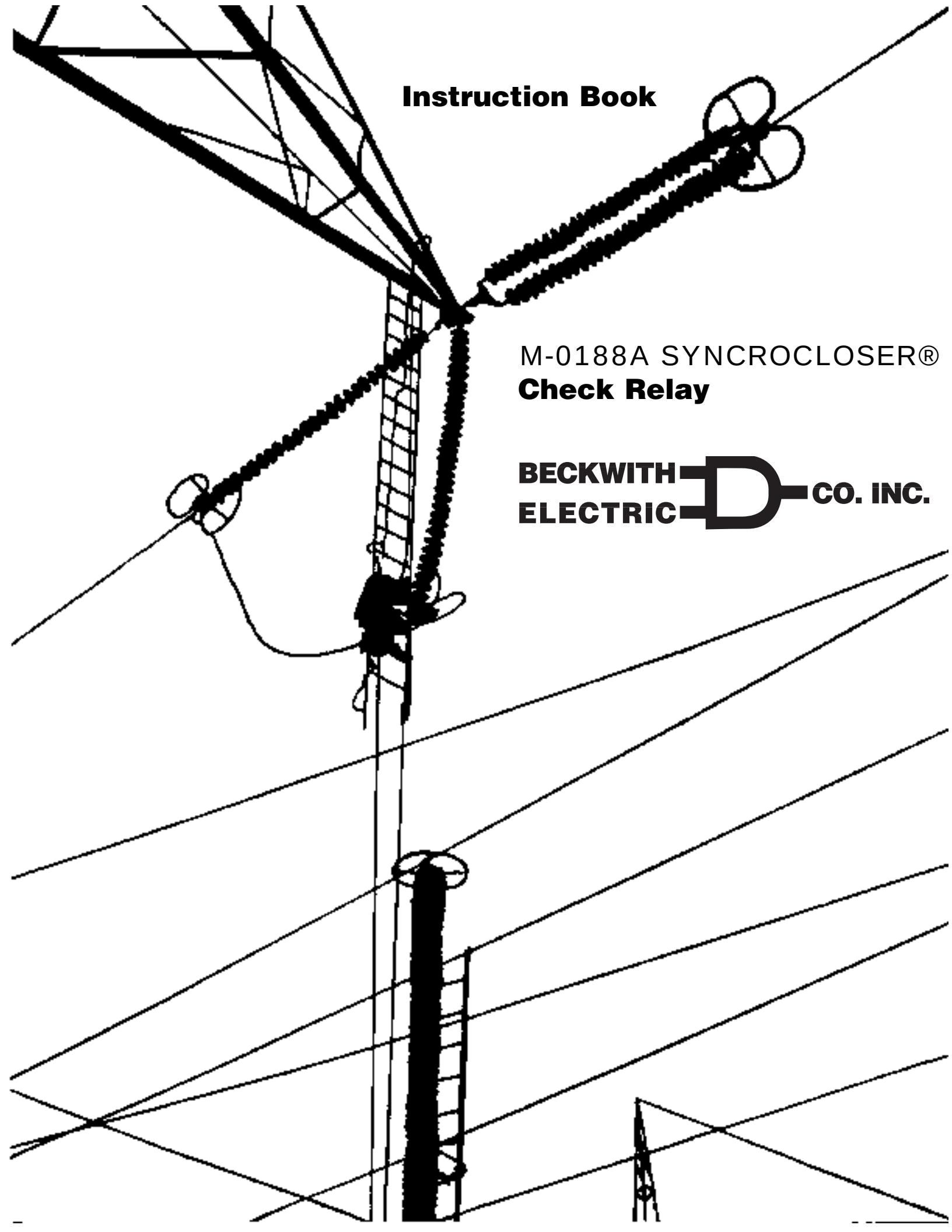
Instruction Book



M-0188A SYNCROCLOSER®
Check Relay

BECKWITH ELECTRIC CO. INC.

Syncrocloser® Check Relay M-0188A

- **Accurate, independent controls require no additional instrumentation for field setting**
- **Voltage limit ranges and dead line/dead bus closing features are optional**
- **Remote contacts to shift phase angle or time setpoints are standard**
- **Transducer analog outputs are SCADA compatible**

Inputs

Line Voltage: 120 V ac nominal, 145 V ac maximum continuous. Will withstand 240 V ac for 1 second.

Bus Voltage: 120 V ac nominal, 145 V ac maximum continuous. Will withstand 240 V ac for 1 second.

Select Dead Bus Close (by closing contact)*

Select Dead Line Close (by closing contact)*

* **NOTE**: One input must be greater than 100 V ac to ensure output relay closure.

Jump to wider Phase Angle and/or Time (by opening contact)

Enable Sync-Check

■ **NOTE**: Line and Bus voltage inputs are transformer-isolated, allowing greater flexibility in applications.

Burden

Whichever input voltage is high, 11 VA; the other input 1 VA.

Controls

UPPER VOLTAGE LIMIT, either input: 100 to 140 V ac, accuracy ±2% of full scale

LOWER VOLTAGE LIMIT, either input: 90 to 120 V ac, accuracy ±2% of full scale

DELTA V LIMIT: 1 to 4 V, accuracy ±5% of full scale (other ranges available)

DEAD LINE LIMIT: 10 to 60 V, accuracy ±7% of full scale

DEAD BUS LIMIT: 10 to 60 V, accuracy ±7% of full scale

PHASE ANGLE LIMIT: ± degrees, 0 to 30°, accuracy ±5% of full scale (other ranges available)

TIME to close after **PHASE ANGLE LIMIT OK**, 0 to 15 seconds (0 to 1.5 seconds available), accuracy ±5% of full scale

LED Indicators

All LEDs are lit when conditions are met to close the breaker.

BUS UPPER VOLTAGE LIMIT OK
LINE UPPER VOLTAGE LIMIT OK
BUS LOWER VOLTAGE LIMIT OK
LINE LOWER VOLTAGE LIMIT OK
DELTA V OK
LINE HOT
BUS HOT
ANGLE OK

■ **NOTE**: All LED indicators except **ANGLE OK**, included when related option is chosen.

Breaker Close Relay

Dry output contacts rated to make and carry 20 A at 250 V dc, and interrupt 0.9 A at 120 V dc or 0.4 A at up to 250 V dc inductive load. Open contacts will withstand 1500 V ac for 1 minute. Contacts to ground will withstand 1500 V ac for 1 minute.

Response Time

When the Line and Bus inputs are first applied to the unit, the voltage magnitude circuits require approximately 0.5 seconds to sense the correct voltage. The unit will simultaneously measure phase angle and close the breaker with proper phase angle only after the time set by the **TIME** dial. In closing on dead line or dead bus, the phase condition is ignored so that the unit will close upon a voltage below the set threshold in approximately 0.5 seconds.

Status Relay Contact

Phase Angle Status Relay: Closed when phase angle is within limits.

Voltage Status Relay: Closed when voltage conditions are within limits.

These are light duty contacts intended primarily for status interrogation by supervisory. They can be used to light local lights that do not exceed 1/2 A at 125 V dc resistive, 1 A at 120 V ac or 250 V dc across open contacts.

