across a Clamping Protector Clamping at 460V, for the Open-Circuit Voltage Waveshape of Fig. 4-1.1 and the Short Circuit Current Waveshape of Fig. 4-1.2.

400V/cm   400us/cm

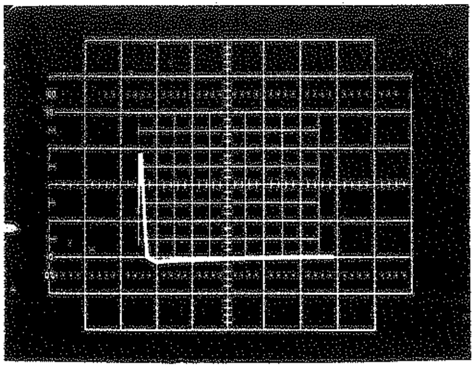


Fig. 4-1.6

Current Wave into the Protector of Fig. 4-1.5

1kA/cm   100us/cm

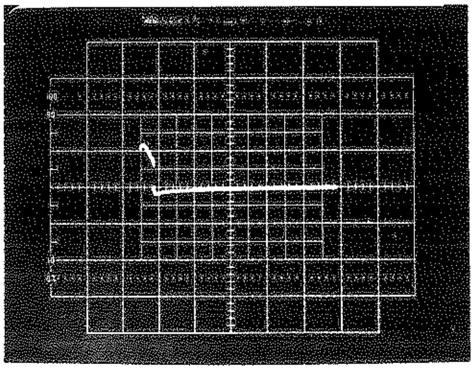


Fig. 4-1.7

Voltage Wave Across a Clamping Protector Clamping at 460V, for the Open-Circuit Voltage Waveshape of Fig. 4-1.3 and the Short Circuit Current Waveshape of Fig. 4-1.4.

NOTE: USES OPTION G FILTER

400V/cm   100us/cm

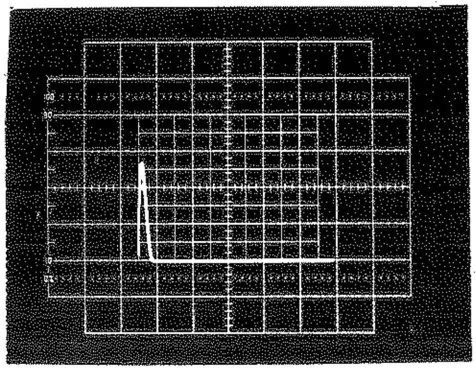


Fig. 4-1.8

Current Wave into the Protector of Fig. 4-1.7

NOTE: USES OPTION G FILTER

1kA/cm   100us/cm

4.7 Option F31-05, 480V Surge Line Voltage

1. General

The Option F31-05 is designed to permit operation of the Model F31 on ac power lines operating at voltages to 480V rms. An external Surge Line Power Unit, the Model F48, is provided. It contains a 480V surge line breaker, power interlock relays and associated circuitry.

WARNING

> The Model F48 power interlock relays use the mercury-plunger design, to guarantee trouble-free operation for tens of millions of cycles. HOWEVER, as indicated on the Model F48 front panel, <u>it is mandatory that the F48 be kept essentially horizontal at all times that surge-line power is applied</u>, so these relays will provide proper interlock operation.

2. Specifications

The specifications of the Model F31 with Option F31-05 are as follows:

AC (50/60Hz)	0-480V rms	line to line
	0-277V rms	line to ground
DC	0-120V	line to line

3. Operation

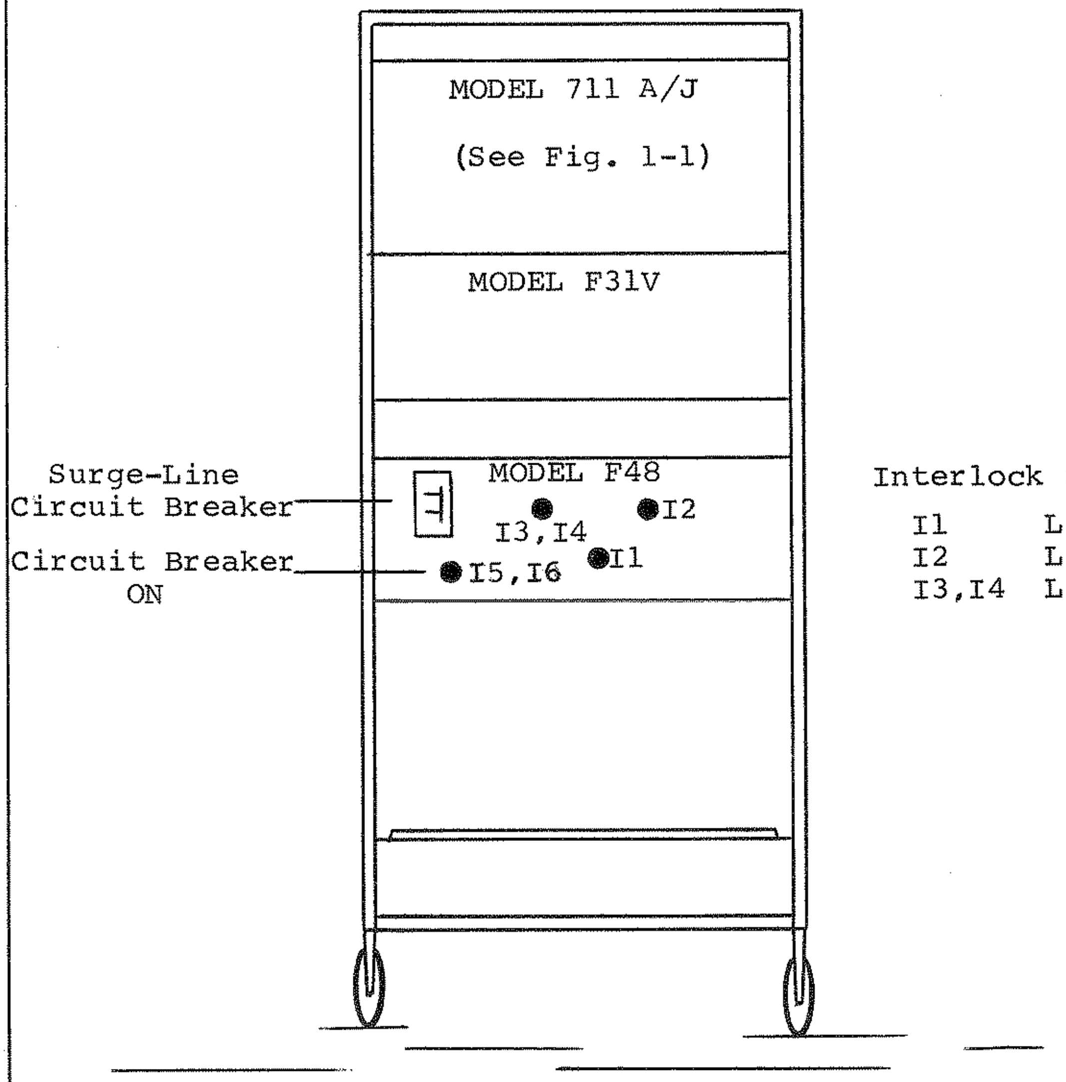
The 30A Surge Line Input Breaker on the Surge Line Power Unit must be ON to provide power to the equipment under test. (Note: the two center poles are the only ones that are used in this application.)

If an interlock condition exists on the associated Model 711A or Model F31*, the interlock relays in the Surge Line Power Unit will open to prevent power from being applied to the Model F31 Surge Coupler/Filter, and in turn, to the equipment under test.

*See pages 2-1, 3-2, and 4-3 for possible interlock conditions in the Model 711 and F31.

4. Surge Networks supplied with KeyTek 711 Series equipment are modified for use with systems including Option F31-05 to allow operation on 480V Surge Lines.

   SURGE NETWORKS SUPPLIED WITH SYSTEMS INCLUDING OPTION F31-05 CANNOT BE INTERCHANGED WITH OTHER SURGE NETWORKS, AND SURGE NETWORKS SUPPLIED WITH SYSTEMS NOT INCLUDING OPTION F31-05 CANNOT BE USED IN SYSTEMS THAT DO INCLUDE OPTION F31-05.



Interlock relay lights:

I1	Line 1 to ground
I2	Line 2 to ground
I3,I4	Line 2 to line 1

Figure 4-2

Front, 480 Volt Unit:
711 A/J, F31V, F48

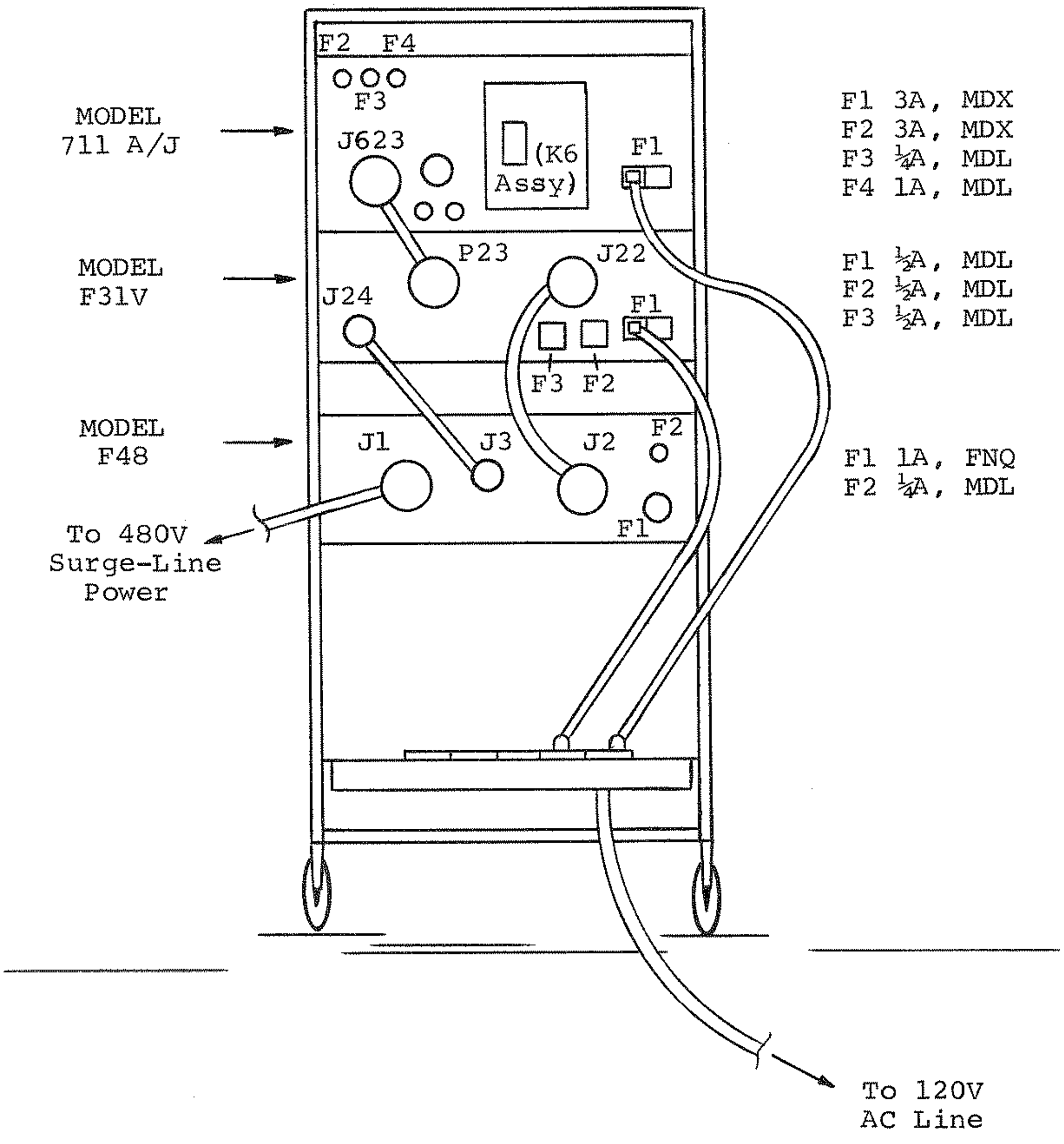


Figure 4-3

Rear, 480 Volt Unit:
711 A/J, F31V, F48

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4.8 Model F33

Model F33 Surge Coupler/Filter is designed to allow coupling to, and back filtering of, a three-phase, five wire line powering equipment under test. The surge can be coupled from any line to any other line or combination of lines.

A surge-line input breaker is provided at the input of the coupler/filter to provide a convenient means of disconnecting the power. Interlock relays open and disconnect input power from the equipment under test (EUT) if any of the interlock conditions in the Model 711A or Model F33 are not met. (See pages 2-1, 3-2 and 3-3 of the 711 Operating Instructions, and section 4.8.2 below).

The Model F33 consists of five separate units. The F49 handles the breakering and interlock relays. Model F41 allows selection of the surge generator LOW connection. The Models F42 and F43 allows selection of the surge generator HIGH connection(s) -- from one to four of the five-wire input lines. Finally, Model F81 Termination Assembly combines, on the front panels of the three, the outputs from the F41, F42 and F43, and makes them available to the Equipment Under Test.

4.8.1 Specifications

1. Surge-Line Voltage

AC	0-277V rms	line to line
	0-277V rms	line to ground
DC	0-120V dc	line to line

2. Surge-Line Current

   20A continuous per phase, 30A intermittent.

4.8.2 Installation (refer to Fig. 4-4 for rear connector locations)

The Model F33 is shipped as part of a total system, including the Model 711A Surge Generator. All rear cables, with the exception of the ac surge-line input cable (to F49, J1), are in place and are connected when the unit is shipped.

1. AC input power

   All units comprising the system that require ac power for operation, are connected to an outlet strip mounted on the Model C12 Instrument Carrier. A single ac line cord is provided for connection to a standard 120V ac (15A) outlet.

2. Surge-Line Input Power (3-phase wye with ground: 5 wires)

   The ac surge-line input cable must be connected at the rear of the Model F49. This line will provide ac power to the Model F81 Output Termination assembly, and, in turn, to the EUT.*

3. Connection to EUT

   AC Power connections to the EUT are made at the Model F81 Termination Assembly. A heavy-duty box terminal is provided for each of the five lines.

   CAUTION: Extreme care must be taken to insure the correct lines are connected to the binding posts as labled. Connecting Line 2 to the terminal marked Line 1, for example, will result in erroneous test information. AND GROUND AND NEUTRAL MUST BE CONNECTED TO THEIR RESPECTIVE TERMINALS!

4.8.3 AC Surge-Line Interlocks

An interlock light will operate on the Model 711 Mainframe, and ac power to the equipment under test will be removed, if any of the following conditions exist.

A. Model F81 Termination Assembly Cover removed.

B. Model 711 Termination Assembly Cover removed.

C. High Voltage Cable from Model 711 to Models F42 and F43, or other cables, disconnected.

D. Coupling mode switch on the Model F41, F42, or F43 not sealed properly.

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*Operation of the surge generator <u>is</u> allowed without connecting the ac surge line; however, no ac power will be applied to the EUT.

4.8.4 Operation

To select the appropriate coupling mode, three switches are provided -- one each, on the front of the Model F41, F42 and F43. Coupling is allowed from any line, to any other line or combination of lines. The high output of the surge generator is coupled via the Model F42 and F43, and the low output of the surge generator is coupled via the Model F41.

As an example, to surge lines 1, 2, and 3 with respect to neutral and ground, the switches must be set as follows:

Model F43	L2 and L3
Model F42	L1
Model F41	G and N*

There is a position on the switches for the Model F43 and F42 that is marked "NO CONN". This position is used when no connection is desired to any of the lines associated with that switch. For example, to surge only line 2 with respect to neutral, the switches must be set as follows:

Model F43	L2
Model F42	NO CONN
Model F41	N

There are eight basic surge modes for a 5-wire wye. They are:

	F41	F42	F43
Line 3 to Line 2	L2	NO CONN	L3
Line 2 to Line 1	L1	NO CONN	L2
Line 3 to Line 1	L1	NO CONN	L3
Line 3 to Neutral	N	NO CONN	L3
Line 2 to Neutral	N	NO CONN	L2
Line 1 to Neutral	N	L1	NO CONN
Lines 3, 2 and 1 to Neutral	N	L1	L2 and L3
Lines 3, 2, 1 and Neutral to Ground	G	N and L1	L2 and L3

*Note: When coupling with respect to neutral and ground together, neutral and ground are electrically shorted at the low end of the surge generator output.

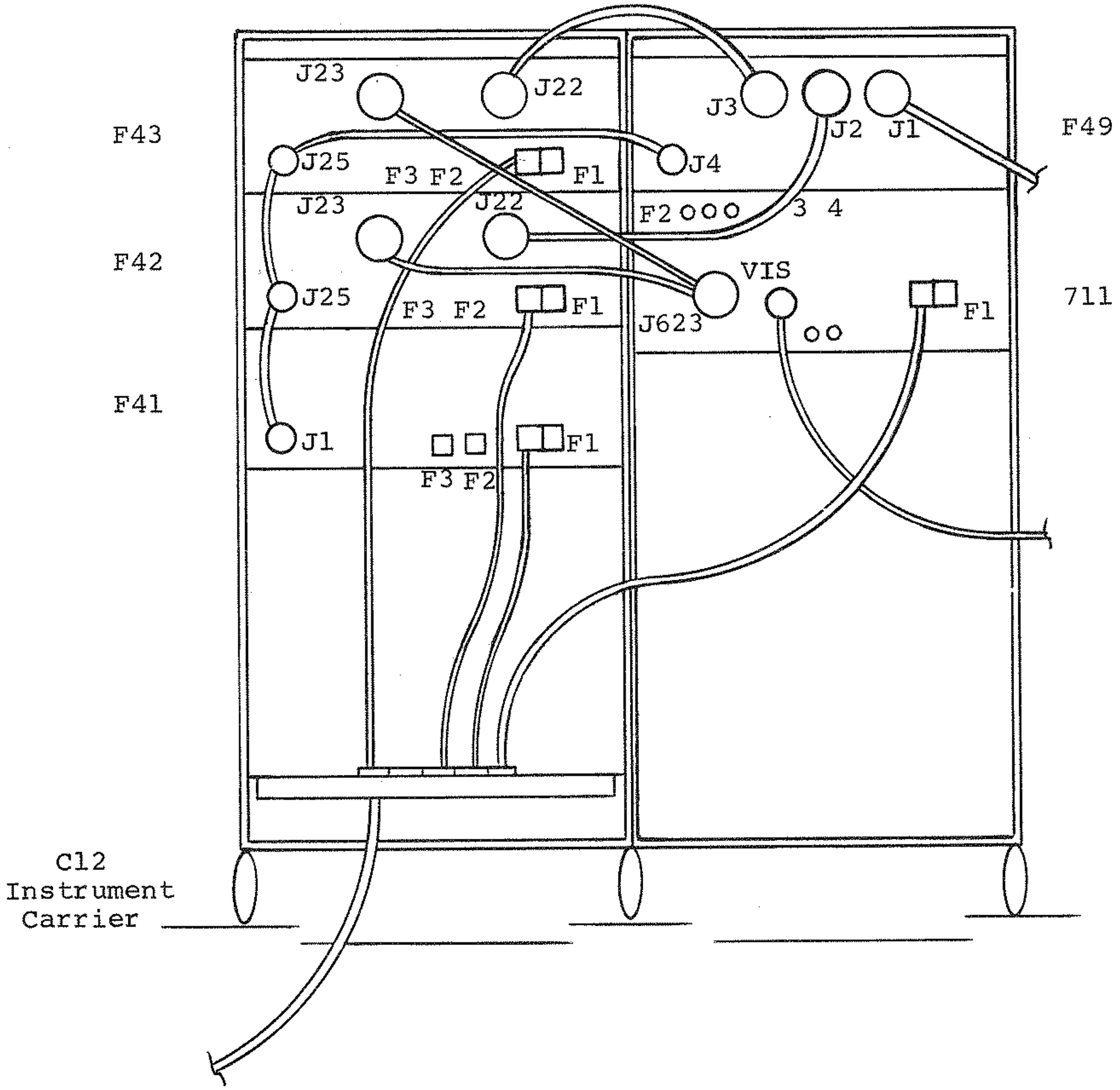

Figure 4-4

Model F33, Rear View
(with Model 711)

4.9 Model F33 with Option F33-02

Model F33 Surge Coupler/Filter is designed to allow coupling to, and back filtering of, a three-phase, five wire line powering equipment under test. The surge can be coupled from any line to any other line or combination of lines.

A surge-line input breaker is provided at the input of the coupler/filter to provide a convenient means of disconnecting the power. Interlock relays open and disconnect input power from the equipment under test (EUT) if any of the interlock conditions in the Model 711A or Model F33 are not met. (See pages 2-1, 3-2 and 3-3 of the 711 Operating Instructions, and section 4.9.2 below).

The Model F33 with Option F33-02 consists of eight separate units mounted on a Model C12 Instrument Carrier. The individual units are:

(1) Model F49:	Contains AC Surge Line Breaker and interlock relays
(2) Model F50:	House the 50A filter chokes
(1) Model F41:	Allows selection of surge generator LOW connection
(1) Model F42 and (1) Model F43:	Together, these units allow selection of surge generator HIGH connection(s)
(1) Model F81:	Termination Assembly that combines the outputs from the Models F41, F42, and F43.
(1) Model F83:	Output Termination Assembly connected between the two Model F50's at the rear of the unit to provide connection of the surge line to the Equipment Under Test (EUT).

4.9.1 Specifications

1. Surge-Line Voltage

AC	0-277V rms 0-277V rms	line to line line to ground
DC	0-120V dc	line to line

2. Surge-Line Current

   50A ac continuous per phase.

4.9.2 Installation (refer to Fig. 4-5 for rear connector locations)

The Model F33 with Option F33-02 is shipped as part of a total system, including the Model 711A Surge Generator. All rear cables, with the exception of the ac surge-line input cable (to F49, J1), are in place and are connected when the unit is shipped.

1. AC input power

   All units comprising the system that require ac power for operation, are connected to an outlet strip mounted on the Model C12 Instrument Carrier. A single ac line cord is provided for connection to a standard 120V ac (15A) outlet.

2. Surge-Line Input Power (3-phase wye with ground: 5 wires)

   The ac surge-line input cable must be connected at the rear of the Model F49. This line will provide ac power to the Model F83 Output Termination assembly, and, in turn, to the EUT.*

3. Connection to EUT

   AC Power connections to the EUT are made at the Model F83 Output Termination Assembly, located at the rear of the Model F50's. A heavy-duty box terminal is provided for each of the five lines.

   CAUTION: Extreme care must be taken to insure the correct lines are connected to the binding posts as labelled. Connecting Line 2 to the terminal marked Line 1, for example, will result in erroneous test information. AND GROUND AND NEUTRAL MUST BE CONNECTED TO THEIR RESPECTIVE TERMINALS!

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*Operation of the surge generator <u>is</u> allowed without connecting the ac surge line; however, no ac power will be applied to the EUT.

4.9.3 AC Surge-Line Interlocks

An interlock light will operate on the Model 711 Mainframe, and ac power to the equipment under test will be removed, if any of the following conditions exist.

A. Model F81 Termination Assembly removed.

B. Model F83 Output Termination Assembly cover removed.

C. Model 711 Front Output Keeper removed.

D. High Voltage Cable from Model 711 to Models F42 and F43, or other cables, disconnected.

E. Coupling mode switch on the Model F41, F42, or F43 not seated properly.

4.9.4 Operation

To select the appropriate coupling mode, three switches are provided -- one each, on the front of the Models F41, F42 and F43. Coupling is allowed from any line, to any other line or combination of lines. The high output of the surge generator is coupled via the Models F42 and F43, and the low output of the surge generator is coupled via the Model F41.

As an example, to surge lines 1, 2, and 3 with respect to neutral <u>and</u> ground, the switches must be set as follows:

Model F43	L2 and L3
Model F42	L1
Model F41	G and N*

There is a position on the switches for the Model F43 and F42 that is marked "NO CONN". This position is used when no connection is desired to any of the lines associated with that switch. For example, to surge only line 2 with respect to neutral, the switches must be set as follows:

Model F43	L2
Model F42	NO CONN
Model F41	N

*Note: When coupling with respect to neutral and ground together, neutral and ground are electrically shorted at the low end of the surge generator output.

There are eight basic surge modes for a 5-wire wye. They are:

	F41	F42	F43
Line 3 to Line 2	L2	NO CONN	L3
Line 2 to Line 1	L1	NO CONN	L2
Line 3 to Line 1	L1	NO CONN	L3
Line 3 to Neutral	N	NO CONN	L3
Line 2 to Neutral	N	NO CONN	L2
Line 1 to Neutral	N	L1	NO CONN
Lines 3, 2 and 1 to Neutral	N	L1	L2 and L3
Lines 3, 2, 1 and Neutral to Ground	G	N and L1	L2 and L3

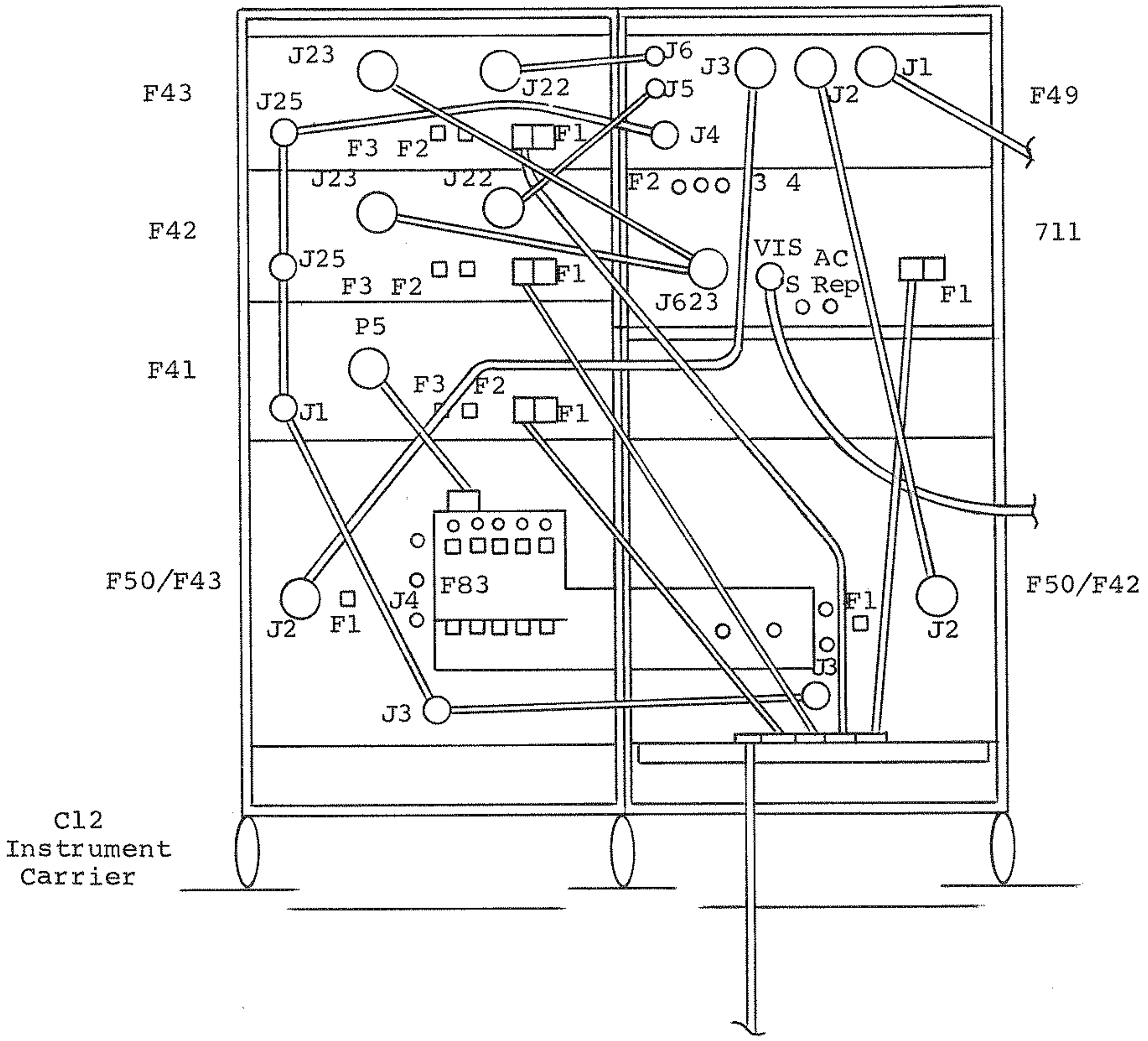

Figure 4-5

Model F33 with Option F33-02, Rear View
(with Model 711)

SECTION 5

5. Voltage/Current Monitors: Option Module VIS-102P

The VIS-102P provides a digital display of the peak voltage, via high voltage differential probe PV-2, and peak current attained, at the Equipment Under Test (EUT). In addition, replicas of the voltage and current surge waves are available from front panel BNC connectors at an attenuated level.

5.1 Installation

1. Check to insure the VIS-102P module is completely seated in the 711A Main Frame.

2. Connect the Differential Probe Module PV-2 to the rear of the VIS-102P via the cable attached to the PV-2. The locking ring on the cable connector should detent.

3. Attach the appropriate Probe Head to the PV-2. (Note: See Section 5.6 for Probe Head information.)

The PV-2 probe clips can now be placed at the EUT to monitor the surge voltage peak at the point of interest (frequently, this is also the point at which the surge is to be injected -- the ac line input to the EUT, or a signal line input).

5.2 Controls

1. MAX, +, -:

   For both voltage and current, the user can select to read MAX (the highest peak, regardless of polarity), + (the positive peak), or - (the negative peak). These selections can be made independently of the polarity of the applied surge wave, and the orientation of the measurement probes. MAX is the recommended selection.

2. Current Range

   Peak current ranges of 100A, 1kA, or 10kA can be selected via front panel push switches. Since the VIS-102P has a useable overrange factor of 1.5, these ranges are useable to 150A, 1.5kA, and 15kA respectively.

3. Pulse

   The PULSE switch and PULSE ready light, used to initiate the surge wave, are located on the front panel of the VIS-102P. Operation of the PULSE switch is described in Section 1.2.8.

5.3 Indicators

1. Voltage Range LEDs

   The Voltage Range LEDs are located above the digital voltage display and marked V (for volts), and kV (for kilovolts). The V LED will be ON when using a 1kV probe head, and the kV LED will be ON when using a 10kV probe head.

2. Current Range LEDs

   The current range LEDs are located above the current display and are marked mA, A and kA. (See Section 5.2.2.)

3. Peak LEDs

   Four LEDs annunciate the measurement mode selected by the MAX, +, and - switches for voltage and current. These LEDs are located to the left of the volate and current digital displays to which they refer. + LED ON indicates + peak was selected, - LED ON indicates - peak was selected, and both + and - LEDs ON indicates MAX peak was selected.

4. IL LED

   If the IL LED on the VIS-102P is ON, an interlock condition exists at the rear input of the VIS-102P and the 711A becomes inoperative. The conditions that causes this LED to be ON are:

   A. When using Model F31

      a. Probe head is disconnected

      b. probe is not connected at rear of VIS-102P

      c. incorrect probe used on a live line (see section 5.6)

   B. When using Model 711 front output

      a. probe head is disconnected

      b. incorrect probe used on a live line (see section 5.6)

5.4 Outputs

Two BNC connectors are provided to enable oscilloscope monitoring of a replica of the voltage and current waves. These BNC connectors are marked I Monitor (for current) and V Monitor (for voltage).*

1. I Monitor

   The output level of the I monitor is dependent on the current range selected, with 5V full scale always corresponding to the selected current range: 100A, 1kA, or 10kA. Scale factors and range LEDs are:

Range	Scale Factor	Range LED**
100A	20A/V	A
1kA	200A/V	A
10kA	2kA/V	kA

2. V Monitor

   The V monitor output will always be 5V full scale, with scale factors as follows:

Range	Scale Factor
1kV	200V/V
10kV	2kV/V

5.5 Readouts

The 3½ digit V and I displays annunciate OFL (overflow) for readings beyond 1.5 x full scale on any range. Readings somewhat in excess of 1.5:1 may be displayed, and when they are, they are accurate. Readings over 1.7:1 should not be displayed; if they are, the VIS-102 is not functioning properly.

The first-position leading zero is suppressed. However, if either V or I display is reading below 0.1 x full range, one or more leading zeros will be displayed even if they precede the decimal point. This is normal, and merely indicates that if a lower range is available it should be used to get optimum performance.

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*For longer waves, duration of these replicas may be 10 to 30% low.

**The mA range is provided for extra-low current options and is not used with the standard Model 711 A/J or 711 B/K.

5.6 Probe Heads

Four probe heads are available for use with the VIS-102P. Two of these, the H01C and H10C, are supplied as standard equipment with the 711 A/J and 711 B/K. The remaining two probes are supplied only when Surge Networks with long duration waves (>50us) are purchased.

The probes are as follows:

	PROBE HEAD	max V surge duration	VIS-102P range	max line voltage	probe input impedance
AC Coupled Probes					
1.	H01C	50us	1kV*	277V rms DC-60Hz	1k ohm
2.	H10C	50us	10kV	277V rms DC-60Hz	10k ohm
DC Coupled Probes					
3.	H01T	1000us	1kV*	50V DC/AC	1k ohm
4.	H10T	1000us	10kV	120V AC/DC	10k ohm

The two DC coupled probes, the H01T and H10T, contain thermal switches which are designed to operate in the event max line voltage ratings are inadvertently exceeded.

OVERHEATING OF THE DC COUPLED PROBE HEADS WILL CAUSE A THERMAL SWITCH TO OPERATE OPENING AN INTERLOCK TO PREVENT FURTHER OPERATION OF THE 711 SERIES EQUIPMENT, AND WILL CAUSE THE SURGE LINE TO OPEN IN THE MODEL F31, IF IT IS CONNECTED.

If overheating causes the thermal switch and interlocks to open, disconnect the probe leads from the circuit immediately. The thermal switch will reclose and allow operation after 10 to 20 minutes.

*The 1kV range is designed to be used to 1.5kV. If the actual voltage is greater than ~1.6kV, OFL will be displayed on the VIS-102P or VIS-102PR.

5.7 Voltage Current Monitors Option Module VIS-102PR*

The VIS-102PR is identical in operation and physical appearance to the VIS-102P (described in Section 5 of this manual). In addition to the functions provided with the VIS-102P, the VIS-102PR provides voltage and current information in BCD form at rear panel connector J25. Table5.7-1 lists J25 connector pin information, and provides a brief description of each line.

5.8 VIS-102P Extender

The VIS-102P Extender Module consists of a basic extender, junction box, and cables. To use the extender:

1. Turn off the main power switches on the 711 Mainframe and Model F31 (if used).
2. Remove the probe cable from the rear of the 711 Mainframe.
3. Remove the VIS-102P Option Module.**
4. Insert the VIS-102P Extender Module in place of the VIS-102P.
5. Connect the VIS-102P to the junction box. The probe connector will fit into a large hole in the junction box.
6. The junction box cover will snap open. DO NOT remove any screws in the junction box to gain entrance.
7. Connect the VIS probe through the appropriate opening in the junction box, and connect it to the VIS-102P probe connector.
8. Close the junction box cover.

At this point, the Model 711 can be turned on and operated normally.

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*With 711B mainframe only.

**See Appendix B, "Removing/Replacing Plug-in Units (CPC, ARU, LSU, VIS, etc.)"

TABLE 5.7-1

CONNECTOR J25

Pin #'s	Label	Description
1/2	$\overline{1}$	BCD output lines for voltages and current. I.E., if $\overline{\text{VE}}$ is held low, the voltage will appear in BCD form (for 345 volts, pins 19/20, 17/18, 13/14, 5/6, and 1/2 will be low). If $\overline{\text{IE}}$ is low, the current will appear in BCD form.
3/4	$\overline{2}$	
5/6	$\overline{4}$	
7/8	$\overline{8}$	
9/10	$\overline{10}$	
11/12	$\overline{20}$	
13/14	$\overline{40}$	
15/16	$\overline{80}$	
17/18	$\overline{100}$	
19/20	$\overline{200}$	
21/22	$\overline{400}$	
23/24	$\overline{800}$	
25/26	$\overline{1000}$	
27/28	$\overline{\text{RDI}}$	Ten-range decimal point (1X.XX).
29/30	$\overline{\text{RD2}}$	Hundred-range decimal point (1XX.X).
31/32	$\overline{\text{PLUS}}$	Indicates a positive voltage or current peak measured.
33/34		
35/36	$\overline{\text{DATA RDY}}$	Data is ready to be output.
37/38	$\overline{\text{VE}}$	If held low, voltage will be output.
39/40	$\overline{\text{IE}}$	If held low, current will be output.
41/42	$\overline{+/-}$	If low, the voltage or current is the maximum measured without regard to polarity.
43/44	LG	Logic Ground
45/46	LG	Logic Ground
47/48	SPARE	Spare Line
49/50	$\overline{\text{MINUS AR}}$	Indicates a negative charge voltage in remote operation.

SECTION 6

6. Option Modules

6.1 Line-Synch Option Module LSU-121

The LSU-121 controls the placement of the surge wave, with respect to the ac voltage phase.

6.1.1 Controls and Indicators

1. 60Hz/50Hz switch

   Allows the user to select, via a front panel switch, line synch operation on 50Hz or 60Hz lines. Note: If the switch is in the wrong position, surge placement will not be as per the ANGLE SELECT slide.

2. LS LIGHT

   Indicates that all conditions for LS operation have been met:

   a. Surge line AC is on in Model F31.

   b. Set/Random Switch on LSU-121 panel is in Set (OUT) position.

   NOTE: If LS light is not on, check before proceeding as surge will not be synched with the line.

3. LOCAL

   a. SET (OUT position)

   Activates the line synch function. The surge will be placed at the phase angle as selected by the ANGLE SELECT slide control.*

   b. RAND (IN position)

   Surge placement on the ac line will be random with respect to the ac voltage phase.

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*Detents or stops are provided at 0, 90, 180, 270 and 360 degrees, but selection is continuous between them.

4. SYNCH

   a. -180 (OUT position)

      The AC Line SYNCH output (from the BNC connector on the rear of the Model 711A Main Frame -- see Fig. 2, 711A Rear Panel) will occur 180 degrees prior to the cycle where the surge will be placed.

   b. PRE (IN position)

      The AC line Synch output will occur ~45 degrees prior to the surge wave itself.

6.1.2 Outputs

The LSU-121 has two rear outputs which are available from rear panel BNC connectors. Refer to Fig. 1-2, 711 A/J Rear Panel, for location (page 1-7).

1. AC LINE SYNCH (towards left side of unit from rear)

   Provides a floating (i.e., ungrounded) positive trigger signal for an oscilloscope, which will occur either at 180 degrees prior to the cycle where the surge is to be placed, or ~45 degrees prior to the surge itself. (See A.3.a. and b. of this section for SYNCH control operation.)

2. AC LINE REPLICA (towards right side of unit from rear)

   Provides a floating (i.e., ungrounded) replica of the 50Hz or 60Hz ac surge line voltage, at an attenuated level (approximately 5V rms out for a surge line voltage of 120V; 10V out for a 240V surge line, etc.)

6.2 Line Synch Option Module LSU-122

Option Module LSU-122 provides the capability to place a surge at the desired ac line phase angle. Placement can be accomplished in 15° or 90° increments manually, via front panel controls; remotely, via intputs to connector J22 on the rear panel of the 711 B/K; or automatically advanced in 15° or 90° increments via front panel controls.

6.2.1 Controls

1. STEPS 90°/15°: If set to 90° position, manual or automatic surge advance will occur in 90° steps. If set for 15°, manual or automatic surge advance will occur in 15° increments.

2. FWD/BACK: Determines whether surge advancement will be in the forward (FWD) direction (from 0 to 360) or in the reverse (BACK) direction (from 360 toward 0°).

3. 60Hz/50Hz: Must be set in the 60Hz position for 60Hz ac surge lines, and in the 50Hz position for 50Hz ac surge lines.

4. MAN: First switches to MAN, then each time this button is depressed, the surge phase angle will be advanced in 90° or 15° steps, as determined by the STEPS 90°/15° switch.

5a. REM: When depressed, resets MAN or AUTO ∠ to 0°.

5b. REM: When depressed, surge phase placement is controlled through inputs on connector J22 on the rear panel of the 711 B/K. (Note: When the LSU-122 is used with a Model 711A mainframe, this button just resets MAN or AUTO ∠ to 0°.)

6. AUTO: When depressed, surge phase angle will advance automatically for each successive surge, as determined by the STEPS 15°/90° switch, FWD/BACK switch, and SURGES EA ∠ switch.

7. SURGES EA ∠ : Determines the number of surges to be made at each phase angle and can be set for any number from 0 to 9. If set to 0, the counter will automatically advance to 1 when the AUTO switch is depressed.

8. SYNCH -180/PRE: In the -180 position, a synch for the ac line, will be generated at minus 180° with respect to the specific sine wave where the surge will appear. In the PRE position, a synch is generated at approximately -45° with respect to the sine wave which will contain the surge.

6.2.2 Indicators

1. In the top right-hand corner of the Option Module LSU-122, there is a small yellow LED. This LED will be on only when live ac line voltage is present in the Model F31 or other coupler/filter.

2. Surge phase LED's as in 1 above. Unless ac line voltages present at the Model F31, no LED's will be lit. In a static state, the LED which is lit will indicate the next voltage phase where a surge will occur.

3. Surge each angle LED's -- the illuminated LED will indicate the next surge for an angle to be made.

6.2.3 Installation and Adjustment of LSU-122

When installing a Line Synch Unit, LSU-122 into a Model 711 Surge Generator for which it has not been set up, an initial zero adjustment may be required for both 60 Hz and 50 Hz. The 50/60 Hz selector switch on the front panel must be set to the proper position and the appropriate potentiometer adjusted.

First, switch to the 60 Hz position and adjust R51, 50/60 zero potentiometer for an average positioning of the surge at 0° when the front panel selection is 0° and the ac surge line input is 60 Hz. R51 is the rear pot on the LSU-122 and it is accessible thru the top of the 711 when the 711 top cover is removed.

If 50 Hz operation of the LSU-122 is required, switch to the 50 Hz position and adjust R102B, 50 Hz zero potentiometer for an average positioning of the surge at 0° when the front panel selection is 0° and the ac surge line input is 50 Hz. This pot affects 50 Hz zero only, and it should be adjusted only after R51 has been properly adjusted. R102B is the second pot from the rear of the LSU-122, and it also is accessible thru the top of the 711.

Note 1: An average of about 5 surges is recommended to determine phase position in view of the ~ 15° typical repeatability of phase positioning.

Note 2: For an oscilloscope display of the surge vs. the ac waveform refer to Tables 6-1 and 6-2.

Note 3: For rackmount 711 installation where the top of the 711 is inaccessible, the LSU may be removed from the 711 (with the power off) to make small adjustments at a time to achieve the proper zero potentiometer settings.

6.3 Oscilloscope Display of Line-Synch Operation

For oscilloscope display, because of problems associated with scope writing speed, it is ordinarily difficult simultaneously to show both the narrow surge and the comparatively long, ac power-line frequency sine wave on which it is superimposed and to which it is synchronized in phase. In addition to the difference in writing speeds for the two waves, there is usually the problem of grounds as well; the ac line is a dangerous and uncertain place on which to connect the scope, and the surge itself may be ungrounded.

For the above reasons, the LSU Option Module provides a scope synch output, (selectable to be at -180° on the ac line, or "PRE", about 45° before the surge), and a reduced -- 5% of input -- phase-accurate version of the ac line to which the output is synched. Both of these auxiliary output signals are floating, so that when they are grounded at the scope no ground loops will be introduced. (The coax connectors on which they appear, on the 711 rear panel, are insulated from the panel on which they are mounted.)

Equally important, it is possible with many scopes to intensify a small portion of a large wave, with the intensified portion under position control of an external synch signal. (If it is not, the intensification location can still be controlled via a delay adjust on the scope, but with less precision than a few microseconds out of many milliseconds -- desirable to see a narrow surge on an ac line wave.) NOTE: To take full advantage of the external-synch feature for the intensified portion of the sweep, it is necessary to obtain a pre-trigger from the Model 711 Surge Network front panel.

Using intensification makes it possible to display the surge -- actually picked up for convenience on the 711, VIS Monitor output -- and the ac line sine wave at the same time, with reasonably good intensity balance for both.

Settings are provided for several popular Tektronix oscilloscopes configurations, which can easily be transposed for any other oscilloscope having equivalent capabilities. Table 6-1 shows scope connections; Tables 6-2, 6-3 and 6-4 describe the scope control settings for the Tektronix 7834, 7633 and 466 respectively. Scope connections and settings are provided for the Tektronix 7603 with 7020 Digitizer.

Using the connections and settings from the tables, will make possible displays similar to those of Fig. 6-1. Surges at 0, 90, 180, 270 and 360 degrees for Figs. 6-1 (a) through (e) respectively are shown for a Surge Network P1 Ring Wave, superimposed on a 60 Hz line.

For the photos of Fig. 6-1, the LSU scope synch output was changed at the factory to occur at 0° for display purposes. The only disadvantage of this for normal operation is that normal phase angle tolerance can throw some of the nominally 0° surges slightly below zero, and a 0° synch will then not occur soon enough to enable the surge to be viewed on the display.

Table 6-1

SCOPE CONNECTIONS FOR LS OPTION DISPLAY
(Tektronix 7823, 7633, 466 or equivalent)

	From	Location	To	Signal
1.	Model VIS-102 V Monitor	Model VIS-102 front panel	Scope CH1 input	Scaled version of Model 711 output pulse: 5V full range (i.e., 5V= 10kV for P1, P3).
2.	"5/10V AC" output coax from 711 (Replica)	Model 711 Rear Panel Coax (toward right side of unit from rear)	Scope CH2 input	AC: scaled version of line to which the LS is synched (i.e., rear auxiliary line input on F31.) NOTE: front panel F31 circuit breaker must be ON to obtain this signal.
3.	Model 711 Synch	711 Surge Network panel coax (ungrounded)	Scope DLY'D TRIG IN	Pre-surge, quasi-square wave trigger, lasting beyond 5 usec. +5 to +8V amplitude.
4.	711 AC Line Synch Output	Model 711 Rear Panel Coax (toward left side of unit from rear)	Scope MAIN TRIG IN	Synch at -180° with respect to ac line to which the LS Option is synched (i.e., rear auxiliary line input on F31.) NOTE: front panel F31 circuit breaker must be ON to obtain this signal.

Table 6-2

SCOPE SETTINGS FOR LS DISPLAY
(Tektronix 7834 with 7A18 and 7B92A or equivalent)

	CONTROL	SETTING
1.	MAIN TRIGGERING	
	A. MODE	SINGLE SWEEP
	B. COUPLING	AC HF REJ
	C. SOURCE	EXT
	D. SLOPE	+
	E. LEVEL	Approximately 1 o'clock position.
2.	TIME/DIV	2 msec/div
3.	Gray/black "FULL FOR ALT" knob	pull out and set at 10 usec for P1, .1 msec for P3.
4.	TRACE SEP	Full CCW
5.	Time base INTENSITY	Approximately 3 o'clock position.
6.	DELAY TIME MULT	0
7.	DELAY TRIGGERING	
	A. SLOPE	+
	B. COUPLING	DC
	C. SOURCE	EXT
	D. LEVEL	Approximately 1 o'clock position.
8.	External Trigger Input Termination	50
9.	DISPLAY MODE	Add
10.	TRIGGER SOURCE	MODE
11.	CHANNEL 1	
	A. VOLTS/DIV	1 Volt/div
	B. COUPLING	DC
12.	CHANNEL 2	
	A. VOLTS/DIV	5 Volts/div
	B. COUPLING	DC
13.	Storage mode	VAR PERSIST

Table 6-3

SCOPE SETTINGS FOR LS DISPLAY

(Tektronix 7633 with 7A18 and 7B53A or equivalent)

	CONTROL	SETTING
1.	MAIN TRIGGERING	
	A. MODE	SINGLE SWEEP
	B. AMPLIFIER SOURCE	DC, EXT
	C. SLOPE, LEVEL	+
	D. LEVEL	Approximately 1 o'clock position.
2.	TIME/DIV	2 msec/div
3.	DLY'D TRIG LEVEL	Full CCW
4.	DLY TIME MULT	Full CCW
5.	Gray/black VARIABLE knob	Pull and set a 1 usec for P1, 10 usec for P3
6.	Red CAL knob	Pull
7.	DISPLAY MODE	Add
8.	TRIGGER SOURCE	MODE
9.	CHANNEL 1	1 Volt/div
10.	CHANNEL 2	5 Volts/div

Table 6-4

SCOPE SETTINGS FOR LS DISPLAY
(Tektronix 466 or equivalent)

CONTROL	SETTING
1. MAIN TRIGGERING	
A. MODE	EXTERNAL
B. COUPLING	+
C. SOURCE	AC HF REJ
D. SLOPE	SINGLE SWEEP
E. LEVEL	Approximately 1 o'clock position.
2. DELAY TRIGGER	
A. SOURCE	EXTERNAL
B. COUPLING	+
D. SLOPE	HF REJECT
E. LEVEL	Approximately 1 o'clock position.
3. DELAY TIME POSITION	Full CCW
4. MAIN SWEEP	2 msec/div
5. DELAY SWEEP	Pull and set at 2 usec for P1, 20 usec for P3
6. HORIZONTAL DISPLAY MODE	A INTENSIFY
7. VERTICAL DISPLAY MODE	ADD
8. CHANNEL 1	.5 Volt/div DC
9. CHANNEL 2	5 Volts/div DC
10. STORAGE MODE	VARIABLE PERSIST.

Table 6-5

SCOPE CONNECTIONS FOR LS DISPLAY UTILIZING TEKTRONIX 7D20 DIGITIZER*

	From	Location	To	Signal
1.	Model VIS-102 V Monitor	Model VIS-102 front panel	Scope CH1 input	Scaled version of Model 711 output pulse: 5V full range (i.e., 5V= 10kV for P1, P3).
2.	"5/10V AC" output coax from 711 (Replica)	Model 711 Rear Panel Coax (toward right side of unit from rear)	Scope CH2 input	AC: scaled version of line to which the LS is synched (i.e., rear auxiliary line input on F31.) NOTE: front panel F31 circuit breaker must be ON to obtain this signal.
3.	711 AC Line Synch Output	Model 711 Rear Panel Coax (toward left side of unit from rear)	Scope MAIN TRIG IN	Synch at -180° with respect to ac line to which the LS Option is synched (i.e., rear auxiliary line input on F31.) NOTE: front panel F31 circuit breaker must be ON to obtain this signal.

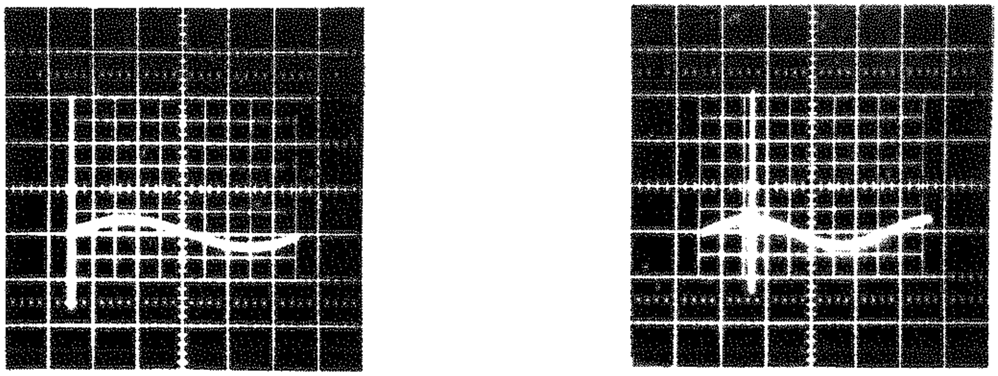
*For P3 (1.2 x 50us voltage; 8 x 20us current) event capture only. The 7D20 sample interval at 2ms/div is 20us. The P1 wave is a damped 100kHz cosine wave, resulting in too short an event for repeatable and easily interpreted event capture at 20us/sample.

Table 6-6

SCOPE SETTINGS FOR LS DISPLAY*
(Tektronix 7603 and 7D20)

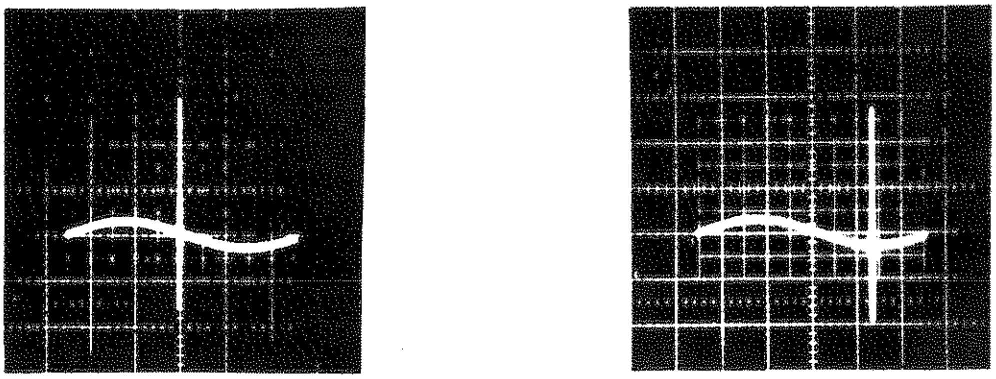
CONTROL	SETTING
1. MAIN TRIGGERING	
A. MODE	HOLD NEXT
B. COUPLING	AC HF REJ
C. SOURCE	EXT
D. SLOPE	+
E. LEVEL	Approximately 1 o'clock position.
F. TRIG POS	0
2. TIME/DIV	2 msec/div
3. AQR MODE	ADD 1
4. CHANNEL 1	
A. VOLTS/DIV	1 volt/div
B. COUPLING	DC
5. CHANNEL 2	
A. VOLTS/DIV	5 volts/div
B. COUPLING	DC

*For P3 event capture only. See note in Table 3.



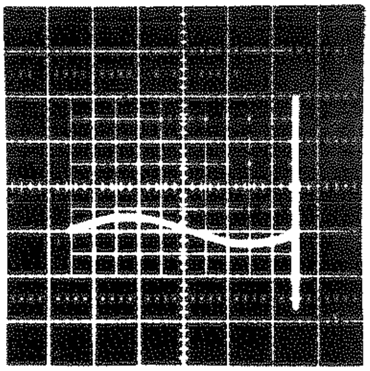
(a) 0°

(b) 90°



(c) 180°

(d) 270°



(d) 360°

Fig. 6-1

LS OPTION DISPLAYS: 0,90, 180, 270, 360°

6.4 Auto/Remote: Option Module ARU-151A*

Auto Remote Unit ARU-151A provides for automatic or remote operation of the 711 B/K.* Automatic repetitive operation is initiated via front panel controls, and remote operation is via control signals at connector J22, located on the rear panel of the 711 B/K.

6.4.1 Controls

1. PRESET STOP -- AUTO MODE: Allows setting of a predetermined number of surges to be made when operating in the AUTO mode. The SURGE COUNT INDICATOR will advance as each surge is made until the number on the SURGE COUNT indicator equals the number set in the PRESET STOP -- AUTO MODE indicator.
2. MAN: When depressed the 711 B/K will operate in a manual mode only.
3. REM: When depressed the ARU-151A will accept control information via rear panel connector J22.
4. AUTO: Must be depressed to allow automatic operation of the 711 B/K via front panel controls on the ARU-151A.
5. ALT POL: When depressed, each successive surge will be reversed in polarity. To select ALT POL, the mechanical charge polarity switch on the 711 B/K front panel <u>must</u> be set to +. (Not with ARU-151.)
6. RUN: In the AUTO mode, depressing the RUN button will initiate automatic operation of the 711 B/K.
7. STOP: Depressing the STOP button will inhibit automatic operation of the 711 B/K.
8. SECONDS/SURGE: There are five buttons labelled 60, 30, 20, 10 and < 10, each with an LED adjacent to it. Any button with a <u>lighted</u> LED, can be selected to define the number of seconds between surges. If the LED next to the button labelled <10 is lighted, and that button is selected, operation will be at the fastest rate allowed by the particular surge network being used.

---

*The ARU-151, with similar functions except for alternating polarity, is supplied with both 711A and 711B mainframes.

9. AUTO-REMOTE Key Switch: In the ON position, remote and automatic operation is allowed, manual is not allowed. In the OFF position automatic and remote operation are not allowed, and manual is allowed.

10. RESET SURGE COUNT: Reset the SURGE COUNT to 0.

11. EXT STOP BNC Connector: A ground applied to the center conductor of this connector will inhibit automatic charging and pulsing operation of the 711 B/K.*

6.4.2 Indicators

1. SURGE COUNT: Digitally displays the number of surges that have been completed.

2. CRD: If lighted, will allow charging in either a positive or negative direction.

3. C-: Indicates a charge is being made in the negative direction, but only for REMOTE and AUTO ALT POL modes (not for MANUAL, or AUTO/NON ALT POL mode).

4. C+: Indicates charge is being made in a positive direction (REMOTE or AUTO/ALT POL only). C+ indicates a negative charge in AUTO/NON ALT POL if manual polarity switch is set to -.

5. CPD: Indicates charge pulse delay has been completed, and the unit can now be pulsed.

6. P: Lights when a pulse is fired.

7. ALT POL interlock LED: To accomplish alternating polarity in an automatic or remote mode, the mechanical Charge +/Charge - selector switch on the front panel of the 711 B/K must be in the + (plus) position. If it is in the - (minus) position, and ALT POL is selected or remote is selected, this LED will light and surge generator operation will be inhibited.