Phase Angle and Time Reduction

The M-0188A provides a feature for programming an external contact closure to change the Phase Angle Limit, the Time setpoint, or both. When the circuit from terminal TB1-15 to terminal TB1-21 is closed the phase angle function, timing function, or both, may be reduced by a specified ratio. Of course this can be used as a widening function by operating with terminals TB1-15 to TB1-21 normally closed.

Analog Outputs

Various dc analog outputs are provided for Bus Voltage, Line Voltage, Delta V and Phase Angle. These analog outputs can interface with most SCADA systems. The accuracy of Bus voltage, Line voltage, and Phase Angle is 1.5% of full scale; the accuracy of Delta V is 2.5 % of full scale.

Reliability

The M-0188A Syncrocloser® Check Relay is assembled on two glass-epoxy printed circuit boards. All semiconductor components are hermetically sealed, and of the highest and most reliable quality available. Highly stable, instrument grade capacitors and resistors are used in critical measurements circuits to minimize the possibility of error.

Transient Protection

All inputs and outputs are fully transient protected and will pass the ANSI C37.90.1-1989 Surge Withstand Capability (SWC) Test, which includes the Fast Transient SWC test. The Bus and Line Input voltages and Breaker Close contacts will withstand 1500 V ac, 60 Hz to chassis or instrument ground for one minute; the Voltage and Phase OK Relay contacts will withstand 2121 V dc to chassis or instrument ground for one minute. Voltage inputs are isolated from each other, from other circuits, and from ground.

All faces of the relay, with the chassis solidly grounded, have been exposed to Radio Frequency Immunity testing and have successfully passed with a field intensity of 20 volts per meter at typical utility frequencies of 144 MHz, 438 MHz, and at 450 MHz.

Environmental

Temperature Range: Units will operate properly over a temperature range of –40 to +80° C.

Humidity: Stated accuracies are maintained at up to 95% relative humidity (non-condensing).

Fungus Resistance: A conformal printed circuit board coating inhibits fungus growth.

Physical

Size: 19" wide x 3–1/2" high x 13" deep (48.3 cm x 8.9 cm x 33.0 cm). Requires two rack units space in a standard 19" rack. May also be panel mounted horizontally or vertically.

Approximate Weight: 15 lbs (6.8 kg)

Approximate Shipping Weight: 20 lbs (9.1 kg)

The M-0188A includes a transparent plastic cover to protect the knobs and to prevent accidental resetting.

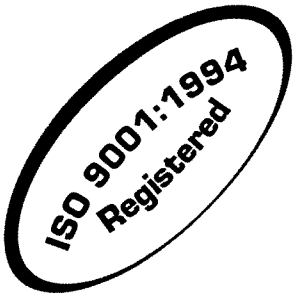
Patent

The M-0188A Syncrocloser® Check Relay is covered by U.S. Patent 4,218,625.

Warranty

The M-0188A Syncrocloser Check Relay is covered by a two-year warranty from date of shipment.

Specification is subject to change without notice.



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800-0188A-SP-0 01/01

WARNING

DANGEROUS VOLTAGES, capable of causing death or serious injury, are present on the external terminals and inside the equipment. Use extreme caution and follow all safety rules when handling, testing or adjusting the equipment. However, these internal voltage levels are no greater than the voltages applied to the external terminals.

DANGER! HIGH VOLTAGE

– This sign warns that the area is connected to a dangerous high voltage, and you must never touch it.

PERSONNEL SAFETY PRECAUTIONS

The following general rules and other specific warnings throughout the manual must be followed during application, test or repair of this equipment. Failure to do so will violate standards for safety in the design, manufacture, and intended use of the product. Qualified personnel should be the only ones who operate and maintain this equipment. Beckwith Electric Co., Inc. assumes no liability for the customer's failure to comply with these requirements.

– This sign means that you should refer to the corresponding section of the operation manual for important information before proceeding.

Always Ground the Equipment

To avoid possible shock hazard, the chassis must be connected to an electrical ground. When servicing equipment in a test area, the Protective Earth Terminal must be attached to a separate ground securely by use of a tool, since it is not grounded by external connectors.

Do NOT operate in an explosive environment

Do not operate this equipment in the presence of flammable or explosive gases or fumes. To do so would risk a possible fire or explosion.

Keep away from live circuits

Operating personnel must not remove the cover or expose the printed circuit board while power is applied. In no case may components be replaced with power applied. In some instances, dangerous voltages may exist even when power is disconnected. To avoid electrical shock, always disconnect power and discharge circuits before working on the unit.

Exercise care during installation, operation, & maintenance procedures

The equipment described in this manual contains voltages high enough to cause serious injury or death. Only qualified personnel should install, operate, test, and maintain this equipment. Be sure that all personnel safety procedures are carefully followed. Exercise due care when operating or servicing alone.

Do not modify equipment

Do not perform any unauthorized modifications on this instrument. Return of the unit to a Beckwith Electric repair facility is preferred. If authorized modifications are to be attempted, be sure to follow replacement procedures carefully to assure that safety features are maintained.

PRODUCT CAUTIONS

Before attempting any test, calibration, or maintenance procedure, personnel must be completely familiar with the particular circuitry of this unit, and have an adequate understanding of field effect devices. If a component is found to be defective, always follow replacement procedures carefully to that assure safety features are maintained. Always replace components with those of equal or better quality as shown in the Parts List of the Instruction Book.

Avoid static charge

This unit contains MOS circuitry, which can be damaged by improper test or rework procedures. Care should be taken to avoid static charge on work surfaces and service personnel.

Use caution when measuring resistances

Any attempt to measure resistances between points on the printed circuit board, unless otherwise noted in the Instruction Book, is likely to cause damage to the unit.

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M-0188A SYNCROCLOSER® CHECK RELAY
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INTRODUCTION

Please refer to the M–0188 Application Guide in conjunction with this Instruction Book since information contained in one is not usually repeated in the other.

The Beckwith Electric M–0188 Syncrocloser® Check Relay uses advanced state-of-the-art semiconductors and circuits to achieve an overall stability and resolution unattainable with current electromechanical sync-check relays. Modern hybrid and monolithic semiconductors using ion implantation and laser trimming are incorporated throughout the Syncrocloser Line to gain temperature stability without critical compensation or trimming.

THEORY OF OPERATION

Refer to Figure 1 Block Diagram. Each input (line, bus) is passed through a transformer and scaled down from 120 V ac to 6 V ac. The scaled down voltage is converted to a dc voltage by the ac to dc converter. This converter is an active full-wave rectifier and filter, which eliminates the usual highly temperature-dependent diode drop of conventional full-wave rectifiers. Full-wave rectification was chosen over half-wave rectification because the filter time response is much faster for a given ripple voltage. This is due to the fact that full-wave rectification results in a voltage containing no fundamental frequency components, only harmonics.

Upper and lower voltage comparators compare the output of each ac to dc converter to a portion of a highly stable hybrid 10 V reference. LEDs located on the front panel indicate the condition of each input (line, bus) with reference to upper and lower voltage limits. The dead line/dead bus comparators determine whether either input (line, bus) is below the threshold of the comparator setting. The comparison voltage is the stable 10 V reference, and LEDs indicate each input status.