8. RUN: annunciates the fact that the 711 B/K is running or "timing out" in an automatic mode.

*If a surge has already been started it will be completed.
NOTE: Manual and Remote charging and pulsing are not affected by the Stop input command.

9. STOP: Lights in the automatic mode when the 711 B/K is not running or not "timing out".

10. SELECT LONGER: When lit, indicates that the Surge Network in use requires a longer SECONDS/SURGE time selection.

6.4.3 Remote Operation

Remote Operation of the 711 B/K is accomplished via rear panel connectors J22 and J25. Connector J22 provides all control operations, and connector J25 provides BCD readout information for voltage and current, a data ready line, and a control line to select either voltage or current. Tables 5.7-1 and 6.4.3-1 describe all the input and output lines for these connectors.

6.4.4 ARU-151A Extender

The ARU-151A Extender Module consists of a basic extender unit, cable, and junction box. To use the extender:

1. Turn off main power switches on the 711 Mainframe and Model F31 (if used).
2. Remove the ARU Option Module.*
3. Insert the ARU basic extender unit in place of the ARU.
4. Connect the ARU-151A to the extender junction box.

The 711 can now be turned on and operated normally.

---

*See Appendix B, "Removing/Replacing Plug-in Units (CPC, ARU, LSU, VIS, etc.)"

6.4.5 Surge Network Allowed Duty Cycles (secs/surge)

Network	secs/surge with ARU
P1	<10
P3	20
P3C	30
P7	30
P9	<10
P21	30
P41	30

TABLE 6.4.3-1

CONNECTOR J22

Pin #'s	Label		Description
1/2			
3/4	$\overline{\text{C-}}$		Causes 711B to charge in a negative direction. A surge will be generated automatically after a time delay. (Only available with ARU-151A).
5/6	$\overline{\text{C+}}$		Causes 711B to charge in a positive direction. A surge will be generated automatically after a time delay.
7/8	$\overline{\text{INH PIN}}$		Allows charge but prevents a surge from being generated until a low appears at $\overline{\text{REM PIN}}$ (or the $\overline{\text{INH PIN}}$ line is released.)
9/10	$\overline{\text{REM PIN}}$		Remote pulse in; causes a pulse to be generated if $\overline{\text{INH PIN}}$ is low.
11/12	$\overline{\text{30R}}$	Only available with LSU-122.	Set-up lines for LS; i.e. if pins 11/12 ($\overline{\text{30R}}$) is held low, the surge will occur at the 30 degree point; if pins 11/12 ($\overline{\text{30R}}$) and 13/14 ($\overline{\text{15R}}$) are both held low, the surge will be at 45 degrees. To surge a line at 90 degrees, pins 11/12 ($\overline{\text{30R}}$) and 17/18 ($\overline{\text{60R}}$) must be low.
13/14	$\overline{\text{15R}}$		
15/16	$\overline{\text{120R}}$		
17/18	$\overline{\text{60R}}$		
19/20	OPTION		
21/22	$\overline{\text{240R}}$		
23/24	OPTION		
25/26	OPTION		
27/28	SPARE		
29/30	LG		Logic Ground
31/32	$\overline{\text{PTR2}}$		Printer 2. Relay closure used to start a printer.
33/34	$\overline{\text{P+}}$		Becomes low when printer relay is activated.

Pin #'s	Label	Description
35/36	$\overline{\text{PTR1}}$	Printer 1. Relay closure used to initiate a print operation.
37/38	OPTION	No connection.
39/40	SPARE	
41/42	SPARE	
43/44	$\overline{\text{LATCH LS}}$	Must be held low to allow remote LS set-up.
45/46	SPARE	
47/48	OPTION	
49/50	SPARE	

SECTION 7

7. Troubleshooting

7.1 Initial Troubleshooting

If the 711A fails to operate, check the following conditions before contacting KeyTek for assistance or service:

1. OPEN INTERLOCK light ON

   See Section 2 "Interlocks", Section 3C, Surge Network Interlocks, and Section 4C, Model F31 Interlocks.

2. CHARGE READY light is OFF

   a. Check ac power line to see that it is connected to an appropriate ac socket and properly connected to the rear of the 711A.

   b. Check ac power line fuse.

3. No voltage indication on analog charge meter.

   a. Set voltage control is fully counter-clockwise; therefore unit is charging to zero volts.

   b. CHARGE/PULSE CONTROL must be in the LOCAL position to allow manual charging (on CPC 101).

   c. Check variac fuse (3A MDX) on 711A rear panel.

7.2 Modules

7.2.1 LSU the timing for the pulse after change cycle is shown in Figure 7-1.

SECTION 8

8. Schematics and Location Drawings

8.1 Symbols and Notations

8.1.1 Units and Component Assumptions

Unless otherwise indicated:

1. resistors are in ohms, inductors in microhenries
2. capacitors <1 are in mfd
3. capacitors ≥ 1 are in pf, except polarized units (marked with a + on one terminal) are in ufd
4. diodes are 1N914
5. quad gates are two-input Nand gates, 74L00; with +5 connected to pin 14, and logic ground connected to pin 7.

8.1.2 Trims and Test Points

1. * Signifies trim on test; except even though omitted for power resistors, all power resistors in the Programmer Networks are in this category.

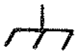
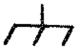
8.1.3 Terminals and Connections

○ outgoing connection to another board

〉 from another point on the same board, possible on another sheet of the same schematic

→ to another point on the same board, again possibly to another sheet of the same schematic

□ see specific schematic

▷	see specific schematic
⬡	see specific schematic
	analog signal ground
	analog power ground
	digital circuit ground, or logic ground
chassis or  chassis	chassis ground

8.1.4 Drawings Supplied

In the case of optional equipment, as well as ancillary instrumentation, schematics and location drawings are supplied only for those items furnished as part of an installation. Thus even though drawings may be mentioned in the text and/or an index, they may not be included in the section that follows.

8. SCHEMATICS

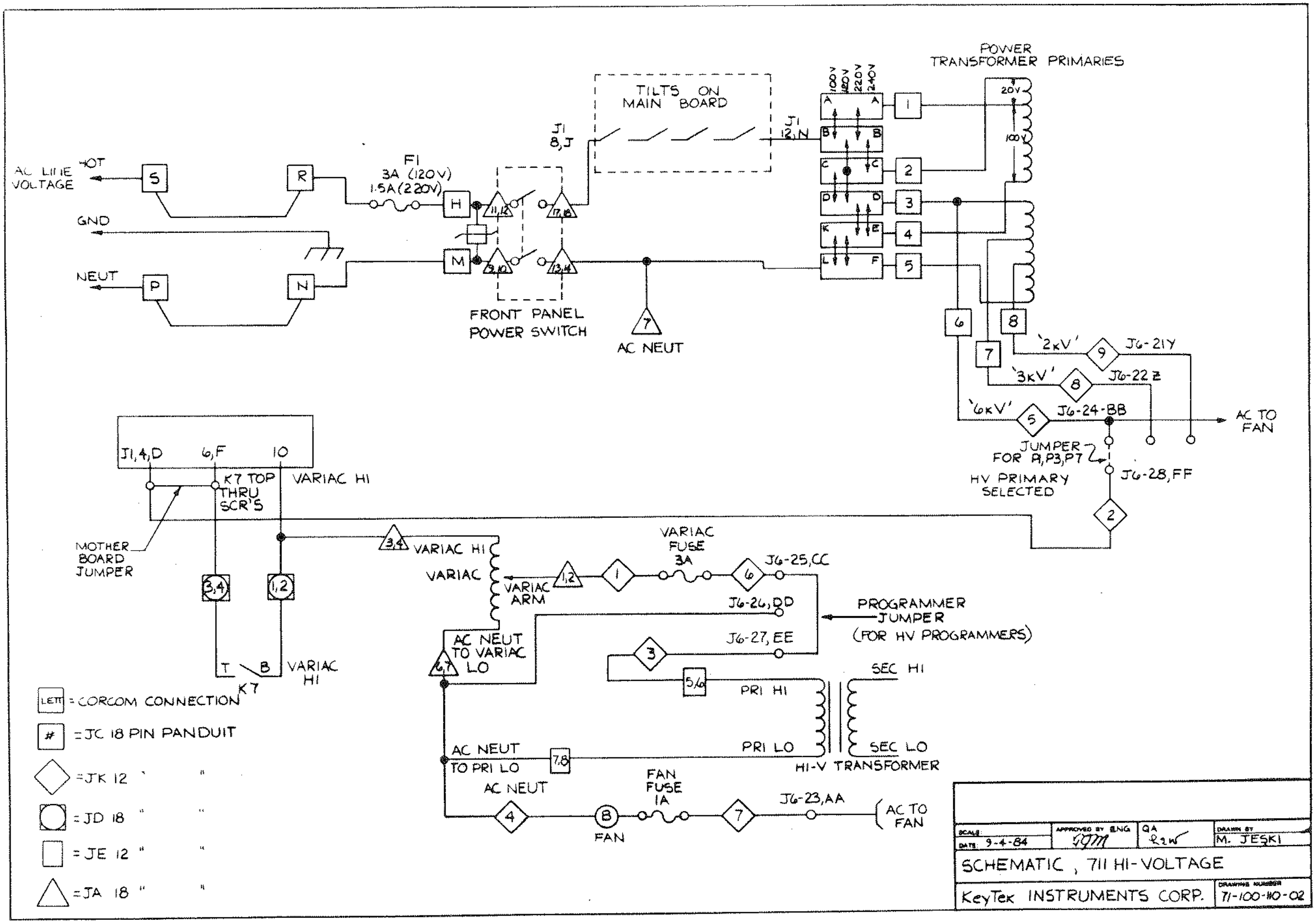
MODEL	DESCRIPTION	DRAWING NO.		PAGE
Model 711	711 Hi-Voltage	71-100-110-02		8-9
	Main Board 711	71-110-110-00	sheets 1 and 2	8-10, 8-11
	Hi Voltage 711	71-110-610-00		8-15
	Hi Voltage Polarity Option	71-110-600-00		8-20
	Charge/Pulse Board	71-100-110-00	sheets 1 and 2	8-25, 8-26
Model ARU-151				
	Auto/Remote	71-120-010-00	sheets 1 to 7	8-30 to 8-36
Model LSU-121				
	Line Synch Unit, LSU 121	71-111-110-00	sheets 1 to 3	8-45 to 8-47
Model LSU-122				
	Line Synch Unit, LSU 122	71-124-000	sheets 1 to 9	8-48 to 8-56
Model VIS-102				
	VIS-102 (Probe Connections)	71-112-110-10	sheets 1 to 9	8-60 to 8-70
	Probe	71-122-110-10		8-75
Programmer --	PC/Box/Hi-V Conns	71-114-210-00		8-100

8. SCHEMATICS cont.

MODEL	DESCRIPTION	DRAWING NO.	PAGE
Model P1			
	P1 Programmer, Trim Mo	71-114-000-00	8-110
Model P3			
	P3 Programmer, Trim Mod.	71-115-110-00	8-130
	P3 Surge Network	71-115-000-00	8-135
Model P21			
	P21 Surge Network	71-121-000-00	8-150, 8-151
Model 711/F31	711/F31 Interlock System	71-100-000-00	8-175
	711/F31 Remote Interlock Plug and Cable (Option)	73-310-184-00	8-180
Model ESU 221			
	Energy Storage Unit, ESU 221	71-128-000-00	8-190

8. SCHEMATICS cont.

MODEL	DESCRIPTION	DRAWING NO.		PAGE
Model F31				
	F31 Control Circuit	73-310-000	sheets 1 to 4	8-200 to 8-203
	F31-V Control Circuit (for 480V unit)	10-018-000-00	sheets 1 to 4	8-210 to 8-213
Model F33				
	F41 Control Circuit	10-011-000-00	sheets 1 and 2	8-230, 8-231
	F42 Control Circuit	10-012-000-00	sheets 1 to 4	8-235 to 8-238
	F43 Control Circuit	10-013-000-00	sheets 1 to 4	8-242 to 8-245
	F49 Control & AC Circuits	10-015-000-00		8-250
	F41-50 Control Circuit	10-025-000-00	sheets 1 and 2	8-255, 8-256
	F42-50 Control Circuit	10-026-000-00	sheets 1 to 4	8-260 to 8-263
	F43-50 Control Circuit	10-027-000-00	sheets 1 to 4	8-270 to 8-273
	F50/F42, 3ϕ 50 Amp	10-045-000-00		8-277
	F50/F43, 3ϕ 50 Amp	10-046-000-00		8-280



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APPROVED BY ENG: GJM
QA: RJW
DRAWN BY: M. JESKI

SCHEMATIC, 711 HI-VOLTAGE

KeyTek INSTRUMENTS CORP.

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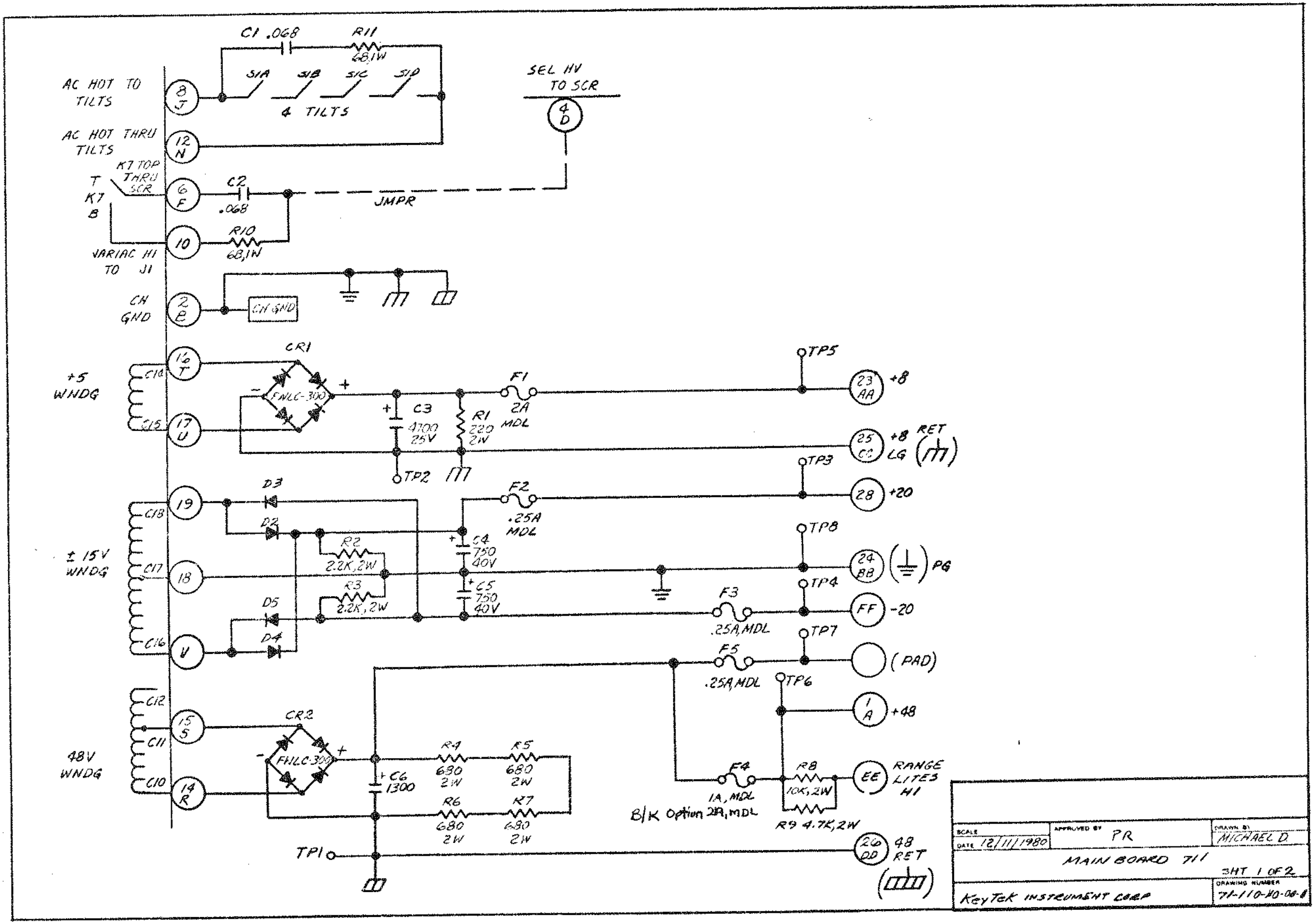
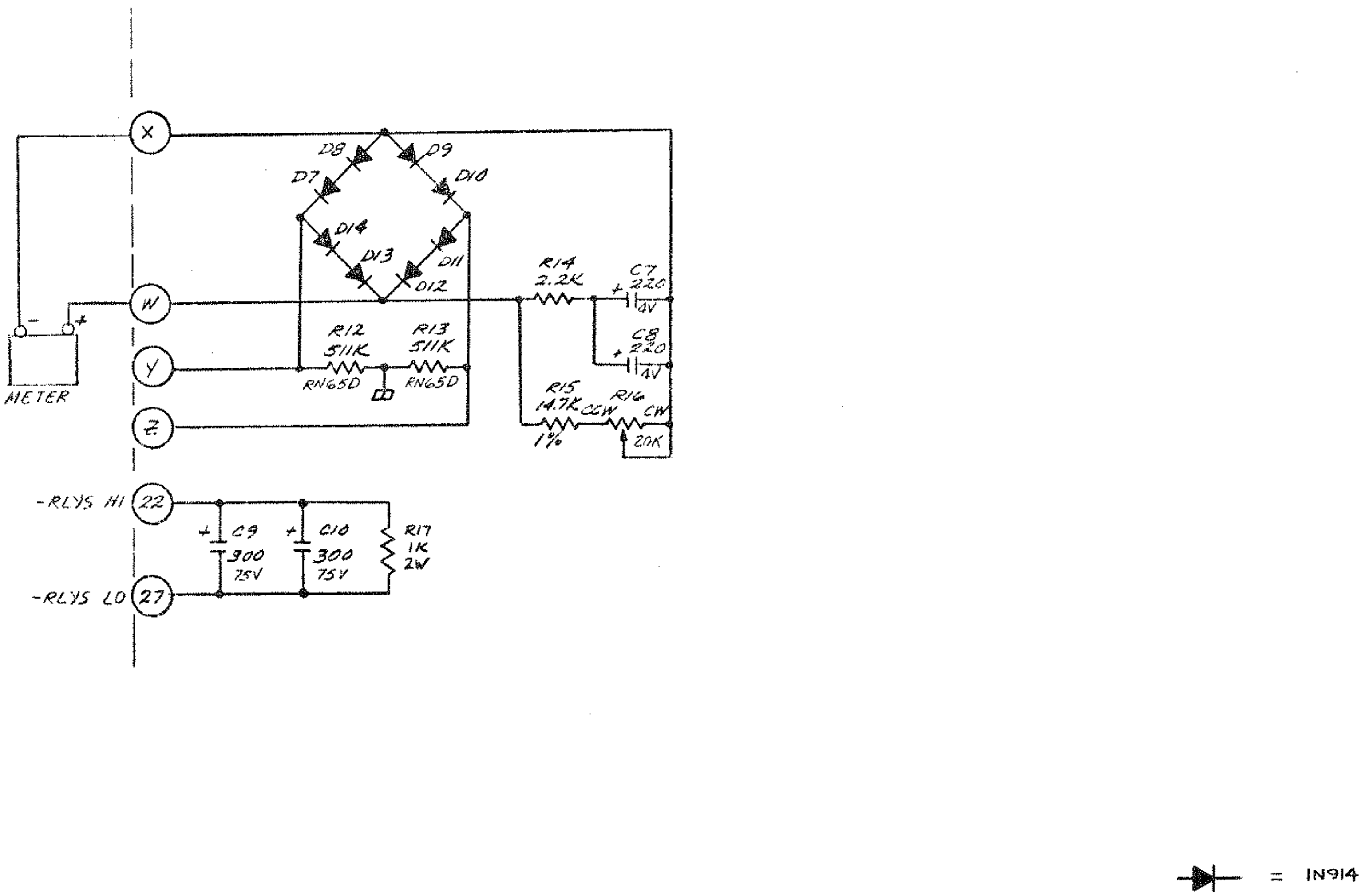

AC HOT TO TILTS
AC HOT THRU TILTS
K7 TOP THRU SCR
T
K7
B
VARIAC HI TO J1
CH GND
+5 WNDG
± 15V WNDG
48V WNDG
C14
C15
C18
C17
C16
C12
C11
C10
8 J
12 N
6 F
10
2 B
16 T
17 U
19
18
V
15 S
14 R
C1 .068
R11 68,1W
S1A
S1B
S1C
S1D
4 TILTS
SEL HV TO SCR
4 D
C2 .068
JMPR
R10 68,1W
CH GND
CR1
FWLC-300
CR2
FWLC-300
C3 4700 25V
R1 220 2W
F1 2A MDL
TP2
TP5
23 AA +8
25 CC +8 LG
RET
D3
D2
D5
D4
R2 2.2K, 2W
R3 2.2K, 2W
C4 750 40V
C5 750 40V
F2 .25A MDL
TP3
28 +20
TP8
24 BB
PG
TP4
F3 .25A, MDL
FF -20
TP7
F5 .25A, MDL
(PAD)
TP6
1 A +48
F4 1A, MDL
B/K Option 2A, MDL
R8 10K, 2W
R9 4.7K, 2W
EE RANGE LITES HI
C6 1300
R4 680 2W
R5 680 2W
R6 680 2W
R7 680 2W
TP1
26 DD 48 RET
SCALE
DATE 12/11/1980
APPROVED BY PR
DRAWN BY MICHAEL D.
MAIN BOARD 711
SHT 1 OF 2
DRAWING NUMBER 71-110-80-08-8
KeyTek INSTRUMENT CORP



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DATE 12/11/80
APPROVED BY P R
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MAIN BOARD 711
SHT 2 of 2
KeyTek INSTRUMENT CORP
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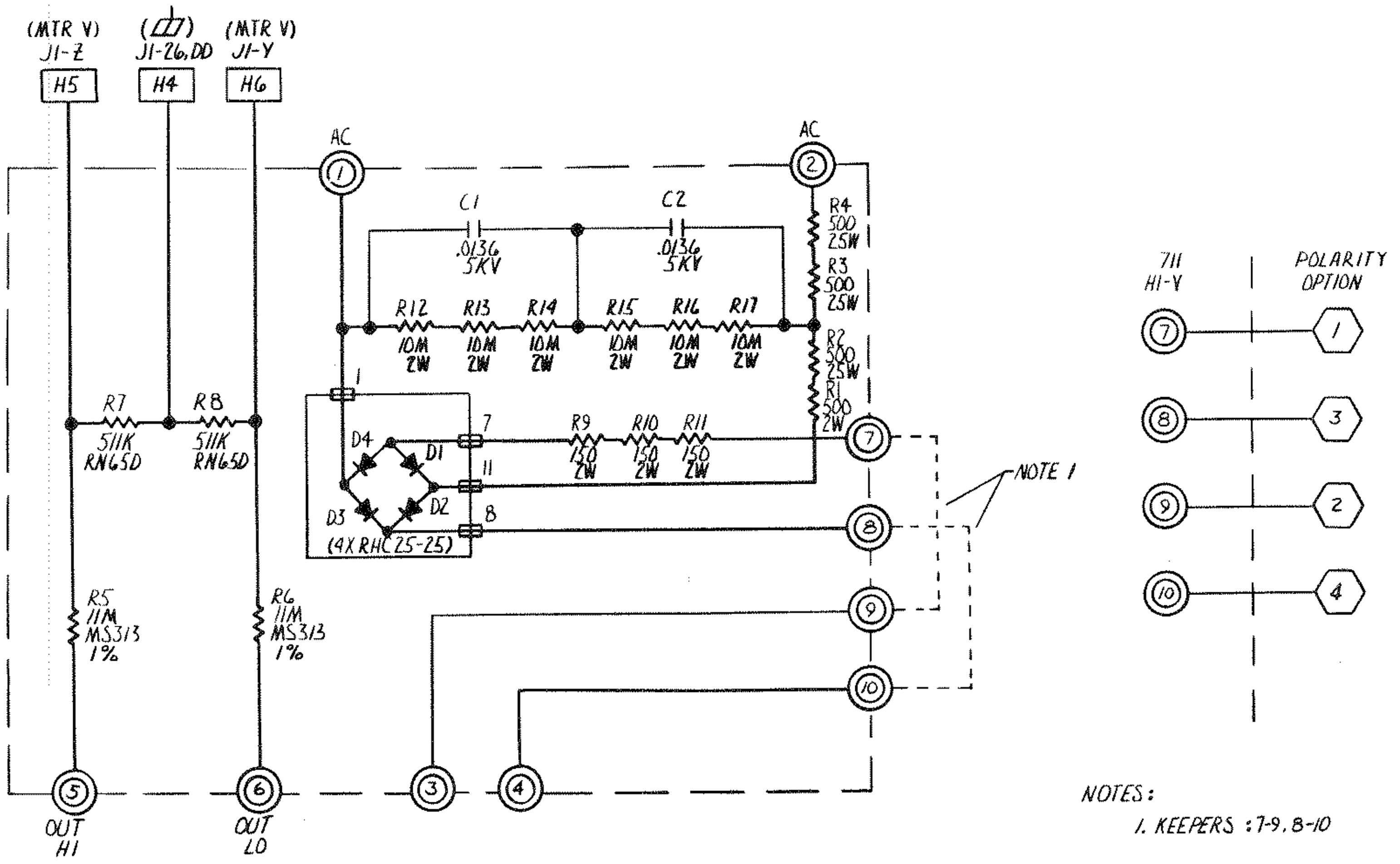
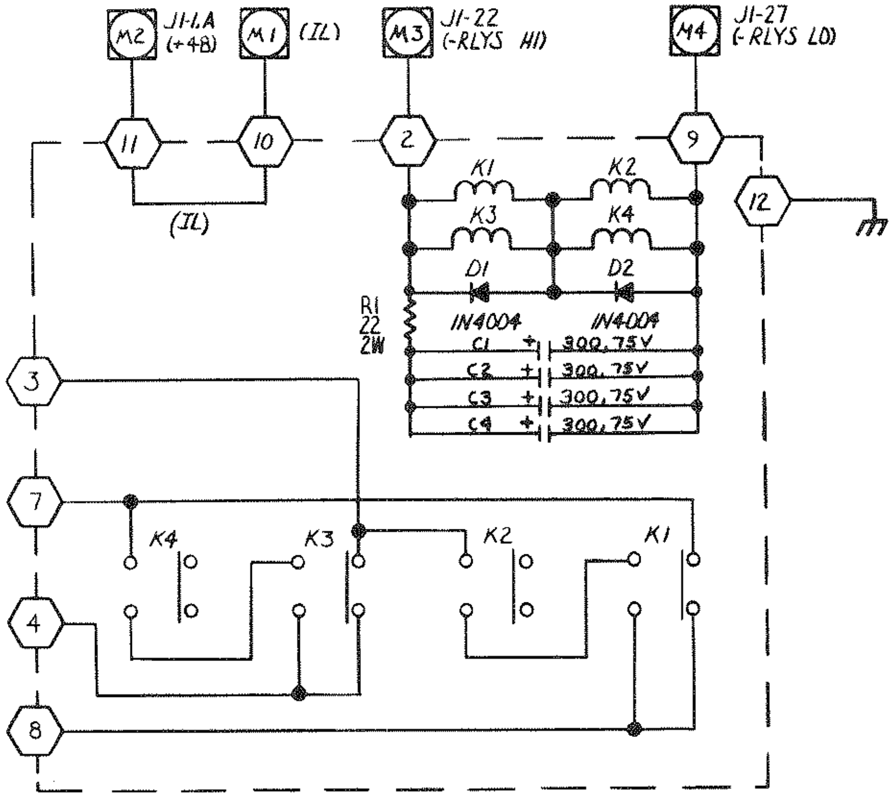


NOTES:
1. KEEPERS :7-9, 8-10

SCALE:
DATE: 4-05-84
APPROVED BY 4-11-84
DRAWN BY JKE
SCHEMATIC, HI VOLTAGE 711
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 71-110-610-00-A



NOTES:

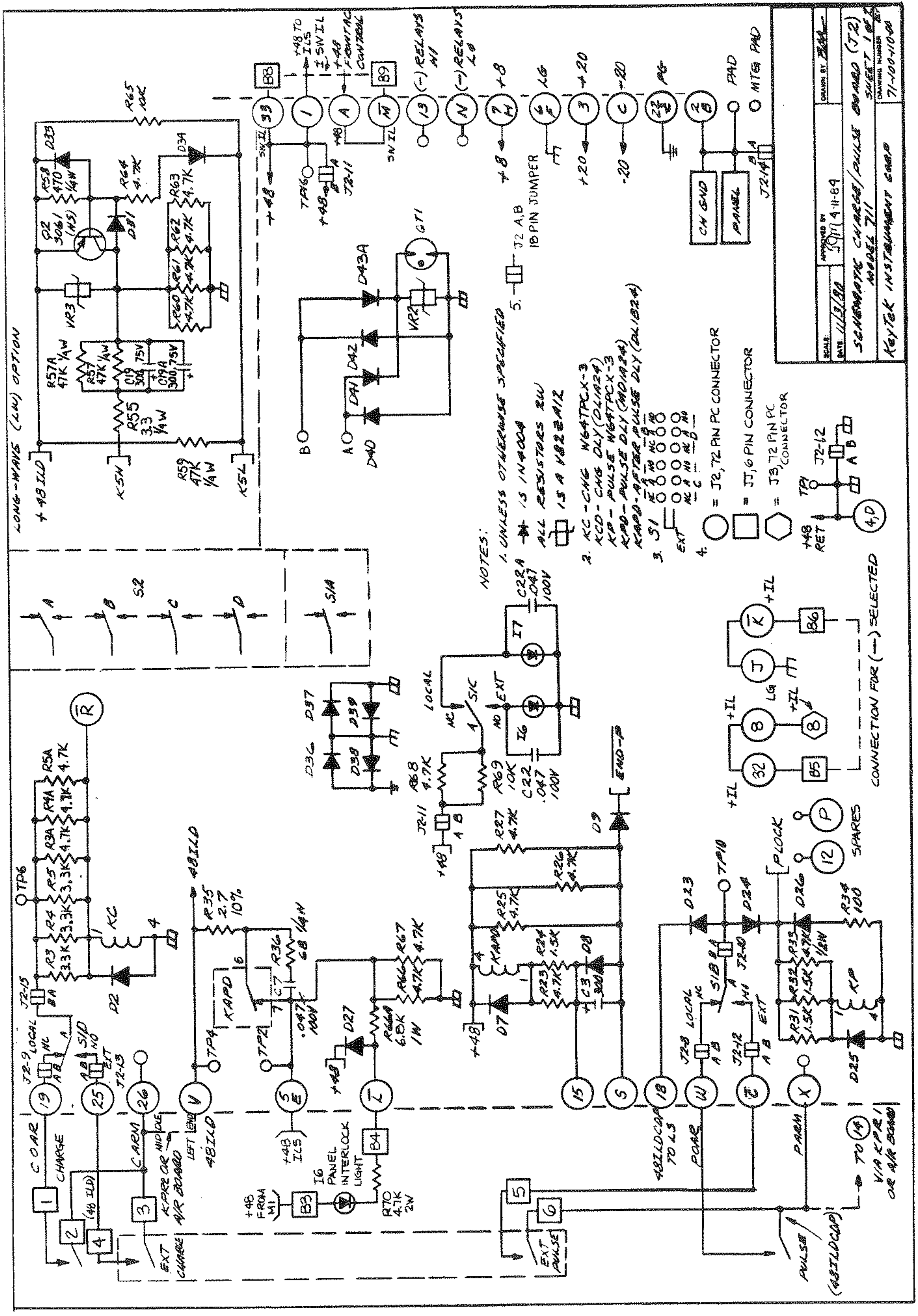
1. KEEPER : 7-8, 1-2, 3-4

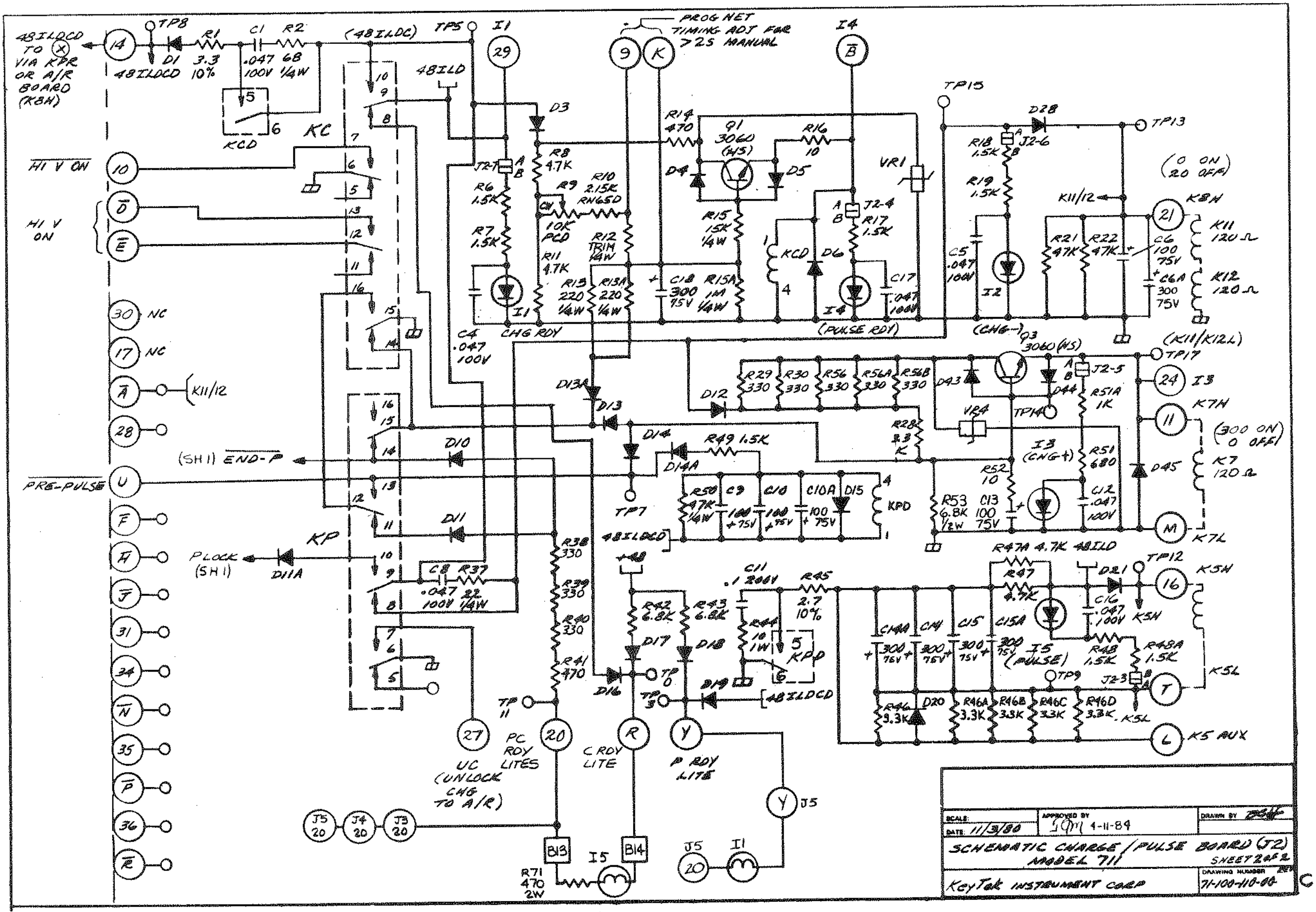
SCALE:
DATE: 4-06-84
APPROVED BY 4-11-84
DRAWN BY JKE

HI VOLTAGE POLARITY OPTION

KEYTEK INSTRUMENT CORP.

DRAWING NUMBER 71-110-600-00-A


SCHEMATIC CHARGE/PULSE BOARD (J2)
MODEL 711
SHEET 1 OF 1
KeyTek INSTRUMENT CORP
DRAWING NUMBER 71-100410-00
DATE 11/3/88
DRAWN BY
APPROVED BY 4-11-89
LONG-WAVE (LW) OPTION
NOTES:
1. UNLESS OTHERWISE SPECIFIED
IS 1N4004
ALL RESISTORS 2W
IS A V82ZA12
2. KC - CHG WGTPCX-3
KCD - CHG DLY (DLIA24)
KP - PULSE WGTPCX-3
KPD - PULSE DLY (MDIA24)
KAPD - AFTER PULSE DLY (DLIB24)
3. S1
4. = J2, 72 PIN PC CONNECTOR
= J1, 6 PIN CONNECTOR
= J3, 72 PIN PC CONNECTOR
5. J2 A,B 18 PIN JUMPER
CONNECTION FOR (—) SELECTED
SPARES
CHARGE
EXT CHARGE
EXT PULSE
PULSE (48ILDCAP)
TO 14 VIA KPR1 OR A/R BOARD
K PR2 OR A/R BOARD
PANEL INTERLOCK LIGHT
+48 FROM M1
+48 TO ILS
FRONT PC CONTROL
(-) RELAYS HI
(-) RELAYS LO
CH GND
PANEL
PAD
MTG PAD
LOCAL
EXT
S1C
S1A
S2



SCALE:

DATE: 11/3/80

APPROVED BY JQM 4-11-89

DRAWN BY

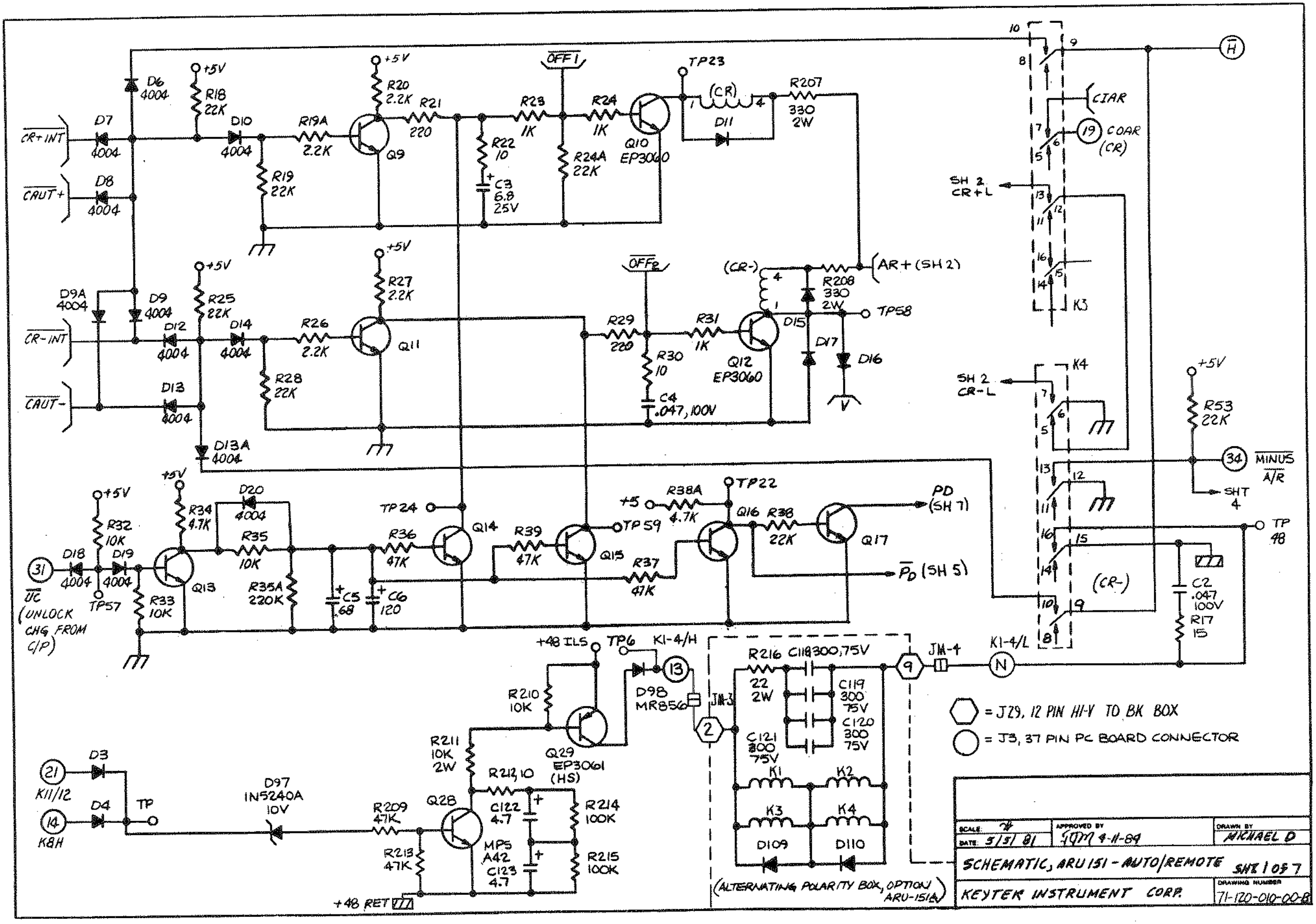
SCHEMATIC CHARGE/PULSE BOARD (J2)
MODEL 711

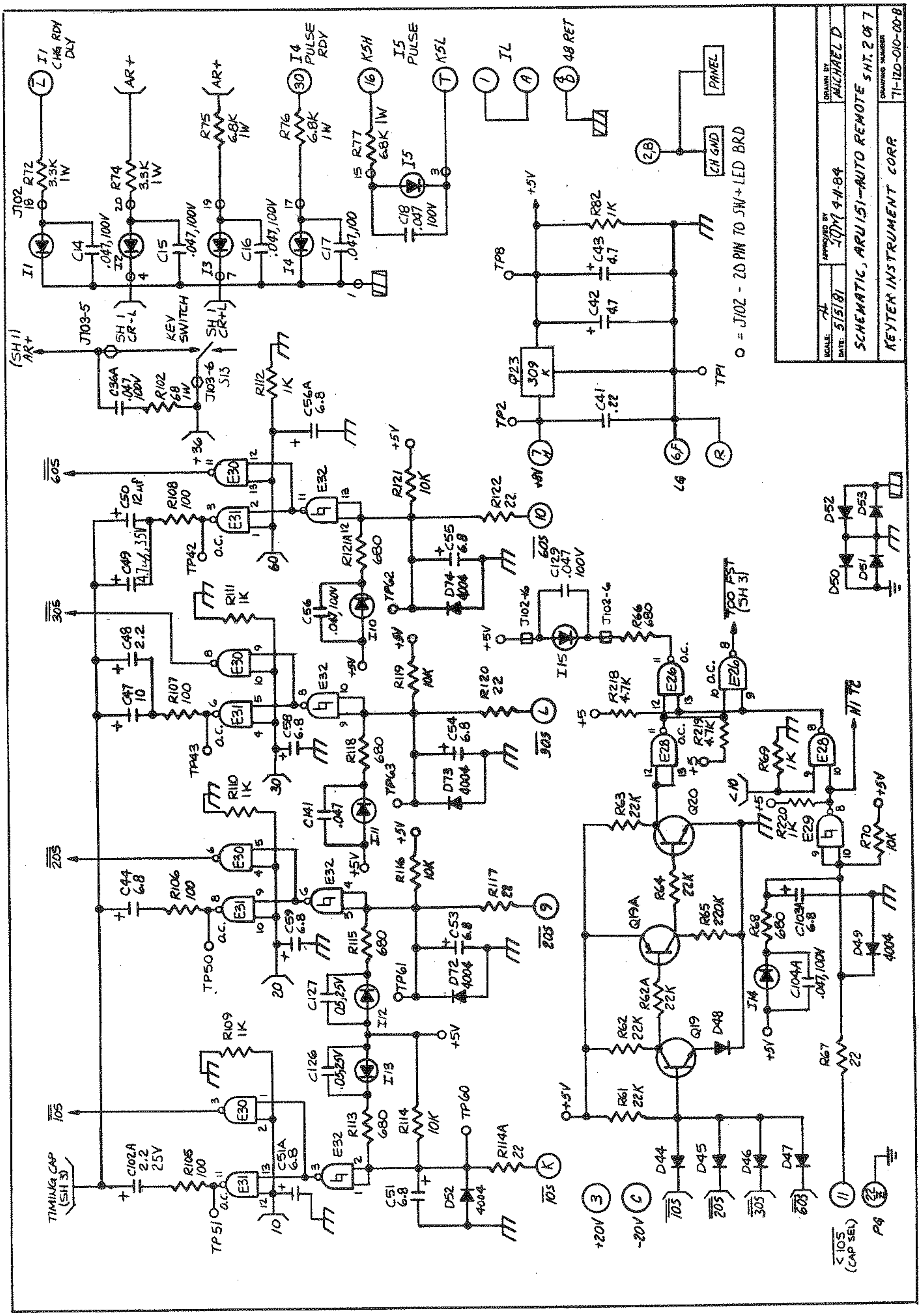
SHEET 2 OF 2

KeyTek INSTRUMENT CORP

DRAWING NUMBER
71-100-110-00

C


CR+ INT
CAUT+
CR- INT
CAUT-
D7 4004
D8 4004
D6 4004
D9A 4004
D9 4004
D12 4004
D13 4004
D13A 4004
+5V
R18 22K
D10 4004
R19A 2.2K
R19 22K
Q9
+5V
R20 2.2K
R21 220
R22 10
C3 6.8 25V
R23 1K
OFF1
R24 1K
R24A 22K
Q10 EP3060
TP23
(CR)
D11
R207 330 2W
+5V
R25 22K
D14 4004
R26 2.2K
R28 22K
+5V
R27 2.2K
Q11
OFF2
R29 220
R30 10
C4 .047, 100V
R31 1K
Q12 EP3060
(CR-)
D15
R208 330 2W
D17
D16
TP58
AR+ (SH 2)
V
+5V
R32 10K
D18 4004
D19 4004
TP57
31
UC
(UNLOCK CHG FROM C/P)
R33 10K
+5V
R34 4.7K
Q13
D20 4004
R35 10K
R35A 220K
C5 .68
C6 120
TP 24
R36 47K
Q14
R39 47K
Q15
TP 59
+5
R38A 4.7K
TP22
Q16
R37 47K
R38 22K
Q17
PD (SH 7)
PD (SH 5)
+48 ILS
TP6
K1-4/H
13
D98 MR856
R210 10K
Q29 EP3061 (HS)
R211 10K 2W
R212, 10
C122 4.7
C123 4.7
R214 100K
R215 100K
Q28
MPS A42
R209 47K
R213 47K
+48 RET
21
K11/12
14
K8H
D3
D4
TP
D97 1N5240A 10V
JM-3
2
R216 22 2W
C118 300, 75V
C119 300 75V
C120 300 75V
C121 300 75V
K1
K2
K3
K4
D109
D110
(ALTERNATING POLARITY BOX, OPTION ARU-151A)
9
JM-4
K1-4/L
N
10
9
8
7
6
5
CIAR
19
COAR (CR)
SH 2 CR+L
13
12
11
16
15
14
K3
H
K4
SH 2 CR-L
7
6
5
13
12
11
16
15
14
(CR-)
10
9
8
+5V
R53 22K
34
MINUS A/R
SHT 4
TP 48
C2 .047 100V
R17 15
= J29, 12 PIN HI-V TO BK BOX
= J3, 37 PIN PC BOARD CONNECTOR
SCALE: ✓
DATE: 5/5/81
APPROVED BY
JQM 4-11-84
DRAWN BY
MICHAEL D
SCHEMATIC, ARU 151 - AUTO/REMOTE
SHT 1 OF 7
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER
71-120-010-00-B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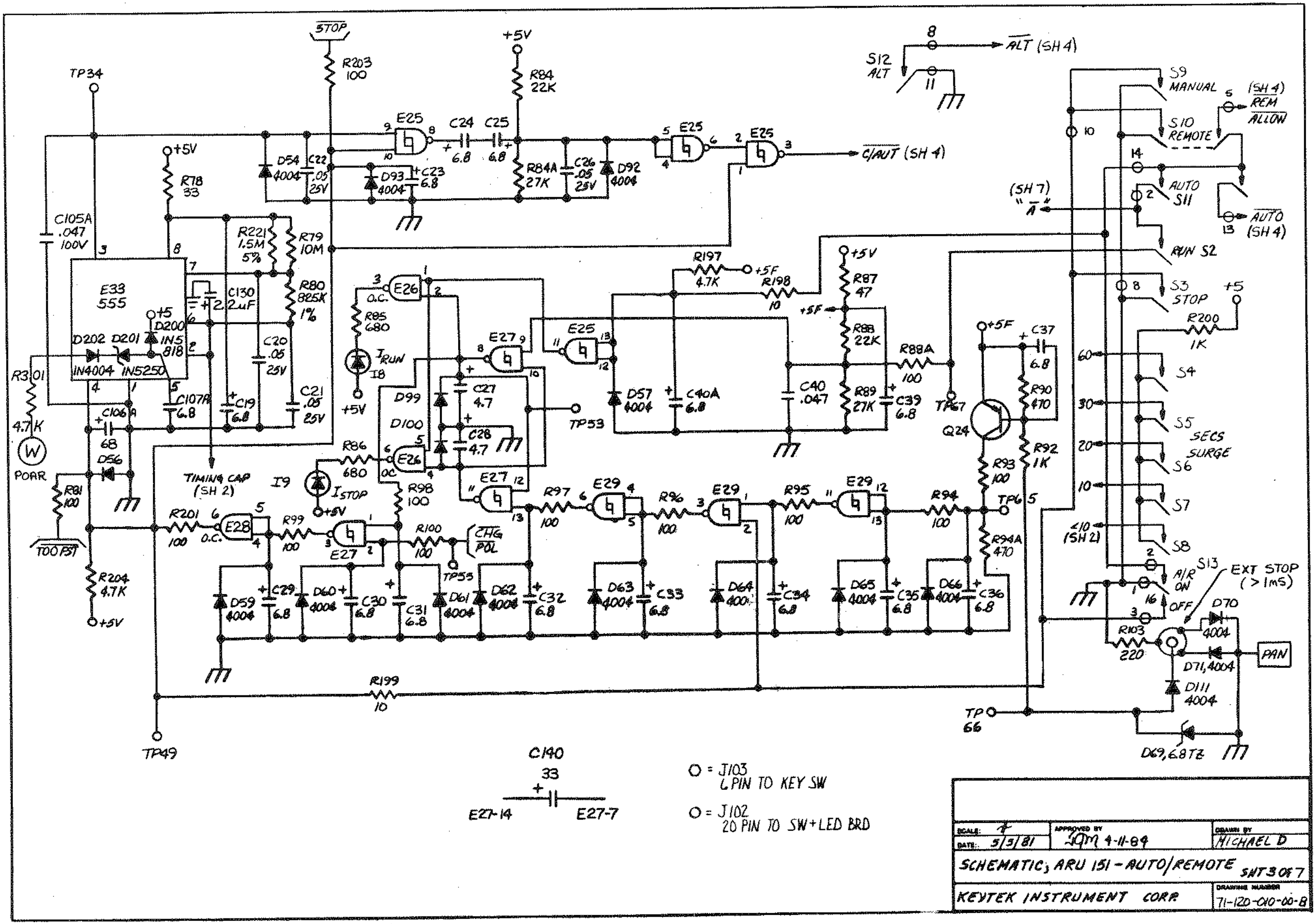
DATE: 5/5/81
APPROVED BY JDM 4-11-84
DRAWN BY MICHAEL D
SCHEMATIC, ARU151-AUTO REMOTE SHT. 2 OF 7
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 71-120-010-00-8
○ = J102 - 20 PIN TO SW+LED BRD
I1 CHG RDY DLY
I4 PULSE RDY
I5 PULSE
K5H
K5L
IL
48 RET
PANEL
CH GND
AR+
J102 18
R72 3.3K 1W
R74 3.3K 1W
R75 6.8K 1W
R76 6.8K 1W
R77 6.8K 1W
C14 .047,100V
C15 .047,100V
C16 .047,100V
C17 .047,100
C18 .047 100V
SH 1 CR-L
SH 1 CR+L
KEY SWITCH
J103-5
J103-6
S13
(SH 1) AR+
C36A .047 100V
R102 68 1W
+36
Q23 309 K
C41 .22
C42 4.7
C43 4.7
R82 1K
TP1
TP2
TP8
+5V
+8V
L6
6,F
R
2,B
605
305
205
105
R112 1K
C56A 6.8
E30
E31
E32
C50 12µf
C49 4.7µf,35V
R108 100
R107 100
R106 100
R105 100
C48 2.2
C47 10
C44 6.8
C102A 2.2 25V
TIMING CAP (SH 3)
TP42
TP43
TP50
TP51
O.C.
60
30
20
10
R121 10K
R122 22
R121A 680
R119 10K
R120 22
R118 680
R116 10K
R117 22
R115 680
R114 10K
R114A 22
R113 680
R111 1K
R110 1K
R109 1K
C55 6.8
C54 6.8
C53 6.8
C51 6.8
C51A 6.8
C58 6.8
C59 6.8
D74 4004
D73 4004
D72 4004
D52 4004
C56 .01,100V
C141 .047
C127 .05,25V
C126 .05,25V
I10
I11
I12
I13
TP60
TP61
TP62
TP63
C129 .047 100V
J102-16
J102-6
I15
R66 680
TOO FST (SH 3)
E26
E28
E29
R218 4.7K
R219 4.7K
R69 1K
R220 1K
R70 10K
HI TC
<10
Q20
Q19A
Q19
R63 22K
R64 22K
R65 220K
R62 22K
R62A 22K
R61 22K
D48
I14
R68 680
C103A 6.8
C104A .047,100V
D49 4004
R67 22
D44
D45
D46
D47
+20V
-20V
<105 (CAP SEL)
PG
D50
D51
D52
D53

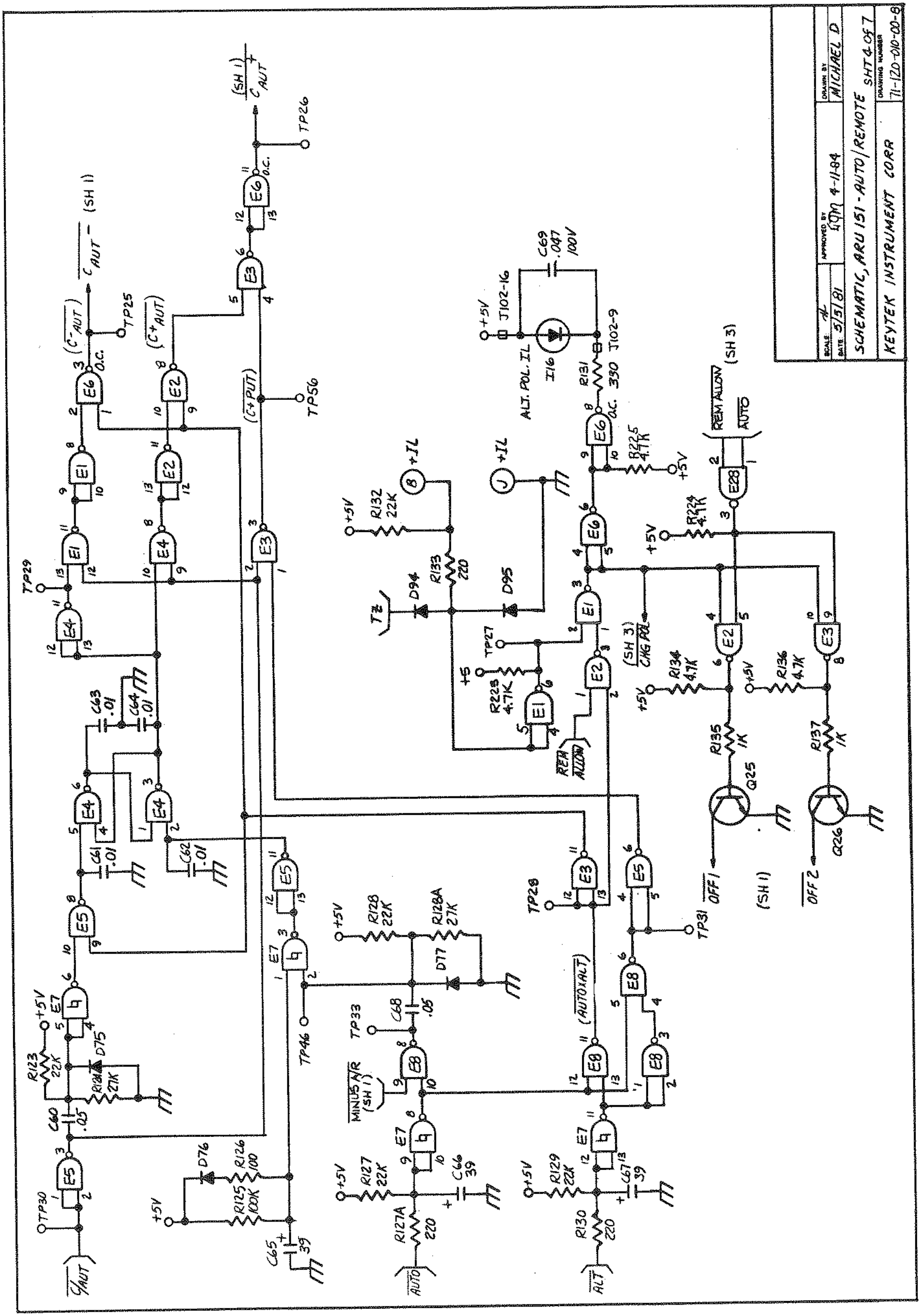


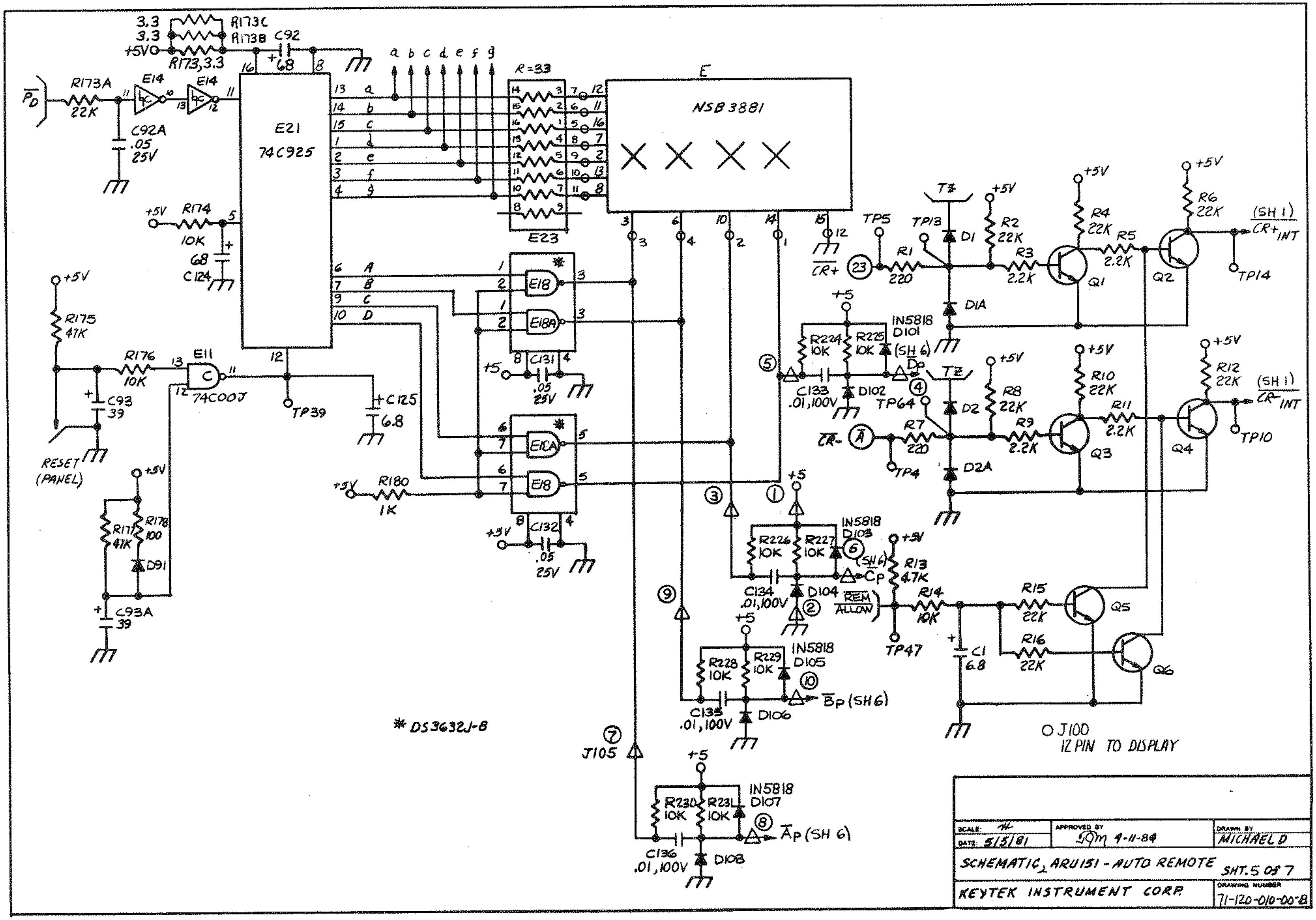
SCALE: —
DATE: 5/3/81
APPROVED BY JQM 4-11-84
DRAWN BY MICHAEL D

SCHEMATIC; ARU 151 - AUTO/REMOTE SHT 3 OF 7

KEYTEK INSTRUMENT CORP

DRAWING NUMBER 71-120-010-00-B


SCALE
DATE 5/5/81
APPROVED BY
4-11-84
DRAWN BY
MICHAEL D
SCHEMATIC, ARU 151-AUTO/REMOTE
SHT 4 OF 7
KEYTEK INSTRUMENT CORR
DRAWING NUMBER
71-120-010-00-B
(SH 1) C+ AUT
TP26
E6
O.C.
E3
(C- AUT)
C- AUT (SH 1)
TP25
(C+ AUT)
E2
(C+ PUT)
TP56
E1
E4
TP29
C63 .01
C64 .01
C61 .01
C62 .01
E5
E7
+5V
R123 22K
R124 27K
D75
C60 .05
TP30
C/AUT
D76
R126 100
R125 100K
C65 39
TP46
R128 22K
R128A 27K
D77
C68 .05
TP33
E8
MINUS H/R (SH 1)
R127 22K
R127A 220
C66 39
AUTO
TP28
(AUTO×ALT)
R129 22K
R130 220
C67 39
ALT
TP31
+IL
R132 22K
R133 220
D94
D95
TZ
+5
R228 4.7K
TP27
REM ALLOW
(SH 3) CHG POL
J102-16
J102-9
C69 .047 100V
I16
ALT. POL. IL
R131 330
R225 4.7K
E28
REM ALLOW
AUTO
(SH 3)
R224 4.7K
R134 4.7K
R136 4.7K
R135 1K
R137 1K
Q25
Q26
OFF 1
OFF 2
(SH 1)

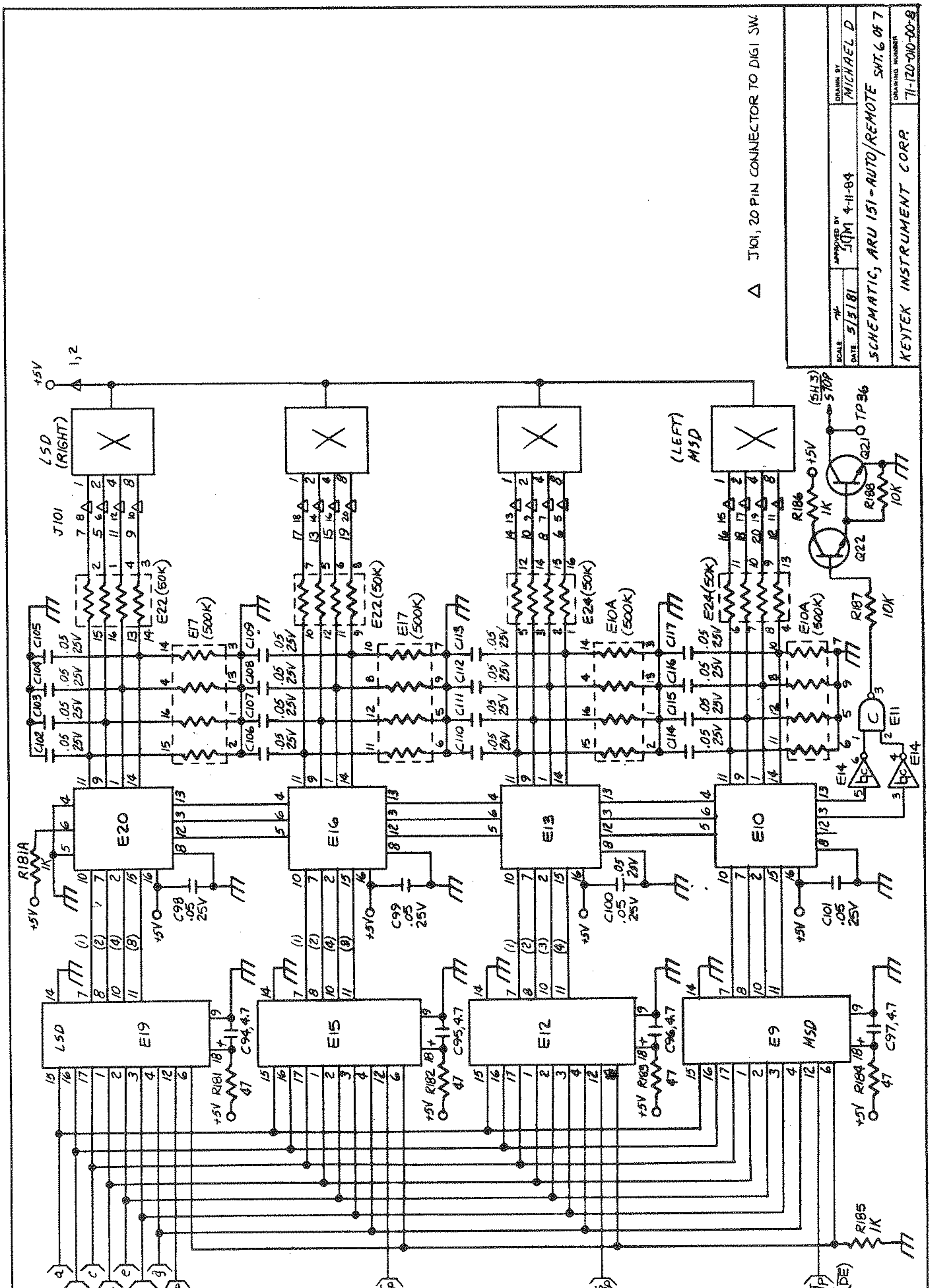


SCALE: ~~
DATE: 5/5/81
APPROVED BY: ЯDm 4-11-84
DRAWN BY: MICHAEL D

SCHEMATIC, ARU151 - AUTO REMOTE
SHT. 5 OF 7

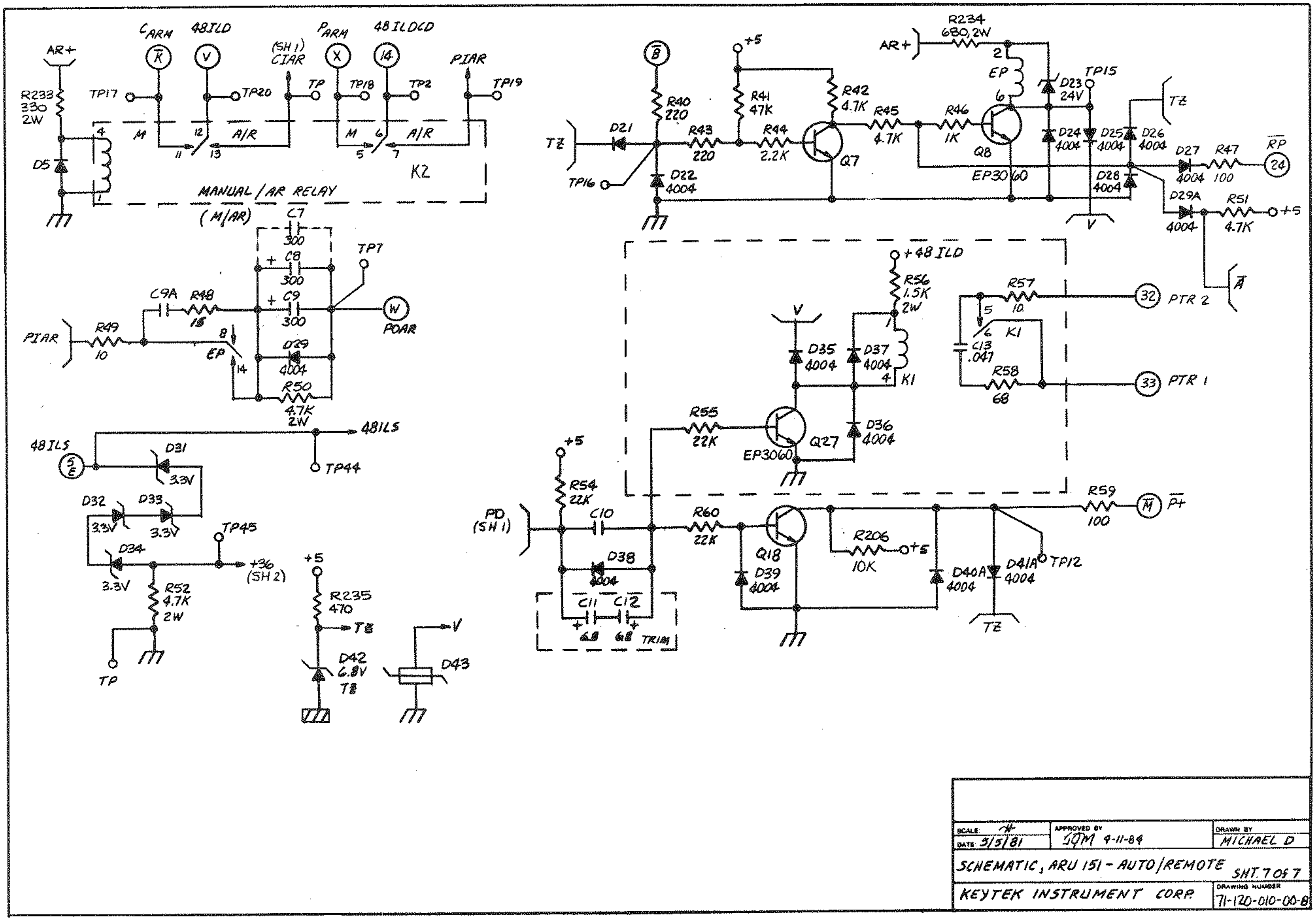
KEYTEK INSTRUMENT CORP.

DRAWING NUMBER: 71-120-010-00-B

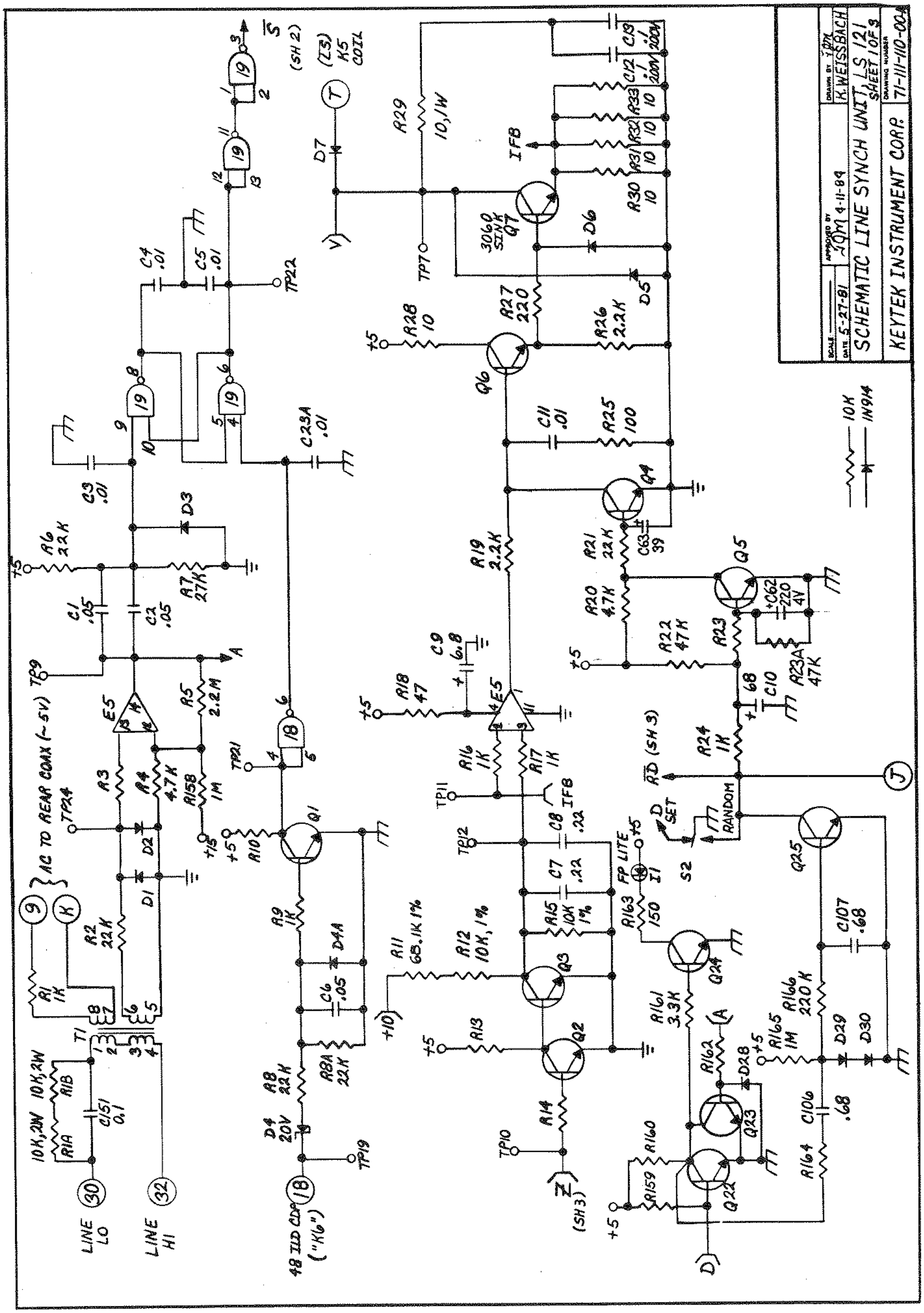


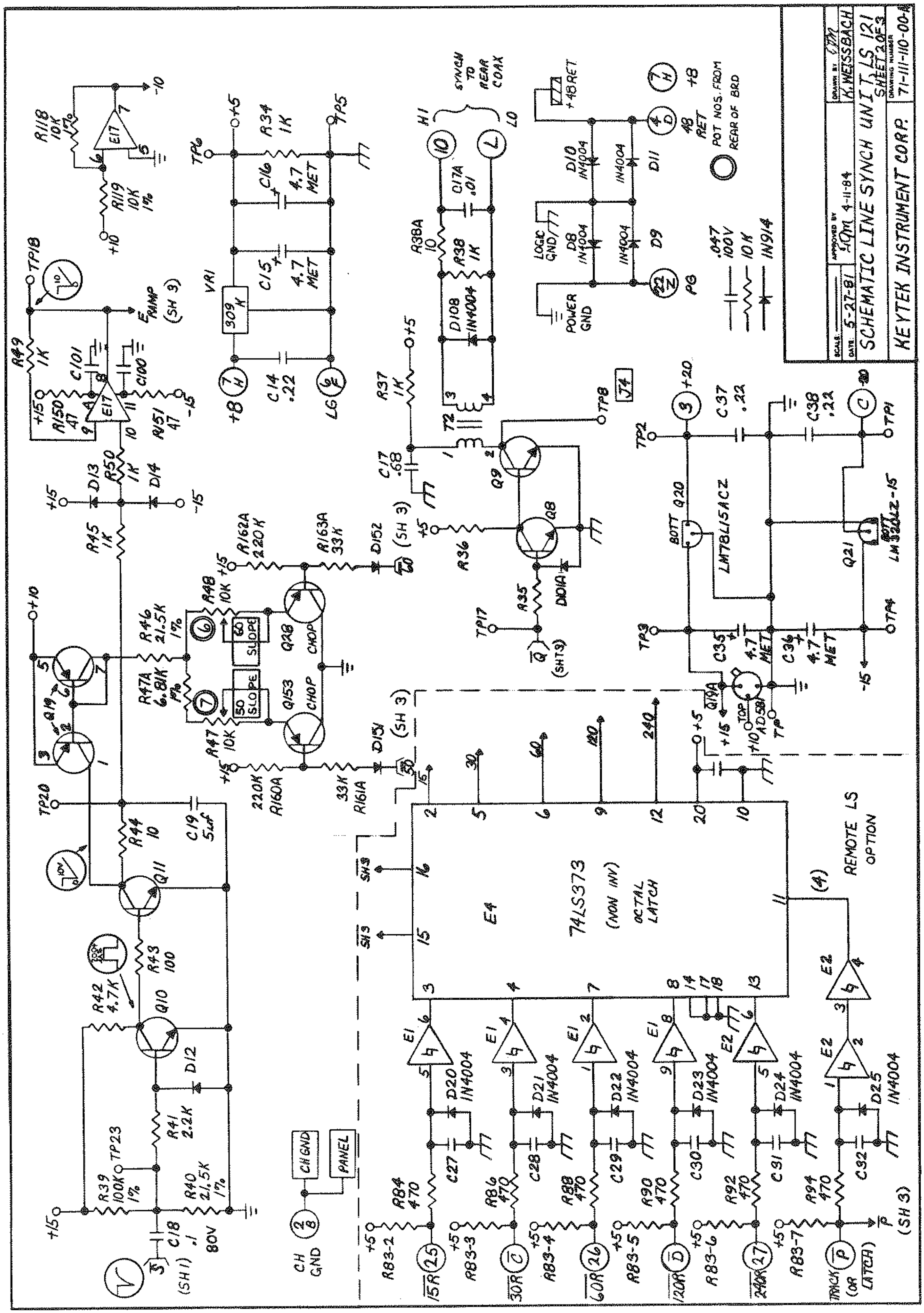
Δ J101, 20 PIN CONNECTOR TO DIGI SW.

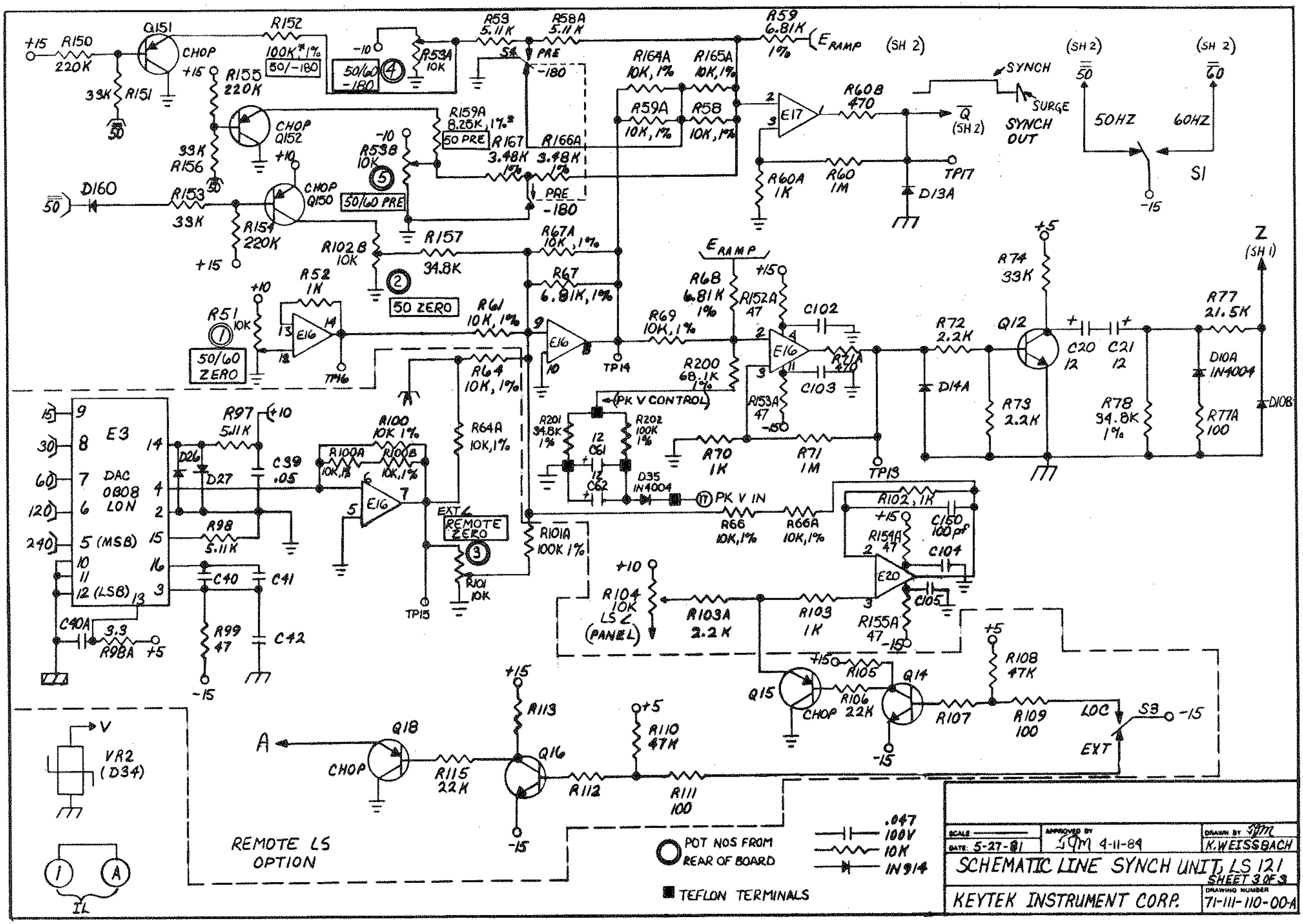
SCALE: ~
DATE: 5/5/81
APPROVED BY JQM 4-11-84
DRAWN BY MICHAEL D
SCHEMATIC, ARU 151 - AUTO/REMOTE SHT. 6 OF 7
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 71-120-010-00-B



SCALE: ⊬ DATE: 5/5/81
APPROVED BY IQM 4-11-84
DRAWN BY MICHAEL D
SCHEMATIC, ARU 151 - AUTO/REMOTE SHT. 7 OF 7
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 71-120-010-00-B


SCALE
DATE 5-27-81
APPROVED BY JQM 4-11-84
DRAWN BY K. WEISSBACH
SCHEMATIC LINE SYNCH UNIT, LS 121
SHEET 1 OF 3
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 71-111-110-00A
LINE LO
LINE HI
30
32
9
K
AC TO REAR COAX (~5V)
10K,2W
10K,2W
R1A
R1B
C151 0.1
T1
R1 1K
R2 22K
D1
D2
R3
R4 4.7K
R158 1M
R5 2.2M
+15
TP24
TP9
E5
C1 .05
C2 .05
R6 22K
R7 27K
D3
C3 .01
A
+5
19
C4 .01
C5 .01
TP22
C23A .01
18
TP21
48 ILD CLP ("K6")
D4 20V
R8 22K
R8A 22K
TP19
R9 1K
C6 .05
D4A
R10
Q1
S̄ (SH 2)
(Z5) K5 COIL
T
D7
V
R29 10,1W
TP7
C12 .1 200V
C13 .1 200V
R30 10
R31 10
R32 10
R33 10
IFB
Q7 3060 SINK
D6
D5
R27 220
R28 10
Q6
R26 2.2K
C11 .01
R25 100
Q4
C63 39
R19 2.2K
R18 47
C9 6.8
R16 1K
R17 1K
TP11
TP12
C8 .22
C7 .22
R15 10K 1%
R12 10K, 1%
R11 68.1K 1%
+10
Q3
Q2
R13
R14
TP10
Z (SH 3)
R21 22K
R20 4.7K
R22 47K
R23
Q5
C62 220 4V
R23A 47K
C10 68
R24 1K
RD (SH 3)
J
D SET
RANDOM
S2
FP LITE
I1
R163 150
Q24
Q25
C107 .68
R161 3.3K
R162
D28
Q23
R165 1M
R166 220K
D29
D30
C106 .68
R160
R159
Q22
R164
D
10K
1N914


SCHEMATIC LINE SYNCH UNIT LS 121
SHEET 2 OF 3
KEYTEK INSTRUMENT CORP.
DRAWN BY K. WEISSBACH
DATE 5-27-81
APPROVED BY 4-11-84
DRAWING NUMBER 71-111-110-00-B
74LS373 (NON INV) OCTAL LATCH
E4
E17
Q9
Q8
Q10
Q11
Q19
Q20 LM78L15ACZ
Q21 LM320LZ-15
Q28 CHOP
Q153 CHOP
60 SLOPE
50 SLOPE
VR1 309 K
T2
J4
REMOTE LS OPTION
SYNCH TO REAR COAX
POT NOS. FROM REAR OF BRD
LOGIC GND
POWER GND
+48 RET
CH GND
PANEL
E RAMP (SH 3)
TRACK (OR LATCH) (SH 3)
.047 100V
10 K
IN914

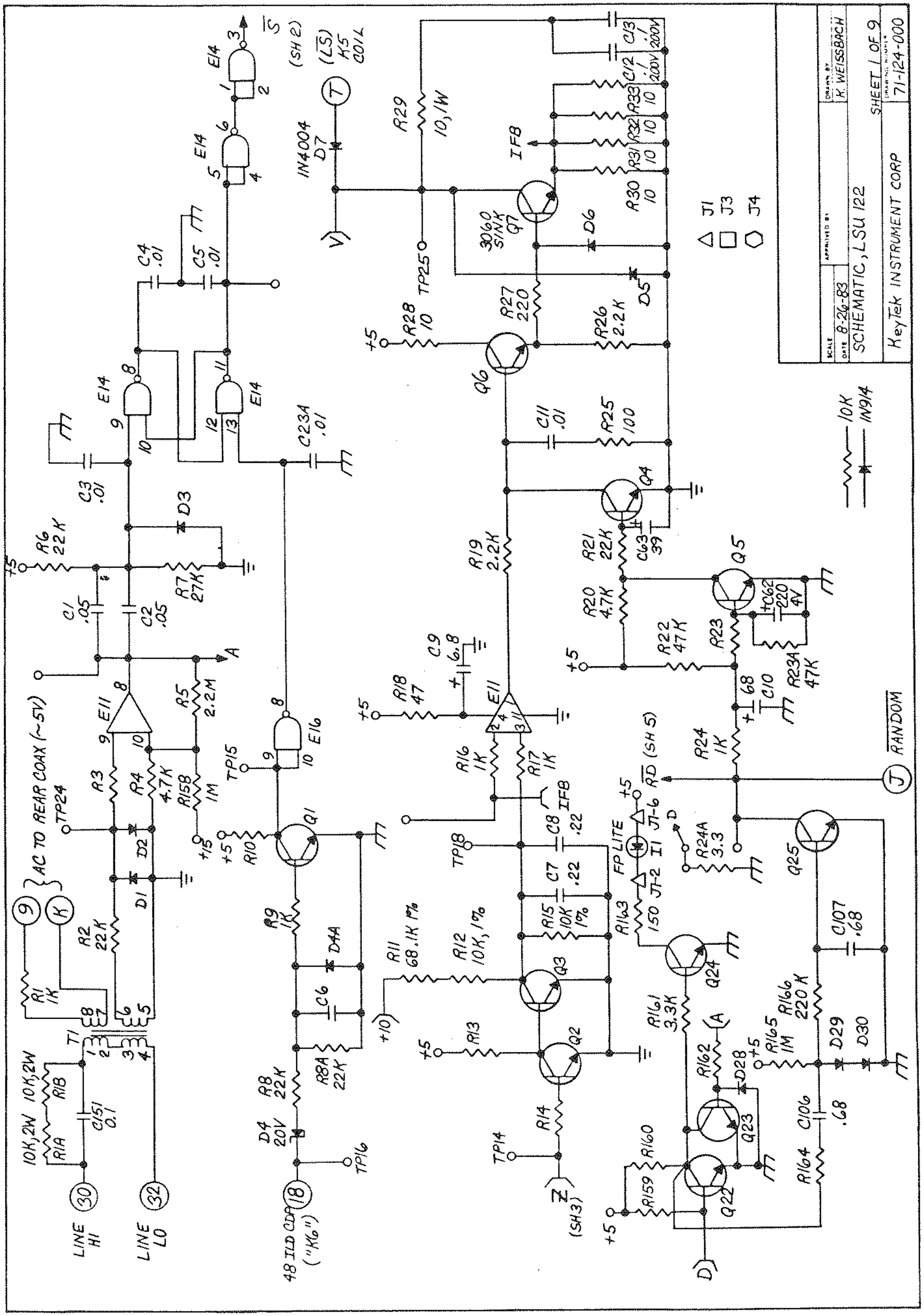


SCALE
DATE: 5-27-81
APPROVED BY JGM 4-11-84
DRAWN BY JGM
K. WEISSBACH

SCHEMATIC LINE SYNCH UNIT, LS 121
SHEET 3 OF 3

KEYTEK INSTRUMENT CORP.

DRAWING NUMBER
71-111-110-00-A



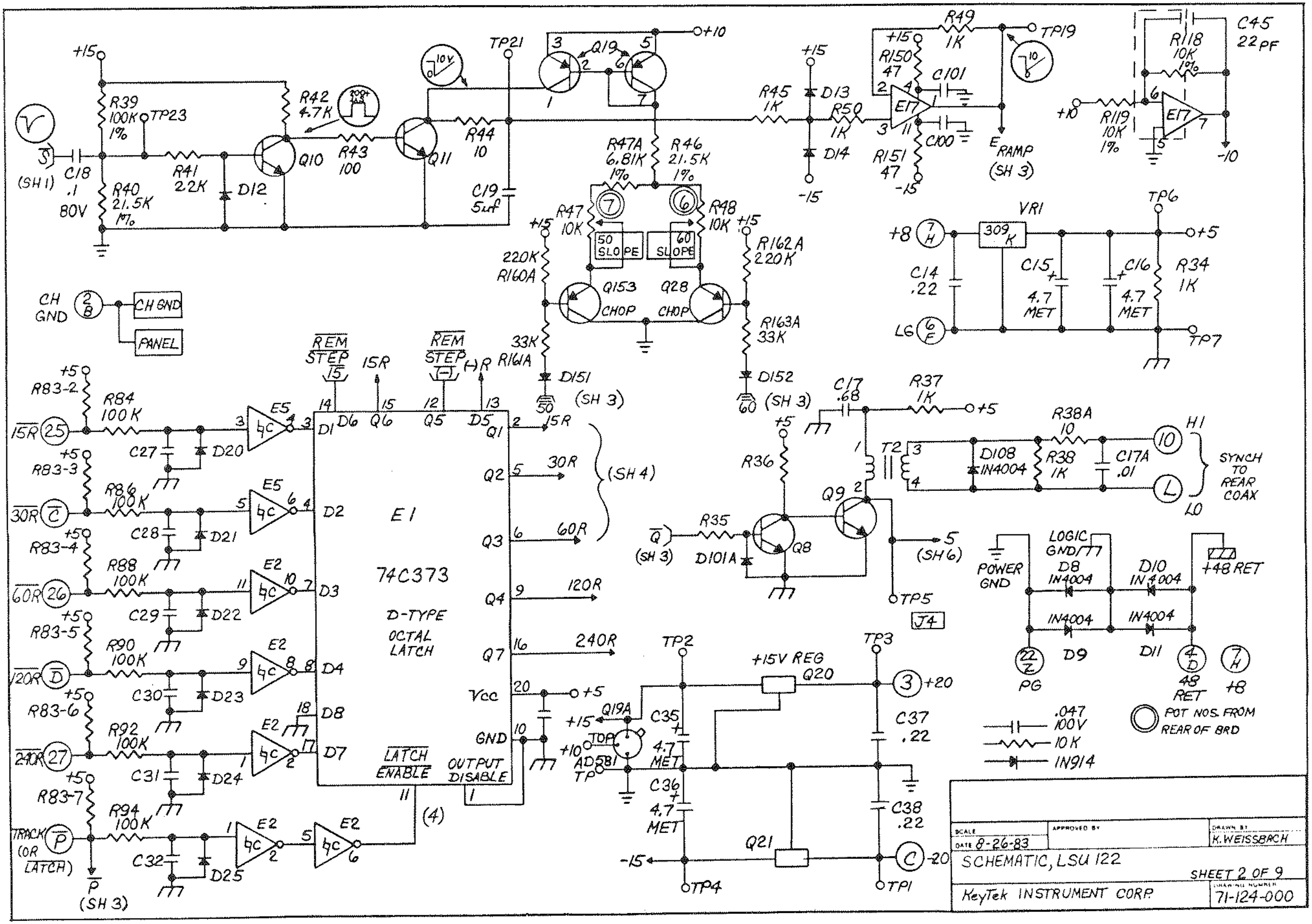
SCALE
DATE 8-26-83
APPROVED BY
DRAWN BY K. WEISSBACH

SCHEMATIC, LSU 122

SHEET 1 OF 9

DRAWING NUMBER 71-124-000

KeyTek INSTRUMENT CORP



SCALE

DATE 8-26-83

APPROVED BY

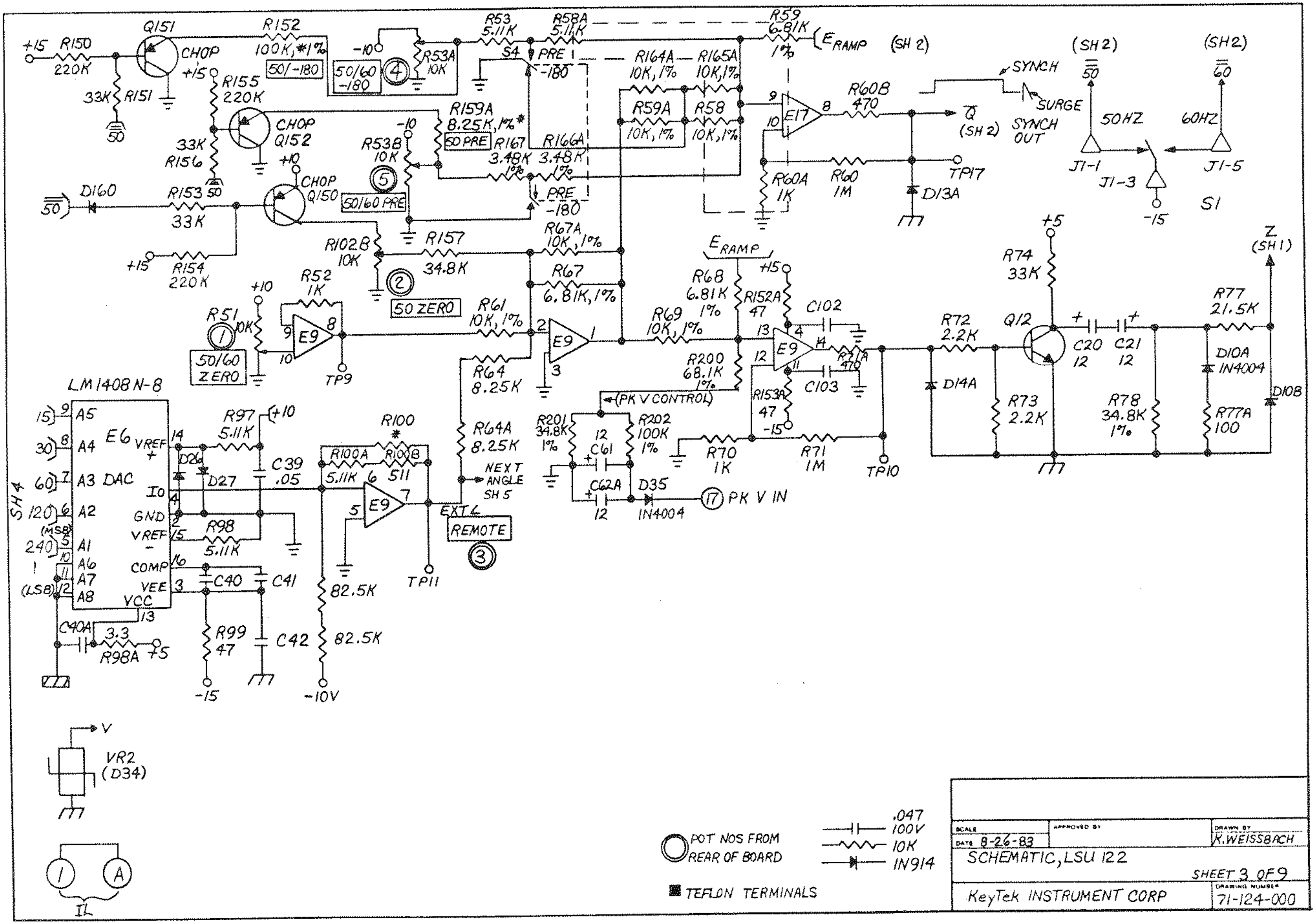
DRAWN BY K.WEISSBACH

SCHEMATIC, LSU 122

SHEET 2 OF 9

KeyTek INSTRUMENT CORP.

DRAWING NUMBER 71-124-000



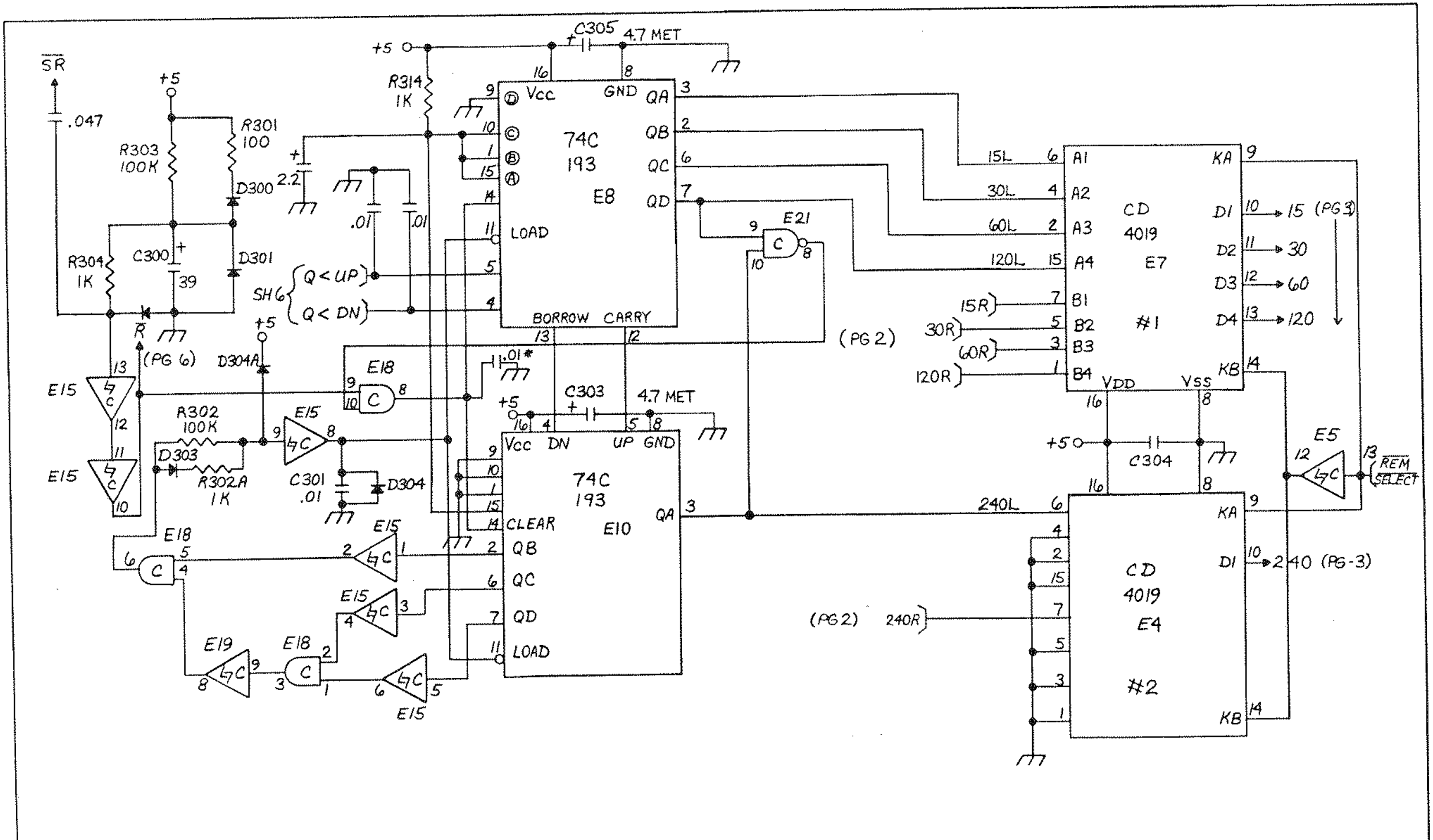
SCALE
DATE 8-26-83
APPROVED BY
DRAWN BY K.WEISSBACH

SCHEMATIC, LSU 122

SHEET 3 OF 9

KeyTek INSTRUMENT CORP

DRAWING NUMBER 71-124-000



SCALE

DATE 8-26-83

APPROVED BY

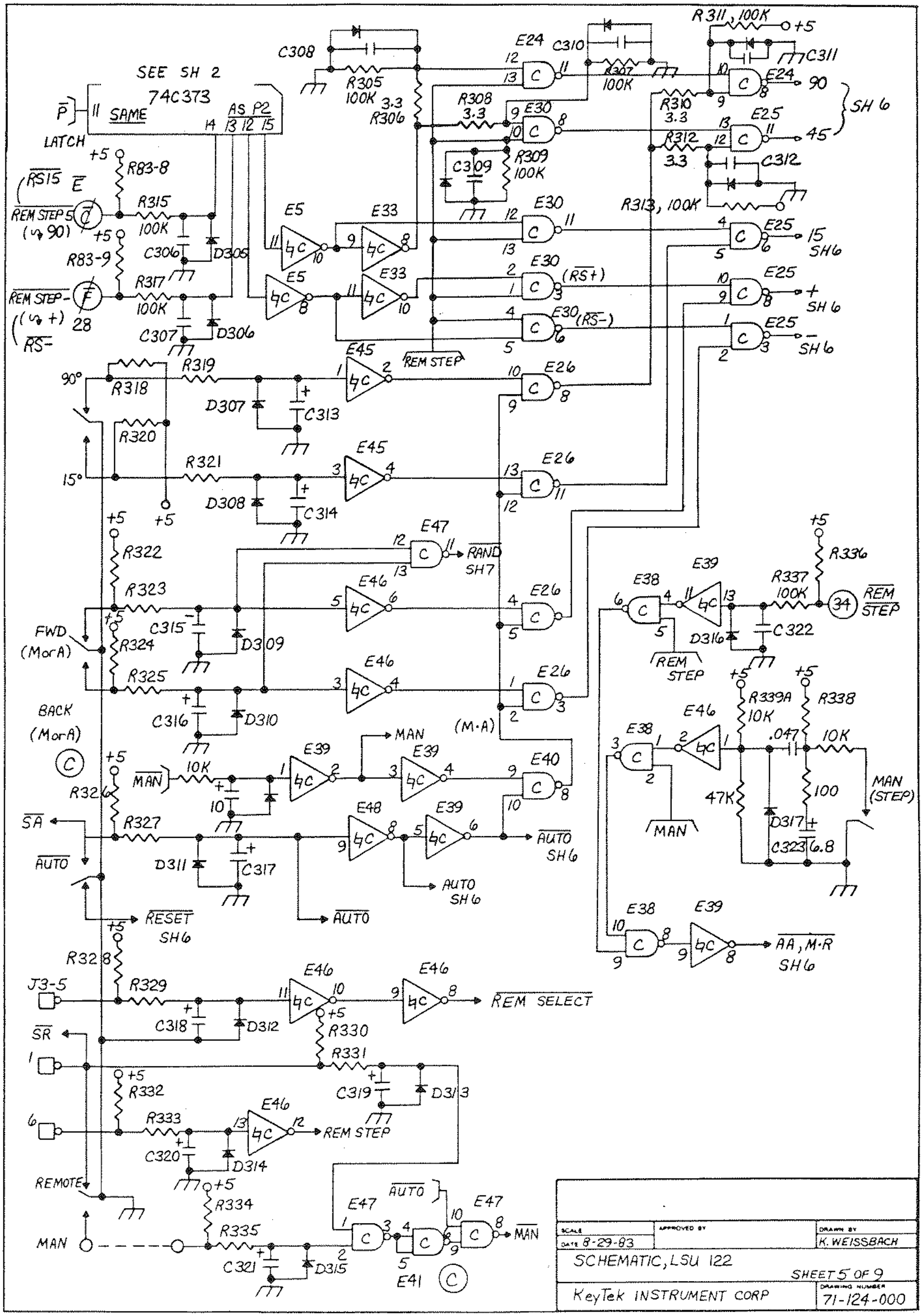
DRAWN BY K. WEISSBACH

SCHEMATIC, LSU 122

SHEET 4 OF 9

KeyTek INSTRUMENT CORP

DRAWING NUMBER 71-124-000



SCALE	APPROVED BY	DRAWN BY
DATE 8-29-83		K. WEISSBACH

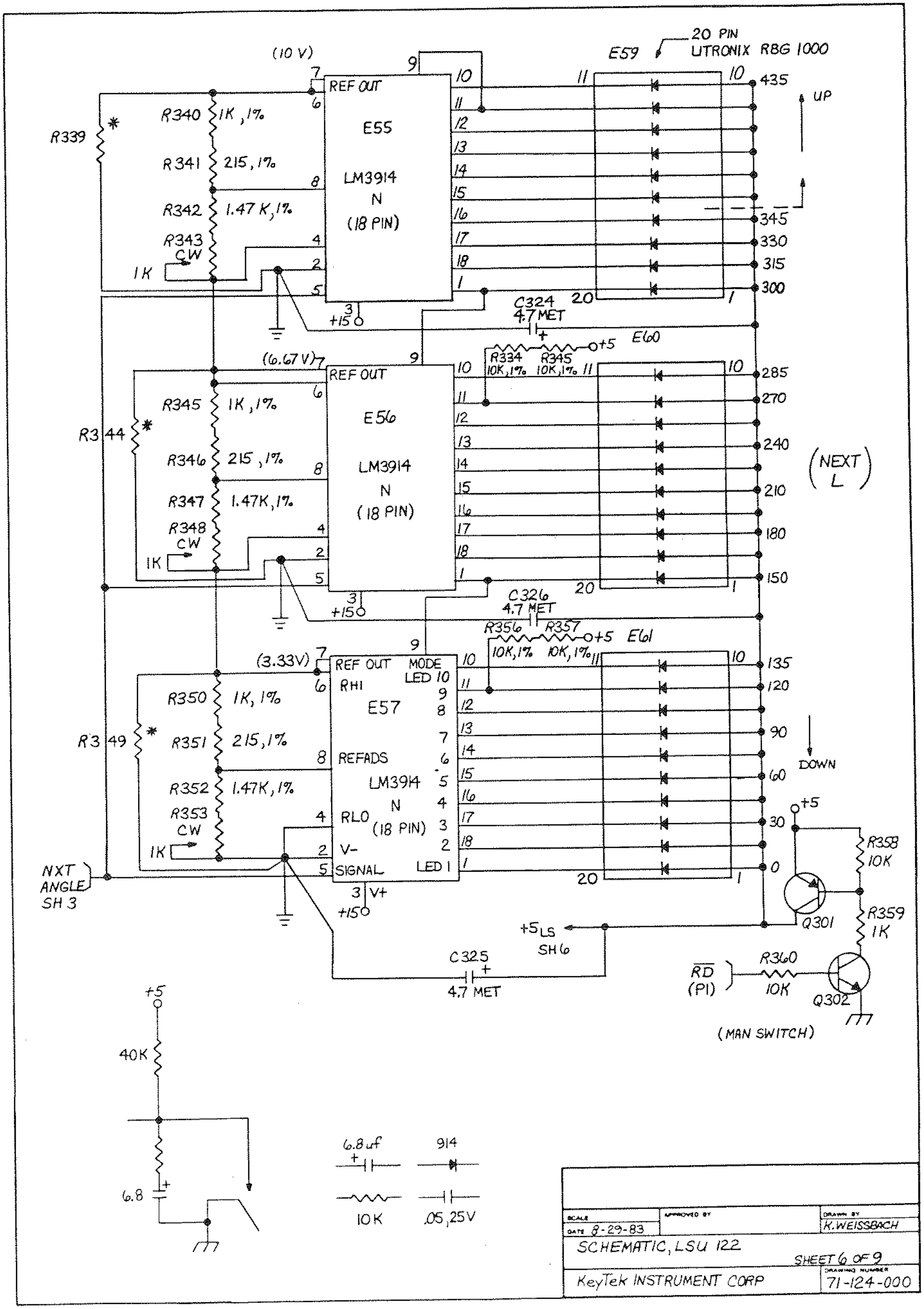
SCHEMATIC, LSU 122

SHEET 5 OF 9

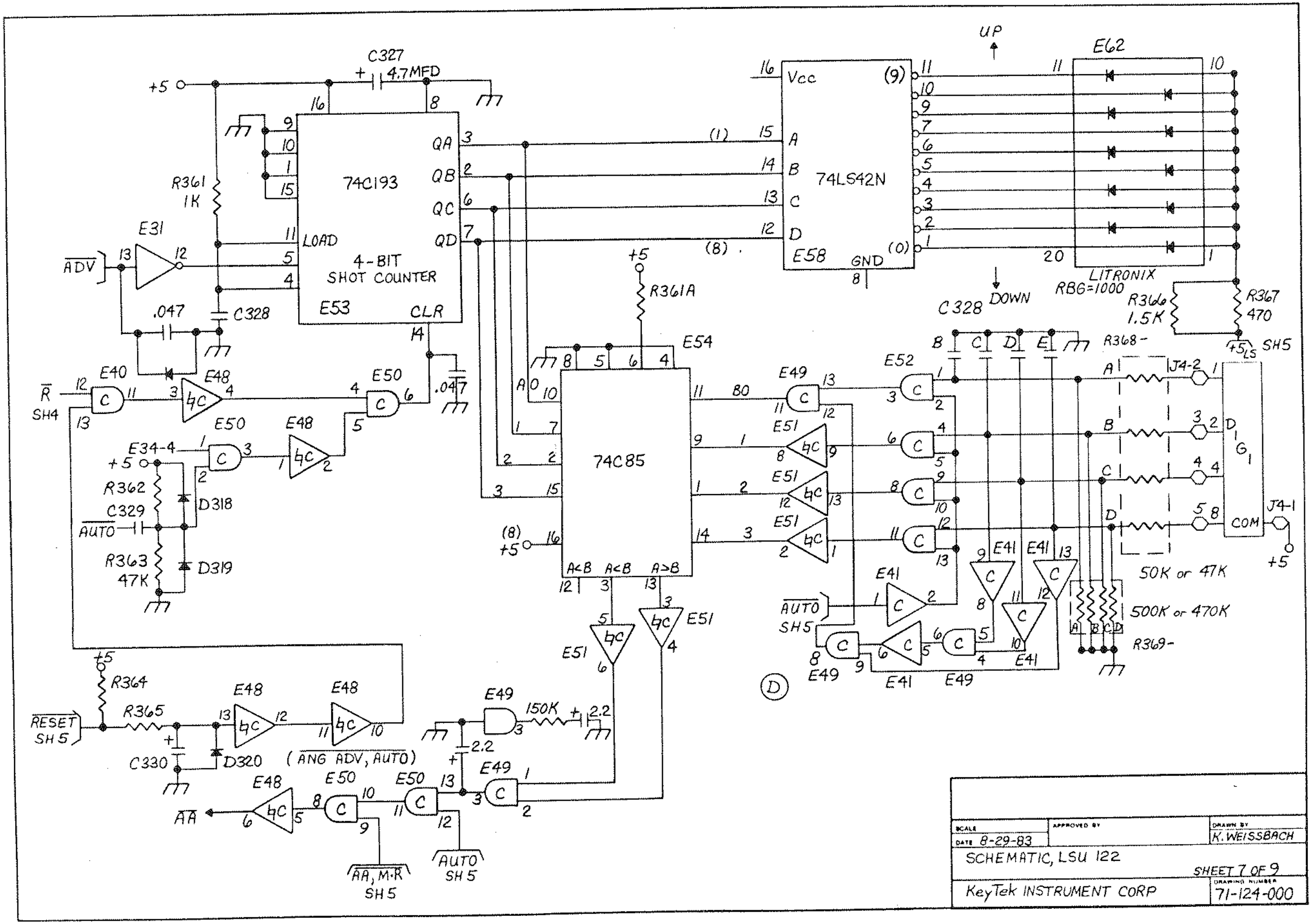
KeyTek INSTRUMENT CORP

DRAWING NUMBER 71-124-000

]



SCALE
DATE 8-29-83
APPROVED BY
DRAWN BY K.WEISSBACH
SCHEMATIC, LSU 122
SHEET 6 OF 9
KeyTek INSTRUMENT CORP
DRAWING NUMBER 71-124-000