An absolute value difference amplifier precisely evaluates the difference voltage (Delta V) between the line and bus input and a comparator compares Delta V to a portion of the stable reference voltage. Again, a front panel LED indicates the status of Delta V. Two zero-crossing detectors generate rectangular waveforms at the zero-crossing of each input. The exclusive OR-gate provides a pulse width proportional to the phase angle between each input. A three-pole active filter provides the required averaging without the excessive time delay of conventional RC filters.

Phase angle voltage varies from 0 to 5 V for a 0° to 180° phase change. A scaling amplifier precisely increases the phase angle voltage (Φ) to provide higher phase angle resolution. The phase angle comparator compares Φ to preset limits and starts a timer when Φ is equal to or less than the preset limit. If Φ is within limits after the timer times out, a "close" condition is sent to the logic section. If all voltages at the inputs are within preset limits, then the output relay is picked up until the phase angle or input voltages drop outside the limits.

Dead Line or Dead Bus Closing may be programmed externally, and are functions of the dead line/dead bus logic. The output relay will pick up whenever a dead condition is sensed at the required input, regardless of phase angle, upper and lower voltage limits, or Delta V. The program may be selected as dead line, dead bus, dead line or dead bus, but **not** dead line and dead bus.

Operating dc voltages are supplied by the power supply section. Input power is driven from either line or bus depending on which is greater in voltage magnitude.

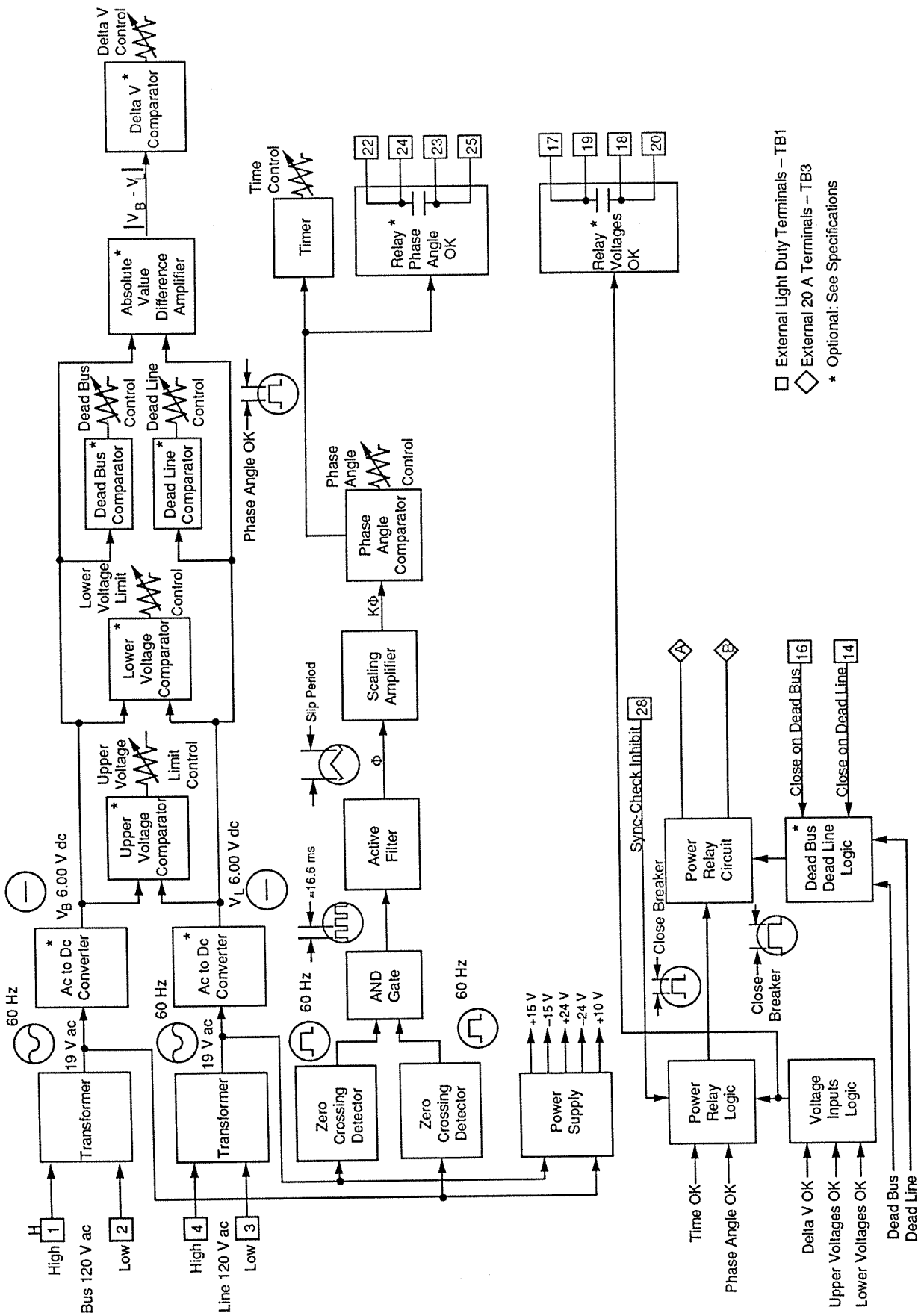


FIGURE 1 Block Diagram

MAINTENANCE

Due to the extremely sophisticated nature of the circuitry in the M–0188 circuitry, field repair is not recommended. All units are fully calibrated at the factory prior to shipment; there is no need to re-calibrate a unit prior to initial installation. Calibration is only required after a component is replaced. In the event that a unit does not operate properly, it should be established that the problem is caused by malfunction of a Beckwith Electric unit and not caused by an external fault or wiring error. Once this is assured, the entire unit should be returned to Beckwith Electric. Pack the unit carefully (in the original carton if possible), assuring that there is adequate packing material to protect the contents.

■ **NOTE:** Any equipment returned for repair must be sent with transportation charges prepaid. The equipment must remain the property of the user. The warranty is void if the value of the unit is invoiced to Beckwith Electric at the time of return or if the unit is returned with transportation charges collect.

If under warranty, units will be repaired rapidly and returned at no cost and with return transportation paid if the fault is found to be due to workmanship or failure of material. If a unit is under warranty and express shipment for return of the repaired unit is requested, shipping charges will be billed at the current rate. If the fault is due to abuse or misuse, or if the unit is out of warranty, a modest charge will be made. Repair can normally be expected to take two weeks, plus shipping time. If faster service is required, it should be requested at the time of return.

■ **NOTE:** Units returned with only a blown fuse are not covered by warranty and a nominal repair charge will be made for replacement of the fuse. Please check the fuses before returning the M–0188 for repair in order to avoid unnecessary repair charges.

To help in analyzing the problem, a complete description of the malfunction and conditions leading to the failure should be included with the unit.

However, if you choose to repair the unit, it is necessary to be completely familiar with the circuitry involved, and have an adequate understanding of field effect devices. Be sure to carefully read the **WARNING** page at the beginning of this manual.