SCALE

DATE 8-29-83

APPROVED BY

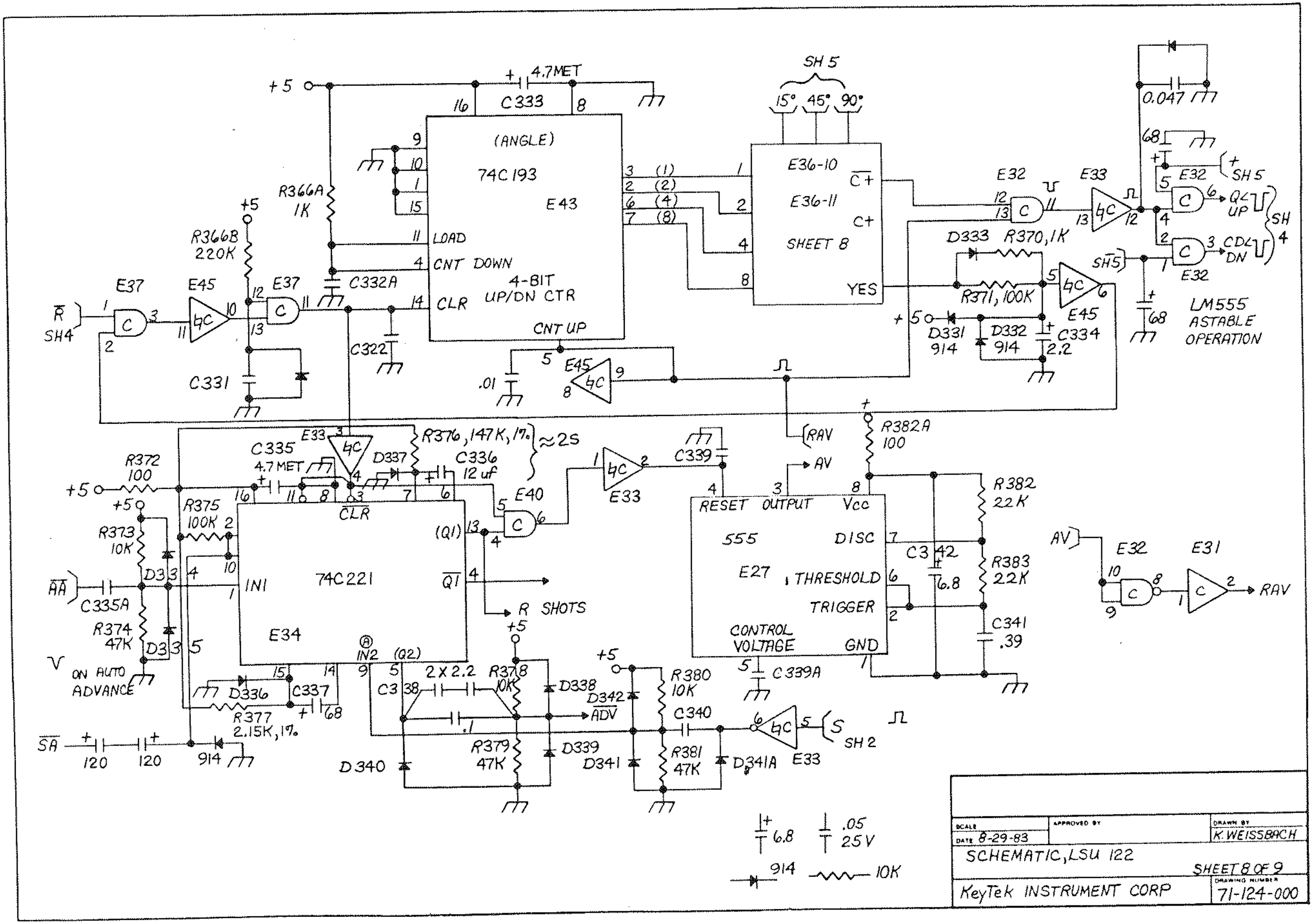
DRAWN BY K. WEISSBACH

SCHEMATIC, LSU 122

SHEET 7 OF 9

KeyTek INSTRUMENT CORP

DRAWING NUMBER 71-124-000



DATE 8-29-83

APPROVED BY

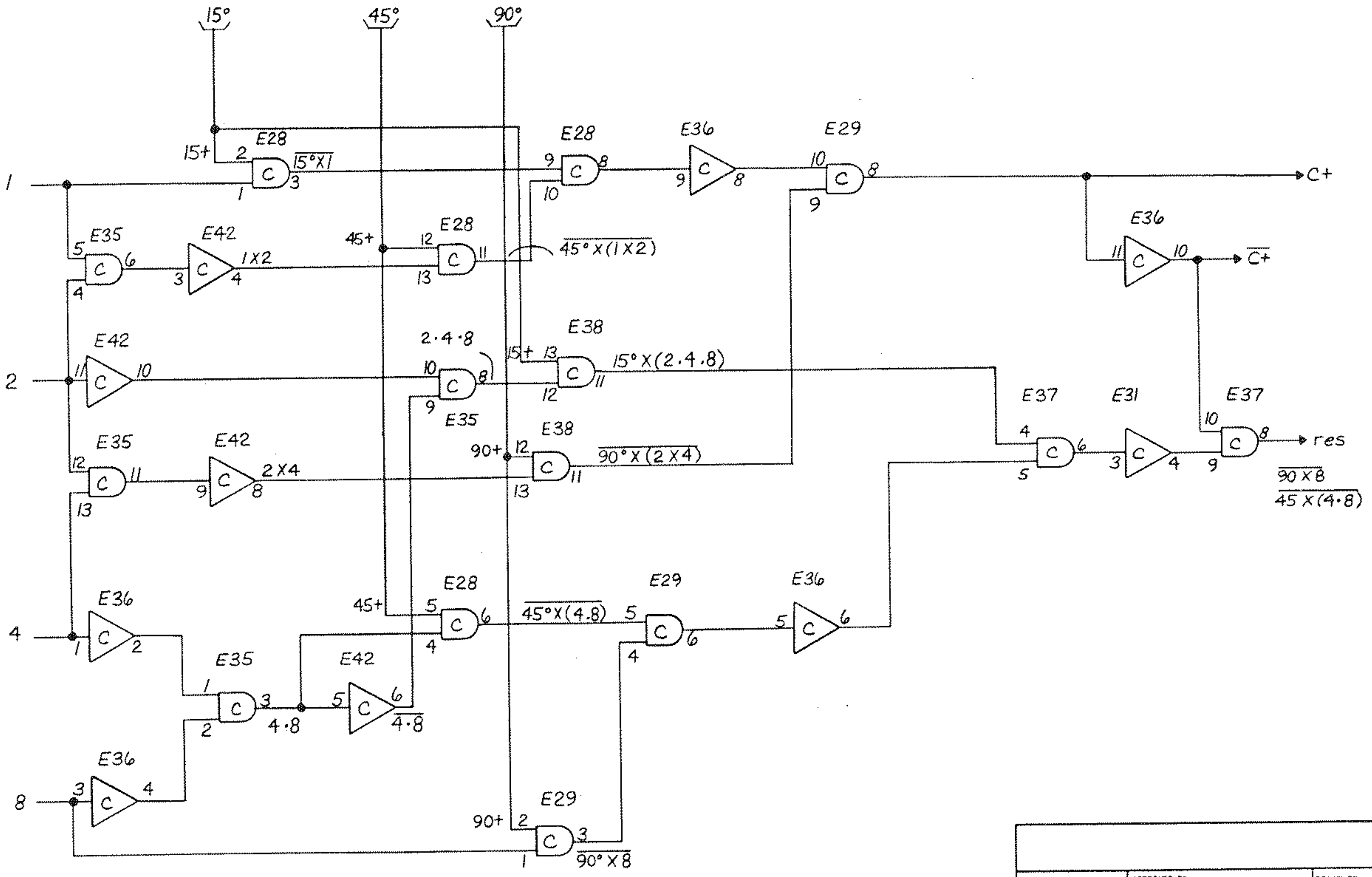
DRAWN BY K. WEISSBACH

SCHEMATIC, LSU 122

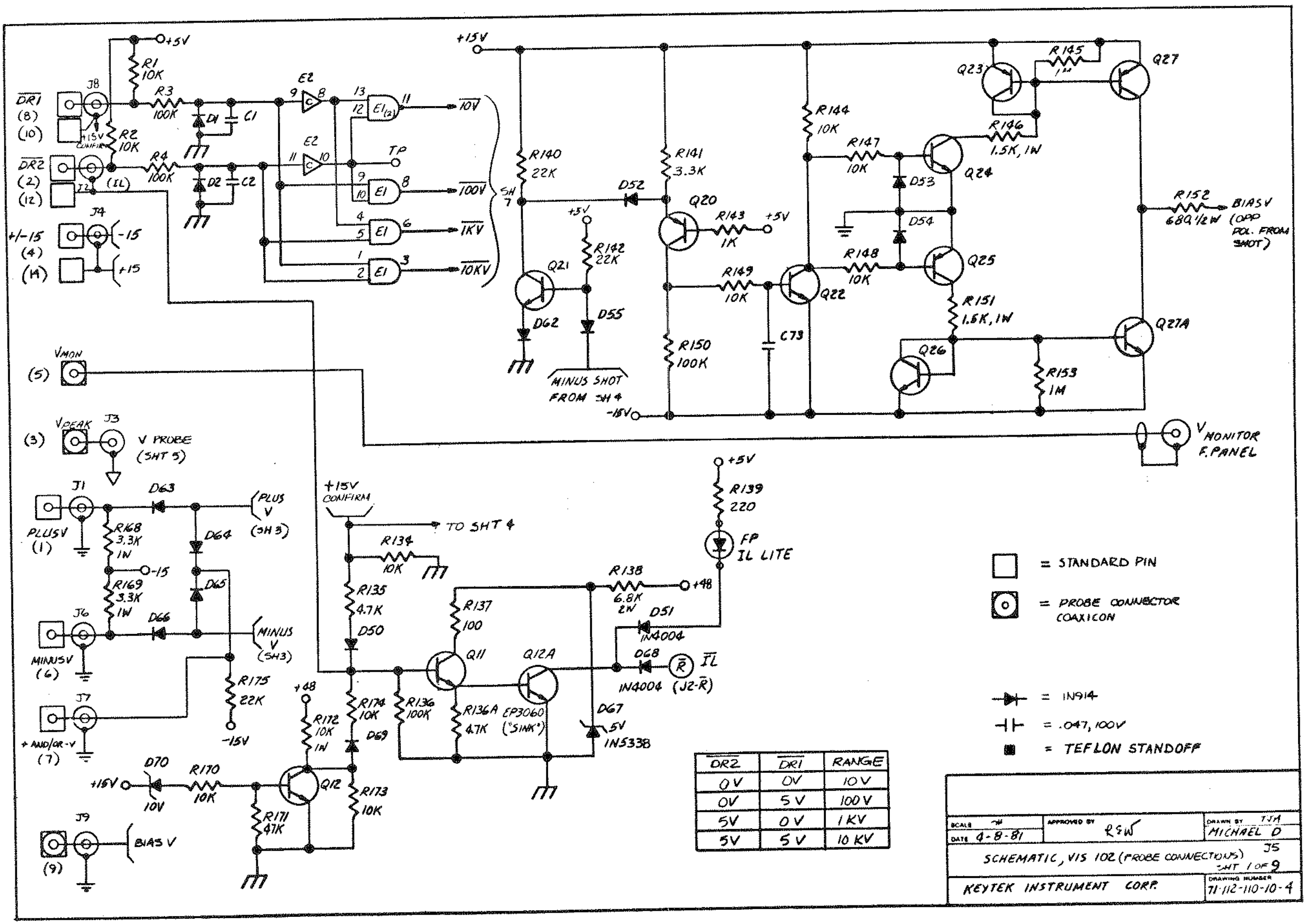
SHEET 8 OF 9

KeyTek INSTRUMENT CORP

DRAWING NUMBER 71-124-000

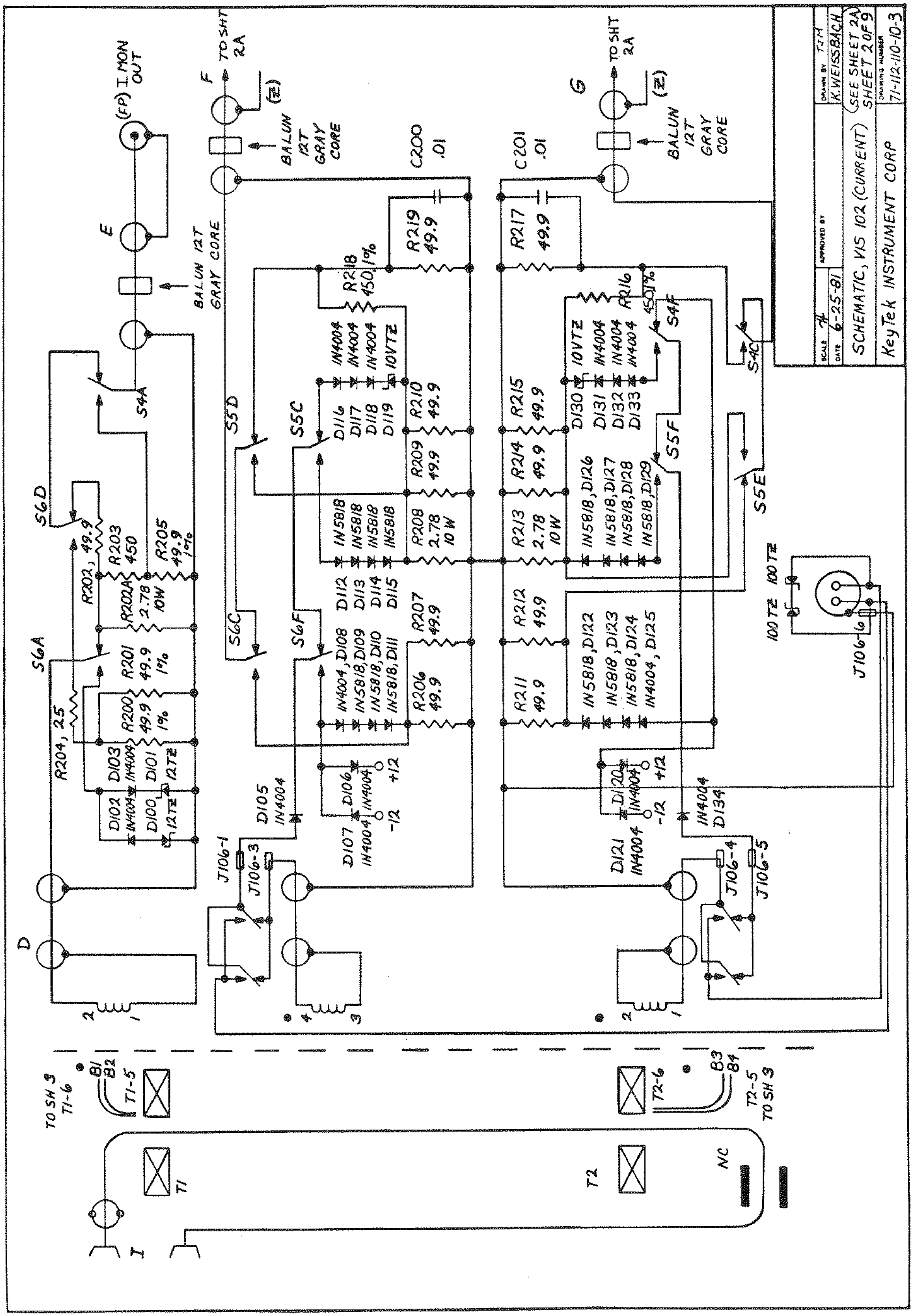


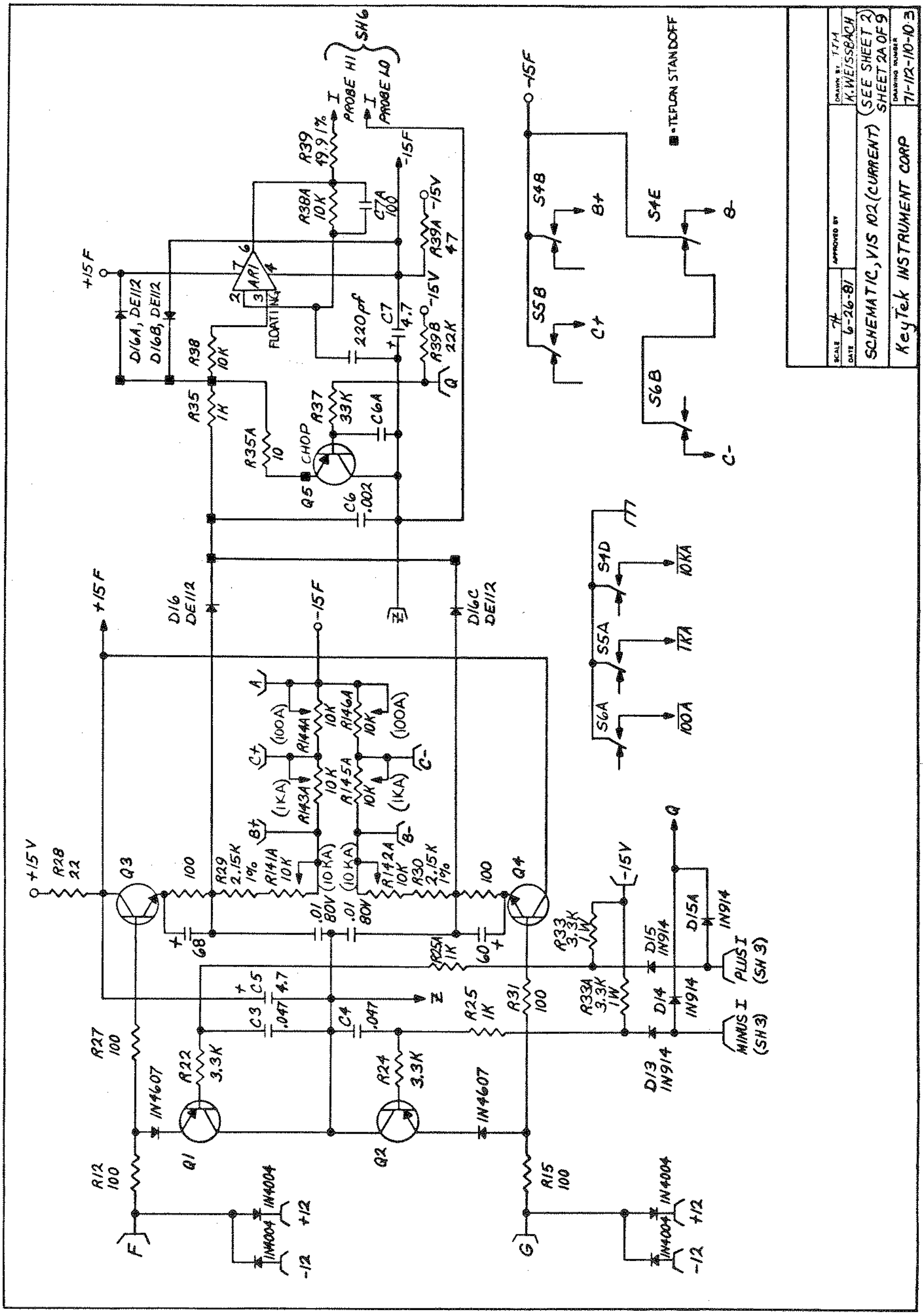
SCALE
DATE 8-29-83
APPROVED BY
DRAWN BY K. WEISSBACH
SCHEMATIC, LSU 122
SHEET 9 OF 9
KeyTek INSTRUMENT CORP
DRAWING NUMBER 71-124-000

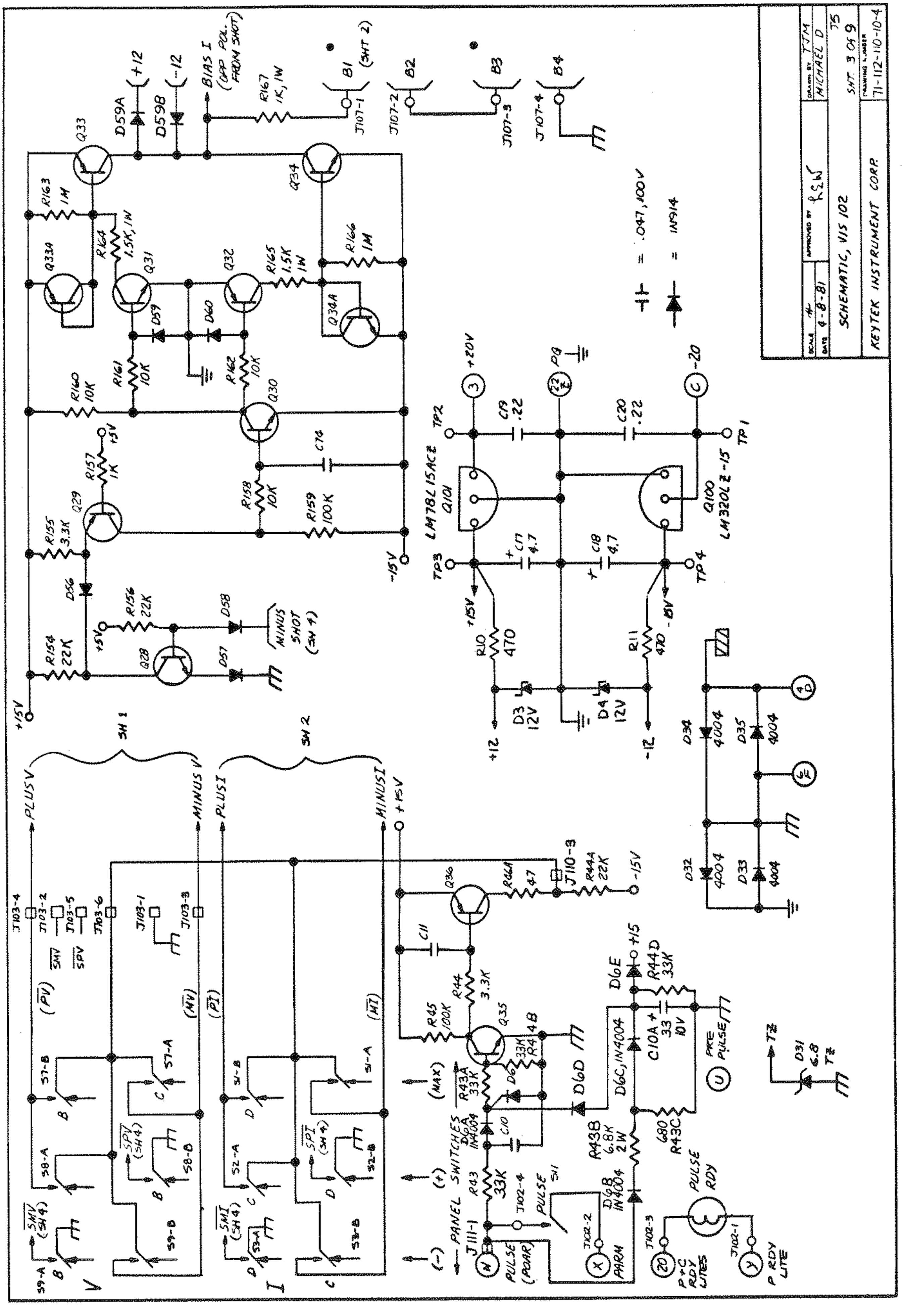


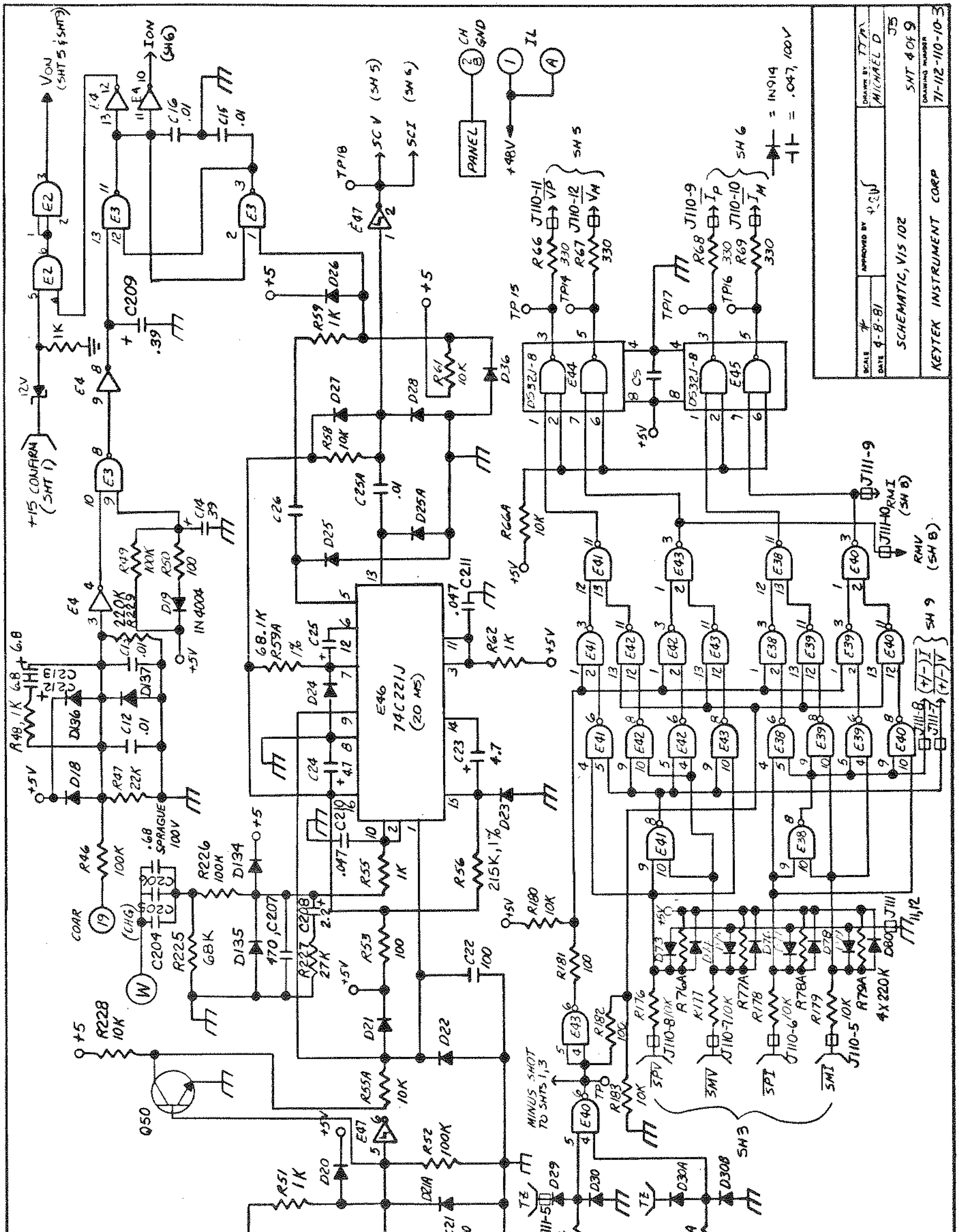
DR2	DR1	RANGE
0V	0V	10V
0V	5V	100V
5V	0V	1KV
5V	5V	10KV

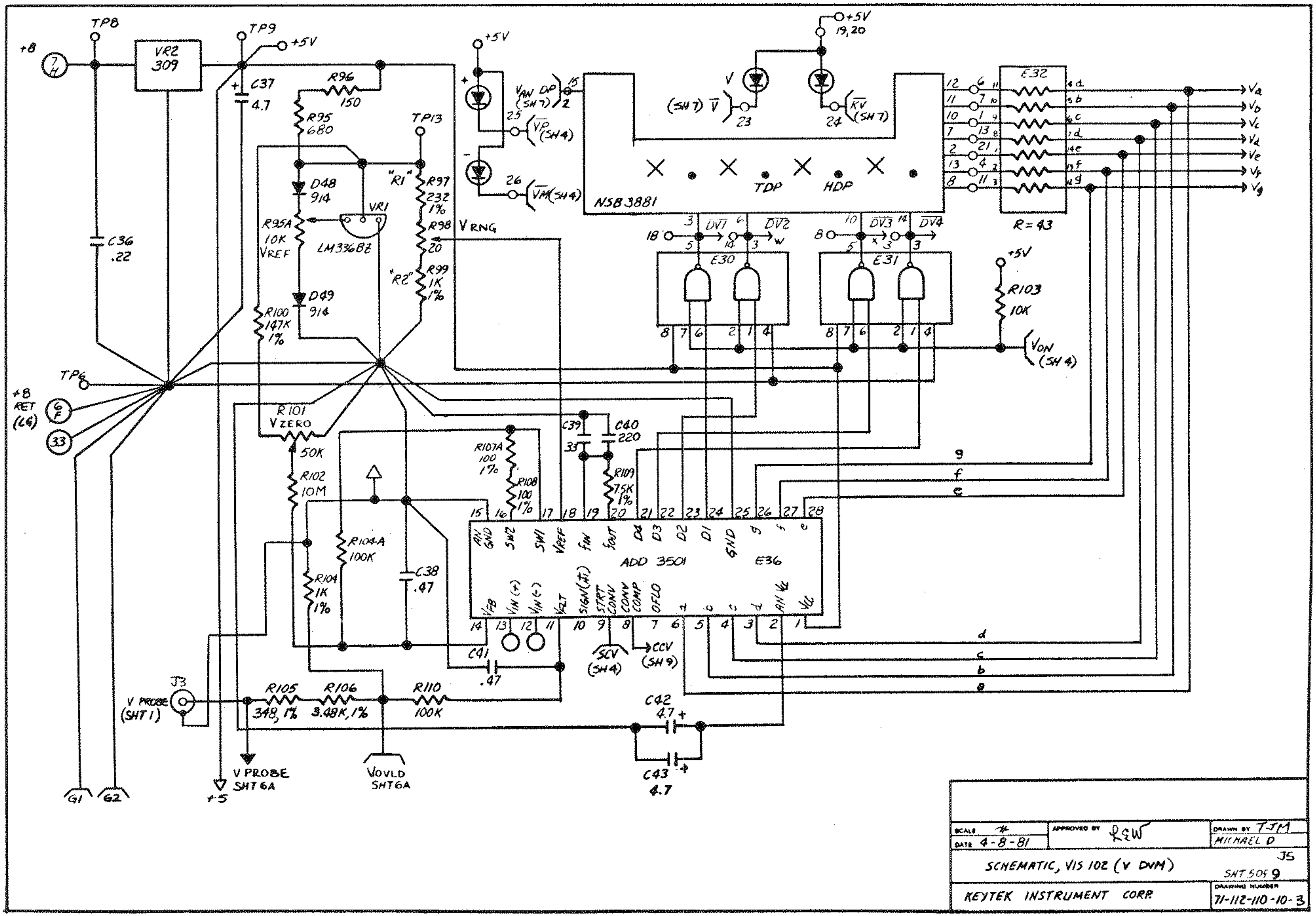
SCALE ~~
DATE 4-8-81
APPROVED BY RSW
DRAWN BY TJM
MICHAEL D
J5
SCHEMATIC, VIS 102 (PROBE CONNECTIONS)
SHT 1 OF 9
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 71-112-110-10-4


SCHEMATIC, VIS 102 (CURRENT)
KeyTek INSTRUMENT CORP
DRAWN BY TJM
K. WEISSBACH
SEE SHEET 2A
SHEET 2 OF 9
DRAWING NUMBER 71-112-110-10-3
SCALE
DATE 6-25-81
APPROVED BY
(FP) I MON OUT
TO SHT 2A
TO SHT 2A
BALUN 12T GRAY CORE
BALUN 12T GRAY CORE
BALUN 12T GRAY CORE
D
E
F
G
C200 .01
C201 .01
R219 49.9
R218 450 1%
R217 49.9
R216 450 1%
S4A
S4C
S4F
S5C
S5D
S5E
S5F
S6A
S6C
S6D
S6F
D116 D117 D118 D119
1N4004 1N4004 1N4004 10VTZ
D130 D131 D132 D133
10VTZ 1N4004 1N4004 1N4004
R210 49.9
R209 49.9
R215 49.9
R214 49.9
R208 2.78 10W
R213 2.78 10W
1N5818 1N5818 1N5818 1N5818
1N5818,D126 1N5818,D127 1N5818,D128 1N5818,D129
R202, 49.9
R203 450
R205 49.9 1%
R202A 2.78 10W
R201 49.9 1%
R200 49.9 1%
R204, 25
D112 D113 D114 D115
D108 1N4004,D108 1N5818,D109 1N5818,D110 1N5818,D111
R207 49.9
R206 49.9
R212 49.9
R211 49.9
1N5818,D122 1N5818,D123 1N5818,D124 1N4004,D125
100TZ
100TZ
J106-6
D103 1N4004
D101 12TZ
D102 1N4004
D100 12TZ
D105 1N4004
D106 1N4004
D107 1N4004
+12
-12
D120 1N4004
D121 1N4004
D134 1N4004
J106-1
J106-3
J106-4
J106-5
2 1
4 3
2 1
TO SH 3 T1-6
B1 B2
T1-5
T2-6
B3 B4
T2-5 TO SH 3
T1
T2
NC
I

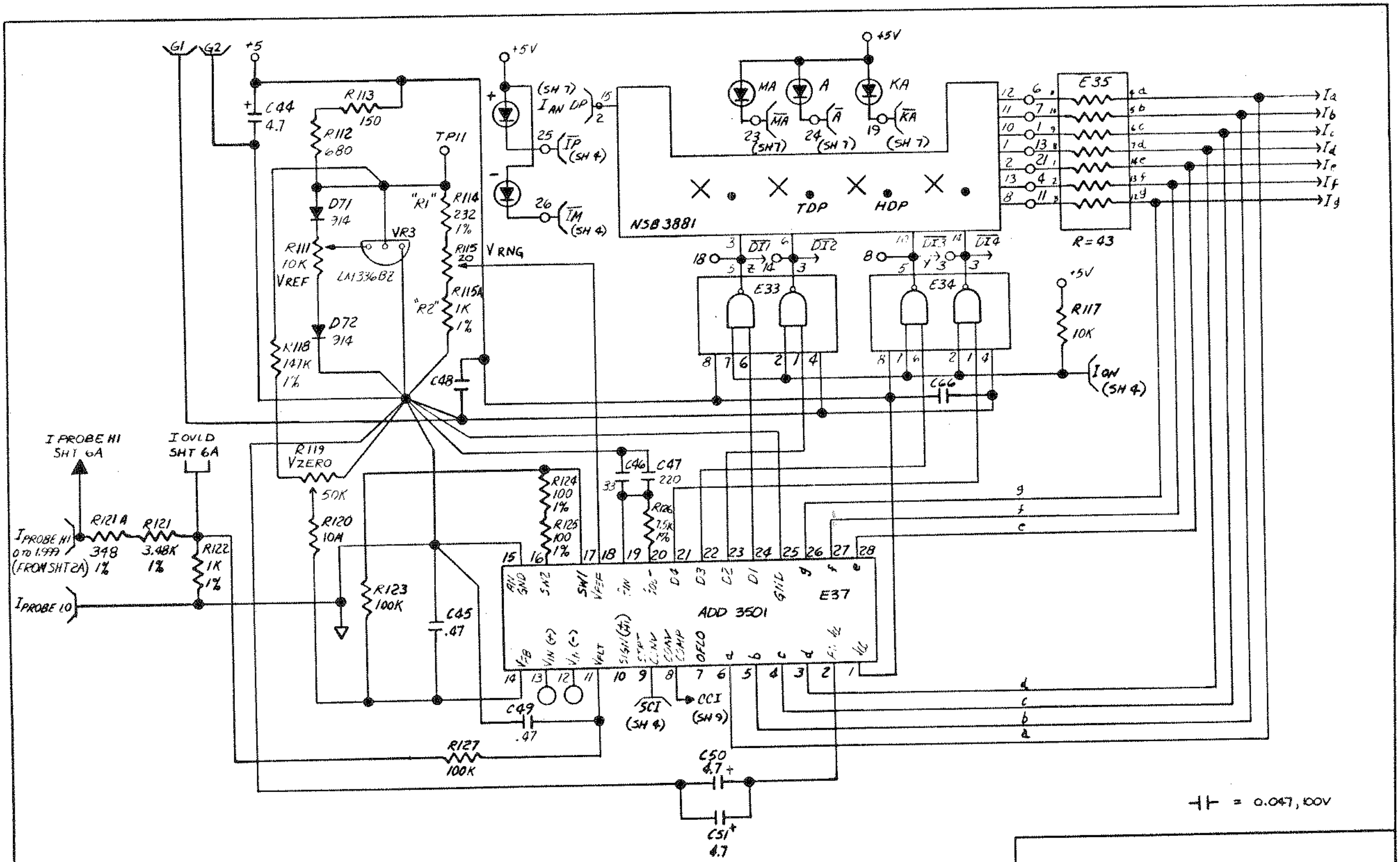

SCHEMATIC, VIS 102 (CURRENT)
KeyTek INSTRUMENT CORP
DRAWN BY TTH
K.WEISSBACH
APPROVED BY
SCALE
DATE 6-26-81
SEE SHEET 2
SHEET 2A OF 9
DRAWING NUMBER 71-112-110-10-3
■ = TEFLON STANDOFF
PROBE HI
PROBE LO
SH6
R39 49.9 1%
R38A 10K
C7A 100
-15F
+15F
R39A 47
-15V
AR1
FLOATING
220pf
C7 4.7
R39B 22K
D16A, DE112
D16B, DE112
R38 10K
R35 1K
R35A 10
R37 33K
C6A
CHOP
Q5
C6 .002
D16 DE112
D16C DE112
S4B
S4E
S5B
S6B
S4D
S5A
S6A
B+
B-
C+
C-
10KA
1KA
100A
+15V
R28 22
Q3
100
R29 2.15K 1%
R141A 10K
R143A 10K
R144A 10K
R146A 10K
R145A 10K
R142A 10K
R30 2.15K 1%
Q4
(10KA)
(1KA)
(100A)
A
.01 80V
68
60
R25A 1K
R33 3.3K 1W
R33A 3.3K 1W
D15 IN914
D15A IN914
D14 IN914
D13 IN914
PLUS I (SH 3)
MINUS I (SH 3)
Q
C5 4.7
C3 .047
C4 .047
Z
R25 1K
R31 100
R27 100
R22 3.3K
R24 3.3K
IN4607
Q1
Q2
R12 100
R15 100
IN4004
+12
-12
F
G


SCHEMATIC, VIS 102
KEYTEK INSTRUMENT CORP.
SHT 3 OF 9
71-112-110-10-4
DATE 4-8-81
DRAWN BY TJM
MICHAEL D
Q33
Q33A
Q31
Q32
Q34
Q34A
Q30
Q29
Q28
D59A
D59B
+12
-12
BIAS I (OPP POL. FROM SHOT)
R167 1K, 1W
B1 (SHT 2)
B2
B3
B4
J107-1
J107-2
J107-3
J107-4
R163 1M
R164 1.5K, 1W
R165 1.5K 1W
R166 1M
D59
D60
R160 10K
R161 10K
R162 10K
R157 1K
+5V
C74
R158 10K
R159 100K
R155 3.3K
-15V
D56
R156 22K
D58
MINUS SHOT (SH 4)
R154 22K
D57
+15V
= .047, 100V
= 1N914
+20V
PG
-20
TP2
C19 .22
C20 .22
TP1
LM78L15ACZ
Q101
Q100
LM320LZ-15
TP3
C17 4.7
C18 4.7
TP4
R10 470
R11 470
D3 12V
D4 12V
D34 4004
D35 4004
D32 4004
D33 4004
SH 1
SH 2
PLUS V
MINUS V
PLUS I
MINUS I
J103-4
J103-2
J103-5
J103-6
J103-1
J103-3
(PV)
SMV
SPV
(MV)
(PI)
(MI)
J110-3
Q36
R46A 47
R44A 22K
C11
R44 3.3K
R45 100K
Q35
R4B 33K
S7-B
S7-A
S8-A
S8-B
S9-A
S9-B
SPV (SH4)
SMV (SH4)
V
S1-B
S1-A
S2-A
S2-B
S3-A
S3-B
SPI (SH 4)
SMI (SH 4)
I
(MAX)
(+)
(-)
PANEL SWITCHES
R43A 33K
D6A 1N4004
D6
C10
D6D
D6C, 1N4004
C10A 33 10V
R44D 33K
D6E
+15
PRE PULSE
R43B 6.8K 2W
680 R43C
R43 33K
J102-4
PULSE S11
J111-1
D6B 1N4004
J102-2
PARM
PULSE (POAR)
J102-3
P+C RDY LITES
PULSE RDY
J102-1
P RDY LITE
D31 6.8 TZ
TZ
W
X
20
Y
U


KEYTEK INSTRUMENT CORP
SCHEMATIC, VIS 102
SCALE
DATE 4-8-81
APPROVED BY
DRAWN BY
MICHAEL D
J5
SHT 4 of 9
DRAWING NUMBER
71-112-110-10-3
E46
74C221J
(20 MS)
= 1N914
= .047, 100V
PANEL
CH GND
IL
+48V
VON (SHT 5 & SHT 7)
ION (SH 6)
SC V (SH 5)
SC I (SH 6)
TP18
E47
C209
.39
+15 CONFIRM (SHT 1)
12V
1K
E2
E3
E4
C16 .01
C15 .01
C14 39
R49 100K
R50 100
D19 1N4004
R48, 1K
6.8
C12 .01
C13 .01
D136
D137
D18
R47 22K
R46 100K
+5V
+5
COAR
19
(UIG)
C204
.68 SPRAGUE 100V
R226 100K
D134
D135
R225 68K
R227 27K
470, C207
C208 2.2
W
R228 10K
Q50
R55 1K
R55A 10K
R53 100
R56 215K, 1%
R59 1K
R59A 68.1K 1%
R58 10K
R61 10K
R62 1K
C22 100
C21 100
C23 4.7
C24 4.7
C25
C25A .01
C26
C210 .047
C211 .047
D20
D21
D21A
D22
D23
D24
D25
D25A
D26
D27
D28
D36
R51 1K
R52 100K
D29
D30
D30A
D30B
J111-5
R64 10K
R65A 10K
PAD
SYNCH J6-16
34
P
J6-6 A/R
JD
JE
8
+IL (MINUS)
36
MINUS A/R
TZ
MINUS SHOT TO SHTS 1, 3
TP
E40
E43
R181 100
R182 100
R183 10K
R180 10K
R176 10K
R177 10K
R178 10K
R179 10K
R76A
R77A
R78A
R79A
4X 220K
D73
D76
D78
D80
K111
J110-8
J110-7
J110-6
J110-5
SPV
SMV
SPI
SMI
SH 3
J111 11,12
E38
E39
E41
E42
J111-8
J111-7
(+/-) I
(+/-) V
SH 9
R66A 10K
RMV (SH 8)
RMI (SH 8)
J111-9
J111-10
E44
E45
DS32J-8
C5
TP14
TP15
TP16
TP17
R66 330
R67 330
R68 330
R69 330
J110-11
J110-12
J110-9
J110-10
VP
VM
IP
IM
SH 5
SH 6



SCALE —
DATE 4-8-81
APPROVED BY REW
DRAWN BY TJM
MICHAEL D
JS
SCHEMATIC, VIS 102 (V DVM)
SHT 5 OF 9
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 71-112-110-10-3

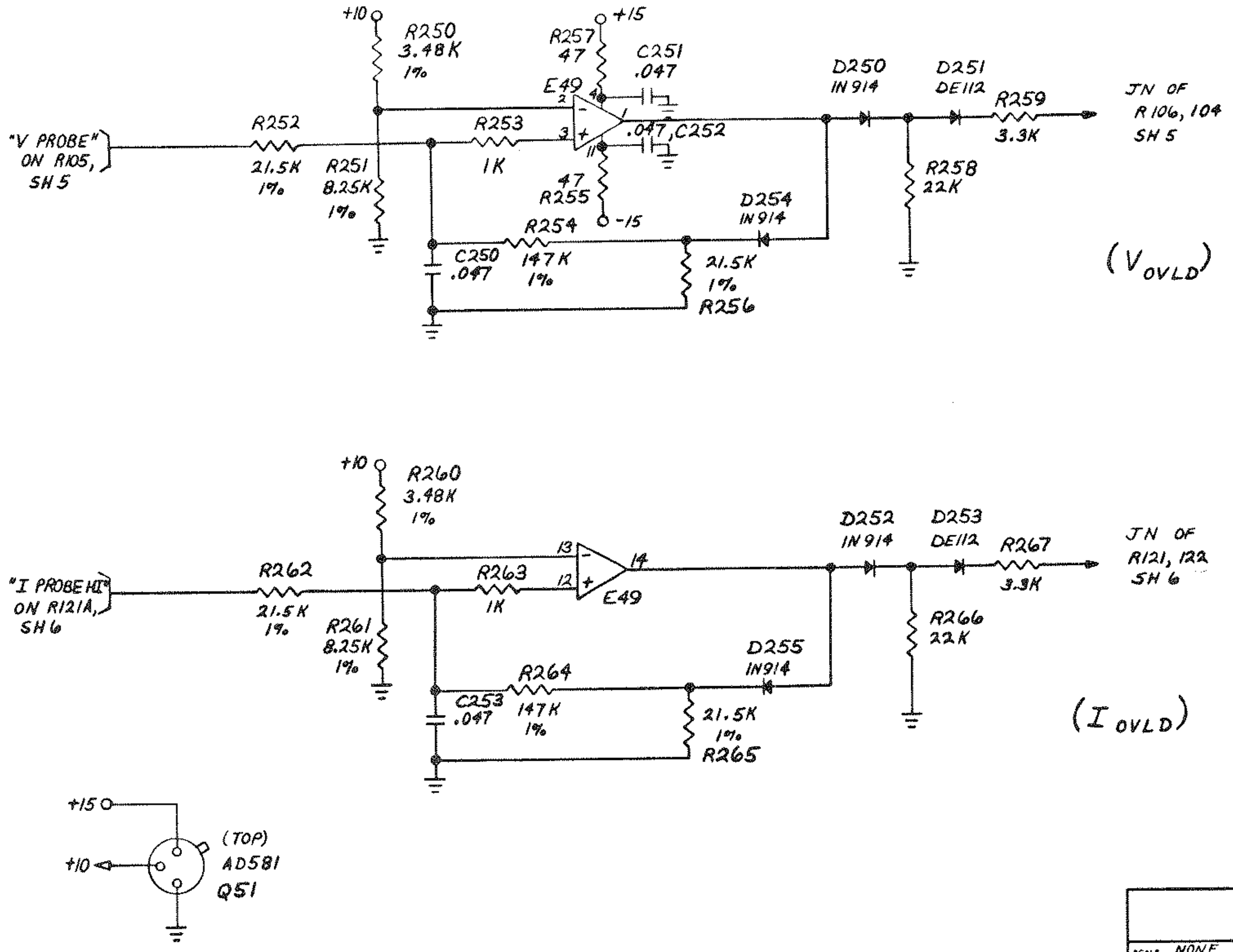


SCALE
DATE 4-8-81
APPROVED BY RCW
DRAWN BY TJM
MICHAEL D
(SEE SHT 6A)
SHT 6 OF 9

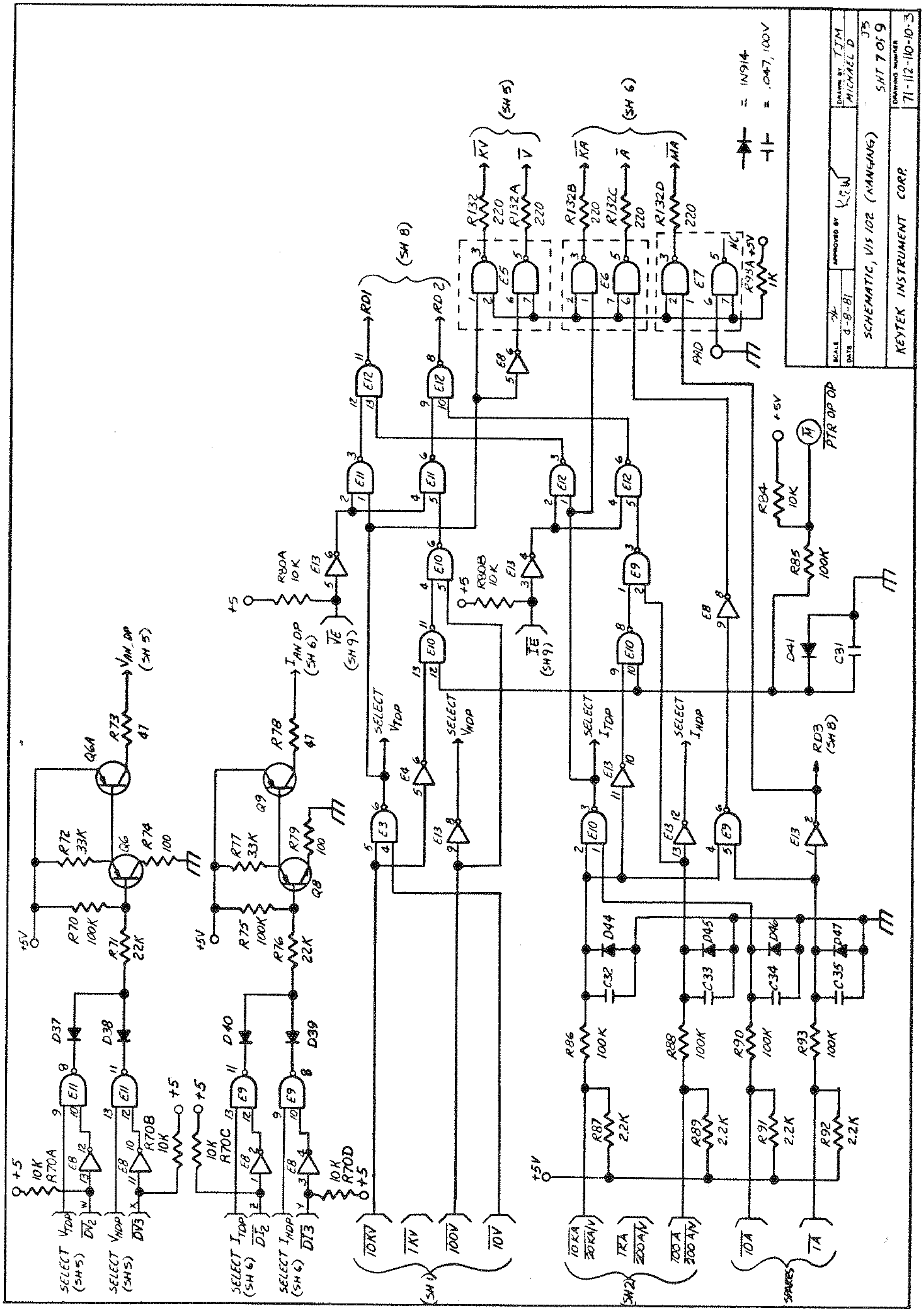
SCHEMATIC VIS102 (I DVM)

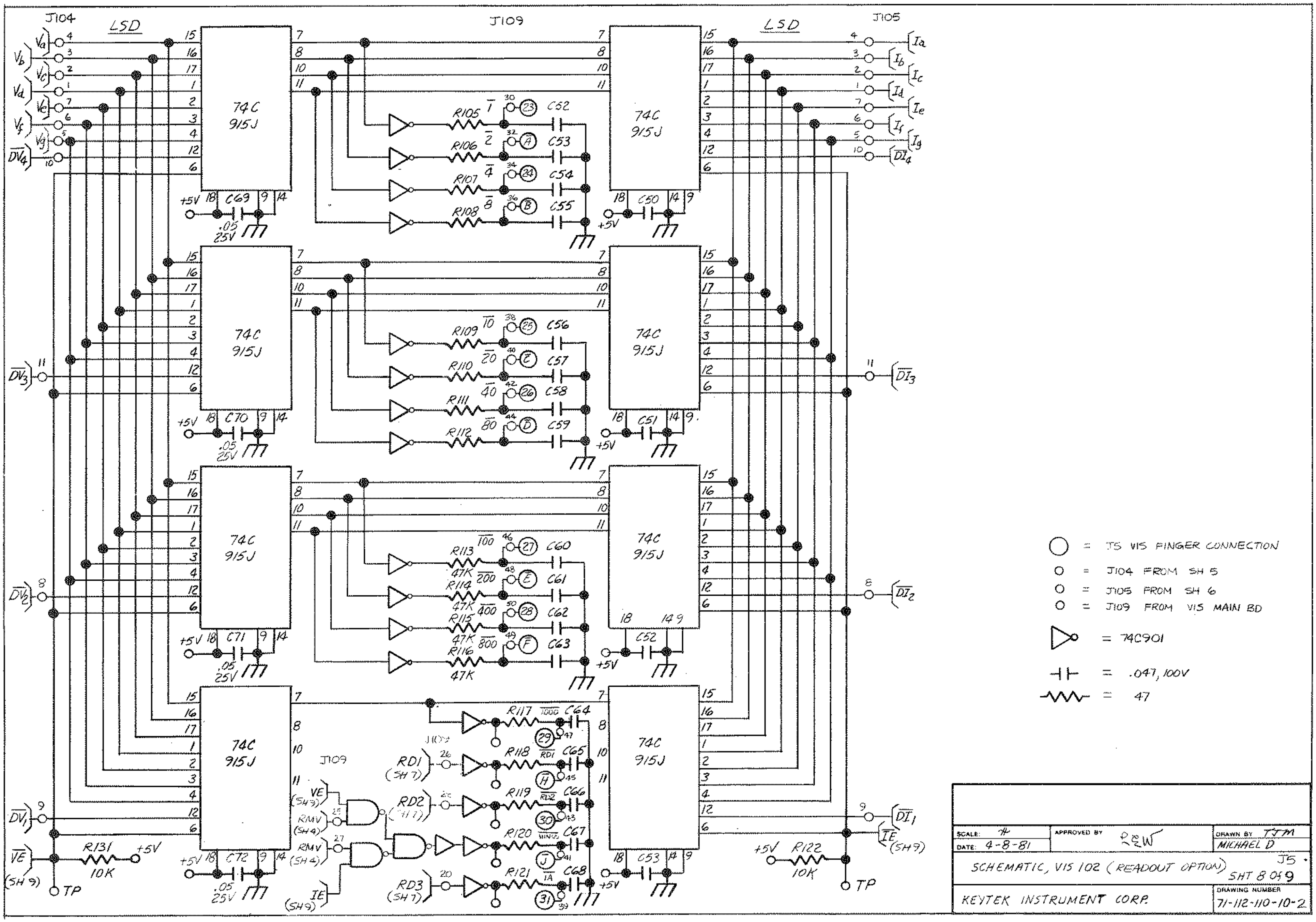
KEYTEK INSTRUMENT CORP

DRAWING NUMBER 71-112-110-10-3



SCALE NONE
DATE 6-17-81
APPROVED BY
DRAWN BY TJM
K.WEISSBACH
SCHEMATIC, V/S OVERLOAD CKTS (SEE SHT 6)
SHEET 6A OF 9
KeyTek INSTRUMENT CORP
DRAWING NUMBER
71-112-110-10-3

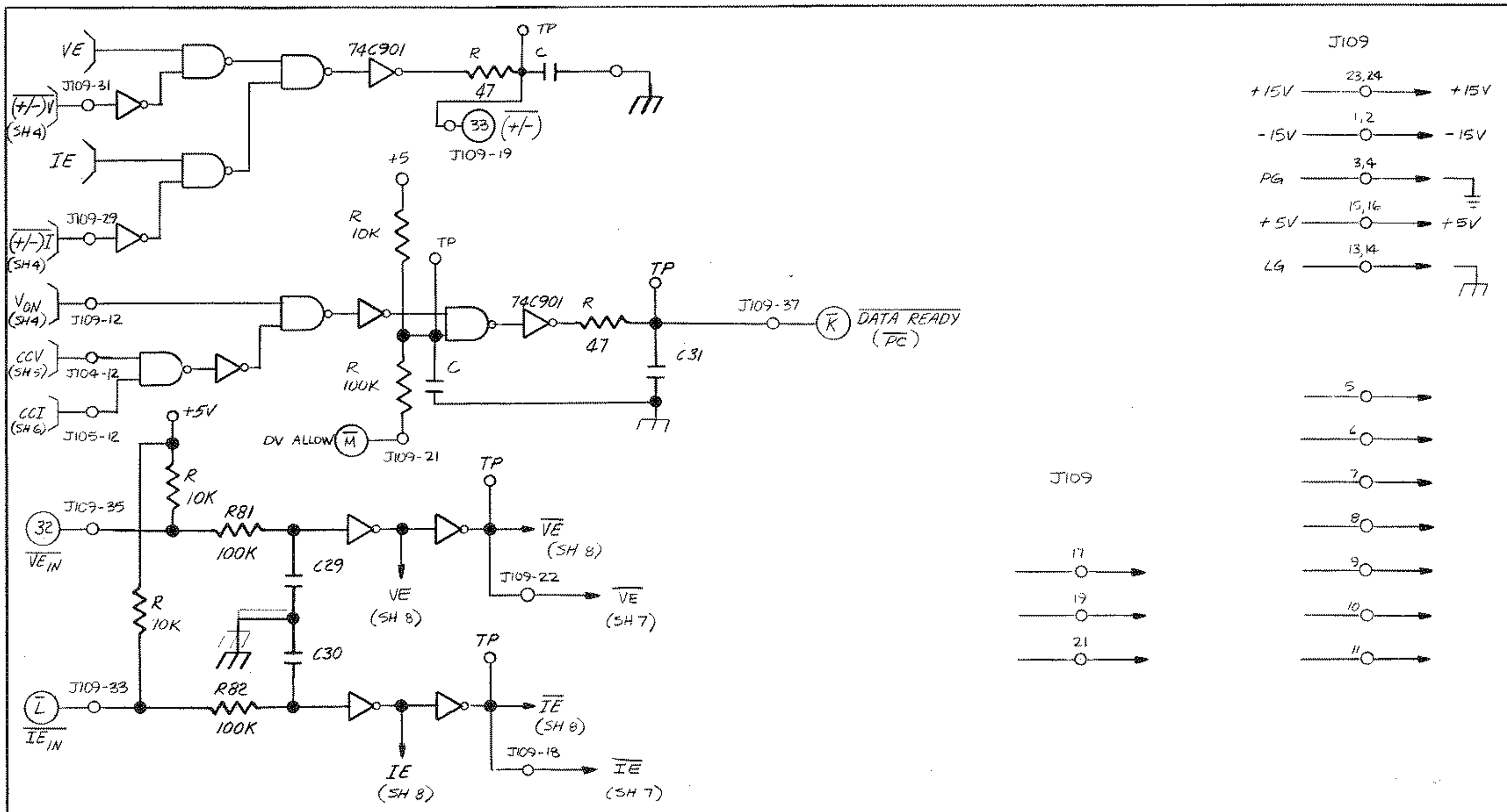

SCHEMATIC, VIS 102 (KANGING)
KEYTEK INSTRUMENT CORP.
SCALE —
DATE 4-8-81
DRAWN BY TJM
MICHAEL D
APPROVED BY
SHT 7 of 9
J5
DRAWING NUMBER 71-112-110-10-3
= 1N914
= .047, 100V
SELECT V_{TDP} (SH5)
SELECT V_{HDP} (SH5)
SELECT I_{TDP} (SH6)
SELECT I_{HDP} (SH6)
$\overline{DV_2}$
$\overline{DV3}$
$\overline{DI_2}$
$\overline{DI3}$
$\overline{10KV}$
$\overline{1KV}$
$\overline{100V}$
$\overline{10V}$
(SH1)
$\overline{10KA}$ / $\overline{20KA/V}$
$\overline{1KA}$ / $\overline{200A/V}$
$\overline{100A}$ / $\overline{200A/V}$
(SH2)
$\overline{10A}$
$\overline{1A}$
SPARES
$V_{AN\ DP}$ (SH5)
$I_{AN\ DP}$ (SH6)
$\overline{VE}$ (SH9)
$\overline{IE}$ (SH9)
SELECT V_{TDP}
SELECT V_{HDP}
SELECT I_{TDP}
SELECT I_{HDP}
RD1
RD2
(SH8)
RD3 (SH8)
$\overline{KV}$
$\overline{V}$
(SH5)
$\overline{KA}$
$\overline{A}$
$\overline{MA}$
(SH6)
PAD
PTR OP OP
R70A 10K
R70B 10K
R70C 10K
R70D 10K
R70 100K
R71 22K
R72 33K
R73 47
R74 100
R75 100K
R76 22K
R77 33K
R78 47
R79 100
R80A 10K
R80B 10K
R84 10K
R85 100K
R86 100K
R87 2.2K
R88 100K
R89 2.2K
R90 100K
R91 2.2K
R92 2.2K
R93 100K
R132 220
R132A 220
R132B 220
R132C 220
R132D 220
R133A 1K
Q6
Q6A
Q8
Q9
D37
D38
D39
D40
D41
D44
D45
D46
D47
C31
C32
C33
C34
C35
E3
E4
E5
E6
E7
E8
E9
E10
E11
E12
E13
+5
+5V
NC