▲ **CAUTION: This unit contains sensitive MOS circuitry that can be damaged by improper repair procedures. Work stations used for repair should be static-free and procedures for handling MOS circuitry should be followed. In addition, any attempt to measure resistances between points on the printed circuit board may cause damage to the unit.**

It is suggested that first a visual inspection be made for any component that does not appear normal or appears to have overheated. Analysis of the circuit will then often lead to the cause of the failure and components that need to be replaced.

If no obvious problems exist, it is suggested that the **TEST** and **CALIBRATION PROCEDURES** be followed until a portion of a circuit is detected which does not perform as expected or until a calibration point is found which will not meet requirements. These procedures should lead to a determination of the defective component.

TEST SOURCES

Two highly stable test sources must be used to test the M–0188. The power system is suitable as one input for a "general" test, but is not sufficiently stable in phase or frequency to determine the limits of the accuracy of the M–0188.

To properly test the M–0188, each input must have a short-term frequency stability of ±0.001 Hz and phase jitter at no more than 0.1° peak to peak.

EQUIPMENT REQUIRED

1. Two distortion free 60 Hz variable sources, as follows:

   A variable frequency, variable phase angle source capable of providing 120 V ac. Maximum phase jitter of 0.1°.

   A fixed frequency source capable of providing 120 V ac. Maximum phase jitter of 0.1°.

2. Two digital multimeters with ac and dc accuracy of 0.2% of full-scale ±1 least significant digit; Hewlett-Packard 3465A or equivalent.

3. A solder sucking syringe or solder wick.

4. A soldering iron - Weller Controlled Output Soldering Station, model MTCPL, 60 W, 120 V, 50/60 Hz or equivalent.

5. A stopwatch or any accurate timing device.

COMPONENT REPLACEMENT PROCEDURE

1. To gain access to the circuit board, remove the top and bottom covers of the unit. Components can now be easily tested or changed. Analysis of the circuit will then often lead to the cause of the failure and components to be replaced.

2. If a component needs to be changed, carefully scrape away the coating surrounding the component using a small sharp knife, being careful not to damage the printed circuit path.

3. Clip out the old component and discard.

4. Remove the clipped wires using the solder wick or syringe. Be sure to leave the holes clear to facilitate insertion of the new component.

   ▲ CAUTION: Do not attempt to melt the solder and push the new component through the hole as the leads are likely to catch the edge of the foil and lift it off the board.

5. When replacing integrated circuits, be sure to insert the unit into the transipad so that the tab fits into the slot. Once this is done, there is only one way to insert the combination into the printed circuit board.

TEST PROCEDURE

Refer to Figure 2 External Connections, Figure 3 Phase and Time Board Component Location and Figure 4 Voltage Option Board Component Location.

UPPER VOLTAGE LIMIT

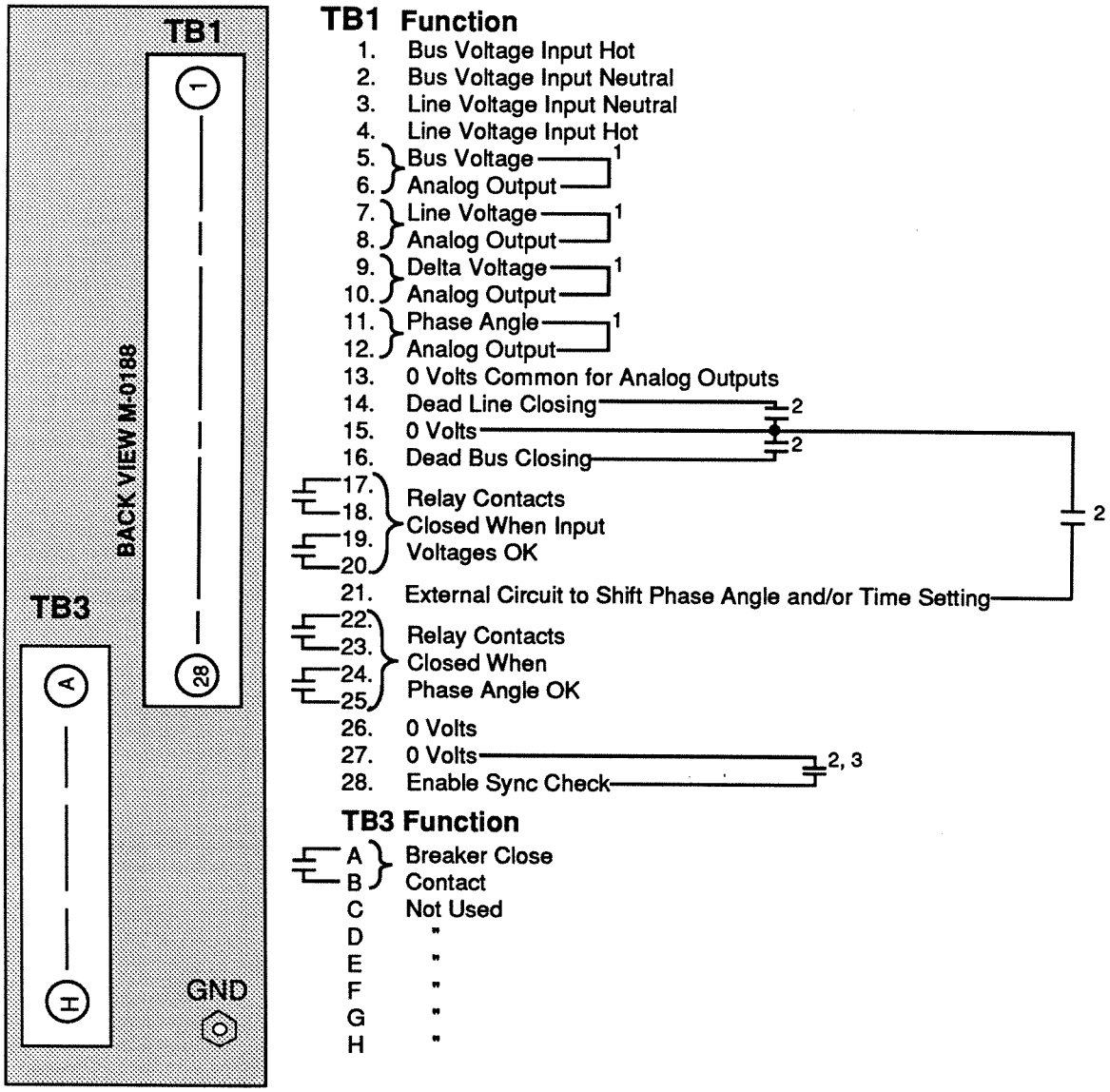
1. Set the **UPPER VOLTAGE LIMIT** control at 125 V.
2. Supply 120 V ac, 60 Hz to the Bus input TB1-1 and TB1-2, noting that TB1-1 is the HOT terminal.
3. Supply 120 V ac, 60 Hz to the Line input TB1-3 and TB1-4, noting that TB1-4 is the HOT terminal.
4. Slowly increase the Bus input until the **UPPER VOLTAGE LIMIT BUS OK** LED turns off. The LED should turn off at 125 V ± 2.8 V.
5. Decrease the Bus input to 120 V.
6. Slowly increase the Line input until the **UPPER VOLTAGE LIMIT LINE OK** LED turns off. The LED should turn off at 125 V ± 2.8 V.
7. Decrease the Line input to 120 V.