SCALE: ⌀
DATE: 4-8-81
APPROVED BY RLW
DRAWN BY TJM
MICHAEL D

SCHEMATIC, VIS 102 (READOUT OPTION)
J5
SHT 8 OF 9

KEYTEK INSTRUMENT CORP.
DRAWING NUMBER
71-112-110-10-2



◯ = J5 - VIS FINGER CONNECTIONS

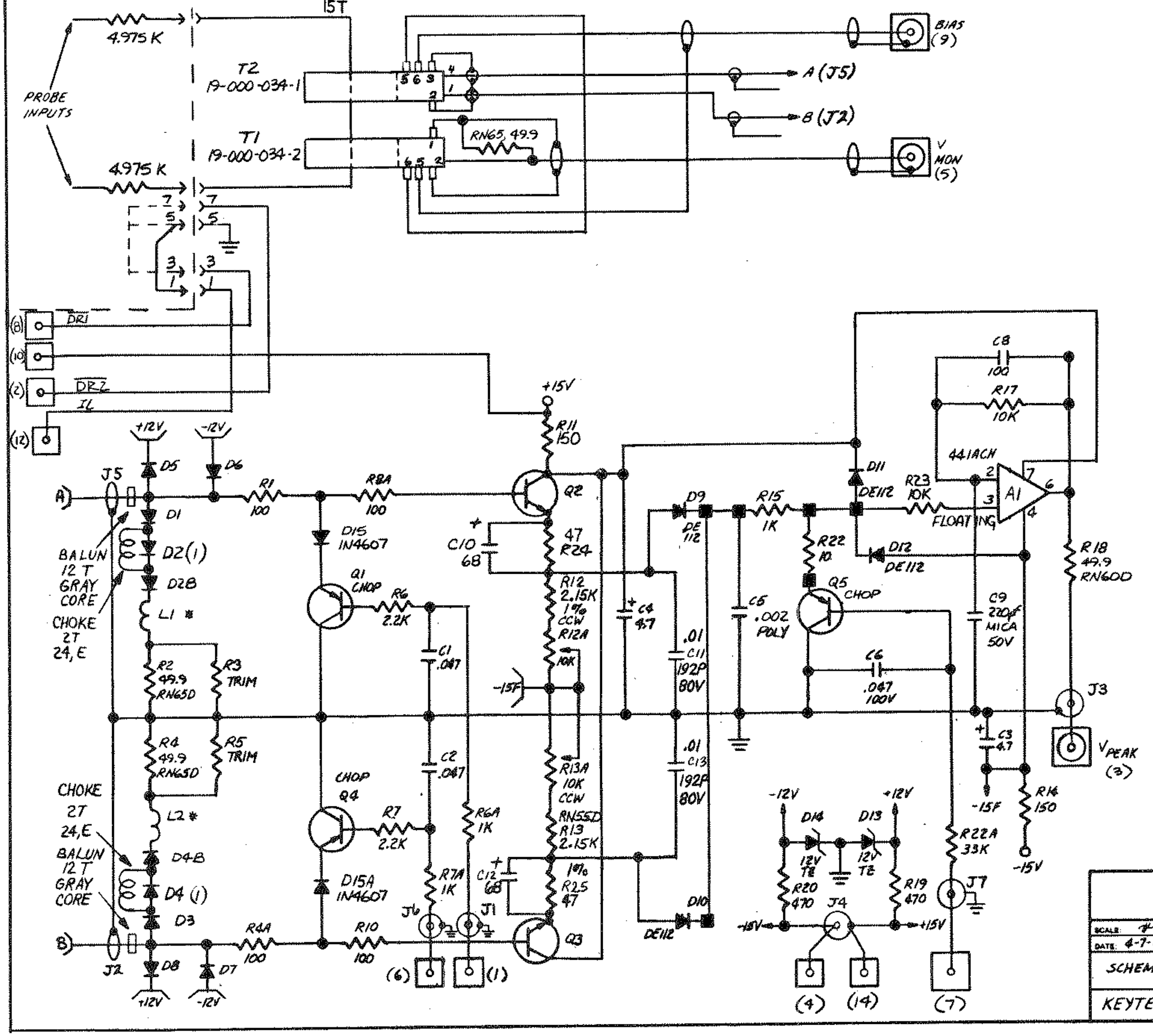
○ = J104 FROM SHT 5

○ = J105 FROM SHT 6

○ = J109 FROM VIS MAIN BD

⊣⊢ = .047, 100V

SCALE: ✗ DATE: 4-8-81	APPROVED BY R2W	DRAWN BY TTM MICHAEL D
SCHEMATIC, VIS 102 (READOUT OPTION)		J5 SHT 9 OF 9
KEYTEK INSTRUMENT CORP.		DRAWING NUMBER 71-112-110-10-2

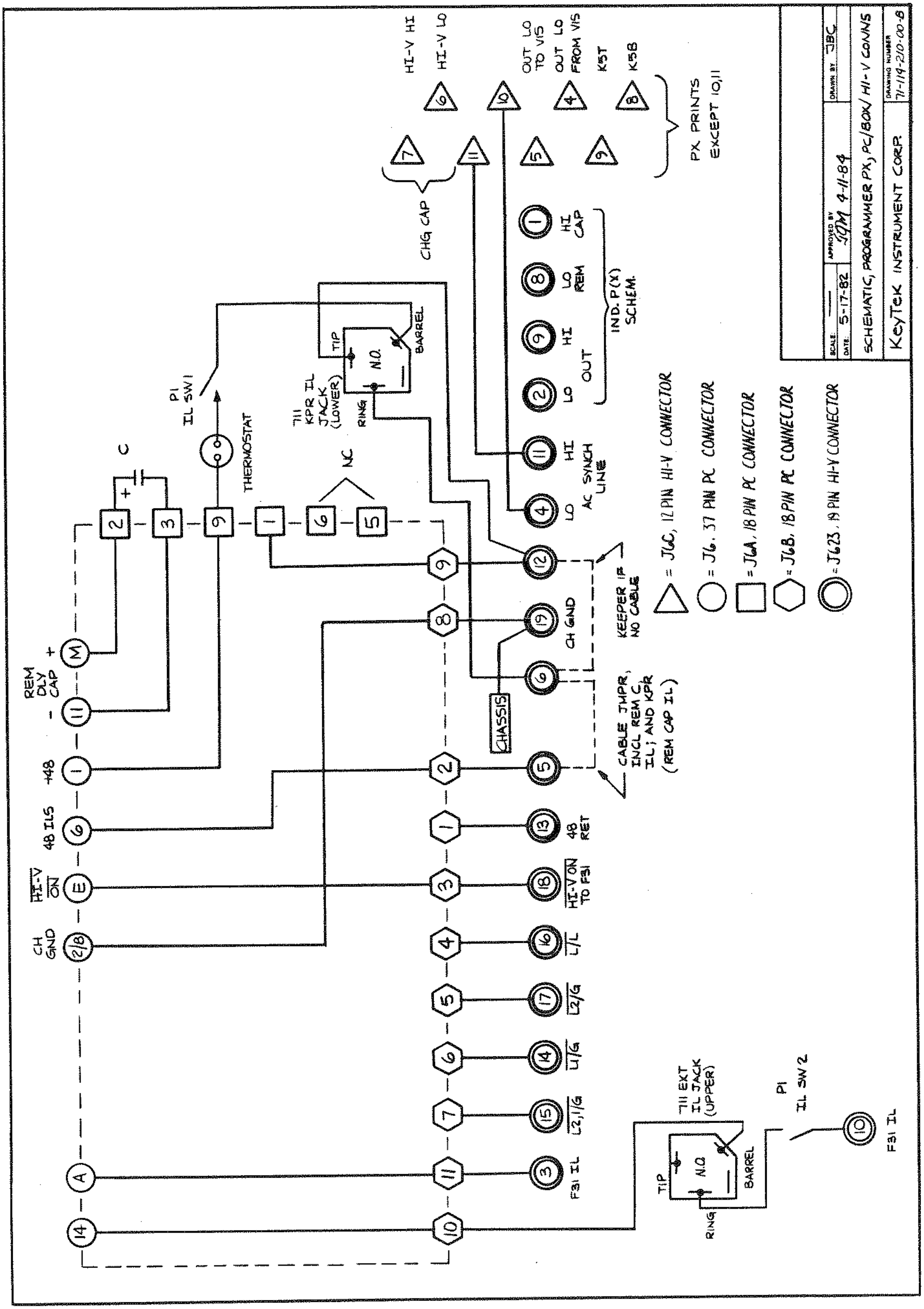


RANGE	DR1	DR2
10KV	OPEN	OPEN
1KV	GND	OPEN
100 V	OPEN	GND
10V	GND	GND

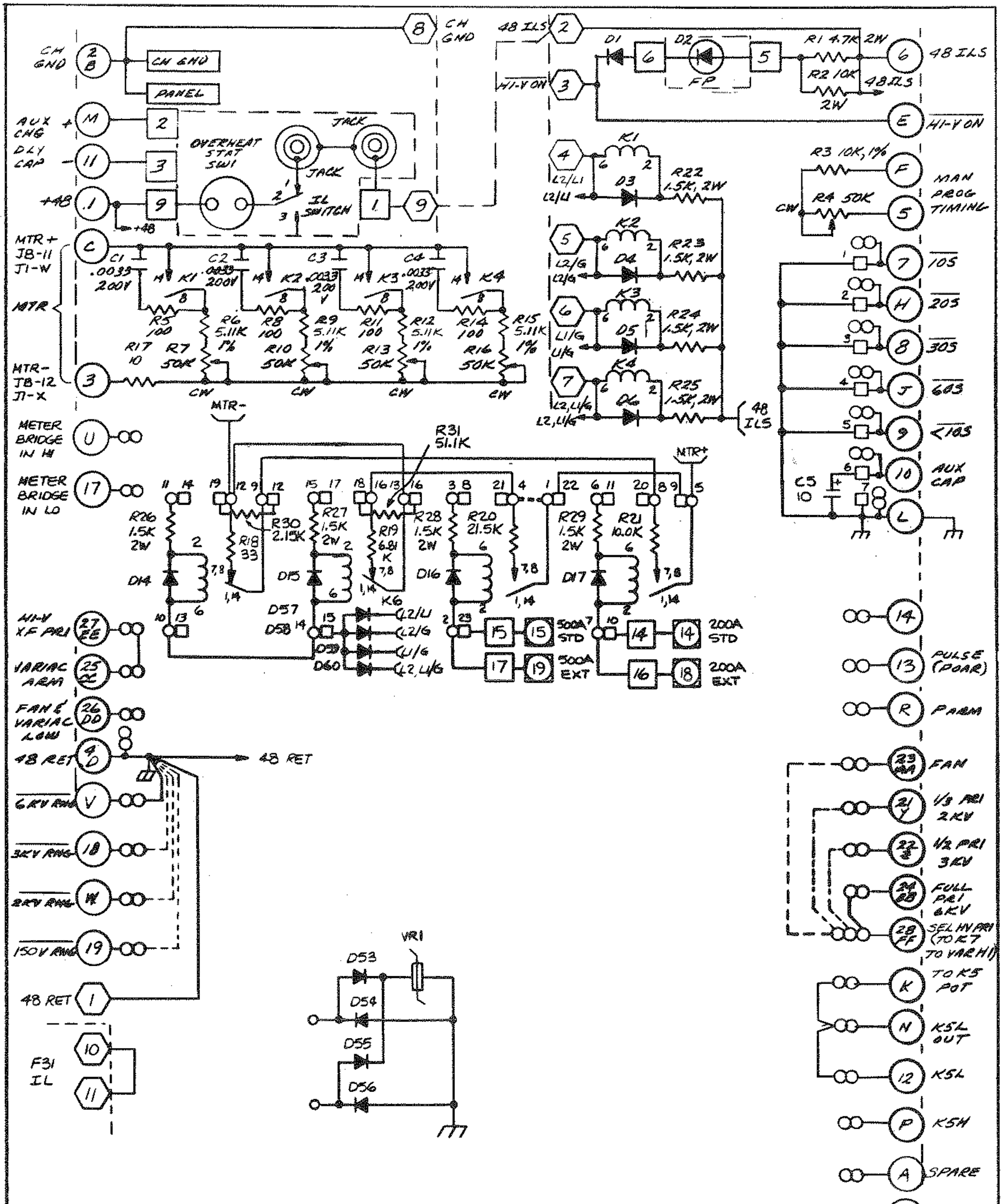
NOTES:

(1) – IN5818 OR EQUIV (SHOTTKY MBR 130P)
F – FIXED POT CONNS.
✱ – TRIM. START WITH JMPR
—▶|— IN4004
◎ = COAXICON PIN
( ) = PIN NO.
■ = TEFLON STANDOFF
□ = STANDARD PIN

SCALE: ✓
DATE: 4-7-81
APPROVED BY
DRAWN BY TJM
MICHAEL D
SCHEMATIC, PROBE
SHT 1 OF 1
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 71-122-110-10-7



SCALE: —
DATE: 5-17-82
APPROVED BY JQM 4-11-84
DRAWN BY JBC
SCHEMATIC, PROGRAMMER PX, PC/BOX/ HI-V CONNS
KeyTek INSTRUMENT CORP.
DRAWING NUMBER 71-119-210-00-B



NOTES:

1. ALL DIODES ARE IN4004
2. ○ INDICATES CONNECTOR J6

○ J6P — PAD NEAR J6

□ J6A — REMOTE TO PX

□ J6AP — PAD NEAR J6A

⬡ J6B — TO HIGH VOLTAGE CONN.

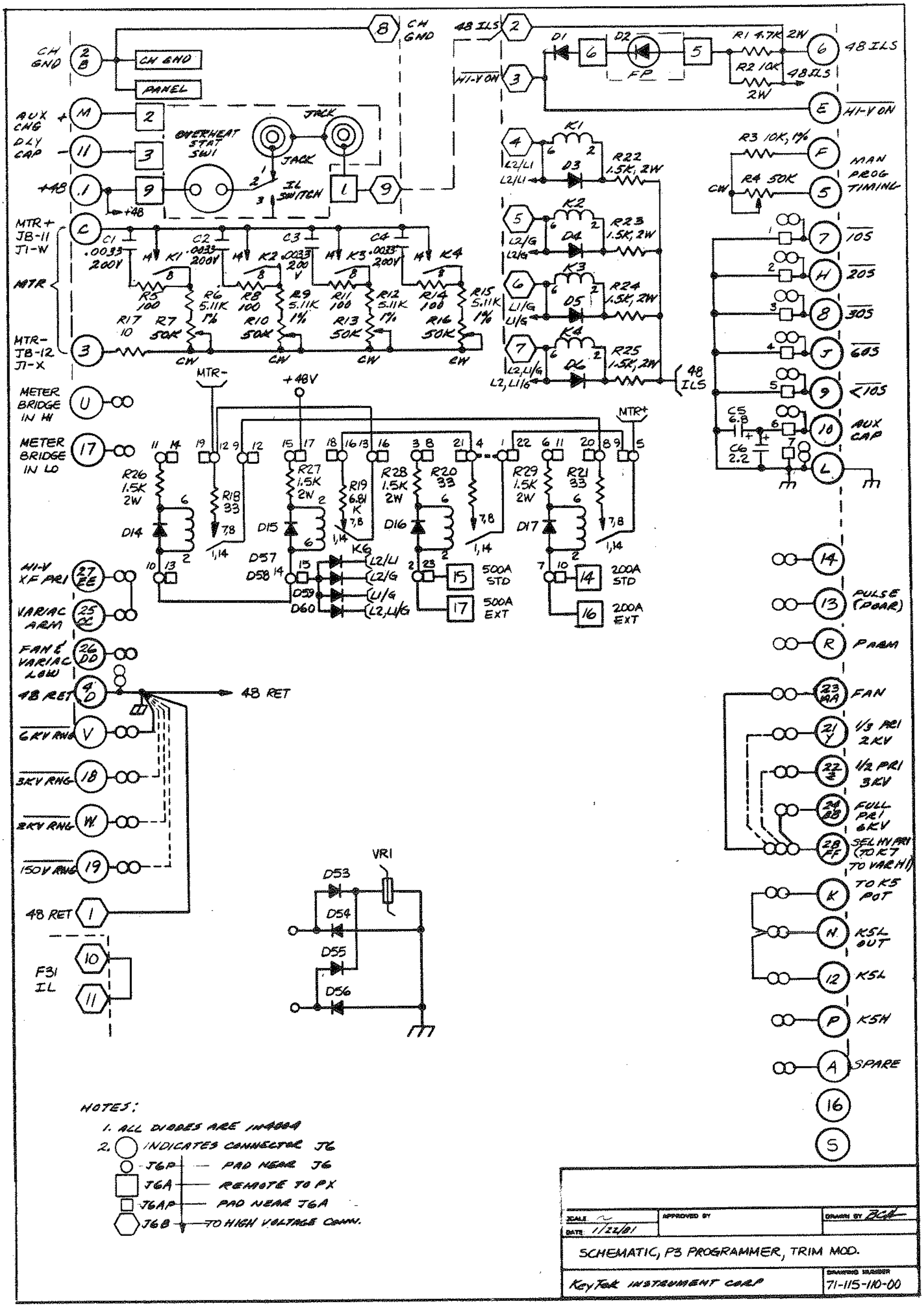
▣ HV SWITCH

SCALE: ~	APPROVED BY	DRAWN BY BCK
DATE 1/22/81		

SCHEMATIC, PI PROGRAMMER, TRIM MOD.

KeyTek INSTRUMENT CORP

DRAWING NUMBER 71-114-000-00-8



NOTES:

1. ALL DIODES ARE IN4004
2. ○ INDICATES CONNECTOR J6

○ J6P — PAD NEAR J6

☐ J6A — REMOTE TO PX

J6AP — PAD NEAR J6A

J6B — TO HIGH VOLTAGE CONN.

SCALE ~

DATE 1/22/81

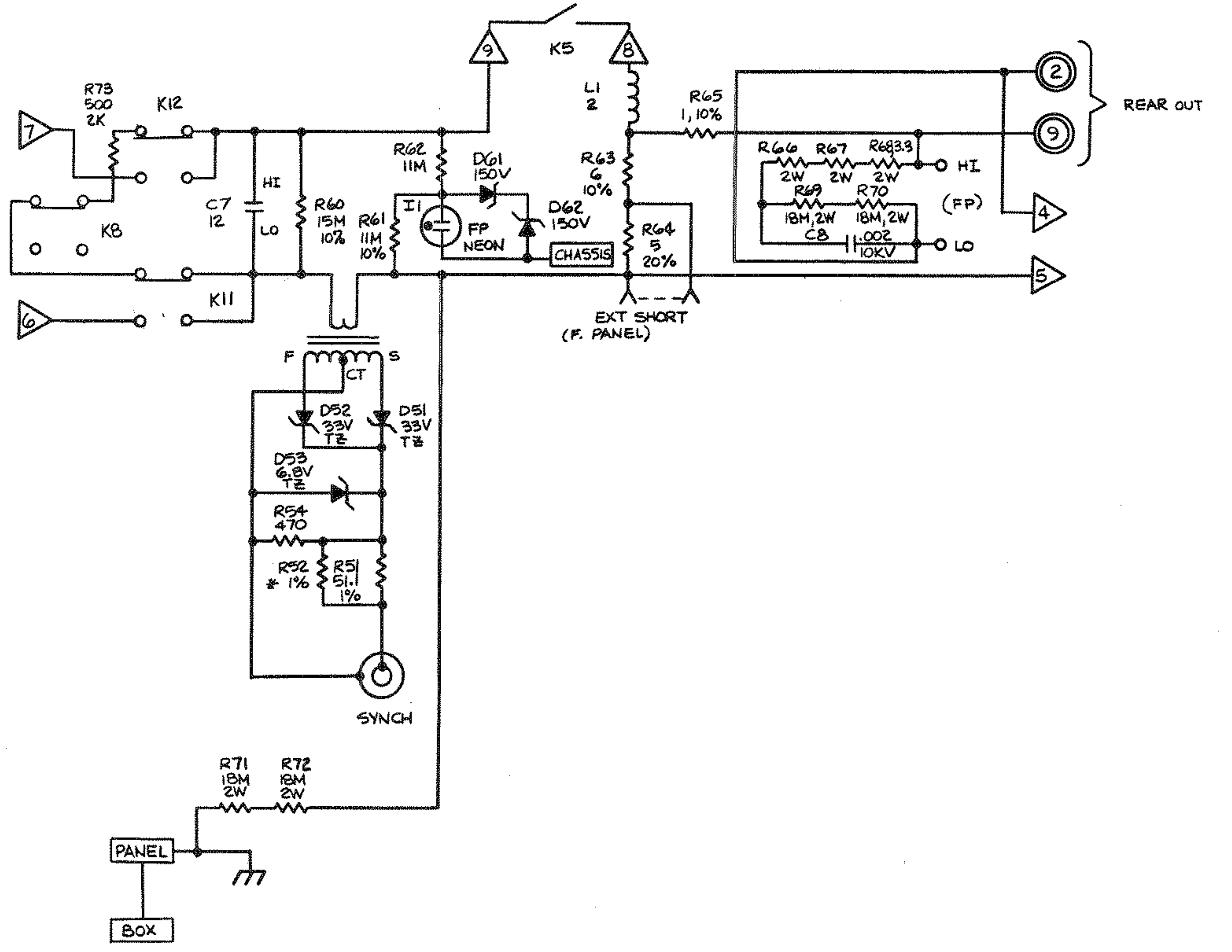
APPROVED BY

DRAWN BY BCL

SCHEMATIC, P3 PROGRAMMER, TRIM MOD.

KeyTek INSTRUMENT CORP

DRAWING NUMBER 71-115-110-00

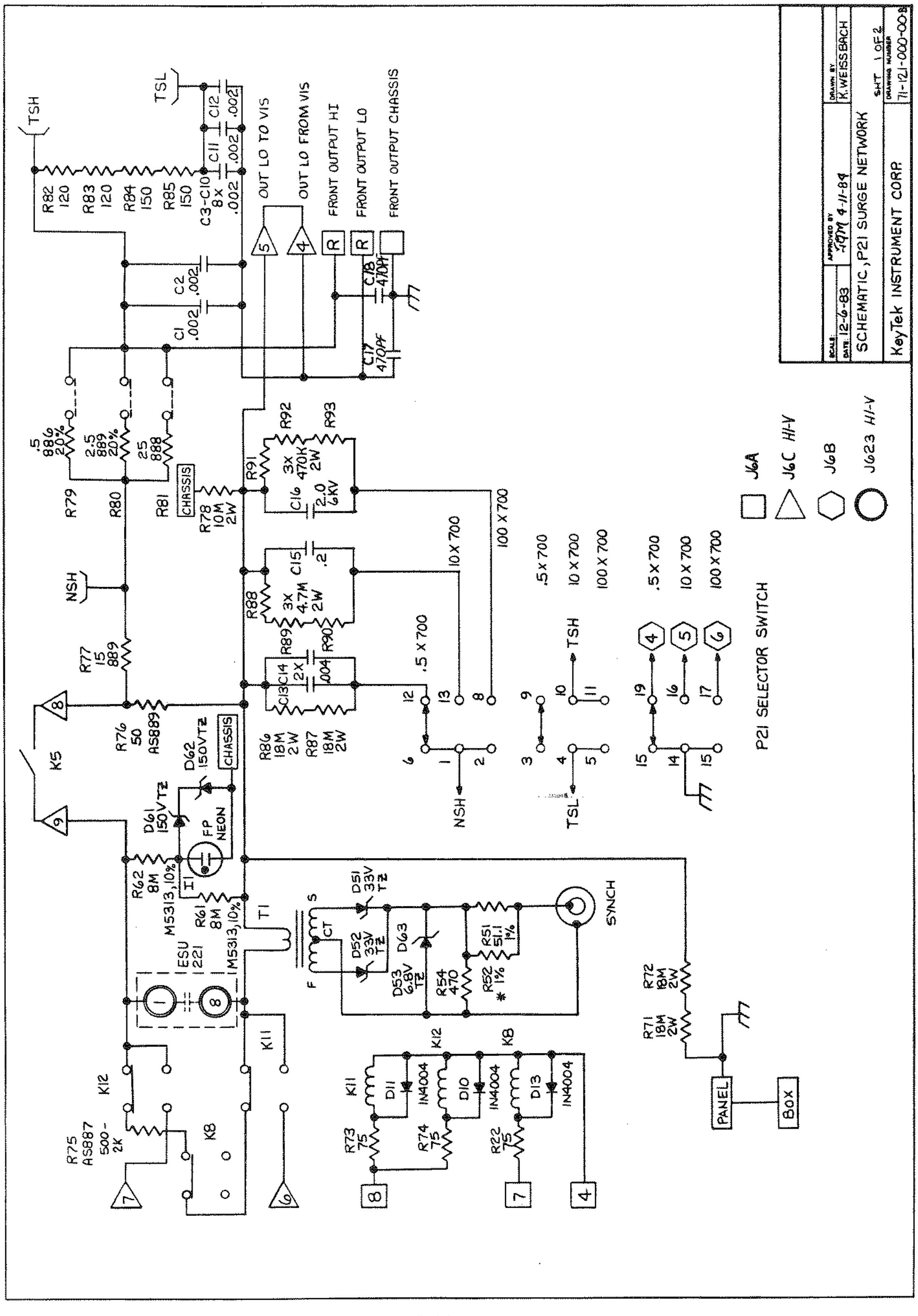


SCALE: ——
DATE: 5-28-82
APPROVED BY
DRAWN BY JBC

SCHEMATIC, P3 SURGE NETWORK

KeyTek INSTRUMENT CORP.

DRAWING NUMBER 71-115-000-001



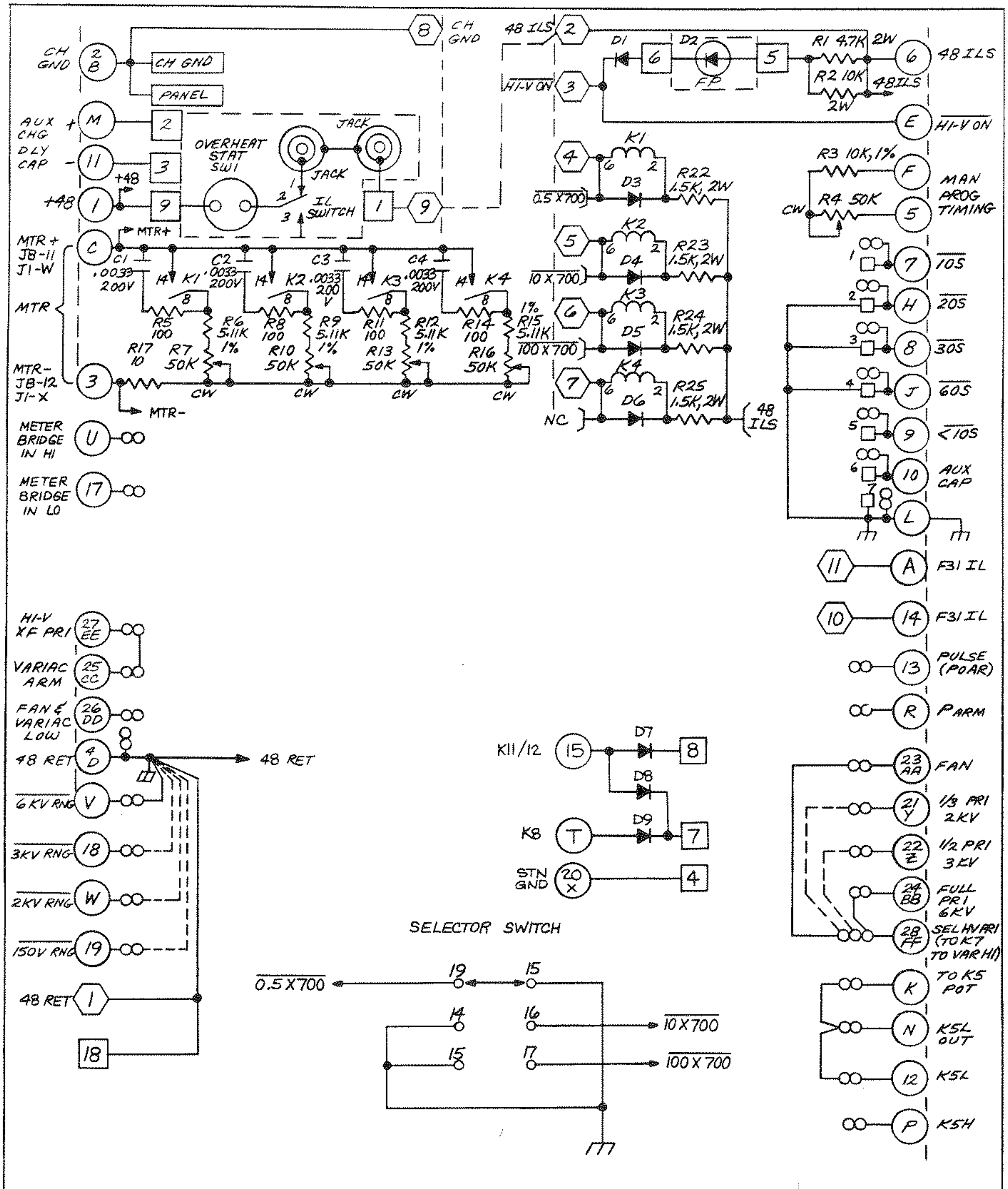
SCALE:
DATE: 12-6-83
APPROVED BY TQM 4-11-84
DRAWN BY K. WEISSBACH

SCHEMATIC, P21 SURGE NETWORK

SHT 1 OF 2

KeyTek INSTRUMENT CORP.

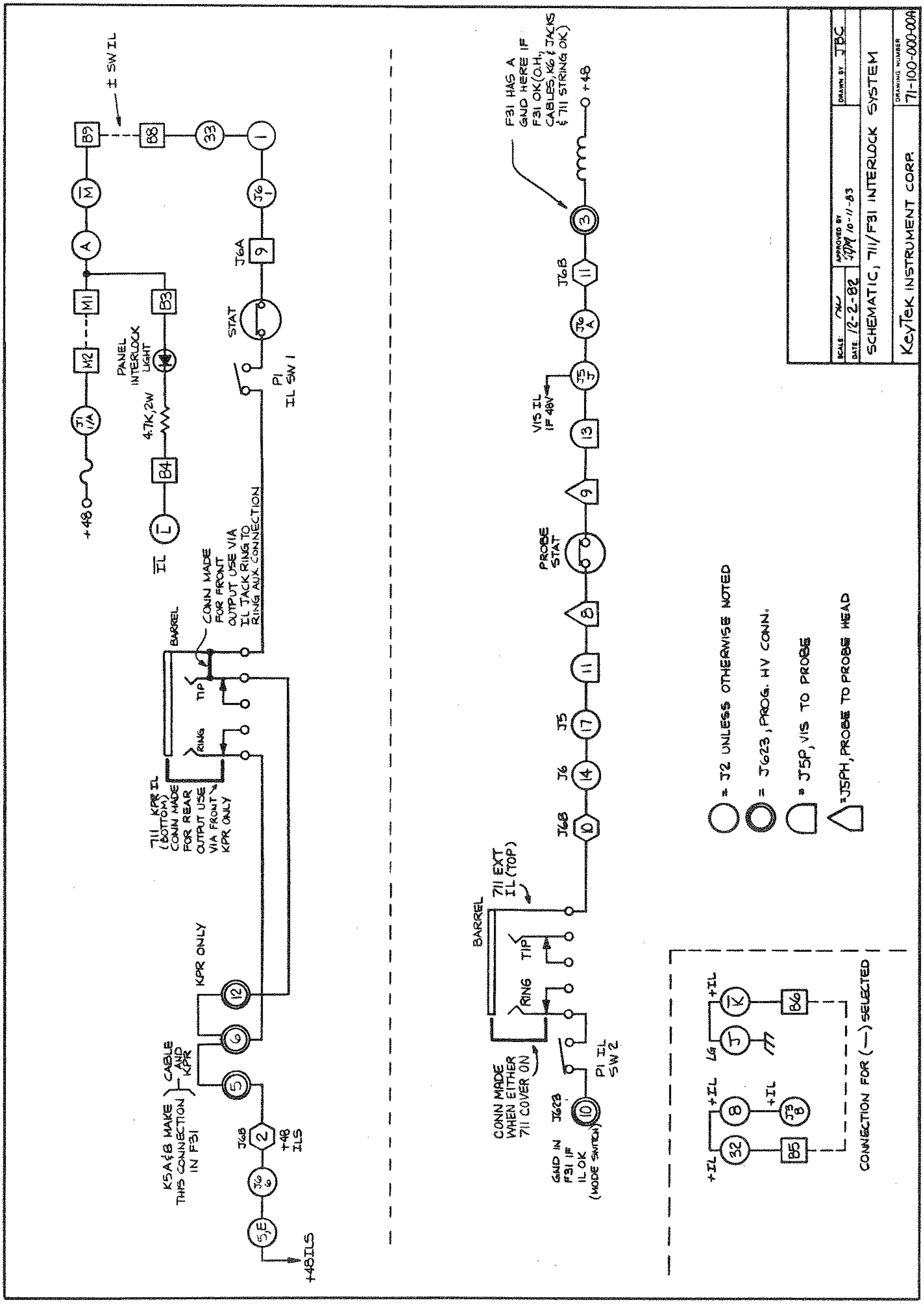
DRAWING NUMBER 71-121-000-008



NOTES:

1. ALL DIODES ARE IN4004
2. ○ INDICATES CONNECTOR J6
   - ○ J6P PAD NEAR J6
   - □ J6A REMOTE TO PX
   - □ J6AP PAD NEAR J6A
   - ⬡ J6B TO HIGH VOLTAGE CONN.
   - ▢ HV SWITCH

SCALE	APPROVED BY	DRAWN BY
DATE 9-12-83	JBC 12-8-83	K. WEISSBACH
SCHEMATIC, P21 PROGRAMMER, TRIM MOD.		SHT 2 OF 2
KeyTek INSTRUMENT CORP		DRAWING NUMBER 71-121-000-00 B

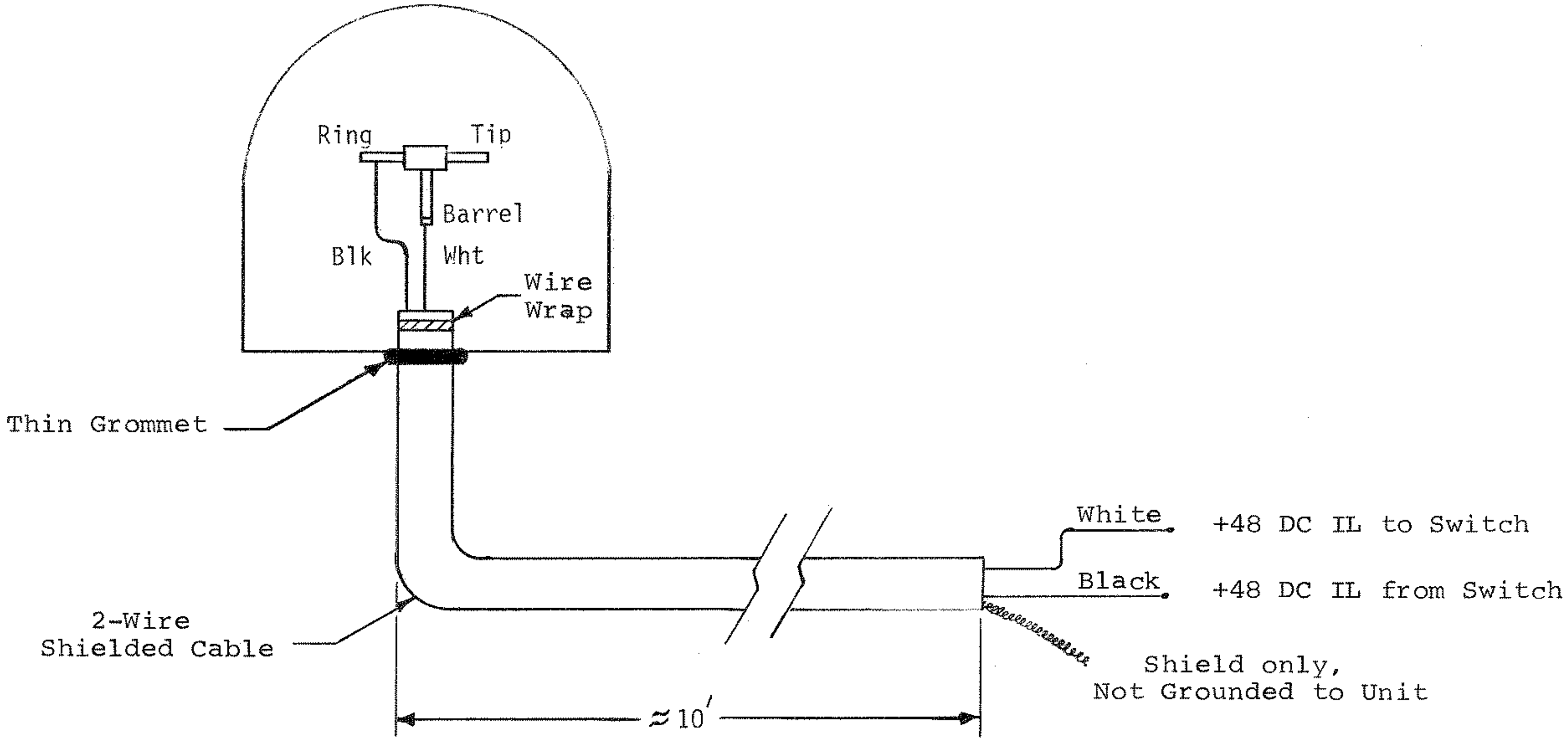


SCALE: NC
DATE: 12-2-82
APPROVED BY JDM 10-11-83
DRAWN BY JBC

SCHEMATIC, 711/F31 INTERLOCK SYSTEM

KeyTek INSTRUMENT CORP.

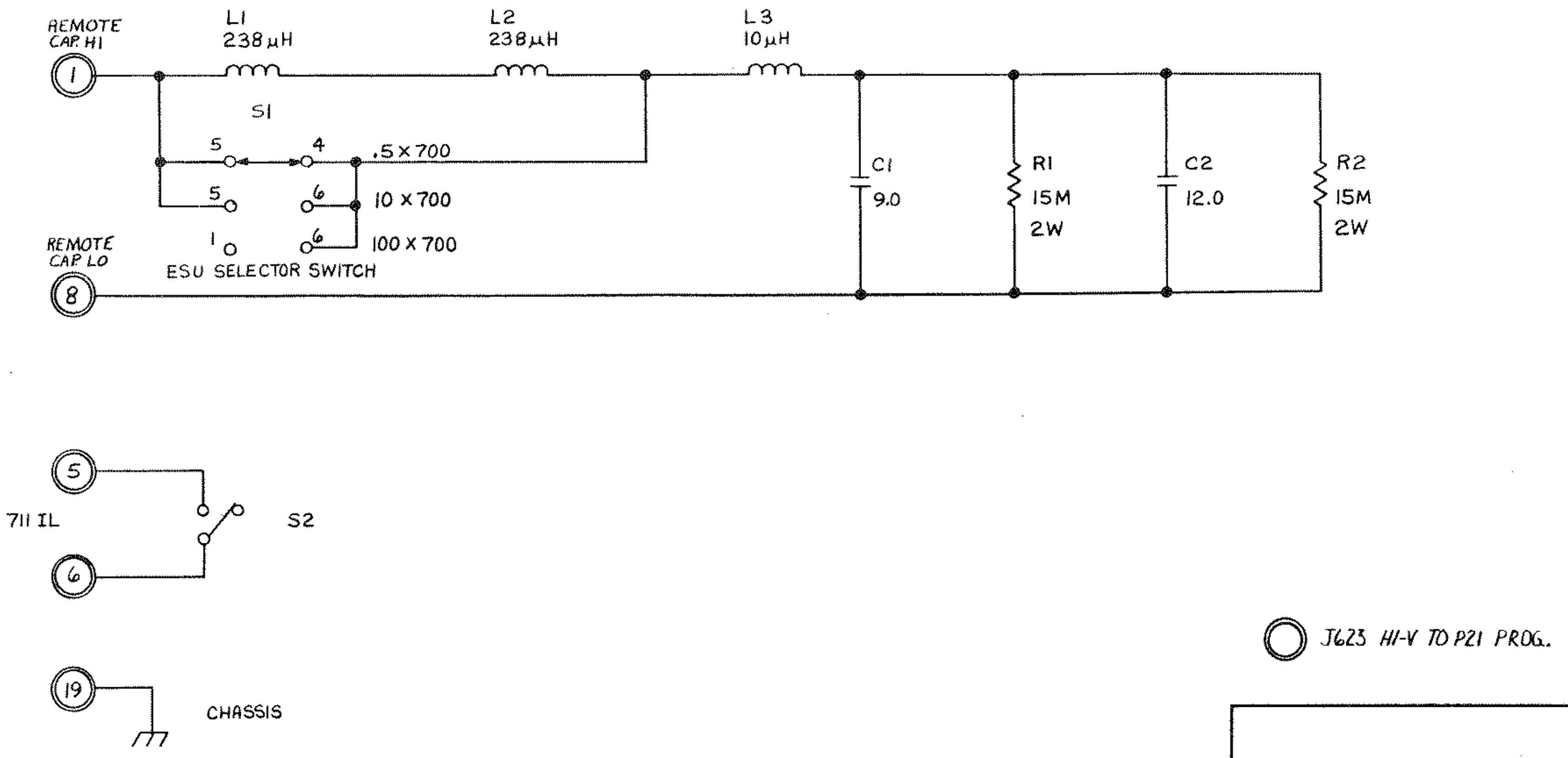
DRAWING NUMBER 71-100-000-00A



SCALE:
DATE 12-2-82
APPROVED BY JBC 12-8-83
DRAWN BY JBC

SCHEMATIC, 711/F31 REMOTE INTERLOCK
PLUG AND CABLE (OPTION)

KeyTek INSTRUMENT CORP.
DRAWING NUMBER 73-310-184-00

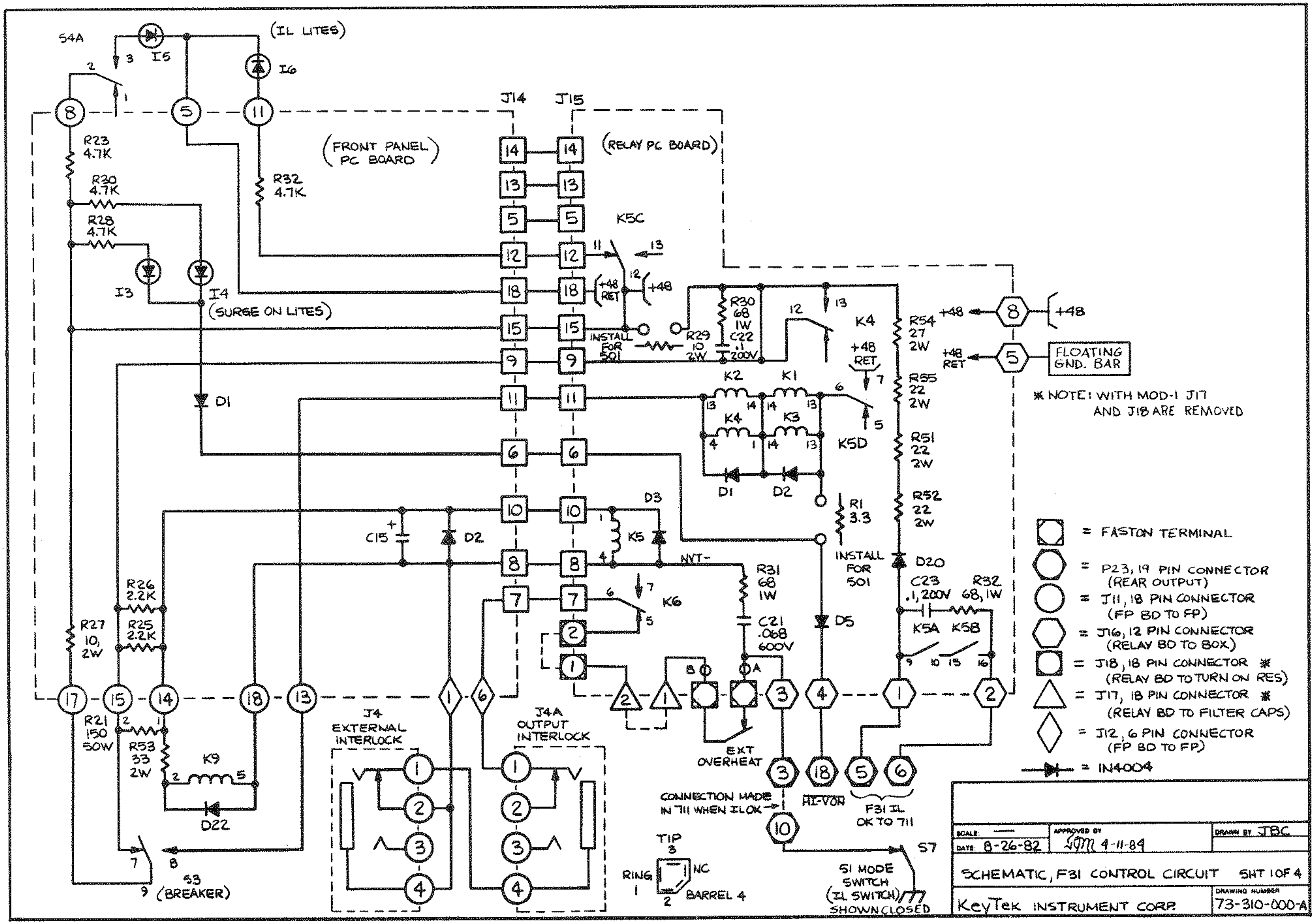


SCALE:
DATE: 12-8-83
APPROVED BY: GGM 4-11-84
DRAWN BY: K.WEISSBACH

SCHEMATIC, ENERGY STORAGE UNIT, ESU 221

KeyTek INSTRUMENT CORP.

DRAWING NUMBER: 71-128-000-00-8



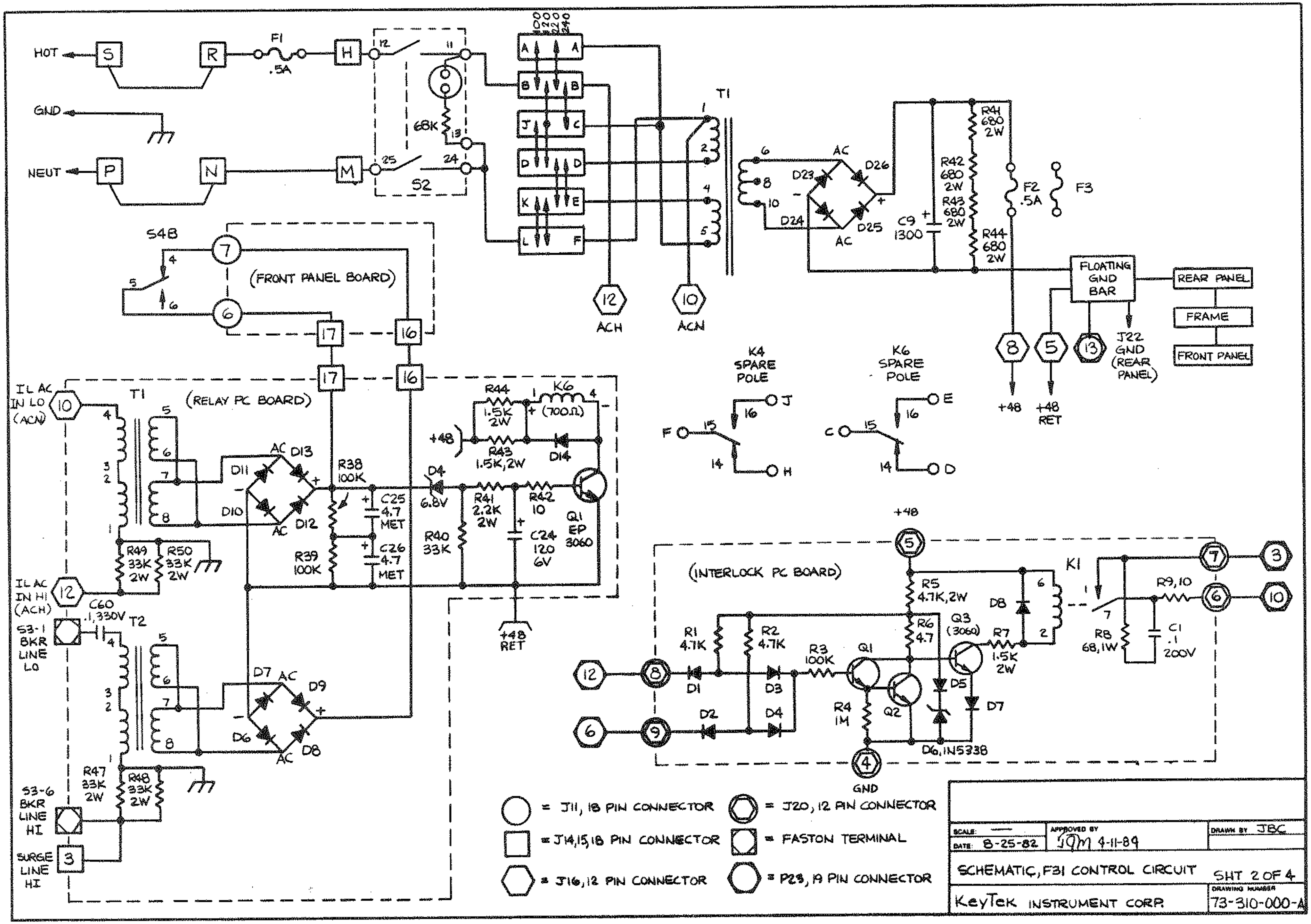
※ NOTE: WITH MOD-1 J17 AND J18 ARE REMOVED

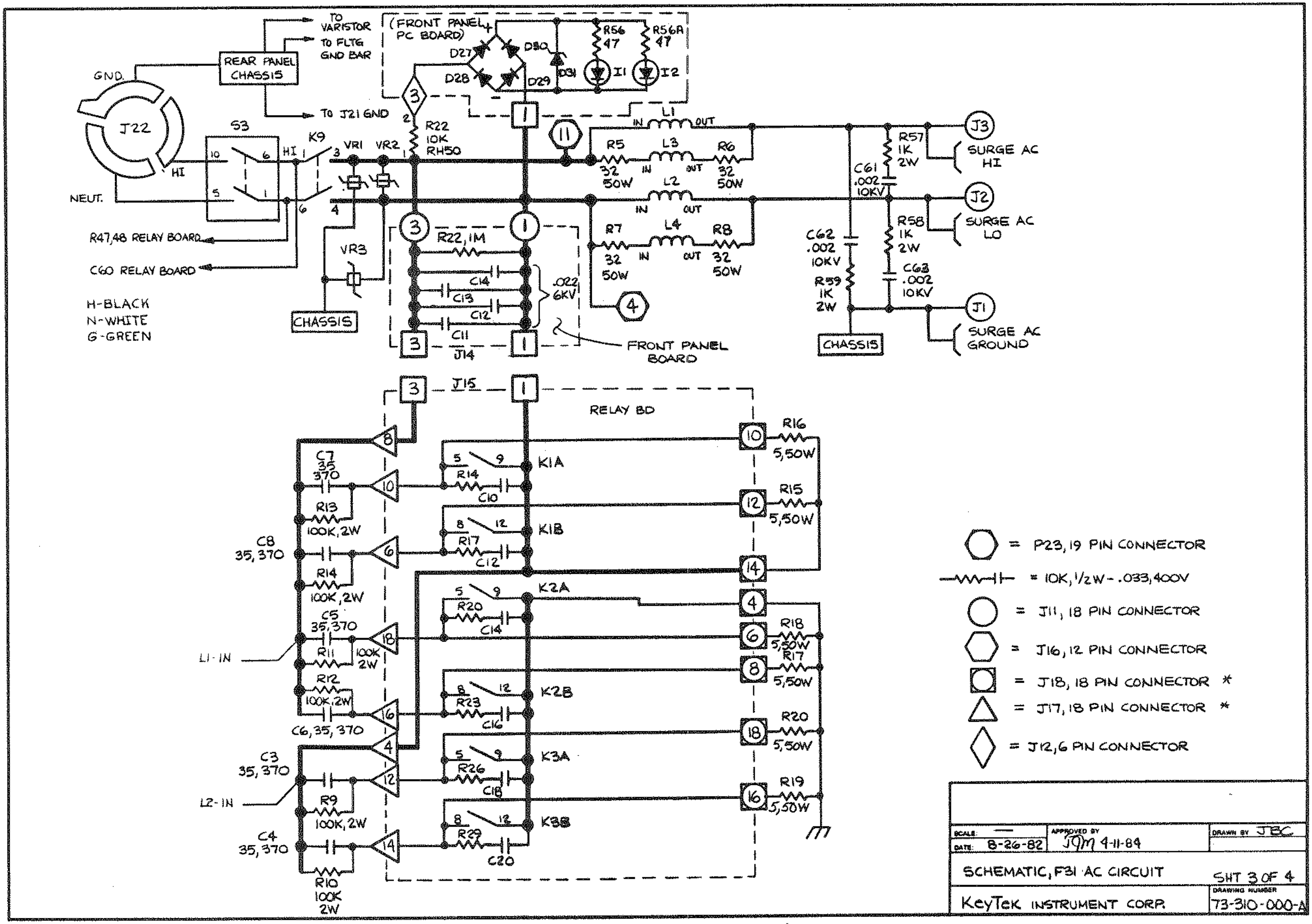
SCALE: —
DATE: 8-26-82
APPROVED BY: JQM 4-11-84
DRAWN BY: JBC

SCHEMATIC, F31 CONTROL CIRCUIT SHT 1 OF 4

KeyTek INSTRUMENT CORP.

DRAWING NUMBER: 73-310-000-A


HOT
GND
NEUT
S
R
P
N
F1 .5A
H
M
12
11
13
24
25
68K
S2
T1
ACH
ACN
6
8
10
D23
D24
D25
D26
AC
C9 1300
R41 680 2W
R42 680 2W
R43 680 2W
R44 680 2W
F2 .5A
F3
FLOATING GND BAR
REAR PANEL
FRAME
FRONT PANEL
J22 GND (REAR PANEL)
+48
+48 RET
S4B
(FRONT PANEL BOARD)
(RELAY PC BOARD)
17
16
IL AC IN LO (ACN)
IL AC IN HI (ACH)
S3-1 BKR LINE LO
S3-6 BKR LINE HI
SURGE LINE HI
C60 .1,330V
T2
R49 33K 2W
R50 33K 2W
R47 33K 2W
R48 33K 2W
D6
D7
D8
D9
D10
D11
D12
D13
R38 100K
R39 100K
C25 4.7 MET
C26 4.7 MET
D4 6.8V
R40 33K
R41 2.2K 2W
R42 10
C24 120 6V
Q1 EP 3060
R44 1.5K 2W
R43 1.5K, 2W
K6 (700Ω)
D14
K4 SPARE POLE
K6 SPARE POLE
F
J
H
C
E
D
15
16
14
(INTERLOCK PC BOARD)
R1 4.7K
R2 4.7K
R3 100K
R4 1M
R5 4.7K, 2W
R6 4.7
R7 1.5K 2W
Q1
Q2
Q3 (3060)
D1
D2
D3
D4
D5
D6, 1N5338
D7
D8
K1
R8 68, 1W
R9,10
C1 .1 200V
GND
= J11, 18 PIN CONNECTOR
= J14,15,18 PIN CONNECTOR
= J16, 12 PIN CONNECTOR
= J20, 12 PIN CONNECTOR
= FASTON TERMINAL
= P23, 19 PIN CONNECTOR
SCALE: —
DATE: 8-25-82
APPROVED BY JGM 4-11-89
DRAWN BY JBC
SCHEMATIC, F31 CONTROL CIRCUIT
SHT 2 OF 4
DRAWING NUMBER 73-310-000-A
KeyTek INSTRUMENT CORP.