LOWER VOLTAGE LIMIT

1. Set the **LOWER VOLTAGE LIMIT** control at 105 V.
2. Supply 120 V ac, 60 Hz to the Bus input TB1-1 and TB1-2, noting that TB1-1 is the HOT terminal.
3. Supply 120 V ac, 60 Hz to the Line input TB1-3 and TB1-4, noting that TB1-4 is the HOT terminal.
4. Slowly decrease the Bus input until the **LOWER VOLTAGE LIMIT BUS OK** LED turns off. The LED should turn off at 105 ± 2.4 V.
5. Increase the Bus input to 120 V.
6. Slowly decrease the Line input until the **LOWER VOLTAGE LIMIT LINE OK** LED turns off. The LED should turn off at 105 ± 2.4 V.
7. Increase the Line input to 120 V.

DELTA V LIMIT

1. Set the **DELTA V LIMIT** control at midscale.
2. Supply 110 V ac, 60 Hz to the Bus input TB1-1 and TB1-2, noting that TB1-1 is the HOT terminal.
3. Supply 110 V ac, 60 Hz to the Line input TB1-3 and TB1-4, noting that TB1-4 is the HOT terminal.
4. Slowly increase the Line input voltage until the **DELTA V LIMIT OK** LED turns off. The LED should turn off at 1/2 the scale setting ±5% of full scale.



■ NOTES:

1. External connections are shown for voltage output. Current output connections are shown in the Application Guide.
2. Close external circuit to enable function. If function is required at all times, permanent enable jumpers may be added.
3. Refer to the Application Guide for Timer Logic Options.

FIGURE 2 External Connections

Example: With a **DELTA V LIMIT** full scale range of 10 V, the midscale value would be 5 V. Therefore, the LED should turn off at 5 V ±0.5 V (voltage difference).

DEAD LINE LIMIT

1. Place a jumper between TB1–14 and TB1–15.
2. Adjust the **DEAD LINE LIMIT** control to 40 V.
3. Slowly reduce the Line voltage. The output Breaker Close Relay should pick up as the Line voltage goes below 40 V. The **DEAD LINE LIMIT OK** LED should extinguish at the same time.
4. Return the Line voltage to 120 V ac.

DEAD BUS LIMIT

1. Place a jumper between TB1–15 and TB1–16.
2. Adjust the **DEAD BUS LIMIT** control to 40 V.
3. Slowly reduce the Bus voltage. The output Breaker Close Relay should pick up as the Bus voltage goes below 40 V. The **DEAD BUS LIMIT OK** LED should extinguish at the same time.
4. Return the Bus voltage to 120 V ac.

PHASE ANGLE LIMIT

1. Adjust the **PHASE ANGLE LIMIT** control to midscale.
2. Slowly adjust the phase difference between the Line and Bus to midscale (15°, 30° or 45° depending on the scale selected). The **PHASE ANGLE LIMIT OK** LED should extinguish as the midscale angle is passed.

TIME (SEC)

Skip this section if the M–0188 was purchased with the Fixed Zero Time Option.

1. Adjust the **TIME** control to full scale (1.5 sec. or 15 sec. depending on the scale selected).
2. Adjust the Line and Bus voltages to 120 V ac with a phase difference of 15°.
3. Adjust the **DELTA V LIMIT** control and **UPPER VOLTAGE LIMIT** control fully clockwise.
4. Adjust the **LOWER VOLTAGE LIMIT** control fully counter-clockwise.
5. Set the **PHASE ANGLE LIMIT** control at 0°.
6. Quickly rotate the **PHASE ANGLE LIMIT** control past 15° and begin timing when the **PHASE ANGLE LIMIT OK** LED lights.
7. End timing when the output Breaker Close Relay picks up. The recorded time should equal the full scale **TIME** setting.

TYPICAL VOLTAGES

FROM	TO	CONDITION	VOLTAGE
T1-3 on TB2	TP6	120 V ac Input to Bus	40 V ac
T2-3 on TB2	TP6	120 V ac Input to Line	40 V ac
TP6	TP1	120 V ac on Line or Bus	+24 V dc
TP6	TP3	120 V ac on Line or Bus	–24 V dc
TP6	TP4	120 V ac on Line or Bus	–15 V dc
TP6	TP2	120 V ac on Line or Bus	+15 V dc
TP6	TP5	120 V ac on Line or Bus	+10 V dc
TP6	U5 - Pin 13	120 V ac on Line or Bus	+12 V dc approx.
TP6	U5 - Pin 9	120 V ac on Line or Bus	+12 V dc approx.
TP6	TP11	100 V ac on Line and Bus 0° Phase Shift	0 V
TP6	TP11	50 V ac on Line or Bus	+10 V dc
TP6	T2-4	120 V ac on Line	6 V ac
TP6	T1-4	120 V ac on Bus	6 V ac
TP6	TP6*	120 V ac on Bus	+6 V dc
TP6	U2 - Pin 13	120 V ac on Line or Bus	+5.25 V dc ±14.5%
TP6	TP2*	120 V ac on Line or Bus	±14 V dc
TP6	TP7*	120 V ac on Line	+6 V dc
TP6	U2 - Pin 9	120 V ac on Line or Bus	+5.25 V dc ±14.5%
TP6	TP1*	120 V ac on Line or Bus	±14 V dc
TP6	TP6*	120 V ac on Bus	+6 V dc
TP6	U2 - Pin 2*	120 V ac on Line or Bus	+6.25 V dc ±12%
TP6	TP5*	120 V ac on Line or Bus	±14 V dc
TP6	U2 - Pin 5*	120 V ac on Line or Bus	+6.25 V dc ±12%
TP6	TP7*	120 V ac on Line	+6 V dc
TP6	TP4*	120 V ac on Line or Bus	±14 V dc
TP6	TP8	Line and Bus Inputs 180° out of phase	+5 V dc
TP6	TP8	Line and Bus Inputs in phase	0 V

* On Voltage Option Board

TP6	TP7	Line and Bus Inputs 180° out of phase	±14 V dc
TP6	TP7	Line and Bus Inputs in phase	0 V
TP6	U6 - Pin 14	120 V ac on Line or Bus	2 V ±2 approx.
TP6	U6 - Pin 1	120 V ac on Line or Bus	6 V ±6 approx.
TP6	U7 - Pin 13	120 V ac on Line and Bus when timer times out	+15 V approx.
TP6	U7 - Pin 12	120 V ac on Line and Bus Both inputs in phase.	+15 V approx.
TP6	U6 - Pin 12*	120 V ac on Line or Bus	+1.75 V dc ±72% approx.
TP6	TP7*	120 V ac on Line	+6 V dc
TP6	U6 - Pin 14*	120 V ac on Line or Bus	±13 V dc
TP6	TP6*	120 V ac on Bus	+6 V dc
TP6	U10 - Pin 3*	120 V ac on Line or Bus	+1.75 V dc ±72% approx.
TP6	U10 - Pin 6*	120 V ac on Line or Bus	±13 V dc
TP6	D15 Anode	All LEDs lit on front panel	+1.5 V
TP6	TP3*	Line 120 V ac Bus 115 V ac ΔV Range 1 - 5	+2.5 V
TP6	U5 - Pin 6*	120 V ac on Line or Bus	±13 V dc
TP6	U5 - Pin 3*	120 V ac on Line or Bus	+1.5 V ±67%

* On Voltage Option Board

▲ CAUTION: Any attempt to measure resistance between points on the printed circuit board is likely to cause damage to the unit.