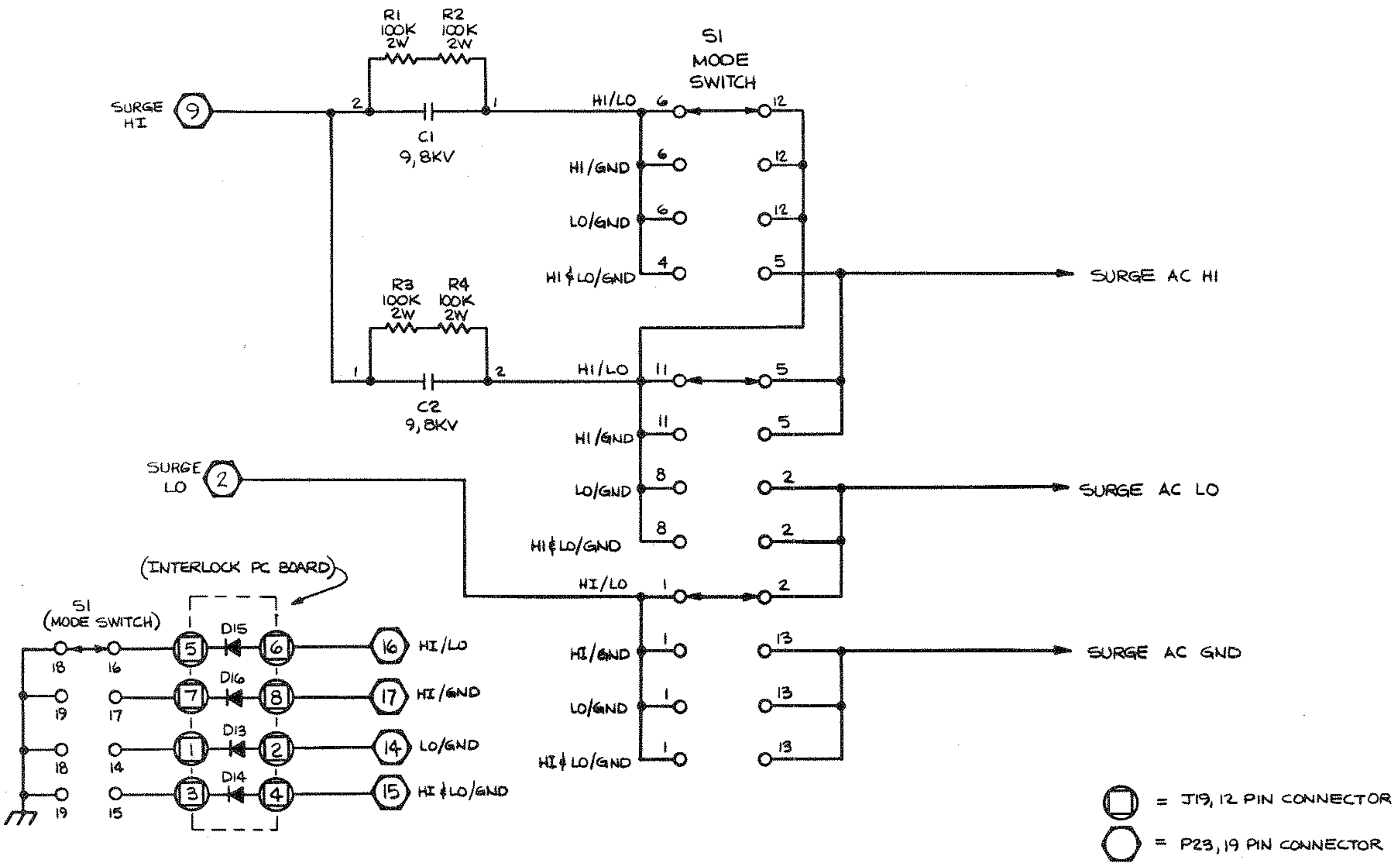
SCALE: —
DATE: 8-26-82
APPROVED BY JTM 4-11-84
DRAWN BY JBC

SCHEMATIC, F31 AC CIRCUIT

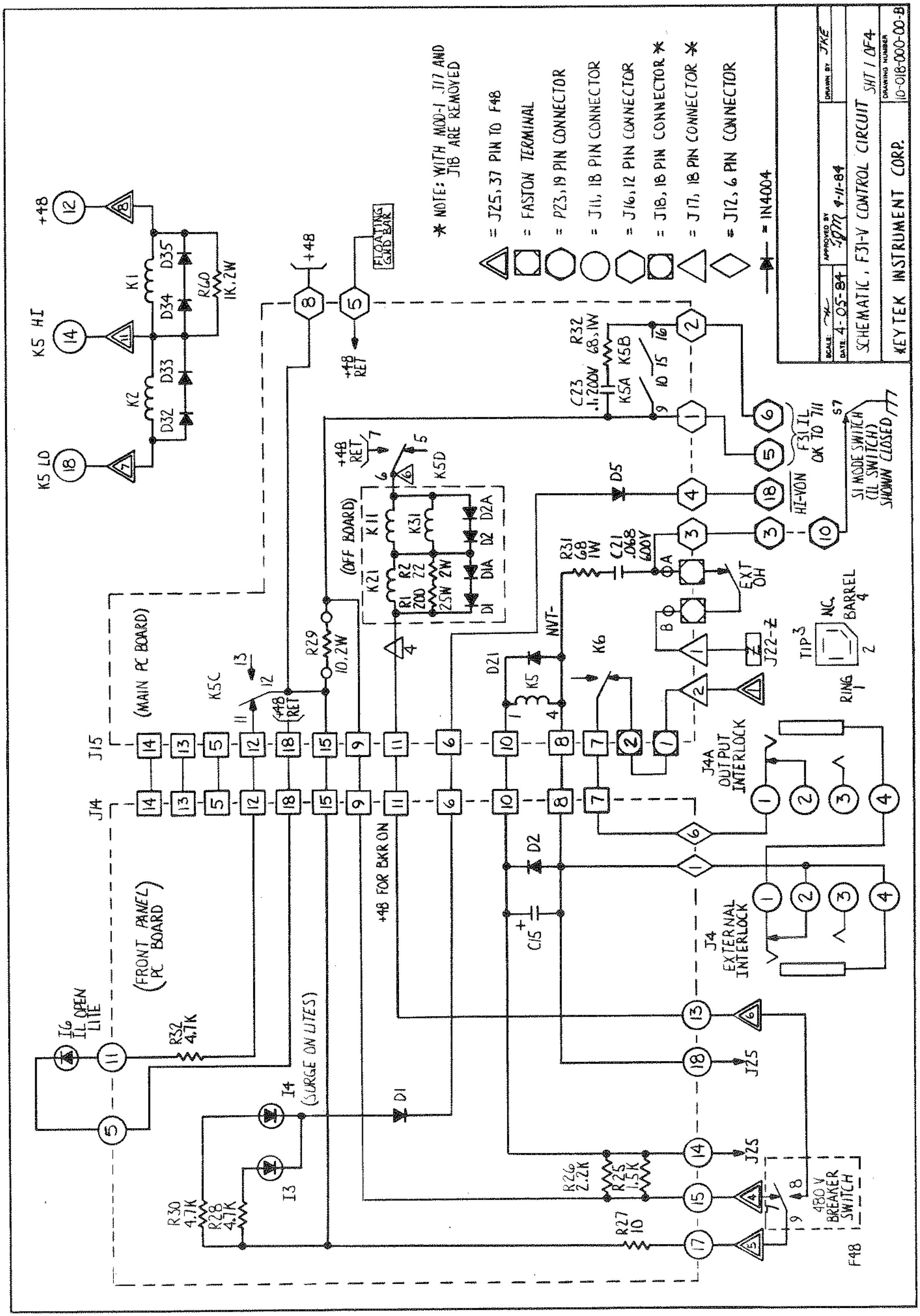
SHT 3 OF 4

KeyTek INSTRUMENT CORP.

DRAWING NUMBER 73-310-000-A



SCALE: — DATE: 8-13-82	APPROVED BY JQM 4-11-84	DRAWN BY JBC
SCHEMATIC, F31 SURGE CIRCUIT		SHT 4 OF 4
KeyTek INSTRUMENT CORP.		DRAWING NUMBER 73-310-000-A



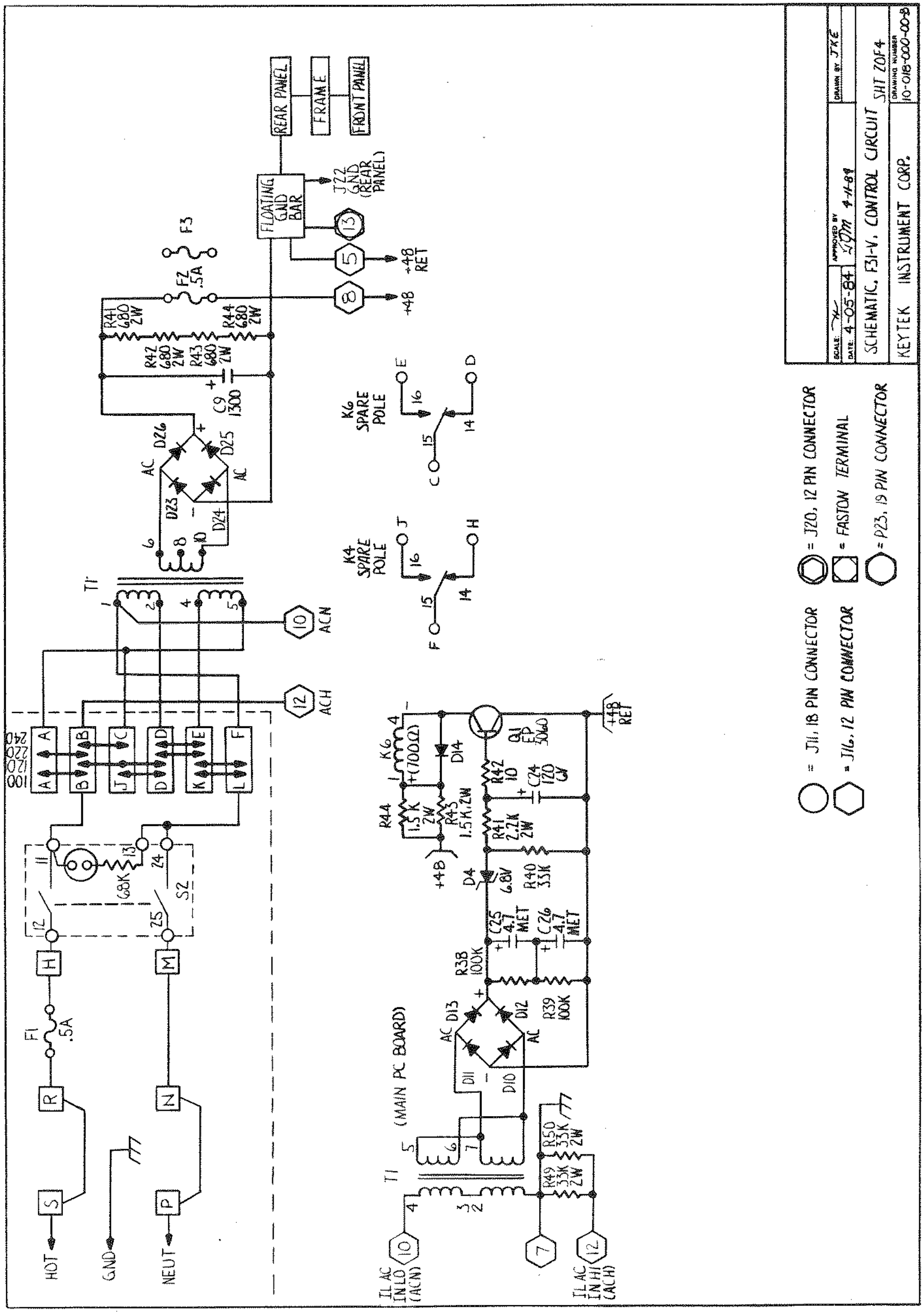
SCHEMATIC, F31-V CONTROL CIRCUIT

KEYTEK INSTRUMENT CORP.

SCALE: — DATE: 4-05-84 APPROVED BY JPM 4-11-84 DRAWN BY JKE

SHT 1 OF 4

DRAWING NUMBER 10-018-000-00-B



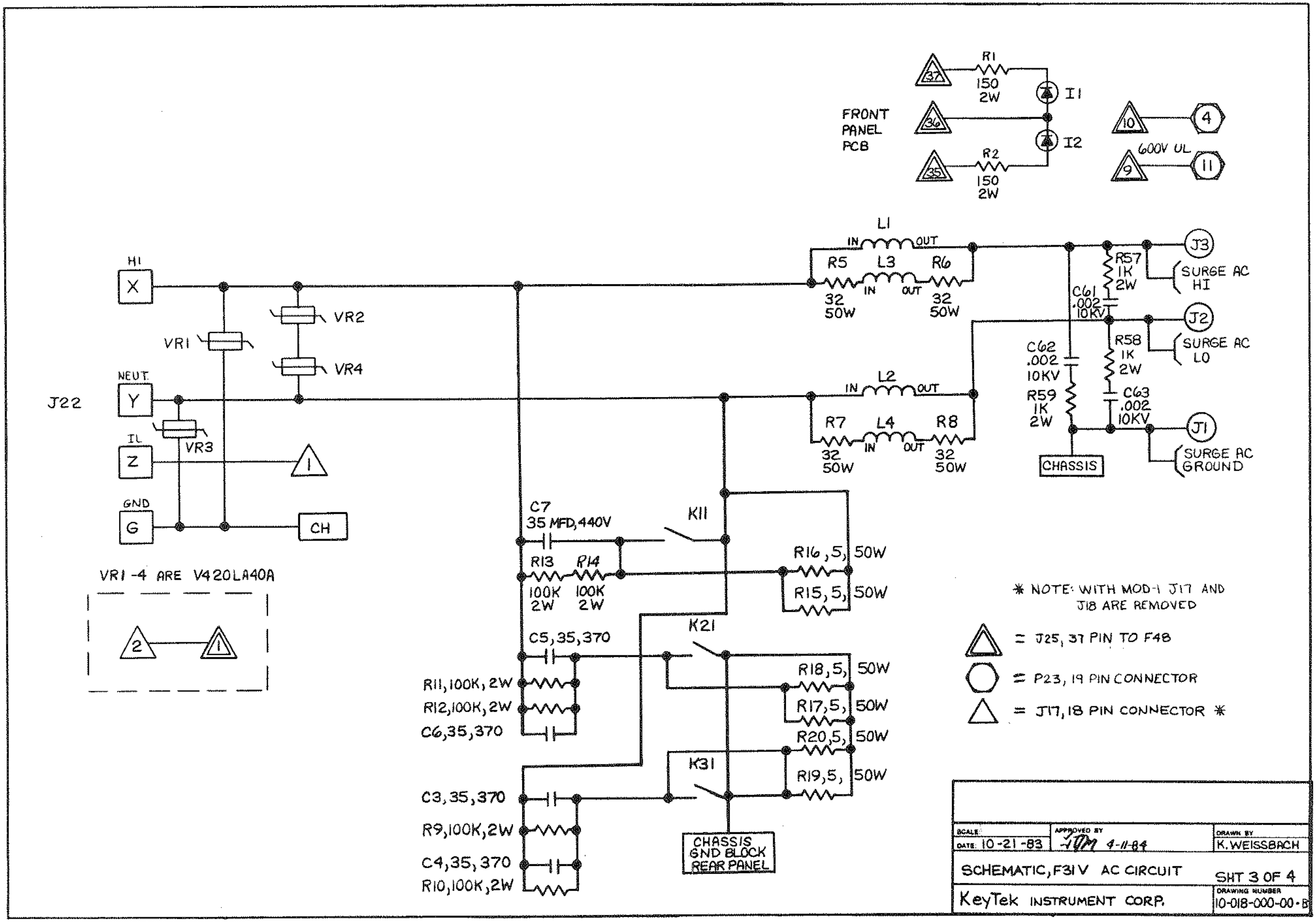
SCALE:
DATE: 4-05-84
APPROVED BY ~~~~ 4-11-84
DRAWN BY JKE

SCHEMATIC, F31-V, CONTROL CIRCUIT

SHT 2OF4

KEYTEK INSTRUMENT CORP.

DRAWING NUMBER
10-018-000-00-B



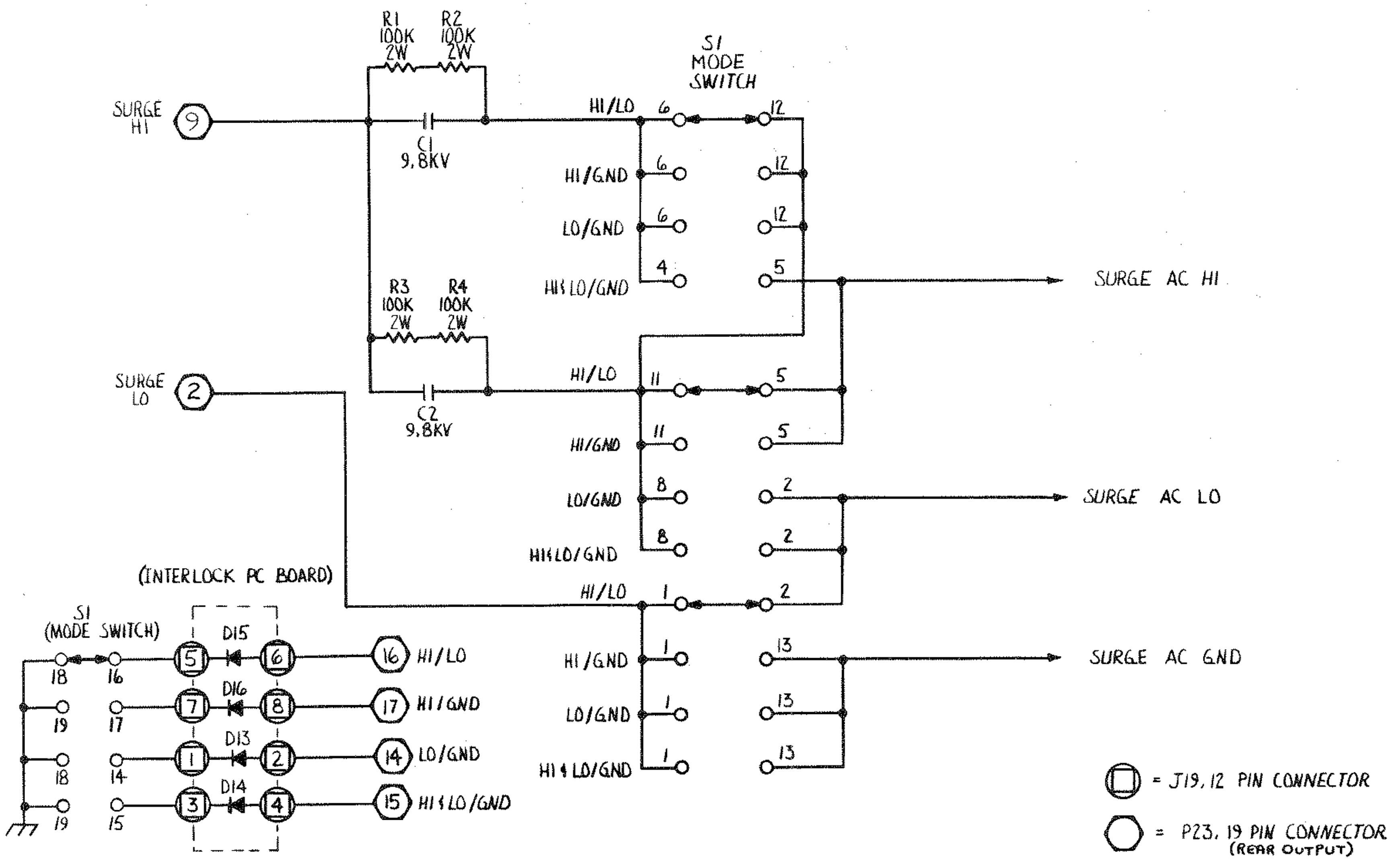
* NOTE: WITH MOD-1 J17 AND J18 ARE REMOVED

△ = J25, 37 PIN TO F48

⬡ = P23, 19 PIN CONNECTOR

△ = J17, 18 PIN CONNECTOR *

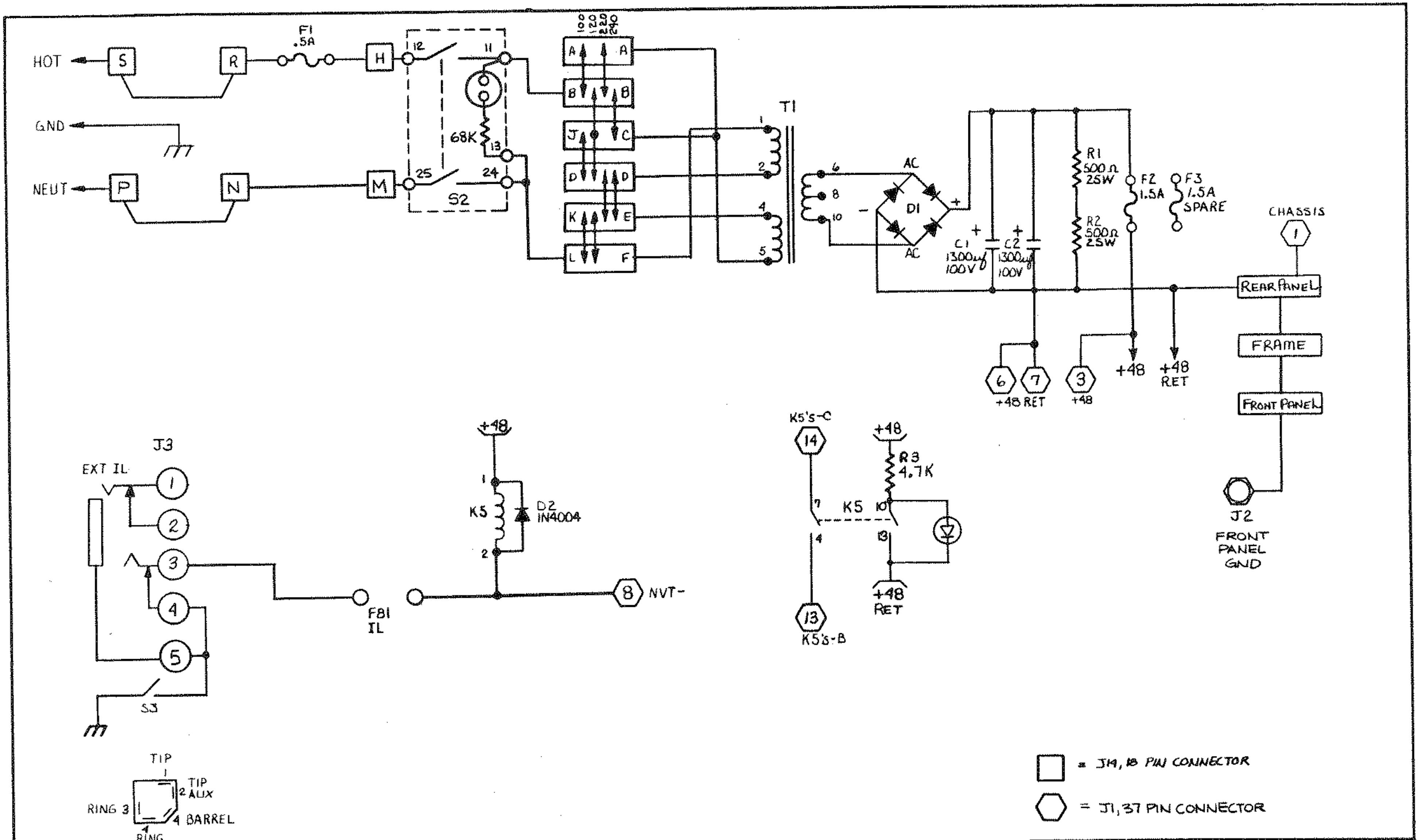
SCALE:
DATE: 10-21-83
APPROVED BY ЛЮМ 4-11-84
DRAWN BY K. WEISSBACH
SCHEMATIC, F31V AC CIRCUIT
SHT 3 OF 4
KeyTek INSTRUMENT CORP.
DRAWING NUMBER 10-018-000-00-B



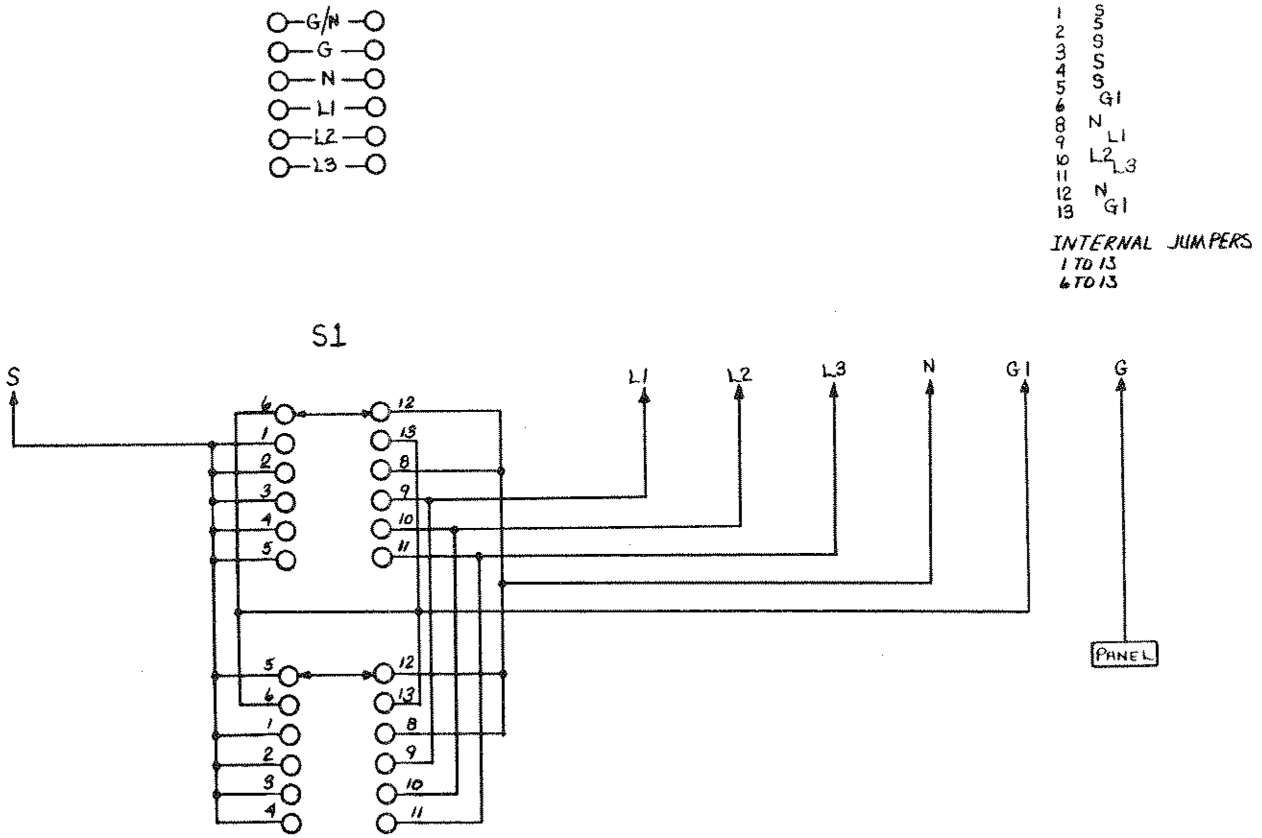
SCALE: —
DATE: 4-05-84
APPROVED BY SJM 4-11-84
DRAWN BY JKE

SCHEMATIC, F31-V, SURGE CIRCUIT SHT 4 OF 4

KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-018-000-00-B



SCALE:
DATE: 1-4-83
APPROVED BY SGM 4-11-84
DRAWN BY TM
SCHEMATIC, F41 CONTROL CIRCUIT
SHT 1 OF 2
KeyTek INSTRUMENT CORP.
DRAWING NUMBER 10-011-000-00-B



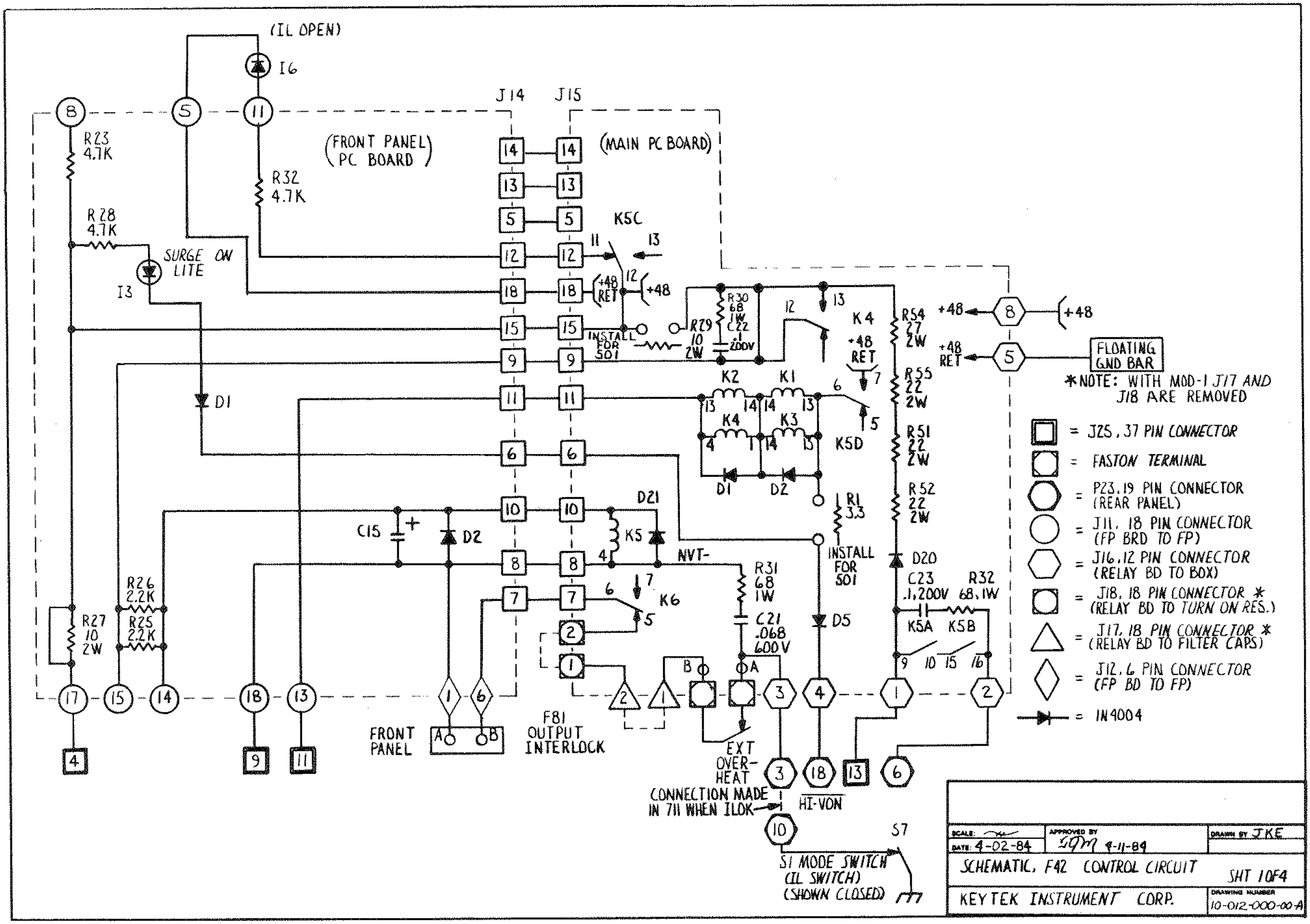
SCALE: ~
DATE: 1-4-83
APPROVED BY JJM 4-11-84
DRAWN BY TJM

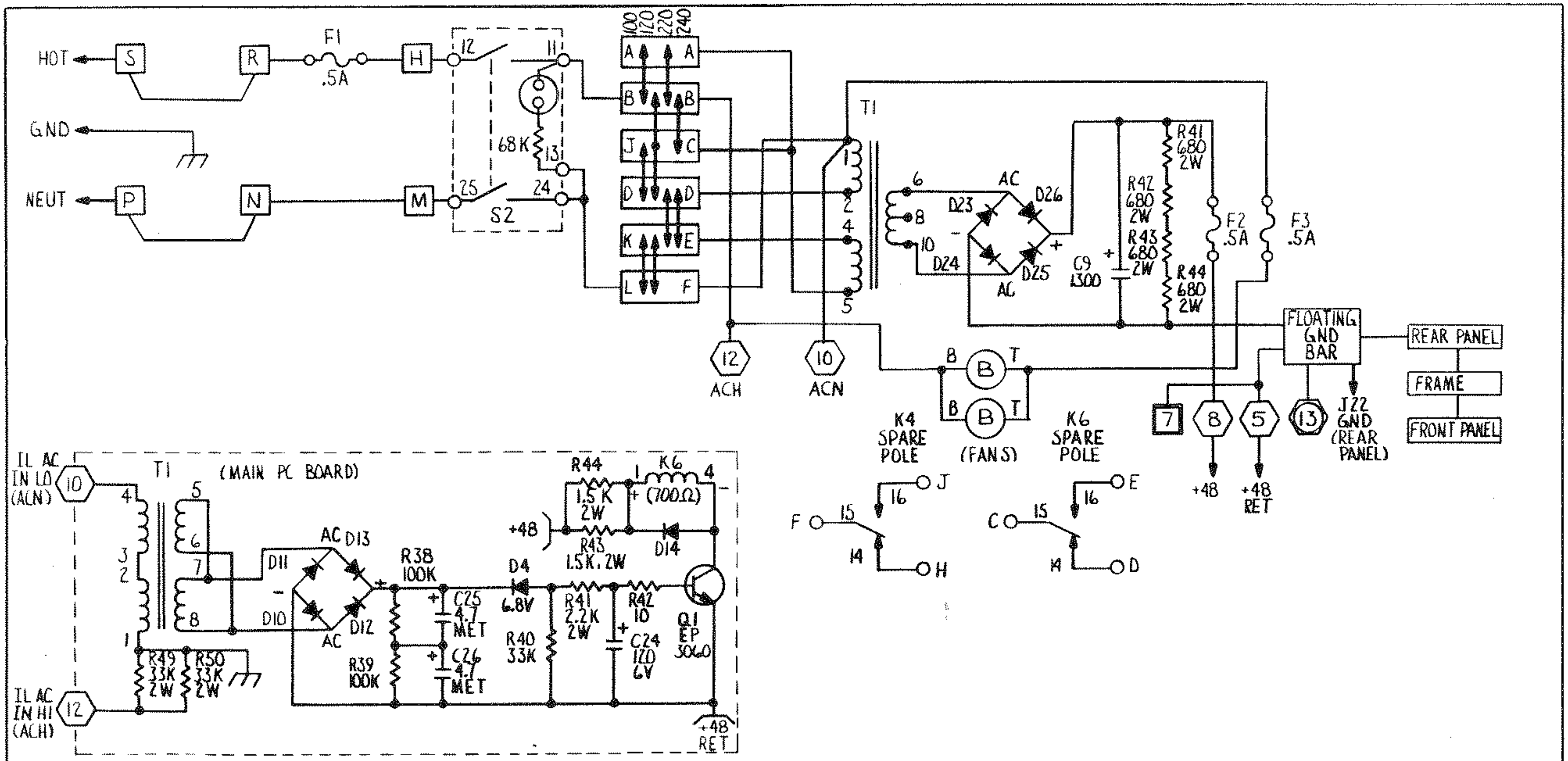
SCHEMATIC, F41 SURGE CIRCUIT

SHT 2 OF 2

KeyTek INSTRUMENT CORP.

DRAWING NUMBER 10-011-000-00-B


(IL OPEN)
I6
J14
J15
(FRONT PANEL PC BOARD)
(MAIN PC BOARD)
R23 4.7K
R32 4.7K
R28 4.7K
SURGE ON LITE
I3
D1
K5C
+48 RET
+48
INSTALL FOR 501
R29 10 2W
R30 68 1W
C22 .1 200V
K4
+48 RET
R54 27 2W
R55 22 2W
R51 22 2W
R52 22 2W
+48
+48 RET
+48
FLOATING GND BAR
*NOTE: WITH MOD-1 J17 AND J18 ARE REMOVED
K2
K1
K4
K3
K5D
D1
D2
R1 3.3
INSTALL FOR 501
D20
C23 .1,200V
R32 68,1W
K5A
K5B
C15
D2
D21
K5
NVT-
R31 68 1W
C21 .068 600V
K6
D5
R27 10 2W
R26 2.2K
R25 2.2K
FRONT PANEL
F81 OUTPUT INTERLOCK
EXT OVER-HEAT
CONNECTION MADE IN 711 WHEN ILOK
HI-VON
S7
S1 MODE SWITCH (IL SWITCH) (SHOWN CLOSED)
= J25, 37 PIN CONNECTOR
= FASTON TERMINAL
= P23, 19 PIN CONNECTOR (REAR PANEL)
= J11, 18 PIN CONNECTOR (FP BRD TO FP)
= J16, 12 PIN CONNECTOR (RELAY BD TO BOX)
= J18, 18 PIN CONNECTOR * (RELAY BD TO TURN ON RES.)
= J17, 18 PIN CONNECTOR * (RELAY BD TO FILTER CAPS)
= J12, 6 PIN CONNECTOR (FP BD TO FP)
= IN4004
SCALE:
DATE: 4-02-84
APPROVED BY SQM 4-11-84
DRAWN BY JKE
SCHEMATIC, F42 CONTROL CIRCUIT
SHT 1OF4
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-012-000-00-A



□ = J25,37 PIN CONNECTOR

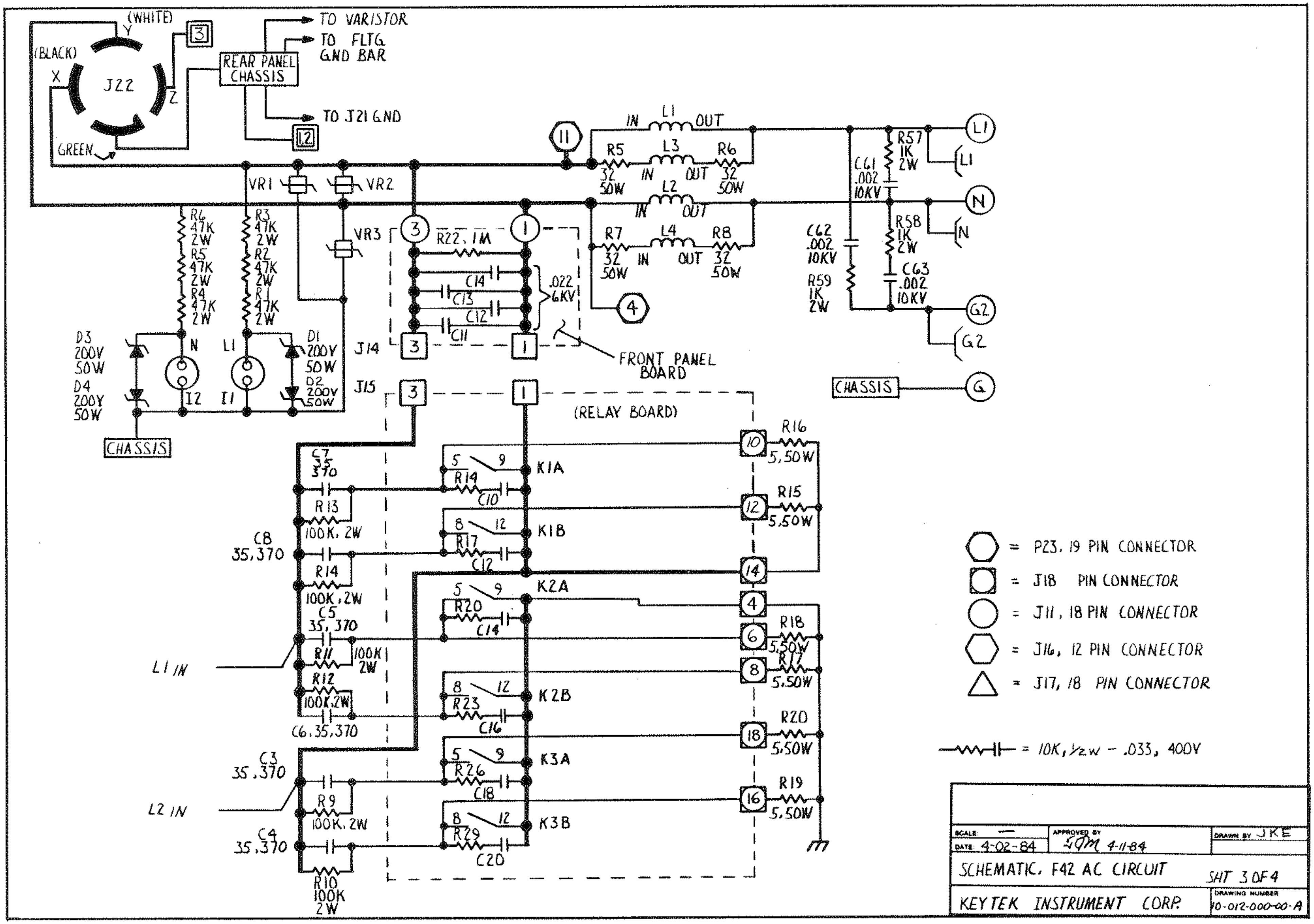
⬡ = J16,12 PIN CONNECTOR
(RELAY BD TO BOX)

○ = P23, 19 PIN CONNECTOR
(REAR OUTPUT)

SCALE: ~~
DATE: 4-02-84
APPROVED BY JQM 4-11-84
DRAWN BY JKE

SCHEMATIC, F42 CONTROl CIRCUIT
SHT 2 OF 4

KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-012-000-00-A



= P23, 19 PIN CONNECTOR

= J18 PIN CONNECTOR

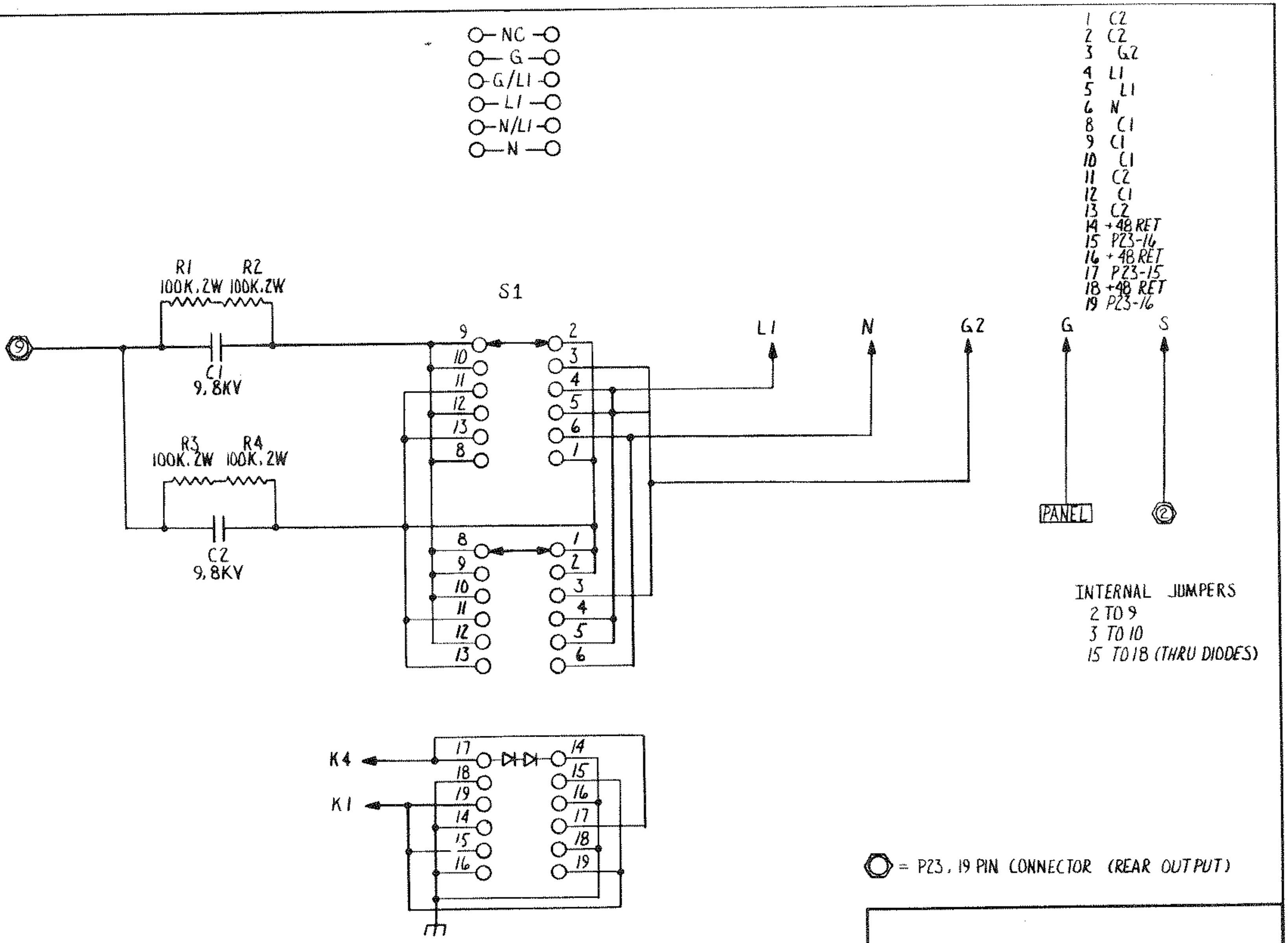
= J11, 18 PIN CONNECTOR

= J16, 12 PIN CONNECTOR

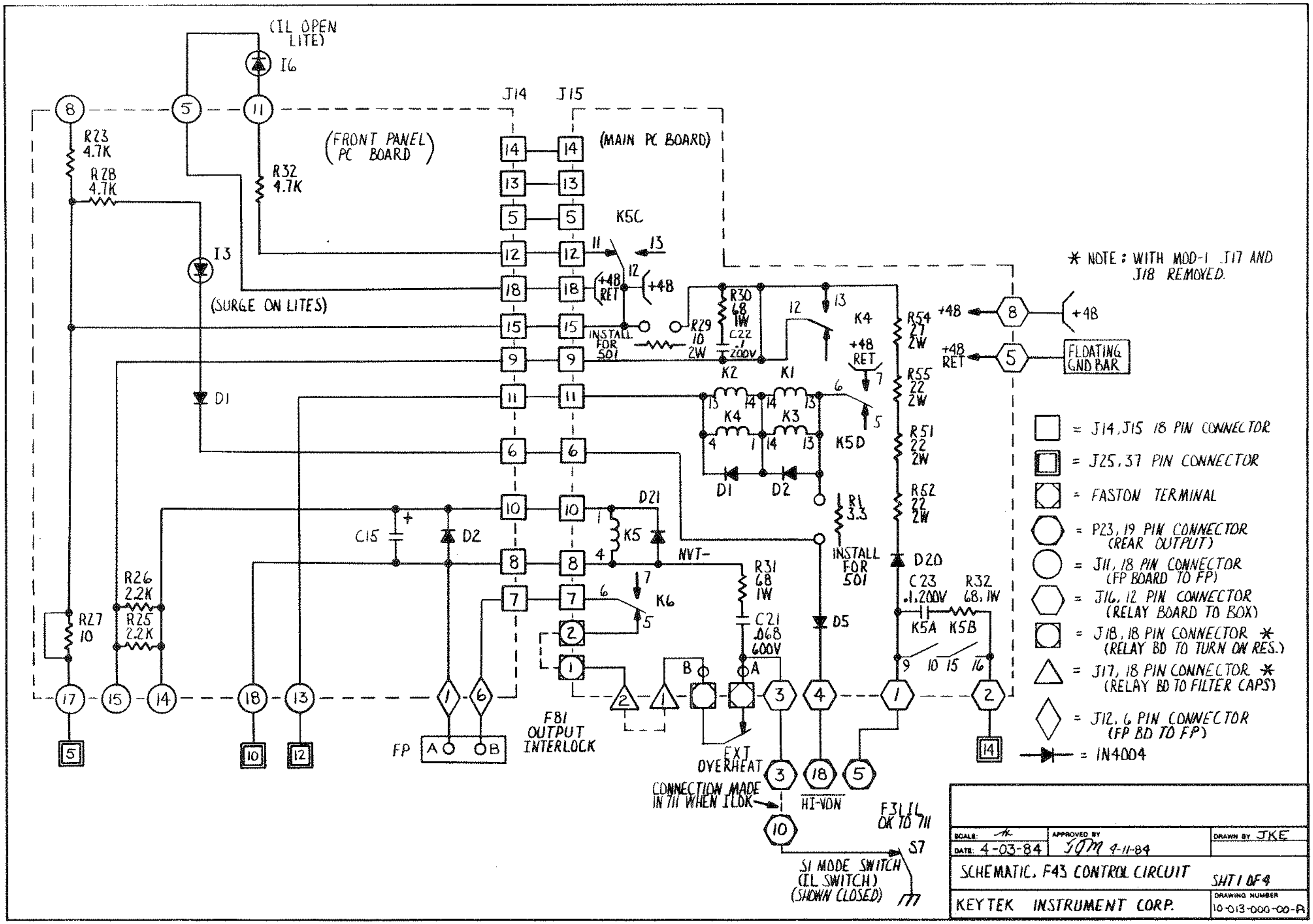
= J17, 18 PIN CONNECTOR

= 10K, ½W - .033, 400V

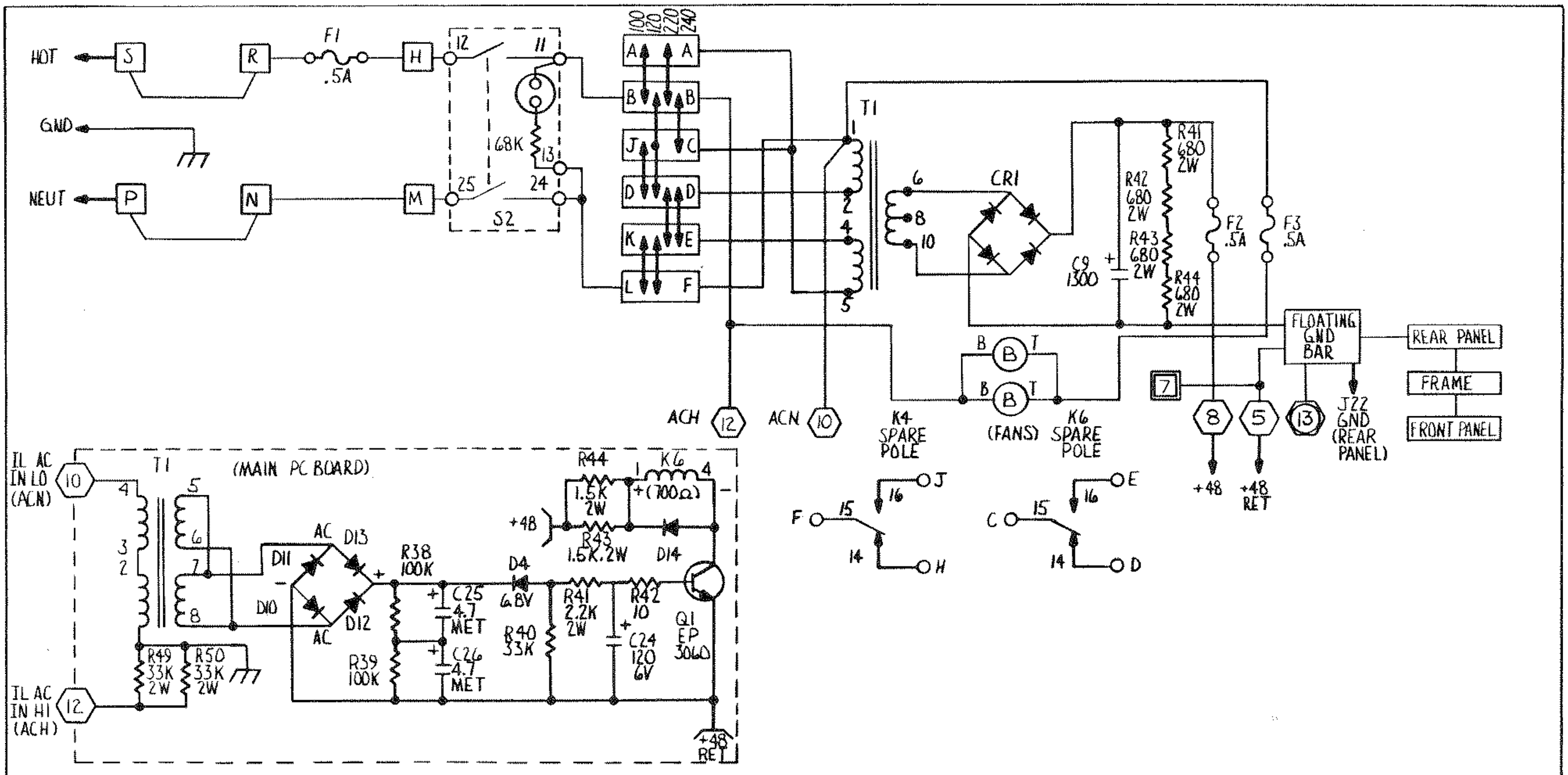
SCALE: —
DATE: 4-02-84
APPROVED BY: SQM 4-11-84
DRAWN BY: JKE
SCHEMATIC, F42 AC CIRCUIT
SHT 3 OF 4
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER: 10-012-000-00-A



SCALE: NC
DATE: 4-02-84
APPROVED BY JQM 4-11-84
DRAWN BY JKE
SCHEMATIC F42 SURGE CIRCUIT
SHT 4 OF 4
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-012-000-00A



SCALE:
DATE: 4-03-84
APPROVED BY TOM 4-11-84
DRAWN BY JKE
SCHEMATIC, F43 CONTROL CIRCUIT
SHT 1 OF 4
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-013-000-00-A



□ = J25, 37 PIN CONNECTOR

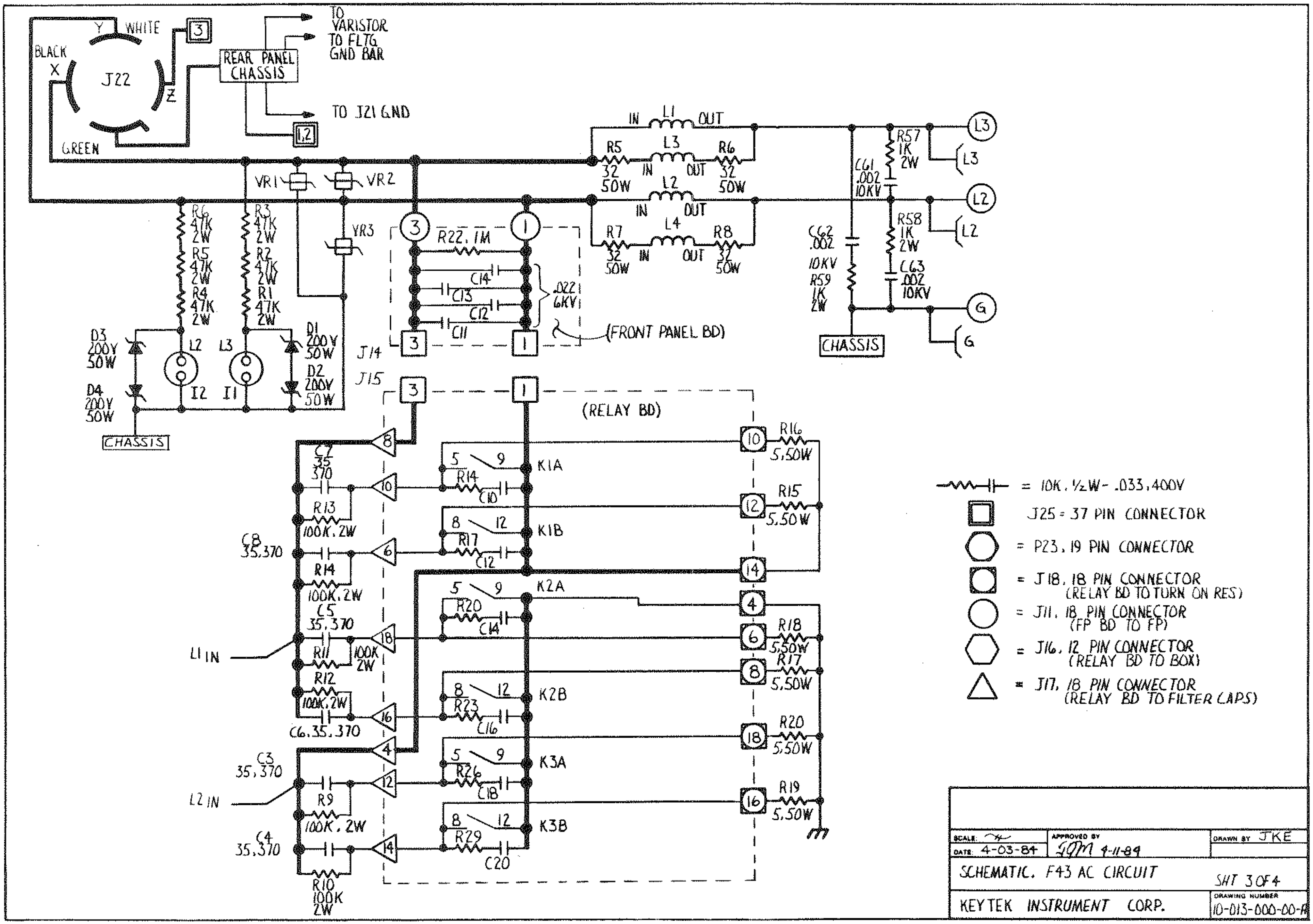
⬡ = J16, 12 PIN CONNECTOR
(RELAY BD TO BOX)