CALIBRATION

■ **NOTE:** The M–0188 unit has been fully calibrated at the factory using highly sophisticated, computer-controlled test equipment. There is no need to re-calibrate the units before initial installation. Further calibration is only necessary if a component was changed during a repair procedure. If calibration becomes necessary, it should be performed before mounting the M–0188 in a rack, since the top cover of the unit must be removed to reach calibration points. Refer to Figure 2 External Connections and Figures 5 and 6 Component Location for Calibration and Range Resistors.

AC TO DC CONVERTER

The ac to dc converter consists of quad op amp U1 with potentiometers R1, R2, R23 and R24 providing calibration for the Line and Bus inputs.

1. Supply 120 V ac, 60 Hz to Bus input TB1-1 and TB1-2, noting that TB1-1 is the HOT terminal.
2. Continuously monitor the Bus input to assure that the 120 V ac supply remains steady.
3. Place the positive lead of the dc voltmeter on Test Point 7 (on the Voltage Option Board).
4. Place the negative lead on Test Point 6 (on the Phase and Time Board).
5. Adjust potentiometer R24 (Line Offset Trimmer) to read 0.00 V dc.
6. Disconnect power to the Bus input TB1-1 and TB1-2.
7. Supply 120 V ac, 60 Hz to the Line input TB1-3 and TB1-4, noting that TB1-4 is the HOT terminal.
8. Place the positive lead of the dc voltmeter on Test Point 6 (on the Voltage Option Board).
9. Place the negative lead on Test Point 6 (on the Phase and Time Board).
10. Adjust potentiometer R2 (Bus Offset Trimmer) to read 0.00 V dc.
11. Supply 120 V ac, 60 Hz to Bus input TB1-1 and TB1-2, noting that TB1-1 is the HOT terminal.
12. Continuously monitor the Bus input to assure that the 120 V ac supply remains steady.
13. Increase the Line input to 130 V ac.
14. Adjust potentiometer R1 (Bus Voltage Trimmer) to read 6.00 V dc.
15. Decrease the Bus input to 100 V ac; the dc voltmeter should read 5.00 V dc.
16. Increase the Bus input to 130 V ac.
17. Decrease the Line input to 120 V ac.
18. Continuously monitor the Line input to assure that the 120 V ac supply remains steady.
19. Place the positive lead of the dc voltmeter on Test Point 7 (on the Voltage Option Board).
20. Place the negative lead on Test Point 6 (on the Phase and Time Board).

21. Adjust potentiometer R23 (Line Voltage Trimmer) to read 6.00 V dc.

22. Decrease the Line input to 100 V ac; the dc voltmeter should read 5.00 V dc.

ABSOLUTE VALUE DIFFERENCE AMPLIFIER

Components U3, U4, U5, and U11 form this circuit.

1. Place a clip lead between TB1-1 and TB1-4.
2. Place a second clip lead between TB1-2 and TB1-3.
3. Supply 120 V ac, 60 Hz to Bus inputs TB1-1 and TB1-2, noting that TB1-1 is the HOT terminal.
4. Place the positive lead of the dc voltmeter on Test Point 3 (on the Voltage Option Board).
5. Place the negative lead on Test Point 6 (on the Phase and Time Board).
6. Adjust potentiometer R71 (Delta V Offset Trimmer) to read 0.001 V dc.
7. Disconnect power to Bus input TB1-1 and TB1-2 and also disconnect the clip leads.
8. Supply voltage to the Bus and Line input terminals according to the values in Table 1.
9. Continuously monitor the voltages to ensure that they remain steady.
10. Place the positive lead of the dc voltmeter on Test Point 3 (on the Voltage Option Board).
11. Place the negative lead on Test Point 6 (on the Phase and Time Board).
12. Adjust potentiometer R48 (Delta V Trimmer on the Voltage Option Board) to read the voltage indicated in Table 1.

Delta V Range	Bus Input TB1–1 (HOT) TB1–2 (NEUTRAL)	Line Input TB1–3 (NEUTRAL) TB1–4 (HOT)	Voltmeter Reading
1 - 5	115 V ac	120 V ac	2.50 V dc
2 - 10	110 V ac	120 V ac	5.00 V dc
3 - 15	110 V ac	125 V ac	7.50 V dc
4 - 20	110 V ac	130 V ac	10.00 V dc
5 - 25	105 V ac	130 V ac	2.50 V dc
6 - 30	105 V ac	135 V ac	2.25 V dc
10 - 50	90 V ac	140 V ac	10.00 V dc

TABLE 1 Delta V Calibration

PHASE ANGLE

1. Place a clip lead between TB1–1 and TB1–4.
2. Place a second clip lead between TB1–2 and TB1–3.
3. Supply 120 V ac, 60 Hz to bus inputs TB1–1 and TB1–2, noting that TB1–1 is the HOT terminal.

4. Attach the positive lead of the dc voltmeter to Test Point 11 on the Phase and Time Board.
5. Attach the negative lead to Test Point 6 on the Phase and Time Board.
6. Adjust R71 (Phase Angle Trimmer) to obtain the lowest possible voltage reading (less than 1 mV dc).
7. Move the positive test lead of the dc voltmeter to Test Point 7 on the Phase and Time Board.
8. Adjust R76 (Phase Angle Offset Trimmer) until the voltmeter reads 0 V dc ± 0.020 V.

TIMER

Skip this section if the Fixed Zero Time Option was chosen. The timer function consists of components U6 and U7.

1. Set the front panel **TIME** control to full scale (15 sec. or 1.5 sec.).
2. Set the front panel **PHASE ANGLE LIMIT** control to 1/2 full scale.
3. Provide 120 V ac to the Bus inputs TB1–1 and TB1–2, noting that TB1–1 is the HOT terminal (only one source).
4. Attach the positive lead of the voltmeter to anode of D60 (on the Phase and Time Board).
5. Attach the negative lead to Test Point 6 (on the Phase and Time Board).
6. Clip one end of a test lead to U6-Pin 13.
7. Begin timing when the other end of the test lead is clipped to Test Point 6 (on the Phase and Time Board).
8. End timing when the dc voltmeter indicates +15 V dc.
9. Repeat steps 7 and 8 while adjusting R56 (Time Trimmer) until the timed period is within ±5% of the full scale setting (i.e., 15 sec. or 1.5 sec.).

HOW TO CHANGE RANGES AND LOGIC

■ NOTE: It is a violation of Beckwith Electric patents to add any options without written permission from Beckwith Electric. Permission is granted to make the changes included in this section.

1. Follow steps 1 through 4 in the **COMPONENT REPLACEMENT PROCEDURE** section using the equipment specified.
2. Referring to the tables below and to the **SELECTED RESISTORS** section of the **PARTS LIST**, choose the correct resistor value, jumper wire or shunt. Use 20 gauge insulated wire for all jumpers. Refer to Figure 5 for the location of these parts.
3. Refer to the **CALIBRATION** section after replacing any components.

RANGES

DELTA V LIMIT (VOLTAGE OPTION BOARD)

								Phase and Time Board
	R81	R48	R73	R80	R78	R50	R103	R20
1 - 5	11 K	50 K	182 K	open	open	180 K	open	1.13 K
2 - 10	11 K	50 K	182 K	5.62 K	open	180 K	open	1.13 K
3 - 15	11 K	50 K	182 K	5.62 K	1.87 K	180 K	open	1.13 K
4 - 20	11 K	50 K	182 K	5.62 K	1.87 K	180 K	jumper	1.13 K
5 - 25	11 K	10 K	35.7 K	open	open	180 K	open	6.81 K
6 - 30	11 K	10 K	24.9 K	open	open	180 K	open	6.81 K
10 - 50	Open	20 K	71.5 K	open	open	91 K	jumper	1.13 K

PHASE ANGLE LIMIT (PHASE AND TIME BOARD)

	R62	R64	R82
30°	16.5 K	12.7 K	open
45°	16.5 K	open	open
60°	48.7 K	open	open
90°	10.0 K	open	Jumper

TIME RANGE (PHASE AND TIME BOARD)

	R42	R43
1.5 sec.	1 M	110 K
15 sec.	1 M	open
6 sec.	392 K	open
Fixed 0*	1 M	110 K

* ■ NOTE: For the Fixed Zero Time Option, also complete the following procedures.

1. Delete R75, the front panel **TIME** control.
2. Install a jumper wire for R83.

PHASE ANGLE/TIME SHIFT (PHASE AND TIME BOARD)

PHASE ANGLE REDUCTION RATIO

Nominal Value	R40	J10*
1/1.5	5.90 K	B&C
1/2	3.01 K	B&C
1/4	1.0 K	B&C
1/5	750 Ω	B&C
4/5	12.1 K	B&C
None		A&B

TIME REDUCTION RATIO

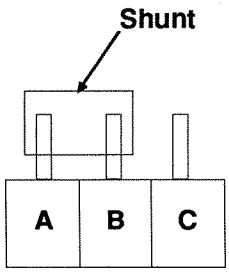
Nominal.. Value	R30	J9*
1/1.5	5.11 K	A&B
1/2	2.49 K	A&B
1/4	787 Ω	A&B
1/5	576 Ω	A&B
Zero Time	Jumper	A&B
None		B&C

* Two-position shunt on the phase and time board.

TIMER LOGIC

Place the two-position shunt over the appropriate pins shown in the table below. J12 is on the Phase and Time Board, and J9 is on the Voltage Option Board.

Timer Logic	J12 Pins	J9 Pins
1	B & C	A & B
2	A & B	A & B
3	B & C	B & C
4	A & B	B & C