○ = P23, 19 PIN CONNECTOR
(REAR OUTPUT)

SCALE: NA
DATE: 4-03-84
APPROVED BY JQM 4-11-84
DRAWN BY JKE

SCHEMATIC, F43 CONTROL CIRCUIT
SHT 2 OF 4

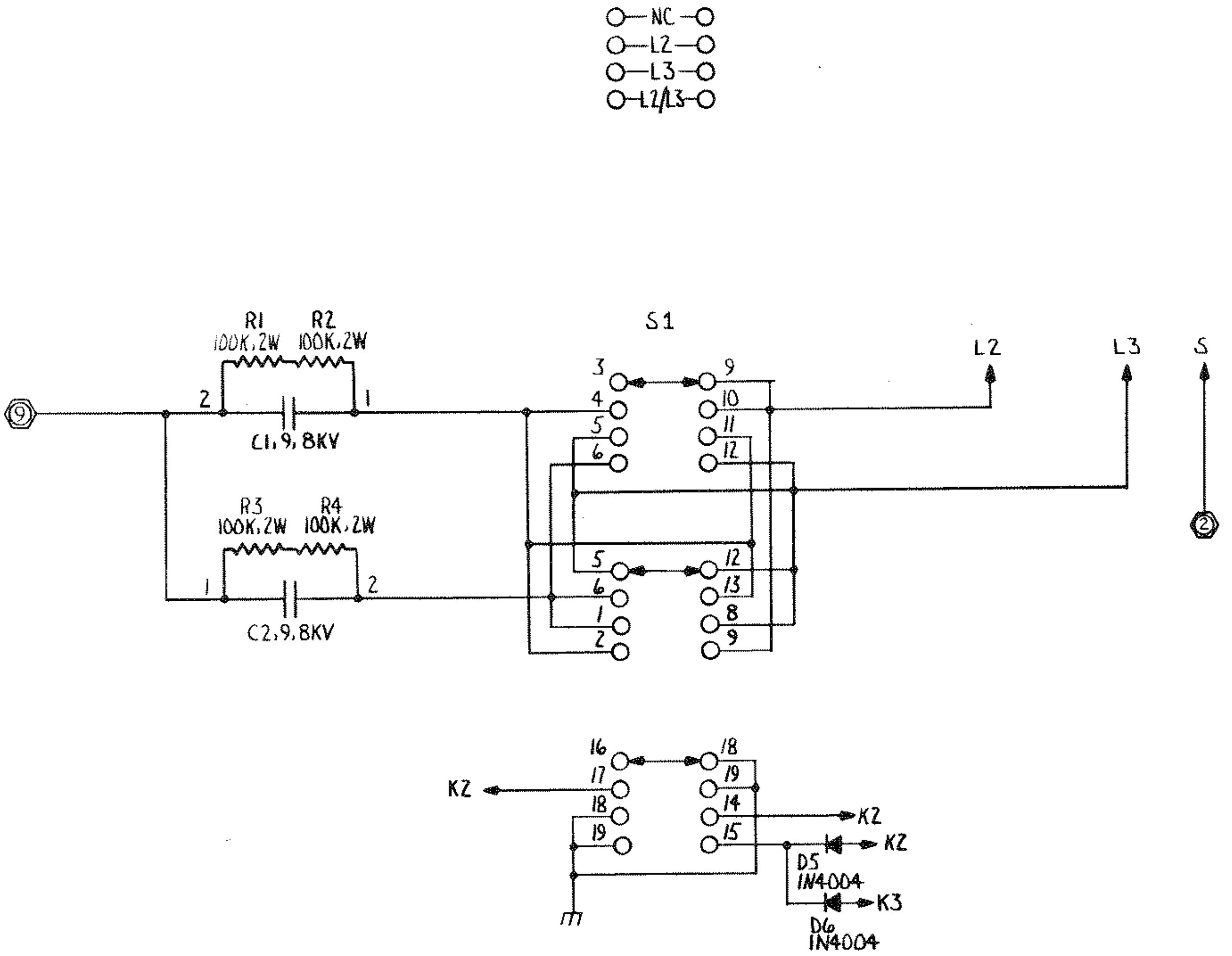
KEY TEK INSTRUMENT CORP.
DRAWING NUMBER 10-013-000-00-A



SCALE: ~~
DATE: 4-03-84
APPROVED BY JQM 4-11-84
DRAWN BY JKE

SCHEMATIC, F43 AC CIRCUIT
SHT 3 OF 4

KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-013-000-00-A

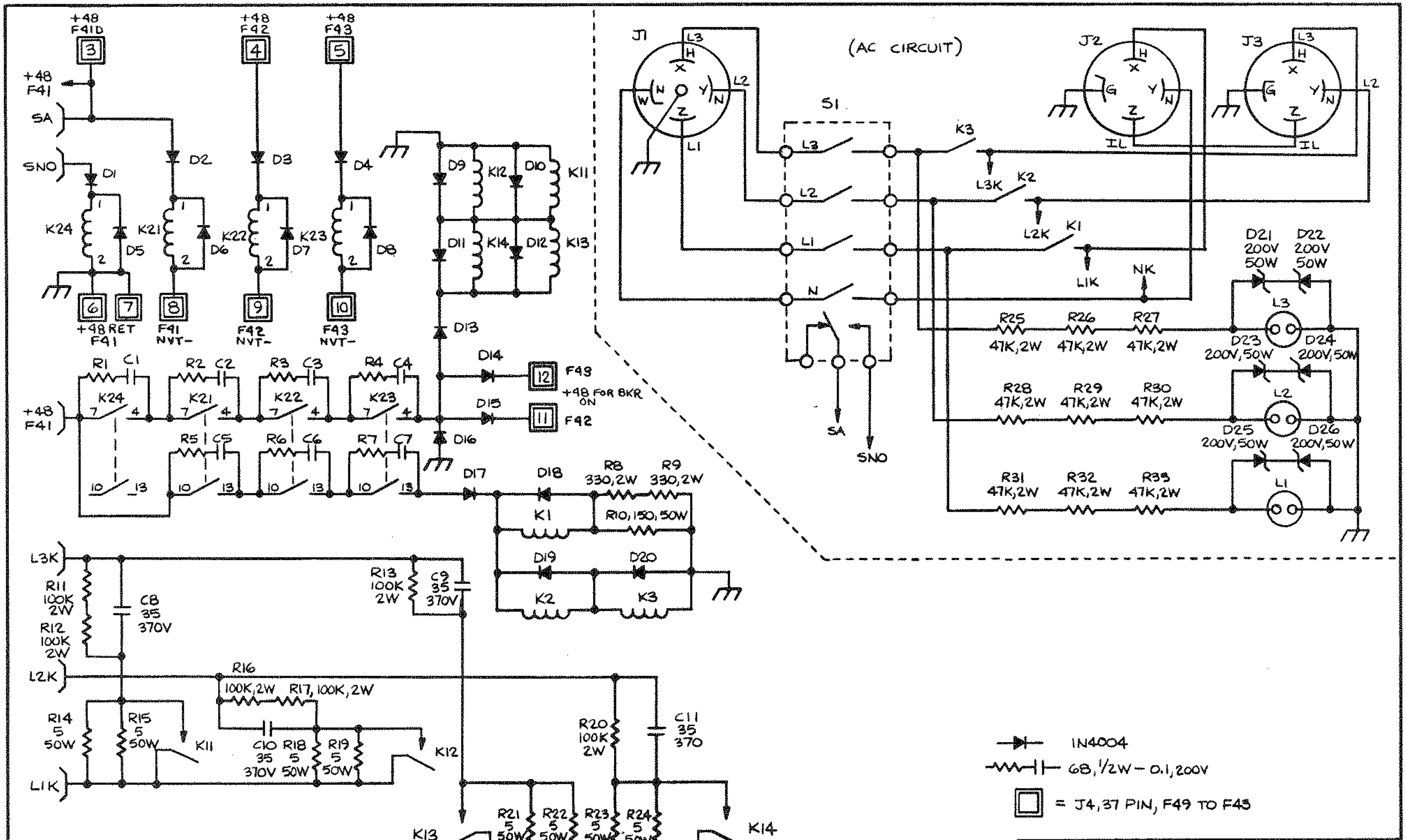


1	C2
2	C1
3	NO CONN
4	C1
5	L3
6	C2
8	L3
9	L2
10	L2
11	C1
12	L3
13	C1
14	PZ3-17
15	PZ3-14, 17(THRU DIODE)
16	NO CONN
17	PZ3-17
18	GND
19	GND

INTERNAL JUMPERS
3 TO 9
5 TO 12
16 TO 18

⬡ = PZ3 19 PIN CONNECTOR
(REAR OUTPUT)

SCALE:
DATE: 4-04-84
APPROVED BY JM 4-11-84
DRAWN BY JKE
SCHEMATIC, F43 SURGE CIRCUIT SHT 4 OF 4
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-013-000-00-A

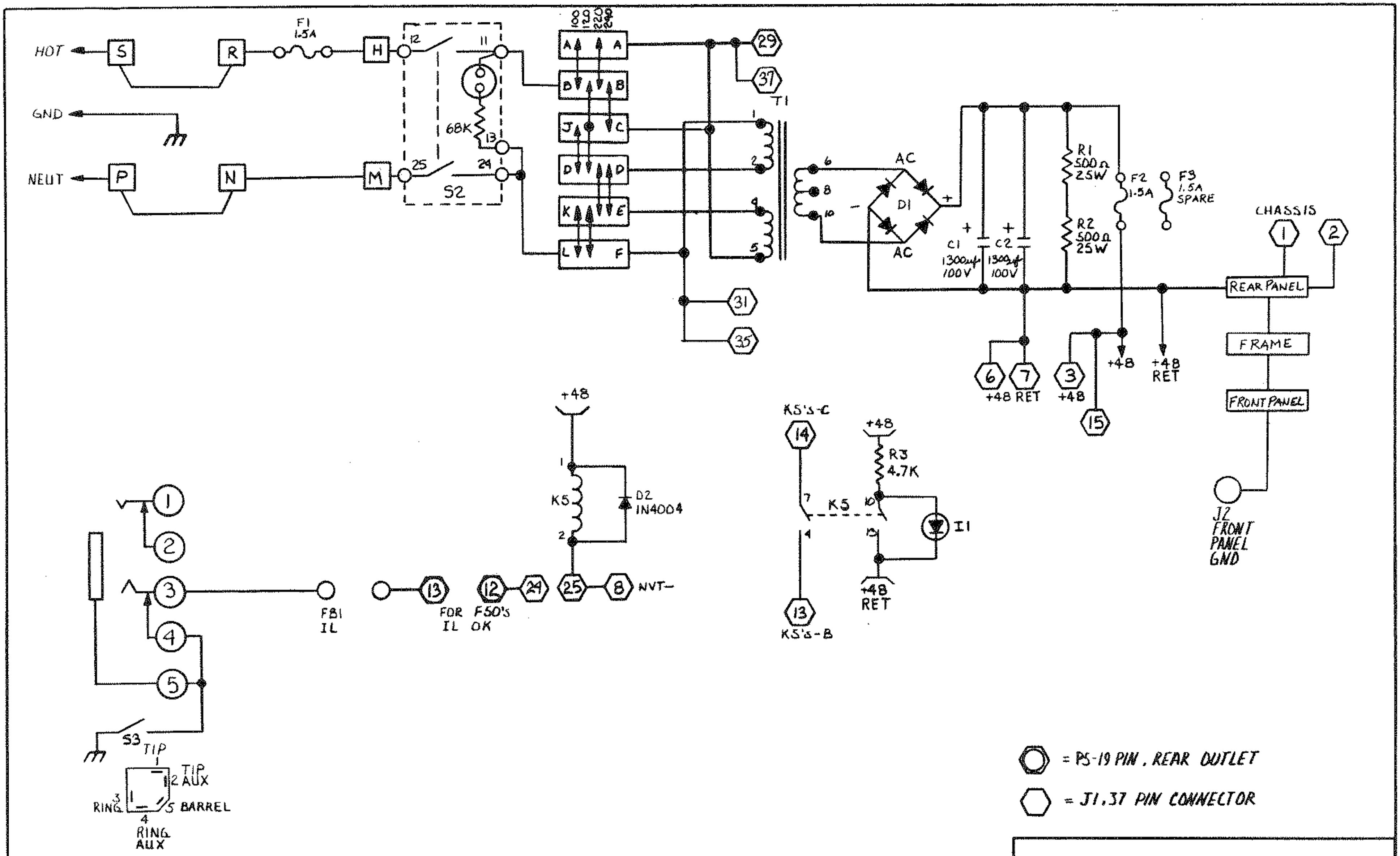


SCALE: ~ DATE: 1-7-83	APPROVED BY KM 4-11-84	DRAWN BY JBC

SCHEMATIC, F49 CONTROL & AC CIRCUITS

KeyTek INSTRUMENT CORP.

DRAWING NUMBER 10-015-000-00

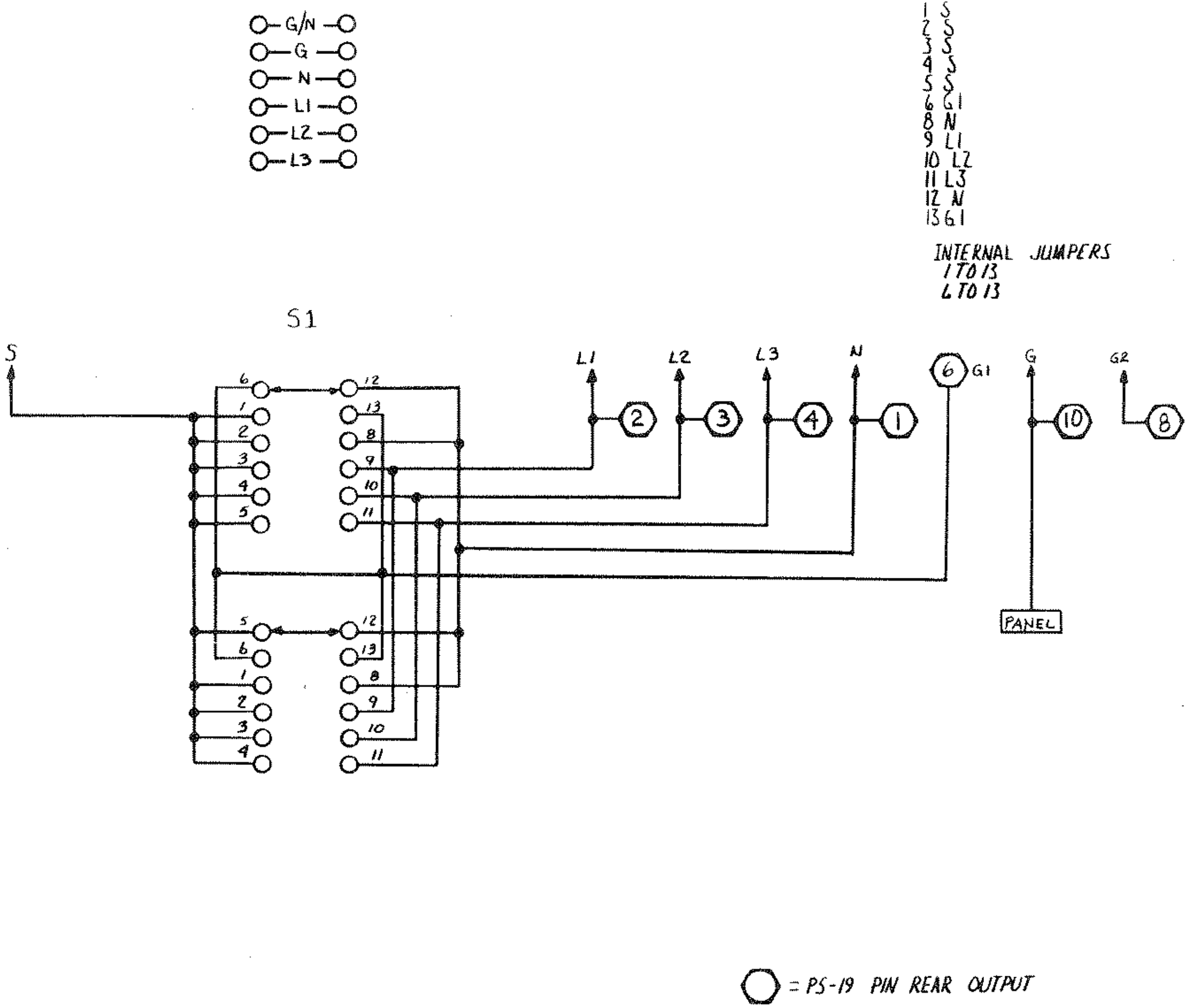


SCALE: —
DATE: 3-26-84
APPROVED BY: JJM
DRAWN BY: DTL

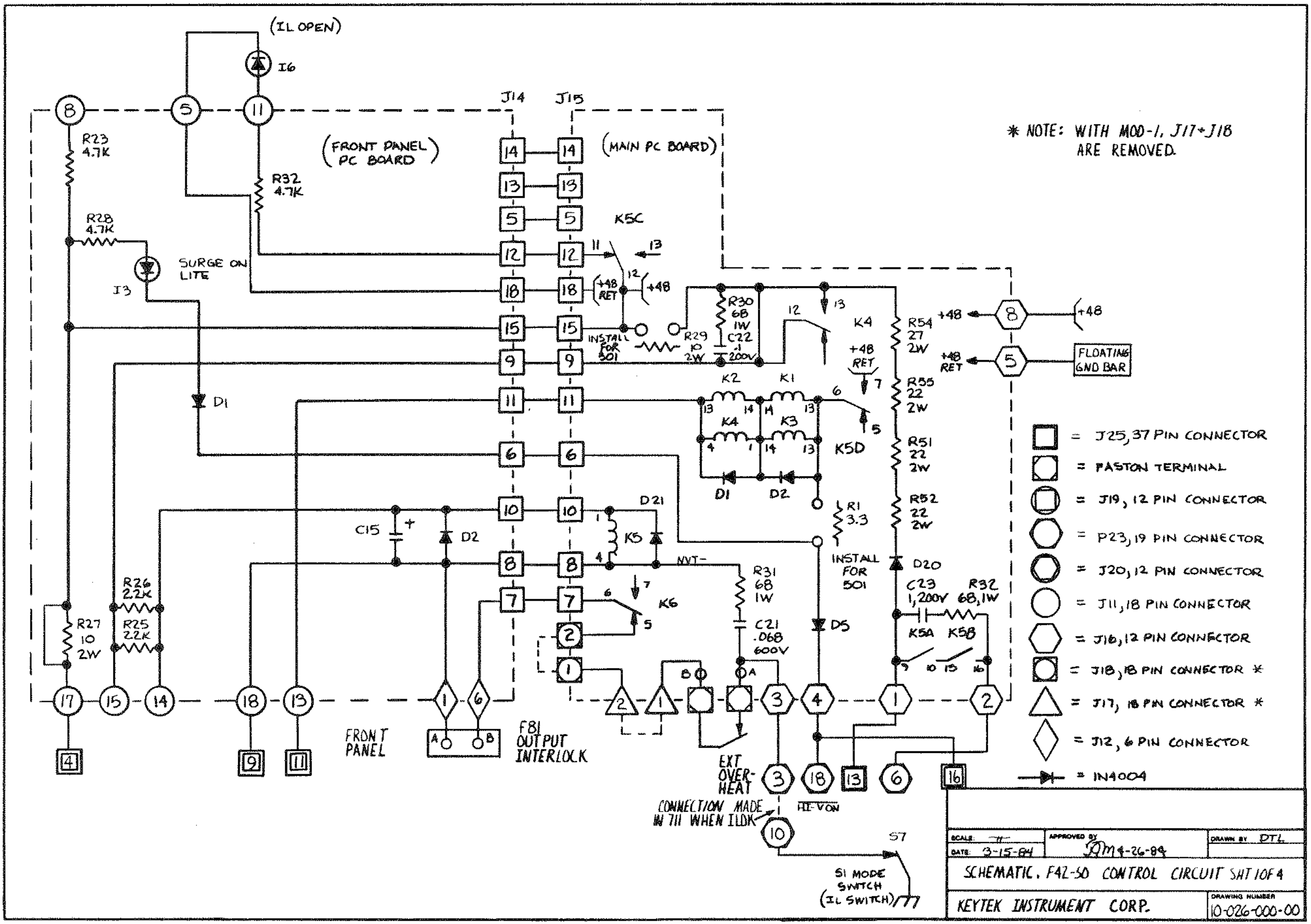
SCHEMATIC, F41-50 CONTROL CIRCUIT SHT 1 OF 2

KEYTEK INSTRUMENT CORP.

DRAWING NUMBER: 10-025-000-00



SCALE: ~ DATE: 3-26-84	APPROVED BY SQM 4-26-84	DRAWN BY DTL
SCHEMATIC, F41-50 SURGE CIRCUIT		SHT 2 OF 2
KEYTEK INSTRUMENT CORP.		DRAWING NUMBER 10-025-000-00



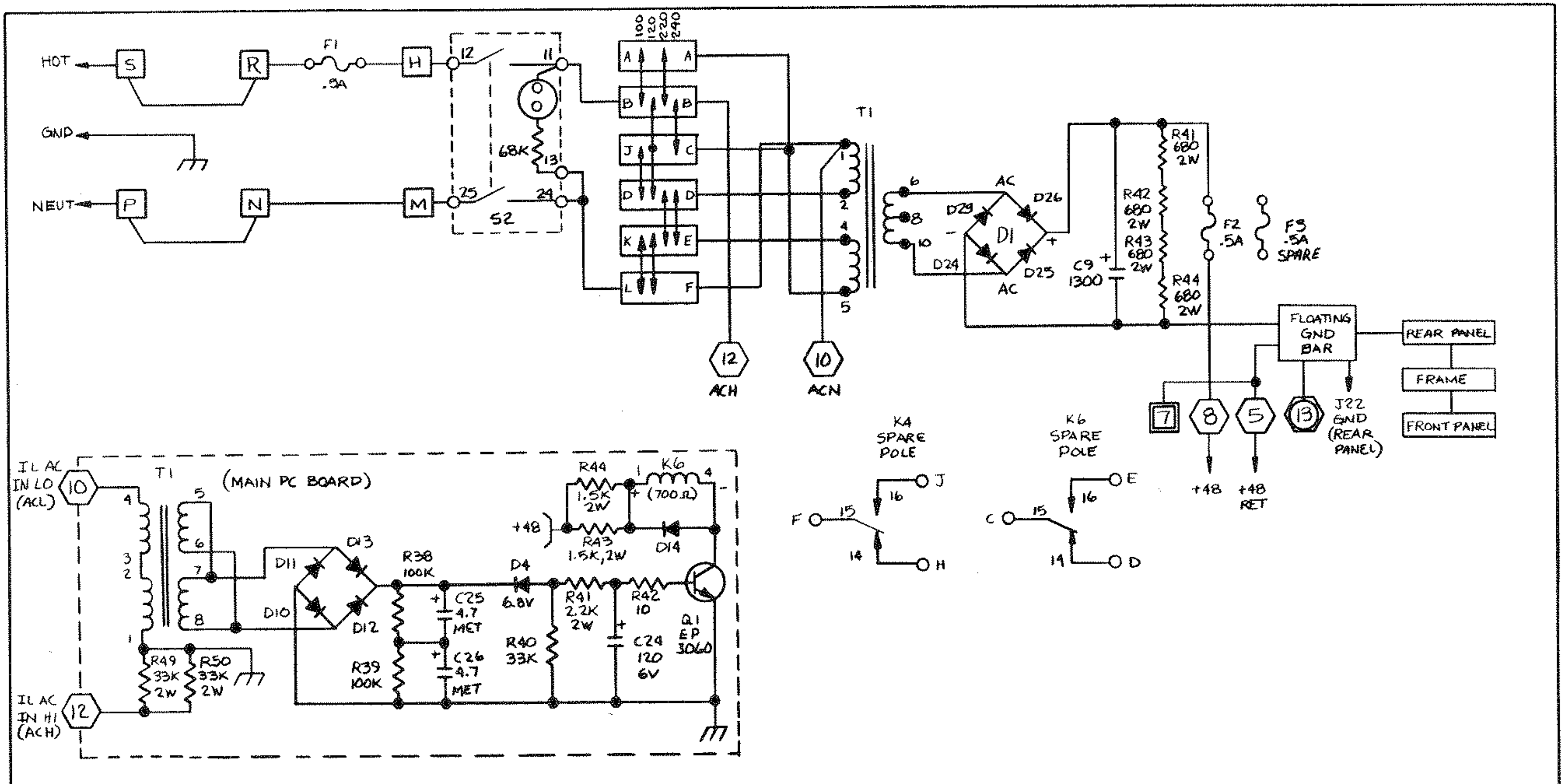
✳ NOTE: WITH MOD-1, J17+J18 ARE REMOVED.

= J25, 37 PIN CONNECTOR
= FASTON TERMINAL
= J19, 12 PIN CONNECTOR
= P23, 19 PIN CONNECTOR
= J20, 12 PIN CONNECTOR
= J11, 18 PIN CONNECTOR
= J16, 12 PIN CONNECTOR
= J18, 18 PIN CONNECTOR ✳
= J17, 18 PIN CONNECTOR ✳
= J12, 6 PIN CONNECTOR
= IN4004

SCALE: —//—
DATE: 3-15-84
APPROVED BY DM 4-26-84
DRAWN BY DTL

SCHEMATIC, F42-50 CONTROL CIRCUIT SHT 1OF 4

KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-026-000-00



= J25, 37 PIN CONNECTOR

= J16, 12 PIN CONNECTOR (RELAY BD TO BOX)

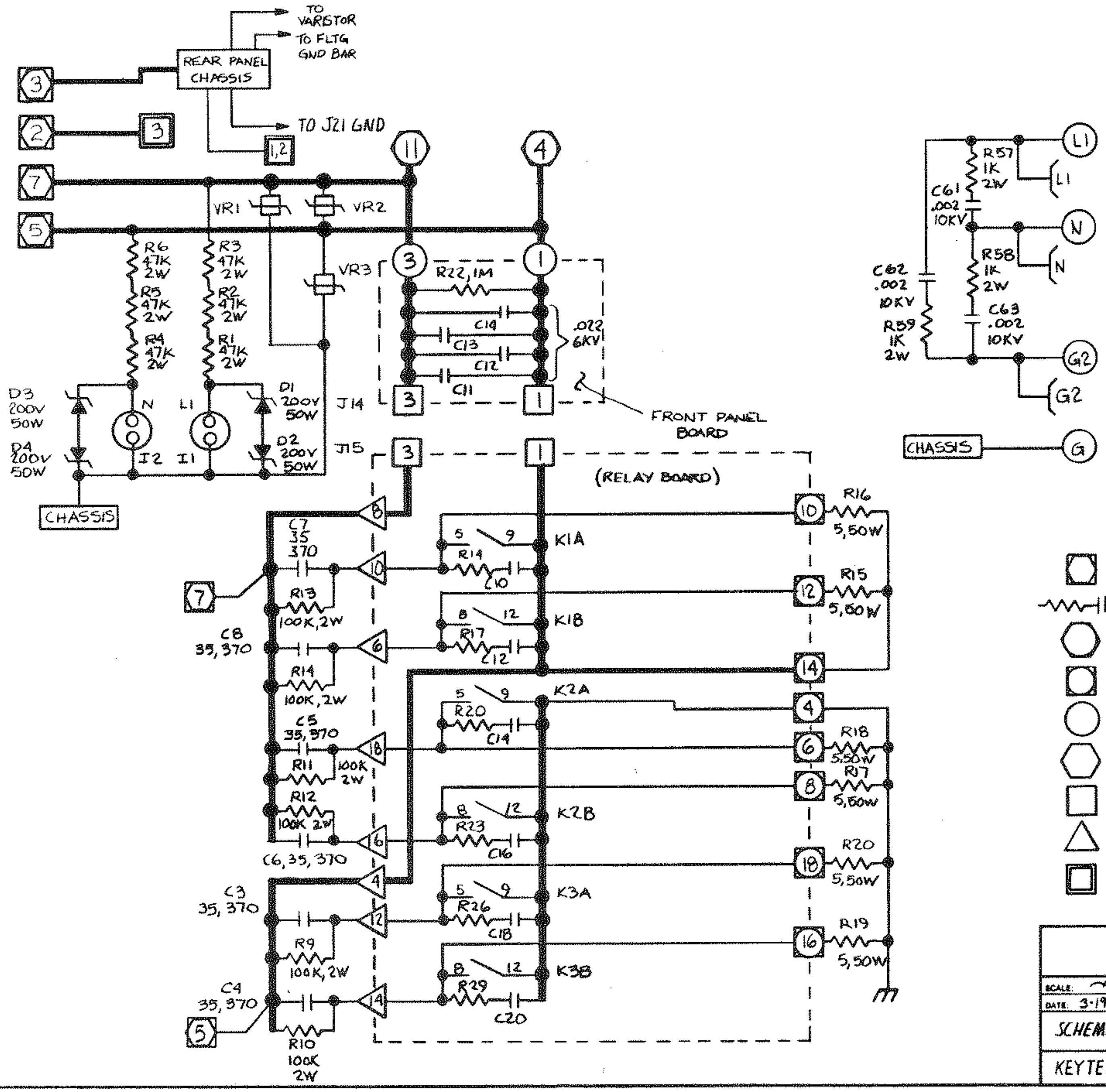
= P23, J9 PIN CONNECTOR (REAR OUTPUT)

SCALE: —
DATE: 3-16-84
APPROVED BY JJM 4-26-84
DRAWN BY DTL

SCHEMATIC, F92-50 CONTROL CIRCUIT SHT 2 OF 4

KEYTEK INSTRUMENT CORP.

DRAWING NUMBER 10-026-000-00



⬡ = J22, 7 PIN CONNECTOR

-\/\/\/-|(- = 10K, ½W - .033, 400V

⬡ = P23, 19 PIN CONNECTOR (REAR OUTPUT)

□ = J18, 18 PIN CONNECTOR (RELAY BD TO TURN ON RESISTOR)

○ = J11, 18 PIN CONNECTOR (FP BOARD TO FP)

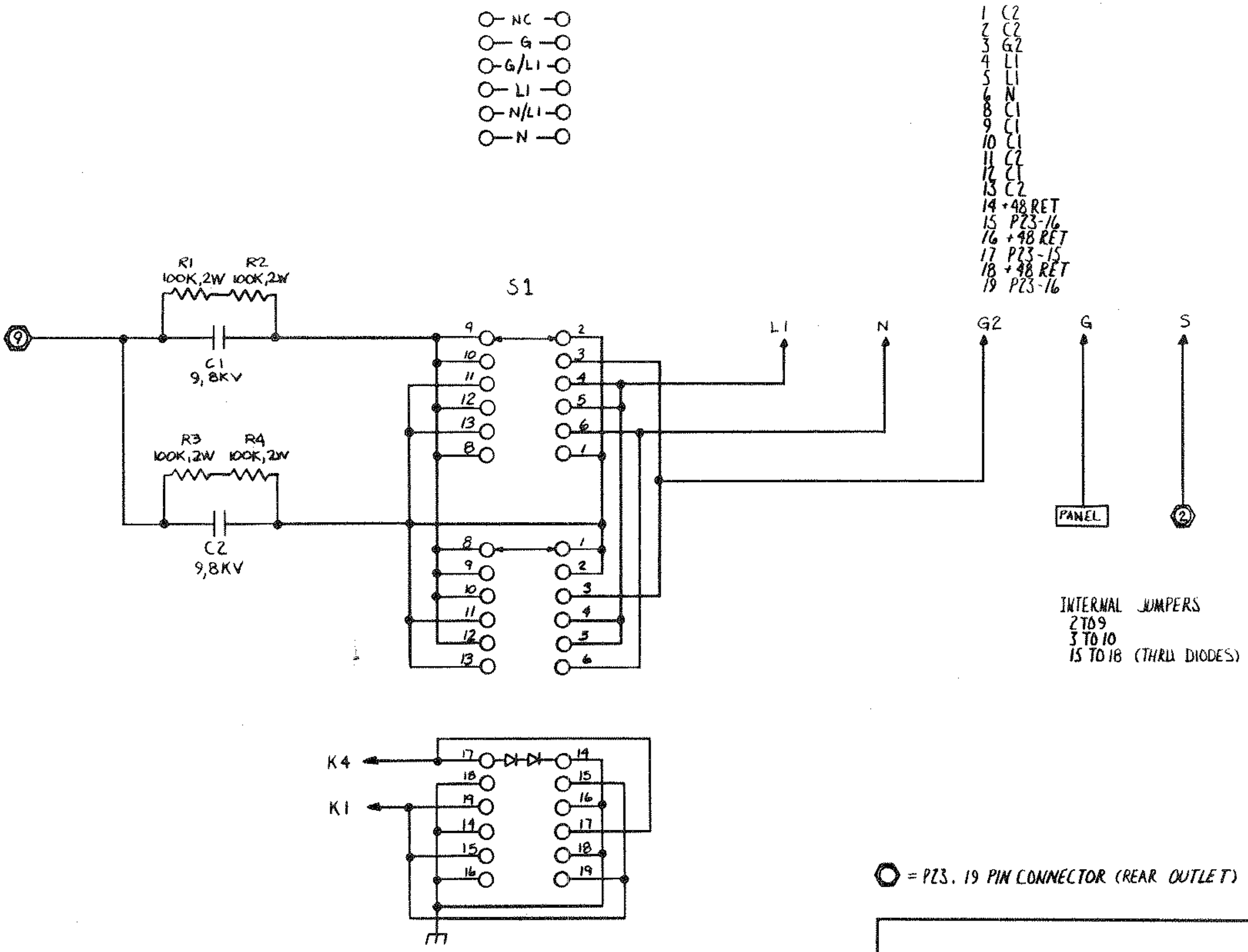
⬡ = J16, 12 PIN CONNECTOR (RELAY BD TO BOX)

□ = J14, J15, 18 PIN CONNECTOR

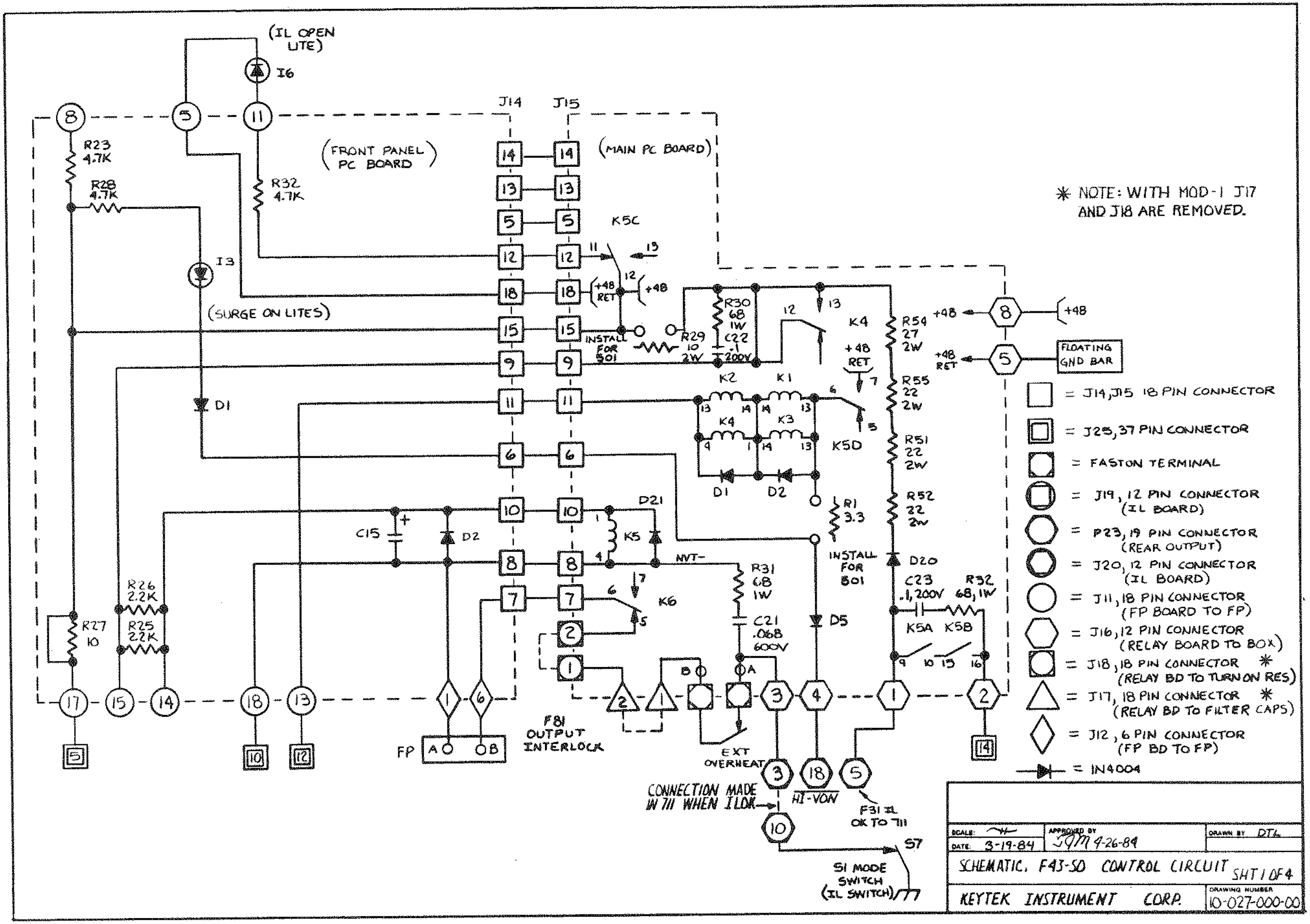
△ = J17, 18 PIN CONNECTOR (RELAY BD TO FILTER CAPS)

▣ = J25, 37 PIN CONNECTOR

SCALE: — DATE: 3-19-84	APPROVED BY JGM 4-26-84	DRAWN BY DTL
SCHEMATIC, F42-SO AC CIRCUIT		SHT 3 OF 4
KEYTEK INSTRUMENT CORP.		DRAWING NUMBER 10-026-000-00



SCALE: —
DATE: 3-19-84
APPROVED BY SJM 4-26-84
DRAWN BY DTL
SCHEMATIC, F42-50 SURGE CIRCUIT SHT 4 OF 4
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-026-000-00

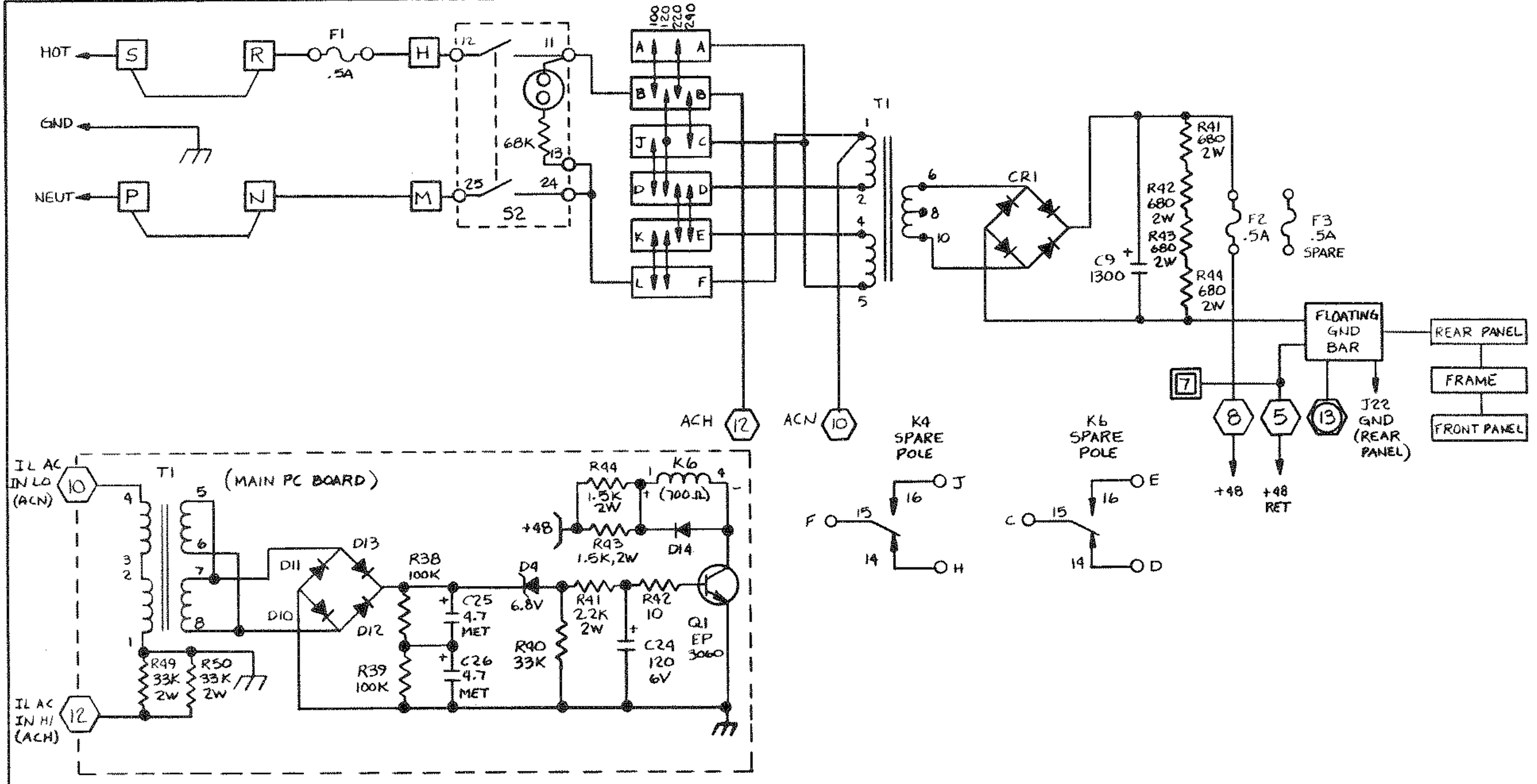


SCALE: —
DATE: 3-19-84
APPROVED BY JJM 4-26-84
DRAWN BY DTL

SCHEMATIC, F43-SO CONTROL CIRCUIT SHT 1 OF 4

KEYTEK INSTRUMENT CORP.

DRAWING NUMBER 10-027-000-00

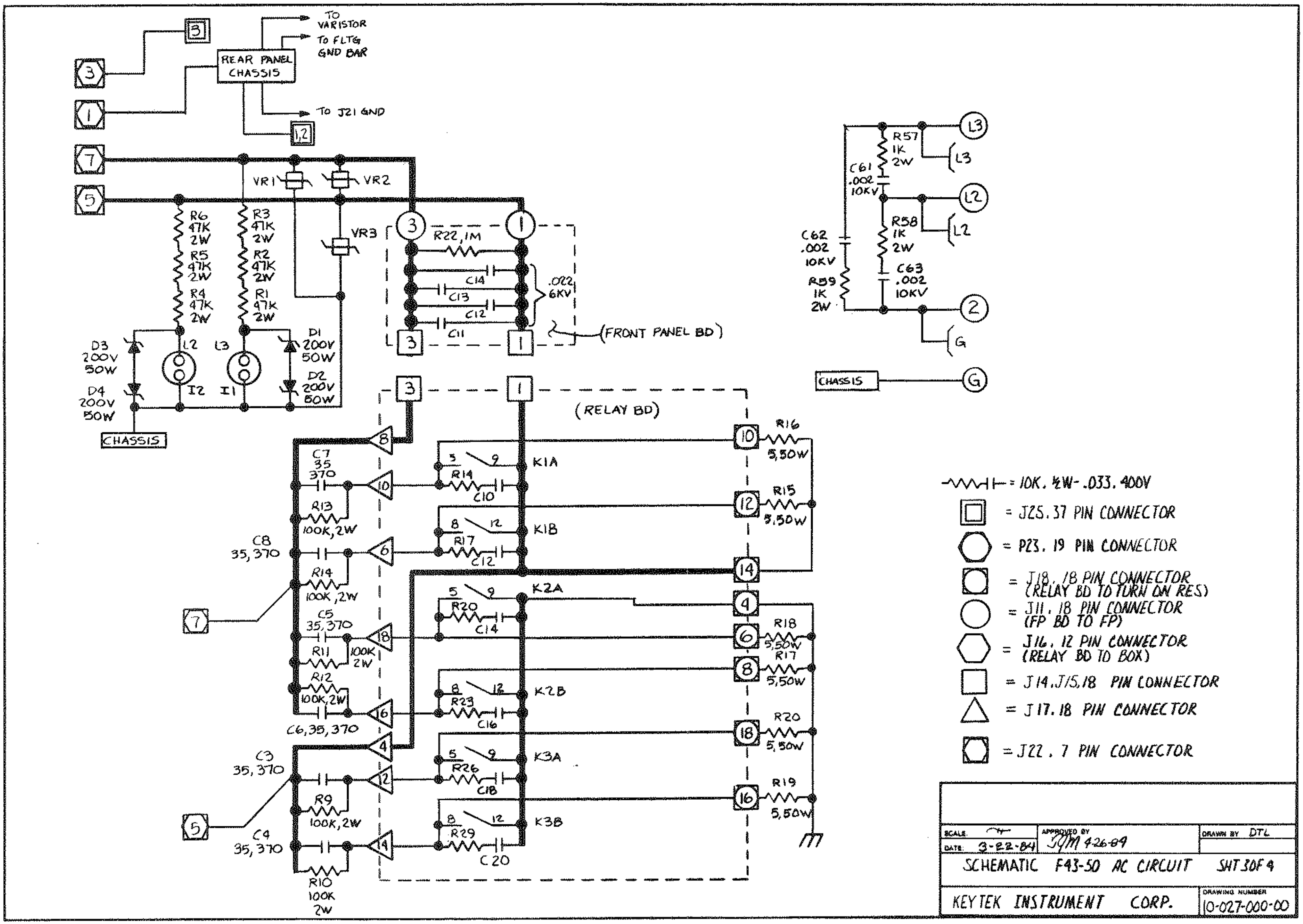


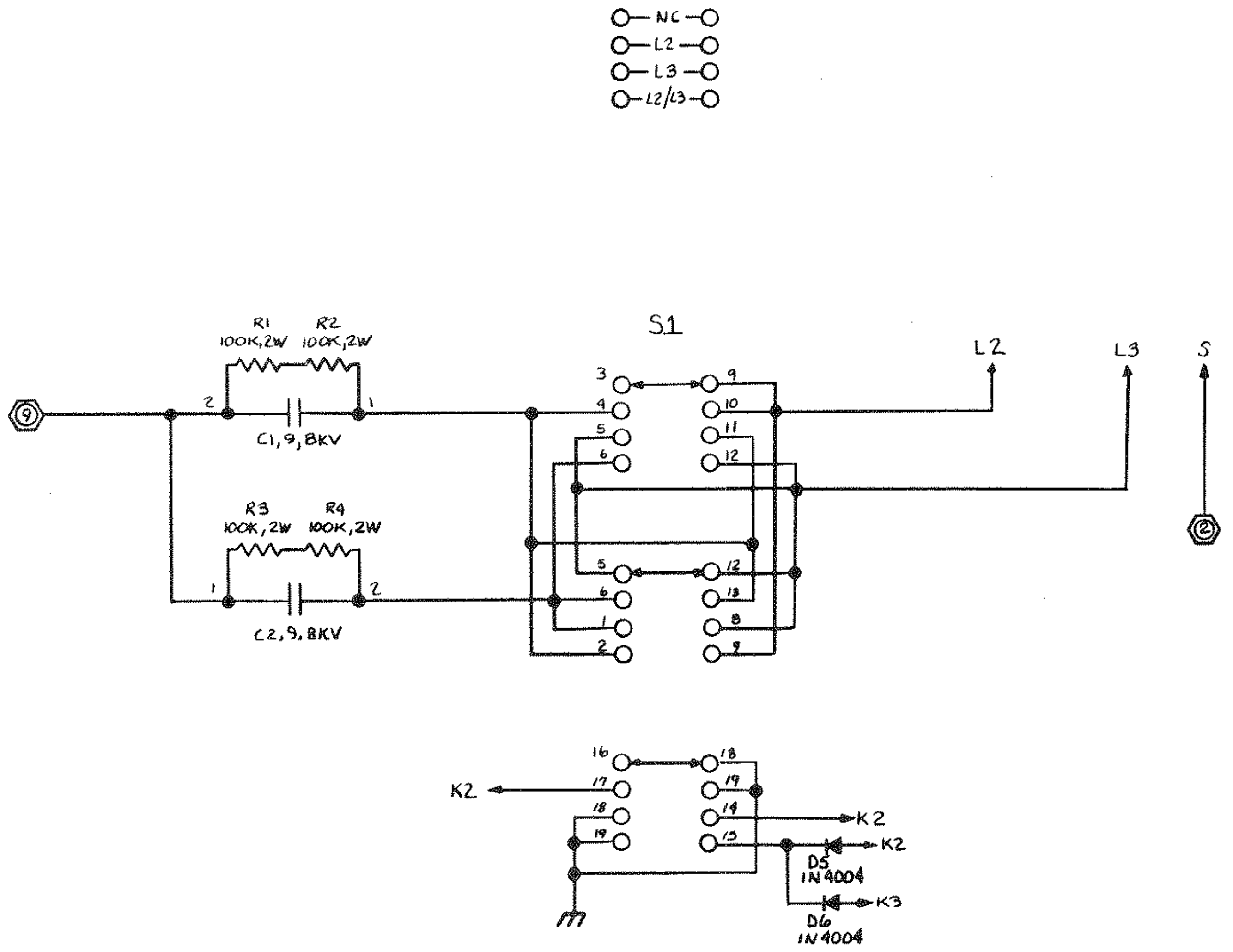
□ = J25.37 PIN CONNECTOR

⬡ =J16. 12 PIN CONNECTOR
(RELAY BD TO BOX)

○ = P23. 19 PIN CONNECTOR
(REAR OUTPUT)

SCALE: — DATE: 3-20-84	APPROVED BY ДМ 4-26-84	DRAWN BY DTL
SCHEMATIC, F43-SD CONTROL CIRCUIT SHT 2 OF 4		
KEYTEK INSTRUMENT CORP.		DRAWING NUMBER 10-027-000-00


TO VARISTOR
TO FLTG GND BAR
REAR PANEL CHASSIS
TO J21 GND
VR1
VR2
VR3
R6 47K 2W
R5 47K 2W
R4 47K 2W
R3 47K 2W
R2 47K 2W
R1 47K 2W
D1 200V 50W
D2 200V 50W
D3 200V 50W
D4 200V 50W
L2
L3
I1
I2
CHASSIS
R22, 1M
C14
C13
C12
C11
.022 6KV
(FRONT PANEL BD)
(RELAY BD)
K1A
K1B
K2A
K2B
K3A
K3B
R14
C10
R17
C12
R20
C14
R23
C16
R26
C18
R29
C20
C7 35 370
R13 100K, 2W
C8 35, 370
R14 100K, 2W
C5 35, 370
R11 100K 2W
R12 100K, 2W
C6, 35, 370
C3 35, 370
R9 100K, 2W
C4 35, 370
R10 100K 2W
R16 5,50W
R15 5,50W
R18 5,50W
R17 5,50W
R20 5,50W
R19 5,50W
R57 1K 2W
C61 .002 10KV
R58 1K 2W
C62 .002 10KV
R59 1K 2W
C63 .002 10KV
L3
L2
G
CHASSIS
= 10K. ¼W-.033. 400V
= J25. 37 PIN CONNECTOR
= P23. 19 PIN CONNECTOR
= J18. 18 PIN CONNECTOR (RELAY BD TO TURN ON RES)
= J11. 18 PIN CONNECTOR (FP BD TO FP)
= J16. 12 PIN CONNECTOR (RELAY BD TO BOX)
= J14. J15. 18 PIN CONNECTOR
= J17. 18 PIN CONNECTOR
= J22. 7 PIN CONNECTOR
SCALE
DATE: 3-22-84
APPROVED BY JGM 4-26-84
DRAWN BY DTL
SCHEMATIC F43-50 AC CIRCUIT SHT 3 OF 4
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-027-000-00

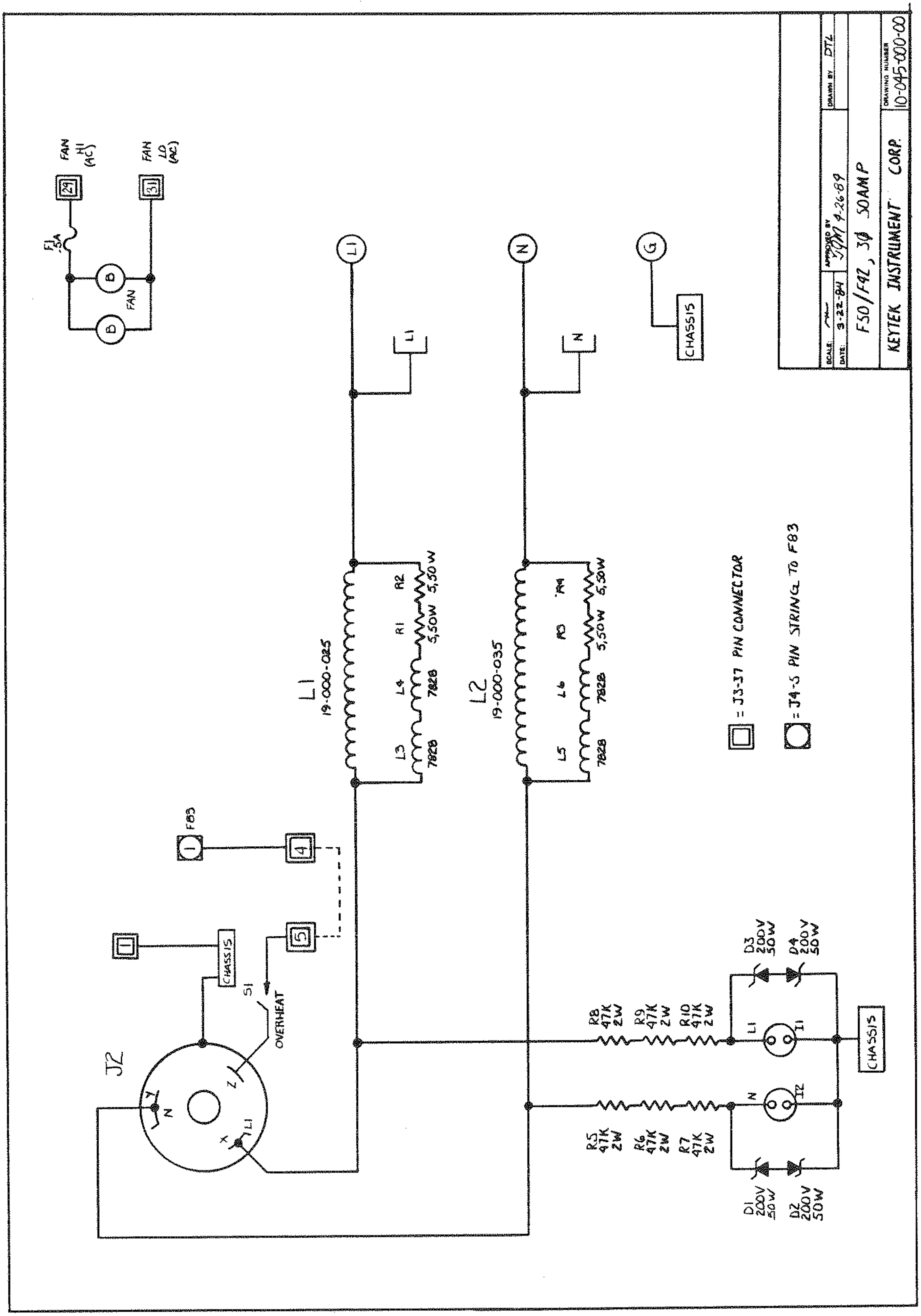


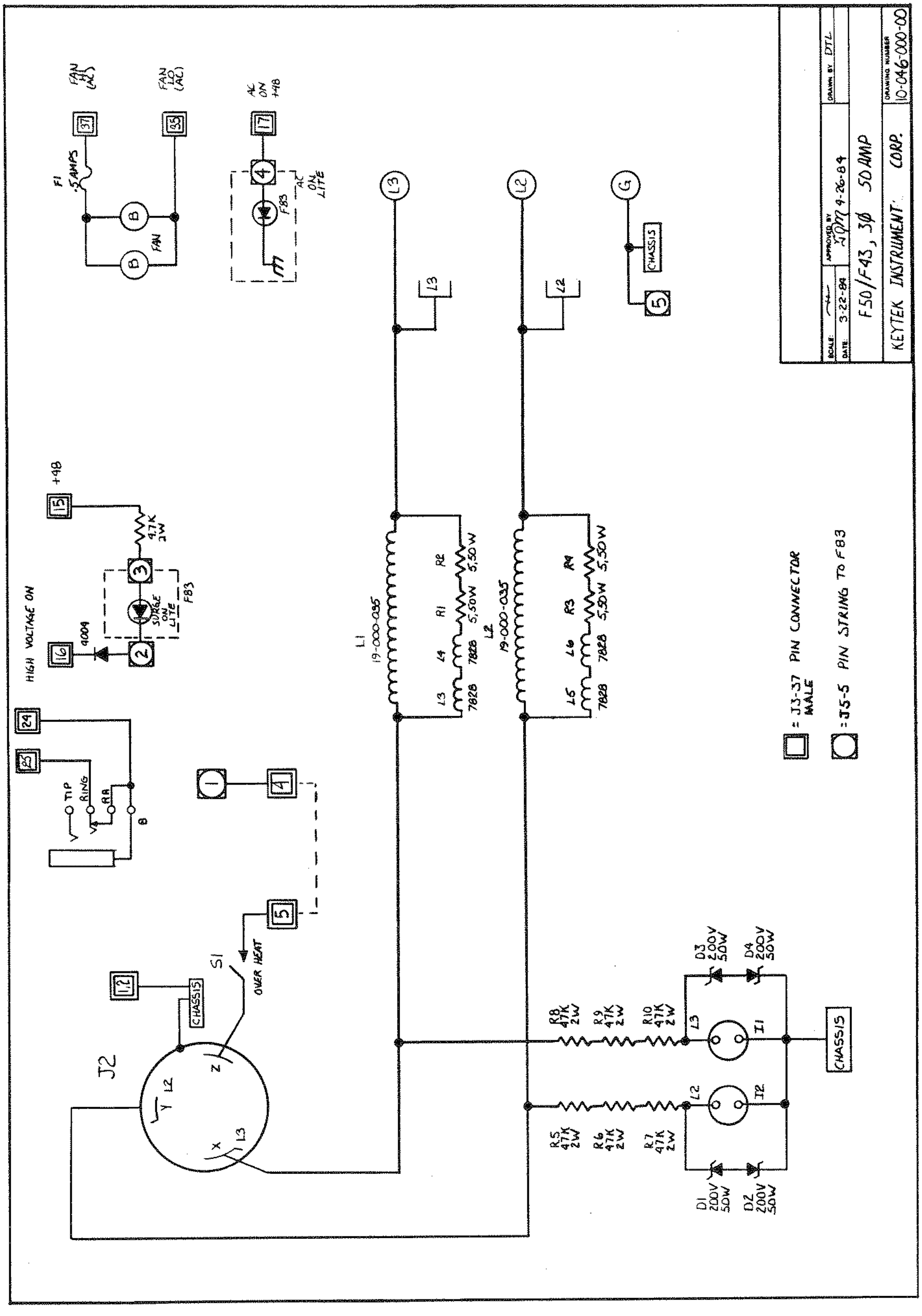
1 C2
2 C1
3 NO CONN
4 C1
5 L3
6 C2
8 L3
9 L2
10 L2
11 C1
12 L3
13 C1
14 P23-17
15 P23-14,17 (THRU DIODE)
16 NO CONN
17 P23-17
18 GND
19 GND

INTERNAL JUMPERS
3 TO 9
5 TO 12
16 TO 18

⎔ = P23 19 PIN CONNECTOR (REAR OUTPUT)

SCALE: —/—
DATE: 3-22-84
APPROVED BY SJM 4-26-89
DRAWN BY OTL
SCHEMATIC, F43-50 SURGE CIRCUIT
SHT 4 OF 4
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-027-000-00


FAN HI (AC)
29
FAN LO (AC)
31
F1 .5A
B
B
FAN
L1
N
G
L1
N
CHASSIS
L1
19-000-035
L3
L4
7828
7828
R1
R2
5,50W
5,50W
L2
19-000-035
L5
L6
7828
7828
R3
R4
5,50W
5,50W
= J3-37 PIN CONNECTOR
= J4-5 PIN STRING TO F83
F83
1
4
5
1
CHASSIS
S1
OVERHEAT
J2
Y
N
Z
X
L1
R8 47K 2W
R9 47K 2W
R10 47K 2W
R5 47K 2W
R6 47K 2W
R7 47K 2W
L1
I1
N
I2
D3 200V 50W
D4 200V 50W
D1 200V 50W
D2 200V 50W
CHASSIS
SCALE:
DATE: 3-22-84
APPROVED BY JOM 4-26-89
DRAWN BY DTL
F50/F92, 3Ø 50AMP
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER
10-045-000-00


FAN HI (AC)
FAN LO (AC)
AC ON +48
37
35
17
F1 .5 AMPS
B
FAN
4
F83
AC ON LITE
L3
L2
G
CHASSIS
5
+48
15
4.7K 2W
3
SURGE ON LITE
F83
2
4004
16
HIGH VOLTAGE ON
24
23
TIP
RING
RA
B
1
4
5
S1
OVER HEAT
12
CHASSIS
J2
Y
L2
Z
X
L3
L1 19-000-035
L3 7828
L4 7828
R1 5,50W
R2 5,50W
L2 19-000-035
L5 7828
L6 7828
R3 5,50W
R4 5,50W
R8 47K 2W
R9 47K 2W
R10 47K 2W
R5 47K 2W
R6 47K 2W
R7 47K 2W
I1
I2
D1 200V 50W
D2 200V 50W
D3 200V 50W
D4 200V 50W
CHASSIS
= J3-37 PIN CONNECTOR MALE
= J5-5 PIN STRING TO F83
SCALE: —
DATE: 3-22-84
APPROVED BY
4-26-84
DRAWN BY DTL
F50/F43, 3Ø 50 AMP
KEYTEK INSTRUMENT CORP.
DRAWING NUMBER 10-046-000-00

SECTION 9

9. Appendix A: Operation at Other AC Line Voltages

The Model 711A may be operated from an ac power source of 100, 120, 220 or 240 volts (±10%), 50-60 Hertz. The selection of the desired voltage is made prior to connecting the instrument to the power source in the following way:

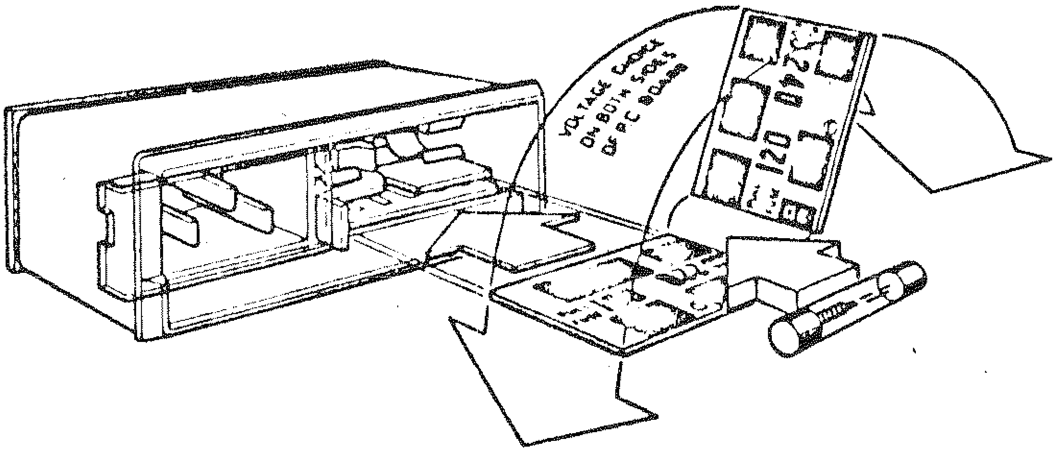
1. Make sure line cord is removed from rear panel.
2. Slide clear plastic protector cover from right to left,* covering the line receptacle and uncovering the fuse.
3. Pull fuse ejector out and all the way to the left, ejecting the fuse and providing access to the voltage selector board.
4. Using a pair of pliers, remove the voltage selector board, replacing it in one of the four possible positions with desired voltage designation showing after it is re-installed.
5. Install the covered fuse: 3A Slow-Blow for 100 and 120V operation, 2A slow-blow for 220 and 240V operation.
6. Push fuse ejector to the right and all the way back in, slide the clear plastic protector plate back in place over the fuse, and install the line cord in the now-uncovered receptacle.

Fig. 9-1 gives additional details.

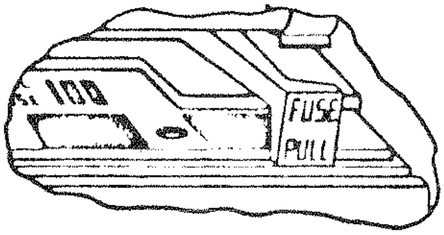
Power dissipation is approximately 50 watts average, 200 watts maximum. During the capacitor charge, peak line current reaches 15A for about 0.1 second, in 120V AC operation; 7-8A for the same duration in 220-240V operation.

*viewed from the rear

A three-conductor power cable is provided; when it is connected to a standard three-wire outlet, the instrument chassis is connected to power system ground. This prevents the instrument case from assuming voltages hazardous to personnel. In the event an adapter is used to connect the three wire cable to a two-wire outlet the green adapter terminal should be connected to the power system ground.



Operating voltage is shown in module window.



SELECTION OF OPERATING VOLTAGE

1. Open cover door and rotate fuse-pull to left.
2. Select operating voltage by orienting PC board to position desired voltage on top-left side. Push board firmly into module slot.
3. Rotate fuse-pull back into normal position and re-insert fuse in holders, using caution to select correct fuse value.

Fig. 9-1

10. Appendix B: Removing/Replacing Plug-in Units (CPC, ARU, LSU, VIS, etc.)

To remove plug in unit such as the Charge/Pulse (CPC), ARU, LSU, VIS, etc. (not including the Surge Network -- for that, see section 3-1):

1. Shut off all Model 711 power.
2. For the VIS, at the rear of the 711 unit, remove the PV-2 Probe to VIS-102 cable connector.
3. Remove the plug-in unit from the 711. This is not easy as removing a Surge Network, since it is done infrequently. The procedure is:

   A. Rotate the rectangular knob at the bottom of the plug-in panel, 90 degrees clockwise.

   B. While bracing yourself with one hand against the upper left of the Model 711, pull very hard on the rotated knob.

   C. Only if the plug-in unit won't become free from its rear connector with a great deal of force, then:

      * Remove 711 top cover, by removing the two screws that secure it in back of the top rear. Slide cover to rear at least 12 to 15 cm.

      * Use a screwdriver at the top front of the plug-in unit, pushing forward against the inner frame of the plug-in unit to assist; while also continuing to pull on the 90 -rotated front knob.

SECTION 11

11. Appendix C

Relevant Application Notes: AN106 and AN111

Application Note 106

Conductive Surge Testing of Circuits and Systems

KeyTek Instrument Corp.
Burlington, Massachusetts
617-272-5170

as presented at the

FAA-NASA Symposium
on Lightning Technology

Florida Institute of Technology
April 22-24, 1980

SUMMARY

Techniques are given for conductive surge testing of powered electronic equipment. Dealt with first are the correct definitions of common and normal mode.

Testing requires not only spike-surge generators with a suitable range of open-circuit voltage and short-circuit current waveshapes, but also appropriate means – termed couplers – for connecting test surges to the equipment under test. Key among coupler design considerations is minimization of "fail positives" resulting from reduction in delivered surge energy due to the coupler.

Also included is some mention of back-filters and the lines on which they are necessary; plus ground-fault and ground potential rise considerations, as well as a method for monitoring delivered and resulting surge waves.

INTRODUCTION

Years of effort by a number of organizations have resulted in several generally-accepted, standard spike-surge test waves. Different waves have been specified for several of the most important application areas. These include waves for simulating typical ac power line spike transients (refs. 1 and 2), and for testing telecommunications lines and protectors both in the U.S. (refs. 3 and 4) and internationally (ref. 5). While specialized areas may require variations in these waves or even totally different ones (refs. 6 and 7), the mainstream – most electronic equipment – can generally be addressed by one or more of the new standards.

Some of the newer waves (refs. 1 and 7) are designed to test not just for susceptibility (upset or malfunction), but also for vulnerability (damage). For this reason they are relatively long impulses, implying the need for coupling and filtering effectiveness at levels well beyond what has been necessary heretofore.

SYMBOLS

C	capacitor (used for wave coupling), μF
$e(t)$	general expression for a time-variant voltage, volts
$e_{IN}(t)$	input signal, volts
$e_{OUT}(t)$	output signal, volts
E	peak of surge wave, volts
$i(t)$	general expression for a time-variant current, amperes
$I(s)$	Laplace transform of $i(t)$
L	inductance, Henries
Q	quality of a resonant circuit, non-dimensional
R	load resistance, ohms
t	time, independent variable, secs
t_a	time of first zero-axis crossing of a capacitor-coupled impulse wave, secs
t_x	time of intersection of a wave with a fixed voltage level V, secs
$t_{.5\ IN}$	time for decay to 50% of peak for a network input impulse, secs
$t_{.5\ OUT}$	time for decay to 50% of peak for a network output impulse, secs
s	the Laplace operator
T	exponential decay wave time-constant, secs
V	fixed clamping voltage, volts
Wo	energy, total deliverable by a surge wave to a load resistance R, joules
W	energy, total actually delivered by a circuit to a load resistance R, joules
W+	energy, total actually delivered by the positive portion of a wave to a load resistor R, joules
W−	energy, total actually delivered by the negative portion of a wave to a load resistor R, joules

COMMON AND NORMAL MODES

Except in the unlikely event that ground is used as a return path, equipment inputs and outputs are usually ungrounded two-terminal-ports. Elsewhere in the system, one line of each such pair may be connected to ground. However, in view of line inductance, for spike surges it is safest to treat this distant ground connection as the high impedance it usually is.

Thus in most surge test situations, at least two essentially ungrounded lines are involved, with the one that may be connected via line impedance to a remote ground referred to as "low." In addition, there exists the local ground, connected via some other line or conduit impedance to a perhaps different but equally remote ground. The situation is shown, highly-simplified, in Figure 1.

One of the major sources of upset or damage due to surge is the circuit involving equipment local ground, or common, and one or both of the input lines. Surge currents seeking earth can usually pass with least resistance and inductance via the ground; thereby causing significant ground potential rise. The effect can produce extreme potentials between local ground — or common — and either or both lines of the pair. This is in fact the original, and now only the alternative, definition (ref. 8) of "common-mode"; i.e., signals applied not to both sides of the input pair *in* common, but rather from any one or more leads *to* common, or ground.

The reason for stressing this correct definition of common mode, is that experience has shown that the terminal pair at which surges can be most damaging is often the one composed of input or output low, and ground. This is one of the *three* common modes for a typical "two-terminal-port." The remaining ones are from high to ground (or common), and finally from high and low simultaneously — perhaps less ambiguous usage than "in common" — to ground.

SURGE TEST WAVES: IMPULSIVE AND OSCILLATORY

Figure 2 shows an oscillatory wave and Figure 3 an impulse, in each case accompanied by conventional definitions (refs. 1 and 12).

Oscillatory surge waves, with effective Q's ranging from 2 or 3 to 20 or 30, are often found in measurements in actual equipment. Some test waves are therefore specified as oscillatory (refs. 1, 2 and 6). However, impulse waves have also been measured (refs. 9 and 10) and generally can convey higher energy content per surge. In addition, in view of flash-over-imposed peak *voltage* limitations in low voltage systems, frequencies on the order of one or just a few kHz must be postulated for oscillatory waves with enough energy to simulate, in the laboratory, damage that has actually occurred; at which point the distinction between impulsive and oscillatory becomes academic. This blurring is particularly true in light of the low Q's, typically 2 to 4, of many measured "oscillatory" waves. Their first overshoot is often no more than 30 to 40% of first peak amplitude. This can be not too dissimilar from the overshoot obtained by capacitance coupling a unidirectional impulse wave for test purposes.

Impulses have also historically been chosen to test surge protectors (refs. 4 and 11), and hence find application in vulnerability, or damage testing, when energy in the tens or even hundreds of joules must be delivered to simulate field situations in which protectors may be involved.

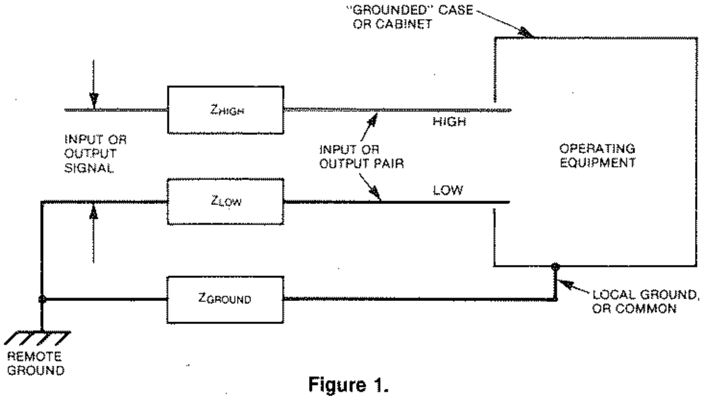


Figure 1.
TYPICAL INPUT OR OUTPUT LINE PAIR
TO/FROM OPERATING EQUIPMENT

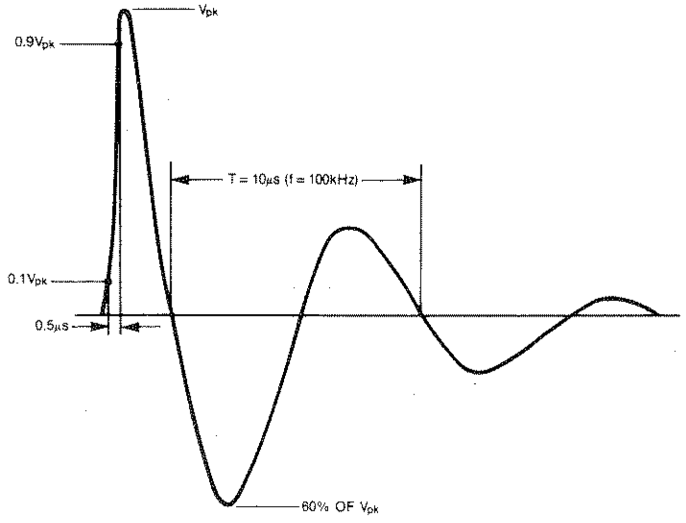
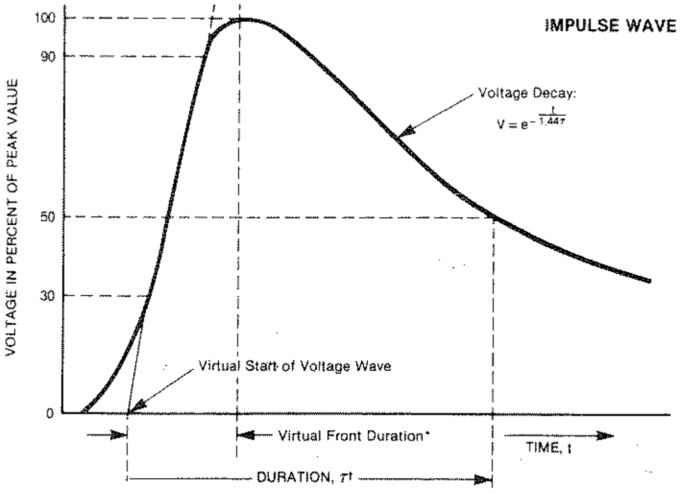


Figure 2.
SPECIFICATION FOR STANDARDIZED
100 KHz "RING" WAVE FROM REFERENCE 1



* 1.67 x the time from 30 to 90% for voltage, or 1.25 x the time from 10 to 90% for current (ANSI Std. C62.1—1971).

† Time from virtual start of wave, to the point following the peak at which the wave has decreased to half the peak value (ANSI Std. C62.1—1971).

Figure 3.
SPECIFICATION FOR STANDARDIZED
IMPULSE WAVE FROM REFERENCE 12

COUPLING THE TEST SURGE WAVES

Wave-coupling requirements are minimal for some of the standard surge waves, particularly for fractional or low-joule oscillatory surges like the IEEE/UL, 100 kHz damped cosine (refs. 1 and 2), or the IEEE power sub-station 1 MHz damped cosine (ref. 6). The low energy levels and oscillatory nature of such waves, make them most suitable for upset rather than damage evaluations. These characteristics also imply small coupling capacitors, typically in the range below one, or at most just a few microfarads, to couple the test surge; even for rather heavy loads. This still holds true, for example, for loads drawing 15 to 30 amperes from a 115 V ac power line, with implications of only a few ohms load impedance. The 1.2 x 50 impulses of the newest IEEE ac power line guide (ref. 1), the 10 x 700 impulses now standard in international telecommunications (ref. 5), and the 10 x 1000 impulses of U.S. telecommunications (refs. 9 and 10), all require more complex and sophisticated approaches both to coupling and to filtering the surge test waves. And so, surely, will the 4 x 200 (or longer) waves implied for power lines by a recent EPRI study (ref. 7). The 4 x 200, if it eventuates, will be even more difficult to couple than the still longer telecommunications waves, since ac load impedances are likely to be lower than telecom loads – just a few ohms for heavy equipment. The combination of low load impedance with relatively long waves implies that coupling capacitors will be huge; and ac lines are seldom as suitable as candidates for gas-tube surge coupling as are telecom lines and others.

All of the long impulse waves carry tens or hundreds of joules. It is therefore important to use these waves with couplers that don't reduce their energy appreciably.

Figure 4 shows a variety of multi-line surge couplers.

CAPACITIVE SURGE COUPLING

The simplest coupler, conceptually, is probably a capacitor. It is suitable for cases in which surged lines can operate normally with the capacitor in place, when the surge isn't present.

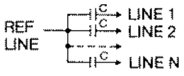
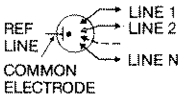
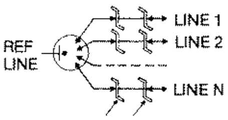
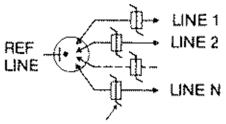
CONDITIONS	COUPLER	APPLICATION NOTES
1. LOW-Z LINES (POWER, ETC.)	 SURGE-RATED CAPACITORS	$\left(\frac{V_{OC}}{I_{SC}}\right) C \geq$ SURGE WAVE DURATION (UNLESS LINE Z IS KNOWN)
2. HI-Z LINES WITH STANDING V< 10 TO 15 V AND NO SIGNIFICANT CURRENT CAPABILITY	 MULTI-ELECTRODE GAS GAP	APPLIED SURGE EDGES MAY BE STEEP DUE TO GAS-TUBE TURNON
3. HI-Z LINES WITH STANDING V> 10 TO 15 V (REPEATERS, ETC.)	 SILICON AVALANCHE DEVICES	AVALANCHE V> CIRCUIT STANDING VOLTAGE
4. SAME AS (3)	 VARISTORS	VARISTOR CLAMP V> CIRCUIT STANDING VOLTAGE

Figure 4.
MULTI-LINE SURGE COUPLERS

The circuit of Figure 5 shows a series capacitor, C, coupling the exponentially-decaying impulse, E exp (–t/T), to a shunt load R. From the surge standpoint, of greatest interest for even this extremely simple circuit are the energy implications.

The input wave is:

$$e(t) = E\,e^{-t/T} \qquad (1)$$

The Laplace circuit equation is:

$$I(s)(R + 1/Cs) = E/(s + 1/T) \qquad (2)$$

from which the output may be solved for as:

$$e_{OUT}(t) = E\left(\frac{RC}{RC - T}\right)(e^{-t/T} - Te^{-t/RC}) \qquad (3)$$

The axis crossing, t_a, is found by setting equation (3) equal to zero and solving for t. It is:

$$t_a = T\left(\frac{RC}{RC - T}\right) \ln (RC/T) \qquad (4)$$

(In the limit, for RC = T, t_a is also equal to T.)

The energy the input wave would deliver to R with C shorted is:

$$Wo = \int_0^{\infty} (1/R)e^2(t)dt \qquad (5)$$

which, when solved, yields:

$$Wo = E^2T/2R \qquad (6)$$

Total energy delivered to R by the actual output wave of equation (3) is

$$W = \int_0^{\infty} (1/R)e_{OUT}{}^2(t)dt \qquad (7)$$

which yields

$$W = (E^2T/2R)\left(\frac{RC}{RC + T}\right) \qquad (8)$$

Finally, the fraction of Wo delivered, from equations (6) and (8), is:

$$W/Wo = RC/(RC + T) \qquad (9)$$

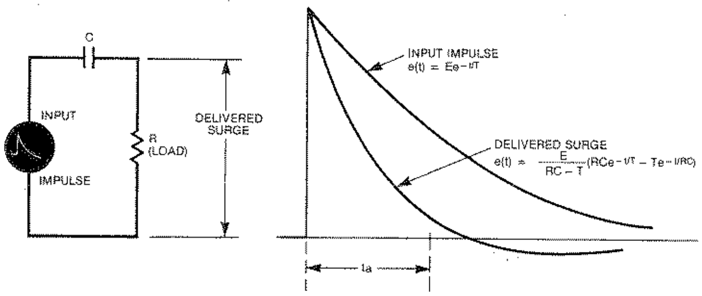


Figure 5.
CAPACITOR-COUPLED IMPULSE

Similar calculations for the energy W+ delivered by the (+) portion of the e_{OUT} wave – i.e., integrating from 0 to t_a – and the energy W– delivered by the (–) portion, give results included in the numeric summary that follows.

Conclusions are summarized in Table I for this circuit. Specifically, if the RC time constant is equal to the decay time constant, then W/Wo – the ratio of total energy delivered to R, to what would be delivered if C were either infinite or a short circuit – is ½. Thus half the total available wave energy will be undelivered for this case. Further, the energy W+ contained in the positive-going portion of the delivered wave, will be only .43 times the total available energy.

Increasing the value of the coupling capacitor improves the situation, but a dramatic increase – by perhaps 10 to 1 – is necessary before, as shown in Table I, even 85% of the available energy can be furnished to R during the positive-going portion of the delivered wave. Also note the results of undersizing C. If RC is reduced only by half, to .5T, then just 29% of the available wave energy will be delivered on the positive peak.

Other characteristics of the energy transfer from the impulse wave through the capacitor are also shown in Table I. The axis-crossing, t_a, is given (it is equal to T if RC equals T.) The time to 50% of peak, usually taken as a crucial duration measurement for an impulse, is given in ratio form as $t_{.5\ OUT}/t_{.5\ IN}$. The table shows that this duration ratio tracks, very nearly, the ratio W/Wo of delivered to available wave energy. Finally, the energy in the overshoot, W–, is related to Wo in the ratio W–/Wo.

The implications of the figures of Table I are clear. To couple a typical 50 μS duration impulse to a power system will require on the order of a 100 to 150 μS time constant to deliver a credible portion of the available wave energy. If the system being surged consumes 15 A at 115 V, say, its impedance will be 115/15 or about 8 ohms, ignoring inductance. Obtaining a 150 μS time constant under these circumstances will require about a 20 μF capacitor, presumably at six to eight kV, to deliver a typical 6 kV surge (ref. 1). Such capacitors imply large filter inductors and capacitors for the L-C filter that will keep the surges from reaching unsurged power lines. As a result, it may be difficult even to turn the circuit breaker on to activate such a power line, in view of the heavy capacitance loads such filters imply. Electronic or thermal time delays, or variable transformers, may be required to turn on line power.

The simple capacitor can do a fine job of surge coupling; provided it is large enough, and provided that the implications of its large value on the surge-decoupling filter are taken into account. Generally, the capacitor value C should be of such a size that RC, the (load) x (capacitance) time constant, is in *no* event less than T, the impulse wave decay time constant; and preferably 2T. It should also go without saying that the capacitor must have a voltage rating equal to the largest peak expected for the test surge, plus the maximum opposite-polarity voltage that can exist on the driven line at the time of the surge. Any lower rating will risk capacitor failure in the event the driven load breaks down, and the impulse source is stiff enough to charge the capacitor to almost the full impulse peak.

RC/T	t_a/T	$\frac{t_{(.5OUT)}}{t_{(.5IN)}}$	W/Wo	W_+/W_o	W_-/W_o
.1	.3	.1	.09	.09	.01
.5	.7	.3	.33	.29	.04
1	1	.5	.5	.43	.07
2	1.4	.6	.67	.58	.08
10	2.6	.9	.91	.85	.05

Table I.
EFFECT OF CAPACITOR COUPLING
ON IMPULSE PARAMETERS

GAS-TUBE SURGE COUPLING

More complex couplers use gas tubes, alone or in combination with clamping surge protectors, to surge higher-impedance lines which can't operate normally when shunted with large capacitors.

While the gas tube couplers of Figure 4 have the advantage of connecting the surge source only when the surge exists, they have various disadvantages as well. Foremost among them is the fact that a gently-sloping surge front, as may be specified for a particular simulation, will be turned into a super-steep, nanosecond edge when the gas tube conducts. This severe waveform alteration is shown in Figure 6.

Clamping protectors are often used in series with gas tubes as shown in Figure 4, to allow disconnect after the surge even if there is voltage above the gas-tube arc potential "standing" regularly on the line being surged. The series clamping pro-

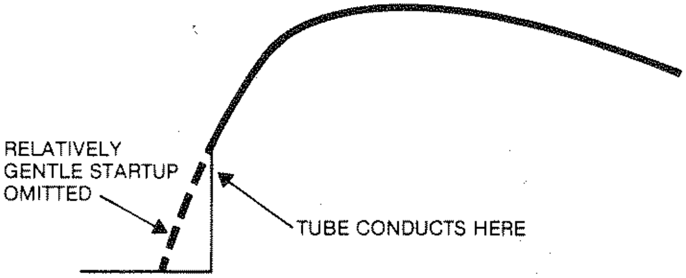


Figure 6.
GAS-TUBE COUPLER MODIFICATION
TO LEADING EDGE OF CLASSIC 10 X 1000 WAVE

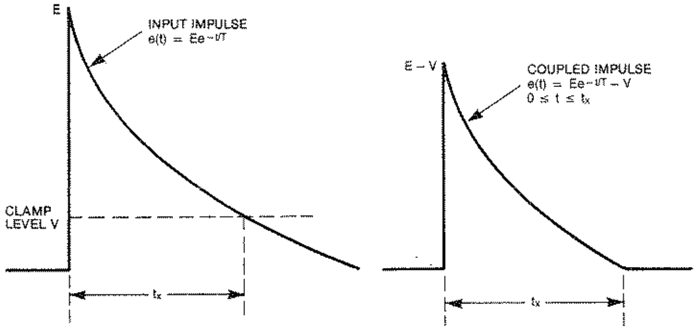


Figure 7.
LOW-END "CHOP" DUE TO USE OF
VARISTOR OR SILICON SUPPRESSOR IN SURGE COUPLER

tectors, however, will have the effect of reducing energy applied to the test piece since they remove the lowest, heavy energy-bearing portion of the decaying exponential. This is true as well if the clamping protector is used alone, without the gas tube, to couple the surge. Figure 7 shows the clipping effect.

For the wave E exp (−t/T) shown in the figure, clipped off below V, the delivered energy to a load R is reduced to 68% of available for V/E = .1 "Available" energy, Wo, is taken to be the energy of the unclipped wave delivered to a load R, again given by equation 7, as $Wo = E^2T/2R$. Actual energy delivered may be found in a manner similar to that used to solve for the capacitor-coupled case, and the ratio likewise can be determined to be:

$$W/Wo = 1 - 4(V/E) + (V/E)^2(3 + 2 \ln (E/V)) \qquad (10)$$

If V/E = .2, less than half of the available energy is delivered – 45% to be exact. A value for V/E of .1, is a typical situation for a 300 to 350 V varistor coupling a 5 to 6 kV wave; at full current, the varistor will require on the order of 600 to 700 V. At lower surge peaks, such as the 3 kV recommended for some surging by IEEE (ref. 1), the same varistor will constitute 20% of peak voltage, i.e. V/E = .2, and over half the available energy will be undelivered. *It is particularly worth noting that even if the surge peak is readjusted to deliver the original desired peak voltage to the load, clipping off the lower "tail" of the exponential will still leave energy errors about equal to half the errors cited above.*

ISOLATING AND SURGING THE EQUIPMENT UNDER TEST

Figure 8 shows the basics for a system to apply normal-mode surges to an Equipment Under Test (EUT). The situation depicts application of test waves to the ac lines powering the EUT, but it could as easily be to any other input or output line pair, so long as surge filters are interposed between the EUT and the lines' destination.

Common-mode surging, between any line(s) and ground, is accomplished in analogous manner, by connecting the surge generator Lo to ground, and employing a multi-line coupler *if* more than one line is to be surged in common mode.

As shown in Figure 8, the ac line to be surged is first applied to an isolation transformer, to provide ground fault isolation. This transformer in no way assists in filtering the surge from the input, it merely makes possible use of the large filter capacitors necessary to reduce the surge at the input, while still retaining the possibility of using a ground fault circuit interrupter (GFCI) in the power line. If a GFCI is not in place or is not required, the transformer may be omitted.

(It should be noted that during the surge test, ac power to the EUT cannot be monitored by a GFCI; so suitable precautions should be taken to operate without one. Even if a GFCI is in place at the input, and an isolation transformer is used as shown, unbalance current in the transformer secondary won't be measured as such by the primary GFCI.)

The ac is then connected to a surge back-filter, consisting in its simplest form of two series chokes – one in each line of the pair – and a total of three capacitors between them and to ground, as shown.

The surge is applied at this point, with no connection mandatory between points A and B in the figure tying the surge generator low to the ground of the EUT, although at least a clamping protector between them is an excellent precaution. The most important point is that continuing grounds from the EUT to other equipment must be disconnected as shown, along with the local EUT ground; in effect, the EUT must become the end of the line for ground. This implies that the case or cabinet of the EUT may rise to a high surge potential during the test. Suitable precautions must be taken, as indicated later on in connection with Figure 9.

The connection between points A and B may be made directly, although an ungrounded-output surge generator as such is still far preferable, so that it may be grounded at this point only, if at all. Of course for common-mode surging, the connection must be omitted between A and B, as must be the protector.

Note that all ground and low lines in the figure are shown as series impedances. This is done to emphasize the fact that if a surge travels via one of them, it will generate a large resulting ground potential rise – possibly as great or even greater than the applied peak surge voltage.

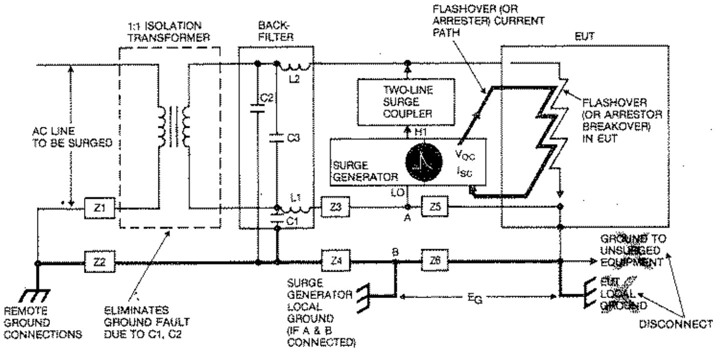


Figure 8.
NORMAL-MODE SURGE TESTING

MONITORING WITHIN SURGED EQUIPMENT

There may be excellent reasons for monitoring the results of the applied surge, deep within the EUT, to find the peak voltage reached across a particular component or circuit for

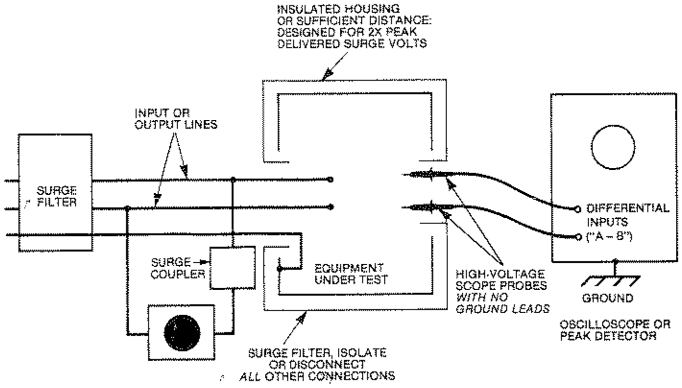


Figure 9.
MONITORING WITHIN SURGED EQUIPMENT

example, or its specific breakdown mode. Figure 9 shows a recommended monitoring scheme, which further illuminates some of the considerations touched on in the preceding section in regard to ground and isolation of other signals to and from the EUT.

The most important point to be made in connection with Figure 9 is the requirement for a barrier surrounding the EUT, to provide safety and a guarantee against flashover to any other object. This barrier may be simply sufficient separation — including from the floor, which must be presumed to contain conduit or other metal. Alternatively, the entire barrier can be physical insulation. In either case, it should be complete, except where penetrated for insertion of input or output lines, and measurement probes; and it should be safe for a peak voltage equal to at least twice the peak of the incident test surge. (Circuits in breakdown can oscillate at high rf frequencies, and can thereby increase applied peaks by a factor approaching two.)

All other lines must be removed from the EUT; or if it is not possible to do so, then they must be surge-back-filtered like the lines actually being surged; since if flashover occurs within the EUT, it may be conducted to any port.

Monitoring is accomplished, as indicated, most readily on a differential basis. This enables use of safely grounded oscilloscope or peak detectors, *with high voltage probes that have no ground leads attached.* "Ground" within the EUT may not be ground at all, and the scope (or peak detectors) should *not* generally be connected to it.

Probes with safe peak-voltage margin for at least twice the applied surge peak should be employed. Ordinary low-voltage scope probes are unsafe, even if the *resulting* circuit peak voltages are thought to be just a few hundred volts; since under fault conditions an internal EUT flashover or other malfunction may apply enough voltage to destroy the probe, the monitor device input circuits, and possibly even other equipment, if it can once enter the laboratory ground system via this route.

Of course, elimination of other input and output lines, or even altering their impedance and so on with filters, may give a less than totally realistic result for surge response. However, nothing short of surging with actual lightning or the other physical phenomena being simulated can eliminate this conceptual limitation. Until generation of such natural phenomena becomes both necessary and practical, the suggested methodologies stand as a reasonable and generally successful approach.

As a final point, oscilloscope (or other monitor) common-mode and noise rejection should be carefully checked. This is best accomplished with both inputs first monitoring the total input surge, and then EUT ground; to insure that oscilloscope readings aren't unduly limited by noise.

CONCLUDING REMARKS

Spike-surge testing of powered electronic equipment has become practical, with the advent of quantitative specifications on standard waves for a variety of different situations. Led by this quantitative approach, it is now possible to couple without undue losses, to calculate, and even to measure the energy levels involved in test surges. Results include increased understandings of failure modes pertinent to specific equipments, waves and so on.

Methods for applying the surges have been developed for normal and all forms of common-mode, along with coordinated filtering to prevent them from reaching unsurged lines. Equally important has been evolution of a simple, safe approach to monitoring surge results deep within the equipment under test, for diagnostic purposes, without jeopardizing the overall system or laboratory ground system.

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Application Note 111

Bi-Wave™ Surge Testing

Single-Output, Voltage and Current Surge Generation for Testing Electronic Systems

KeyTek Instrument Corp.
Burlington, Massachusetts 01803
617-272-5170

as presented at the

1983 IEEE International Symposium
on Electromagnetic Compatibility

Arlington, VA
August 23-25, 1983

ABSTRACT

Historically, spike-surge testing required prior knowledge of test piece impedance – high for insulation, low for arresters – to allow operator selection of a voltage or a current surge. When a modern electronic system connected to the ac power line is the test piece, however, it can be both a high and a low impedance during the same surge, as a result of flashover, or of arrester performance – clamping or crowbar action. Making separate voltage and current surge tests may not detect all potential equipment failures.

New, single-output surge generators, designed specifically to test modern electronics, respond immediately to the input impedance of the circuit or system under test, by supplying either the 1.2 x 50 classic voltage wave or the 8 x 20 traditional current wave, as instantaneously required by the load.

INTRODUCTION

Surge testing evolved in the high-voltage laboratory as a method of testing either insulation or surge arresters.

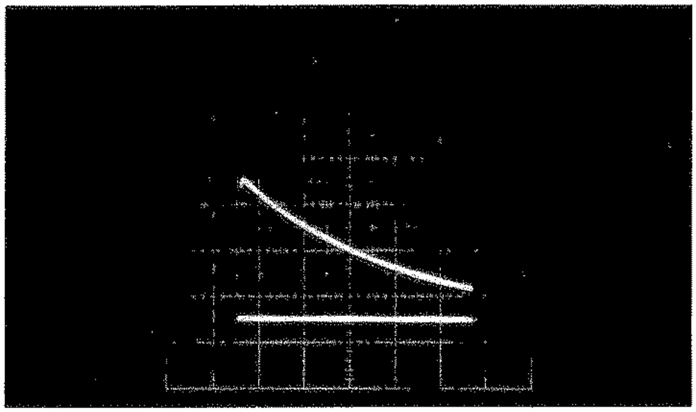

Figure 1.
TYPICAL 1.2 x 50 μs OPEN-CIRCUIT VOLTAGE SURGE WAVEFORM
(1 kV/SMALL DIV, 10 μs/SMALL DIV)

For insulation, a 1.2 x 50 μs high voltage wave (Fig. 1) was applied to the test piece (1). Only milliamperes were available from the surge generator, but that was sufficient: either the insulation flashed over or it didn't.

On the other hand, for a power transmission or distribution arrester, tests were designed in such a way as to force an 8 x 20 μs current wave (Fig. 2) through the device under test, using thousands, or even tens of thousands of amperes (1). The resulting voltage developed across the device was then measured.*

With modern electronic circuits and systems, however, these traditional surge test impedance concepts can be misapplied; to understand this, it is necessary to review the power-line surge environment, as well as surge input characteristics of typical electronic systems.

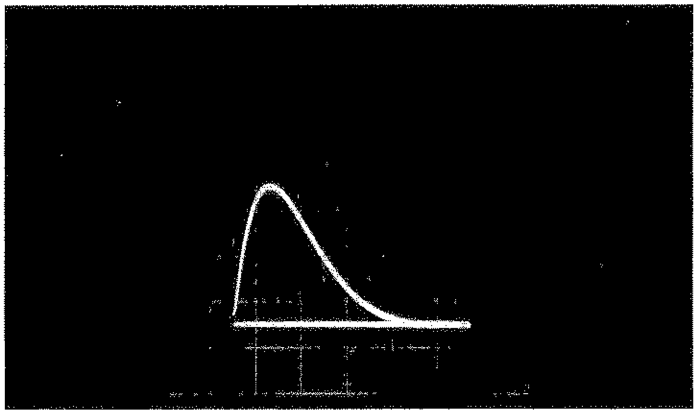

Figure 2.
TYPICAL 8 x 20 μs SHORT-CIRCUIT CURRENT SURGE WAVEFORM
(500 A/SMALL DIV, 5 μs/SMALL DIV)

SURGE ENVIRONMENT VERSUS SURGE INPUT IMPEDANCE FOR MODERN ELECTRONIC EQUIPMENT

Power-Line Surge Environment

IEEE Std 587-1980 characterizes the surge environment at various locations on the ac power line (2). Two primary locations are identified. Category A represents long-branch circuits, i.e. the typical wall socket. Category B is the designation for short-branch circuits, i.e., for higher-power systems, either located at short wiring distances from the breaker box or distribution panel, or driven directly from them via heavy runs. Examples include large computers, industrial lighting systems and so on.

For each Category, open-circuit voltage and short-circuit current waves are specified in IEEE 587. Both Categories A and B require the open-circuit "ring" wave of Fig. 3, a 100 kHz cosine, with 0.5 μs rise time and Q of approximately 3. The maximum peak voltage required for worst-case locations is 6 kV. Category A calls for a corresponding worst-case short-circuit current of 200 A, while Category B specifies 500 A.

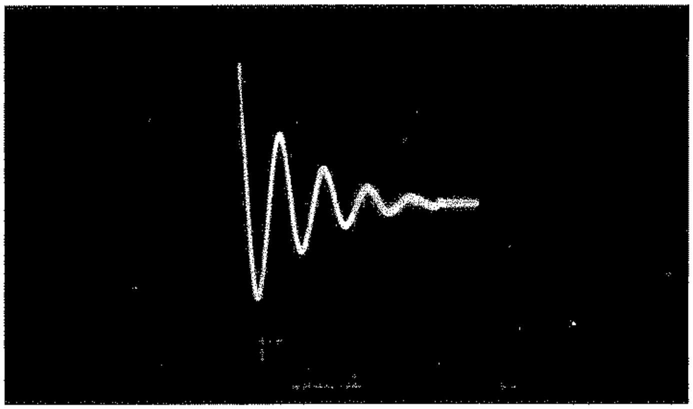

Figure 3.
TYPICAL 100 kHz COSINE "RING" WAVE
(1 kV/SMALL DIV, 5 μs/SMALL DIV)

In addition, Category B – the one of greatest significance for large electronic systems – requires the classic 1.2 x 50 μs open-circuit voltage wave of Fig. 1, with peak voltage for worst-case locations again equal to 6 kV.** The corresponding short-circuit current is the traditional 8 x 20 μs wave of Fig. 2, with a worst-case peak of 3 kA.**

Thus, the Category B surge environment is taken to be a 1.2 x 50 μs voltage wave as high as 6 kV, capable of instantaneous switchover, as may be required by the characteristics of the load driven by the surge, to an 8 x 20 μs current wave as high as 3 kA.

For both Categories, the environment applies a voltage surge due to lightning and/or switching transients, with moderate to high energy levels. The power line surge current isn't limited to just a few milliamperes. And the central issue is that this power-line surge current is available instantaneously, when the electronic system it supplies switches from high to low-impedance during a surge.

This combination voltage/current wave is referred to hereafter as a Bi-Wave™.

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*This is the origin of the 1.2 x 50 μs surge waveshape. When the thyrite material then used for arresters was driven from an 8 x 20 μs current source, it developed a voltage in the form of the 1.2 x 50 μs wave.

**For background on the various quantities involved, as well as other testing implications, see Refs. (2), (3) and (4).

Factors Affecting Input Impedance and The Importance of Surge Characteristics

The input impedance to virtually all circuits and systems can be expected to change, during an applied surge. This change will occur for one of two reasons:

1. Operation of a surge protector within the equipment, involving clamping and/or crowbar action;
2. Insulation flashover or component breakdown.

If a protector causes the impedance change, the current available after clamping or crowbar action will materially influence the size and character of the surge "remnant" or residual surge passed along to the internal circuits being protected. This is also true, of course, in the event of flashover or breakdown. Both the energy and the waveform of the remnant will be marked functions of available surge characteristics.

Surge characteristics may also affect the protectors themselves, either directly or indirectly. As a result, there may be important yet subtle differences between different surge test techniques.

Finally, in the event of flashover or component breakdown, the ability of power follow* to cause further damage can be affected by the surge current itself; so it must be instantaneously available during the test surge, at a realistically high enough level.

BI-WAVE™ TESTING VERSUS SEPARATE VOLTAGE AND CURRENT TESTS FOR TYPICAL PROTECTORS

There are undoubtedly circumstances in which a combination voltage/current surge wave — or Bi-Wave™ — may give the same test results as separate voltage and current surges. However there are also conditions in which test results may be quite different. This section includes three examples of such situations.

1. Surge Remnant Left by a Gas-Tube Surge Protector

When a gas tube is used for surge protection on a 115 or 230 volt ac power line, it is accompanied by a current-limiting series resistor.** Depending on the application, the resistor value will range from a few hundredths to some tenths of an ohm. For a 15A or 20A ac line application, a figure of 0.3 ohm is fairly typical. Fig. 4 shows the circuit.

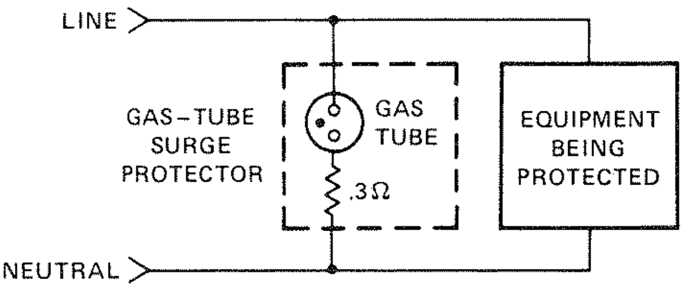

Figure 4.
TYPICAL GAS-TUBE PROTECTOR CIRCUIT
FOR 15 A OR 20 A AC POWER-LINE APPLICATION

Fig. 5A shows the voltage across the gap-resistor combination, for an applied Bi-Wave™ — i.e. for the 1.2 x 50 μs, 6 kV open-circuit voltage, 8 x 20 μs, 3 kA short-circuit current surge described by IEEE Std 587-1980 (2). Because of the steepness of the leading edge of the voltage wave, the gas tube doesn't break over until 1500 volts. Thereafter, the 3 kA, 8 x 20 μs surge current flowing instantaneously after breakover develops a 900 volt surge across the .3 ohm resistor. (The gas tube arc voltage drop is a mere 20-30 volts.) The resulting voltage surge remnant passed on to the Equipment Being Protected has a high peak voltage and is capable of delivering significant energy, on the order of 10 to 15 joules.

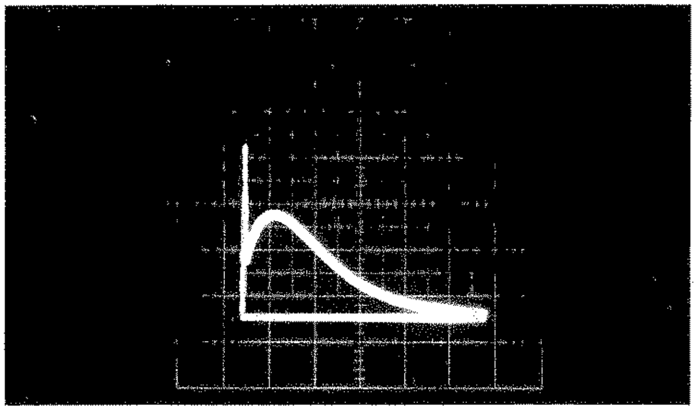

Figure 5A.
VOLTAGE ACROSS A GAS GAP/.3 OHM
RESISTOR COMBINATION FOR AN
APPLIED BI-WAVE™ SURGE
(200 V/SMALL DIV. 5 μs/SMALL DIV)

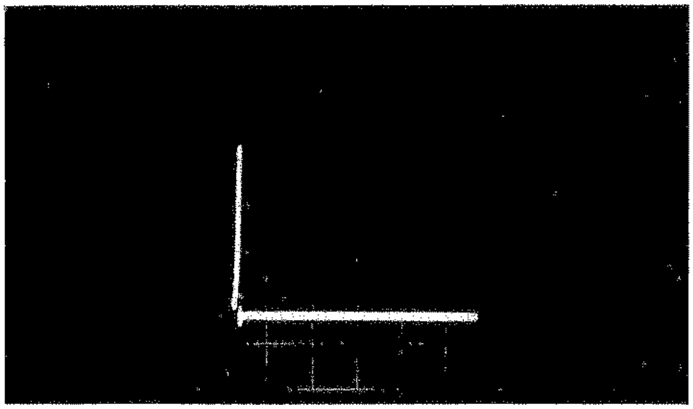

Figure 5B.
VOLTAGE ACROSS A GAS GAP/.3 OHM
RESISTOR COMBINATION FOR A
TYPICAL APPLIED VOLTAGE SURGE
(200 V/SMALL DIV, 5 μs/SMALL DIV)

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*Power follow is the power-line current that flows via the ionized or tracking path established by the flashover or breakdown initiated by the surge. It can cause far more damage than the surge itself.

**To insure turnoff, particularly for loads with power factor different from unity. In some designs, a clamping device such as a varistor is used instead of the resistor.

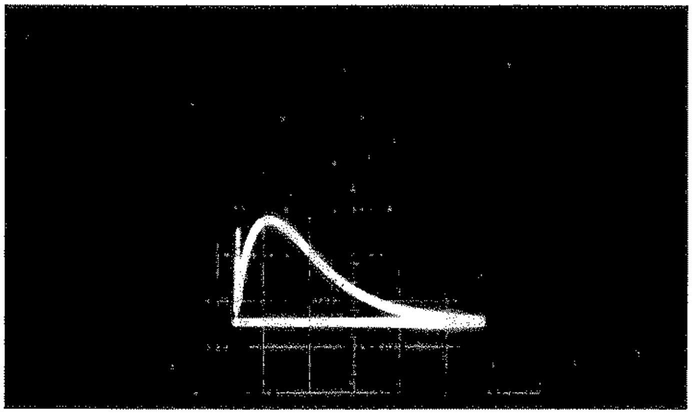

Figure 5C.
VOLTAGE ACROSS A GAS GAP/.3 OHM RESISTOR COMBINATION FOR A TYPICAL APPLIED CURRENT SURGE (200 V/SMALL DIV, 5 μs/SMALL DIV)

By contrast, if instead of using the Bi-Wave surge, tests are made with separate, typical voltage and current surges, results will be as shown in Figs. 5B and 5C respectively.* For a typical separate voltage surge test with a 1.2 x 50 μs shape but only 10 A current capability, for example, Fig. 5B shows the resulting remnant.

Fig. 5C shows the remnant for a typical separate current surge test with 3 kA, 8 x 20 μs (short-circuit) current waveshape, but only 2.4 kV open-circuit voltage compliance. (The compliance of other, separate current surge testers can be even lower.)

For the voltage surge case of Fig. 5B, the peak value of the remnant passed on by the protector is the same as for the Bi-Wave remnant of Fig. 5A. However the energy is comparatively small, since current available after breakover is only 10 A for the voltage test, compared with 3 kA for the Bi-Wave.

For the current surge case of Fig. 5C, the 3 kA surge current, equal to that of the Bi-Wave, insures the same surge remnant energy. But the slower leading voltage edge (a 1.2 x 50 μs wave has a slower front when its peak is 2.4 kV than when it is 6 kV), causes a lower gas-tube breakdown level.** The 800 V gas-tube breakdown in the example shown in Fig. 5C means that the highest voltage passed on to the Equipment Being Protected during the current test is 3 kA x .3 ohms, or about 900 V, versus 1500 V for the exemplary result of Bi-Wave application to the same protector, shown in Fig. 5A.The Bi-Wave remnant has both the high but narrow 1500 V peak, plus the high-energy, 900 V peak wave that follows it.

Thus an Equipment that includes a gas-tube protector may pass separate voltage and current surge tests, while possibly failing the real-world simulation of the combination voltage-current surge, or Bi-Wave. It seems clear that unless the combination wave is used to simulate reality, in some circumstances there exists the possibility of field failures that were not predicted by laboratory testing.

2. Current and Energy Stresses Applied to an MOV Surge Protector

Testing an MOV (Metal-Oxide Varistor) with separate voltage and current surges versus using the combination or Bi-Wave, may lead to results that also differ quite dramatically, specifically in regard to stress applied to the protector itself. The key point is that the MOV clamps at many hundreds of volts. An MOV designed to protect equipment connected to a 115 volt ac line will clamp at 400 to 500 V, and an MOV used on a 220 V line clamps at 900 to 1000 V.

Separate voltage testing is not a major issue. But separate "current" surge testing can be extremely misleading. A so-called "current" surge-test source with compliance of E volts is an E-volt source, with a series resistor designed to produce the desired current *into a short circuit.* Fig. 6A shows the combination or Bi-Wave source preferred by IEEE Std 587-1980 for Category B. It is a voltage source of 6 kV peak, with 2 ohm output resistor designed to deliver 3 kA into a short-circuit. By contrast, Fig. 6B shows a typical current-source generator with only 2.4 kV compliance, or open-circuit voltage. To obtain a 3 kA short-circuit current, it must therefore include a series output resistor of .8 ohms, as shown. (As already mentioned, other separate current-source test generators may have even lower voltage compliance, hence can potentially lead to even more erroneous results.)

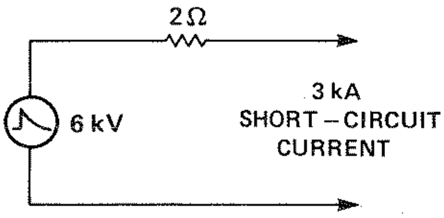

Figure 6A.
COMBINATION OR BI-WAVE™ SURGE TEST GENERATOR WITH 3 kA SHORT-CIRCUIT CURRENT

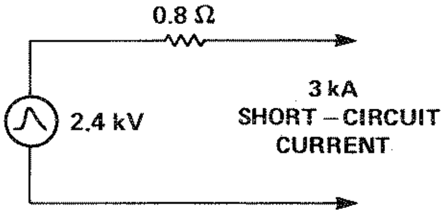

Figure 6B.
TYPICAL CURRENT-SOURCE SURGE TEST GENERATOR WITH 3 kA SHORT-CIRCUIT CURRENT

When the circuit of Fig. 6A drives a protector that clamps at 500 V, say, 5.5 kV is still available across the 2 ohm resistor to deliver a peak of 2750 A into the protector. For the circuit of Fig. 6B, however, only 1900 V divided by 0.8 ohms, or a peak of 2375 A, will be delivered into the protector.

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*For the same gas tube used in the example of Fig. 5A. Of course, different tubes may fire at different points; but the general conclusions will still usually apply.

**A 1.2 x 50 μs shape is still assumed for the open-circuit voltage wave. If the voltage wave itself also has an 8 x 20 μs shape, gas-tube breakover will occur at an even lower potential.