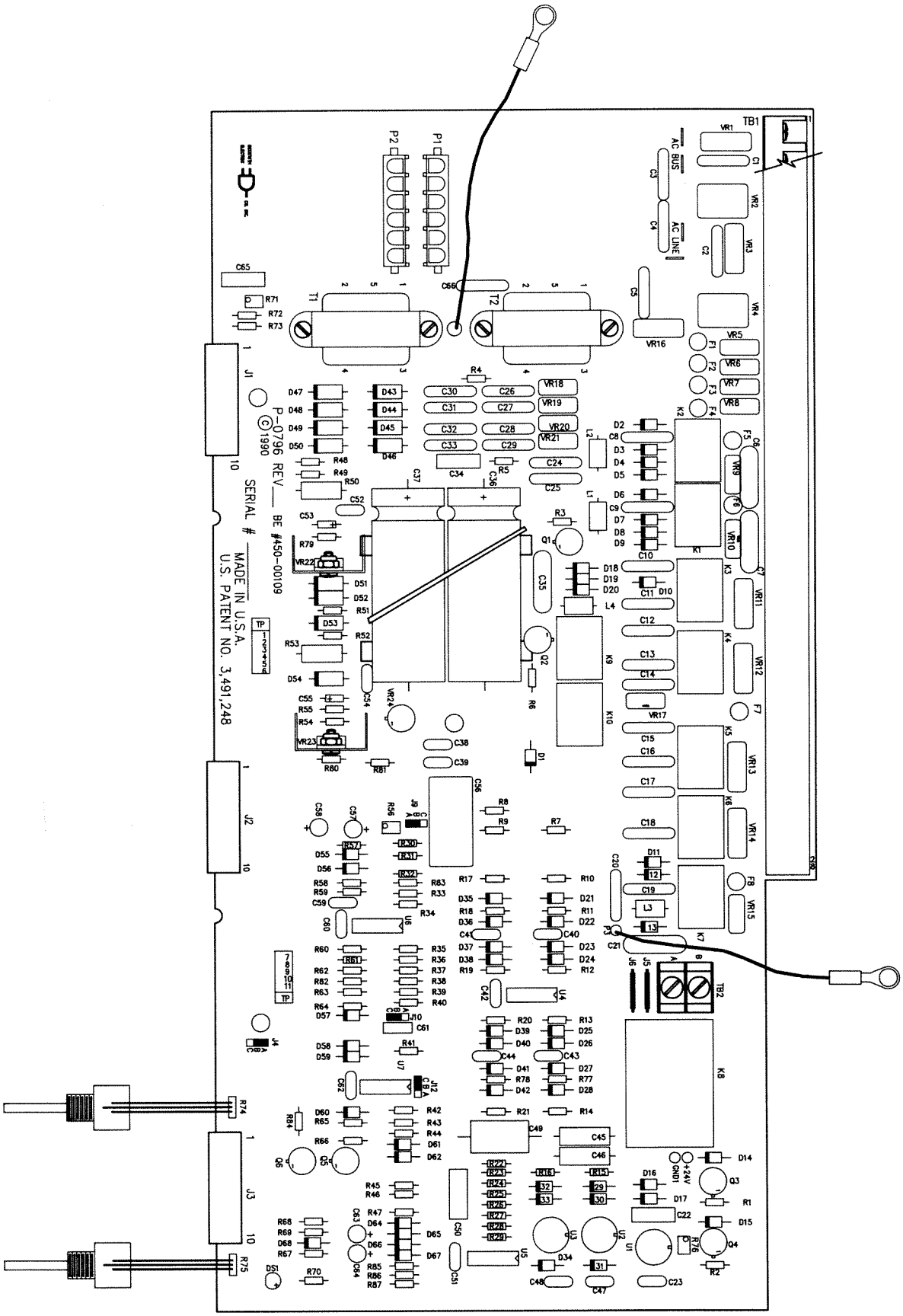


FIGURE 3 Phase and Time Board Component Location

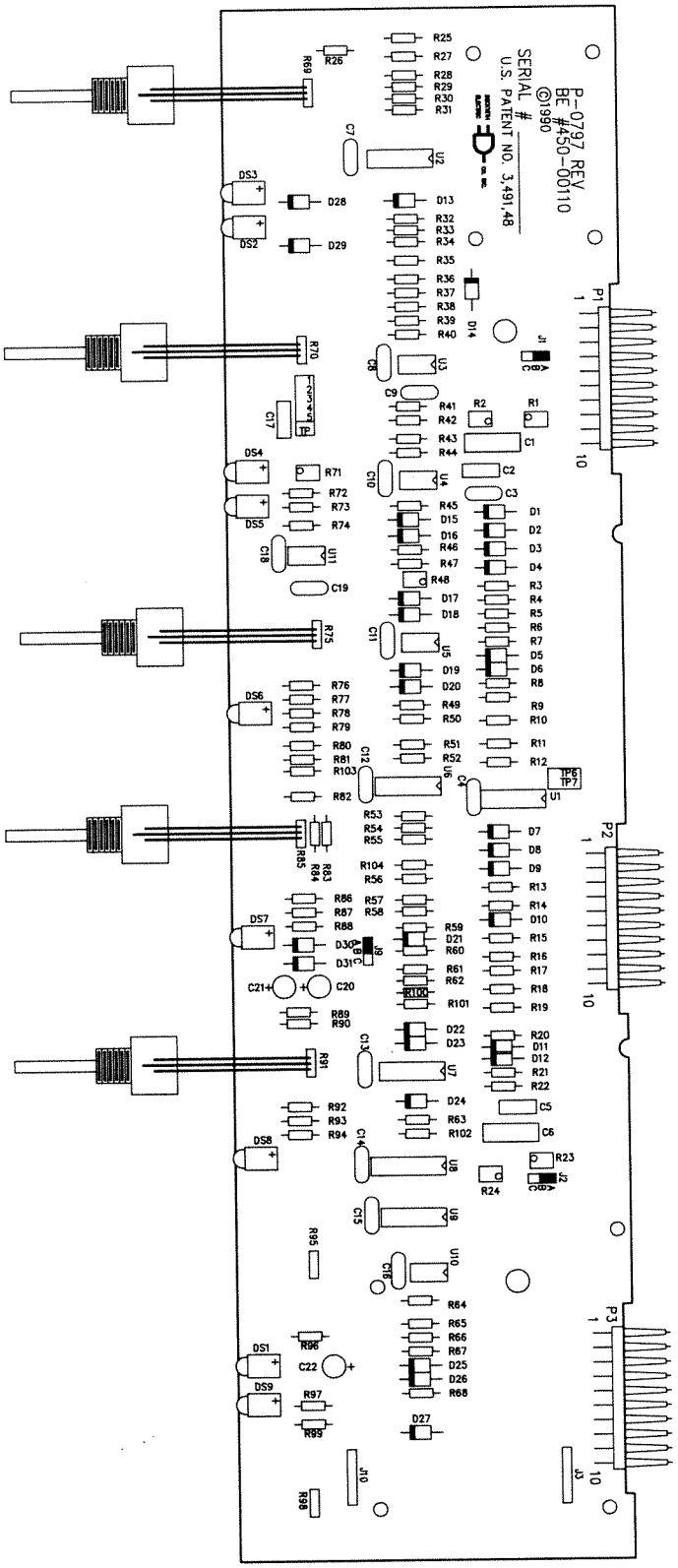


FIGURE 4 Voltage Option Board Component Location

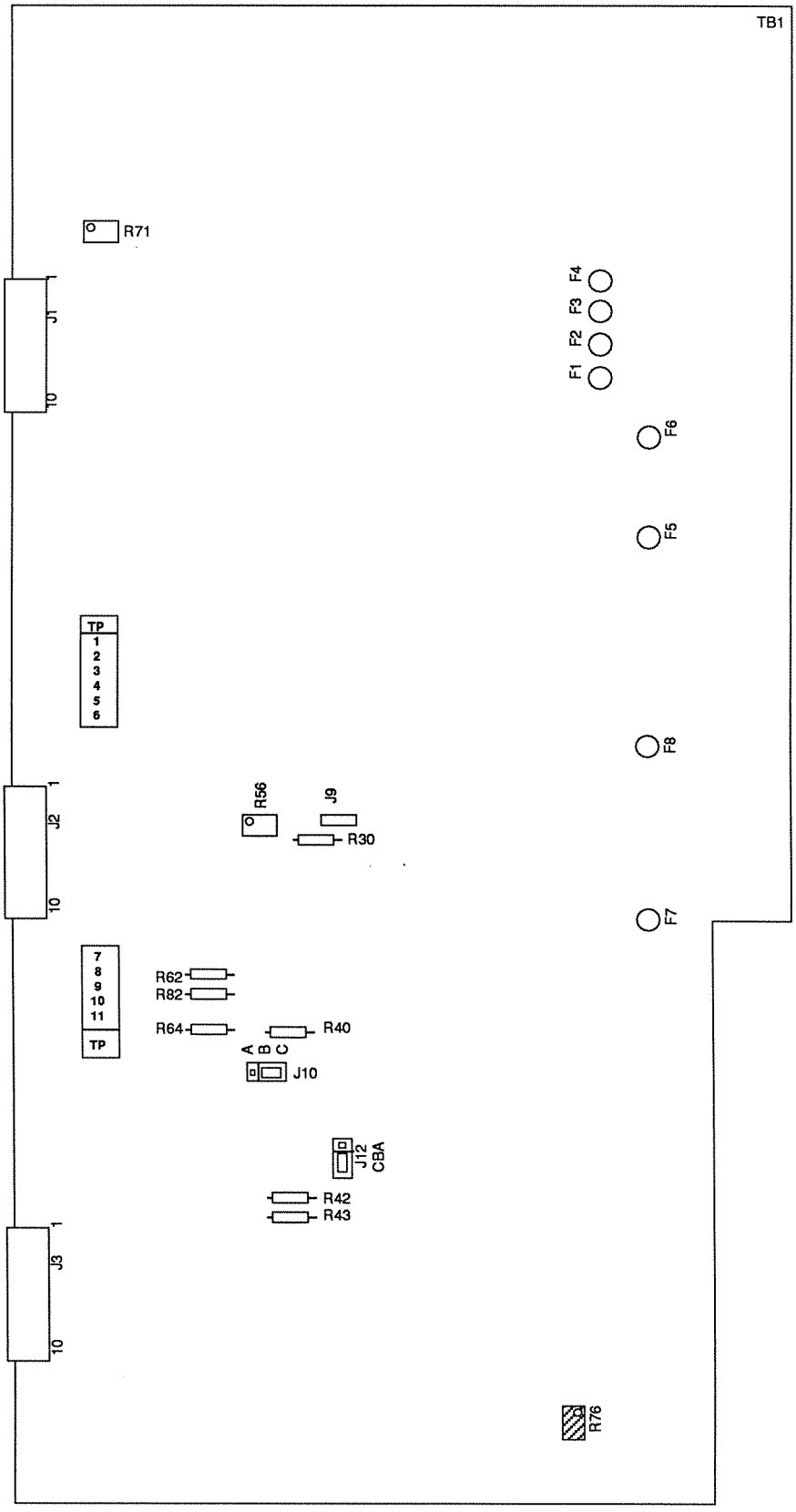


FIGURE 5 Component Location for Calibration and Range Resistors (Phase and Time Board)

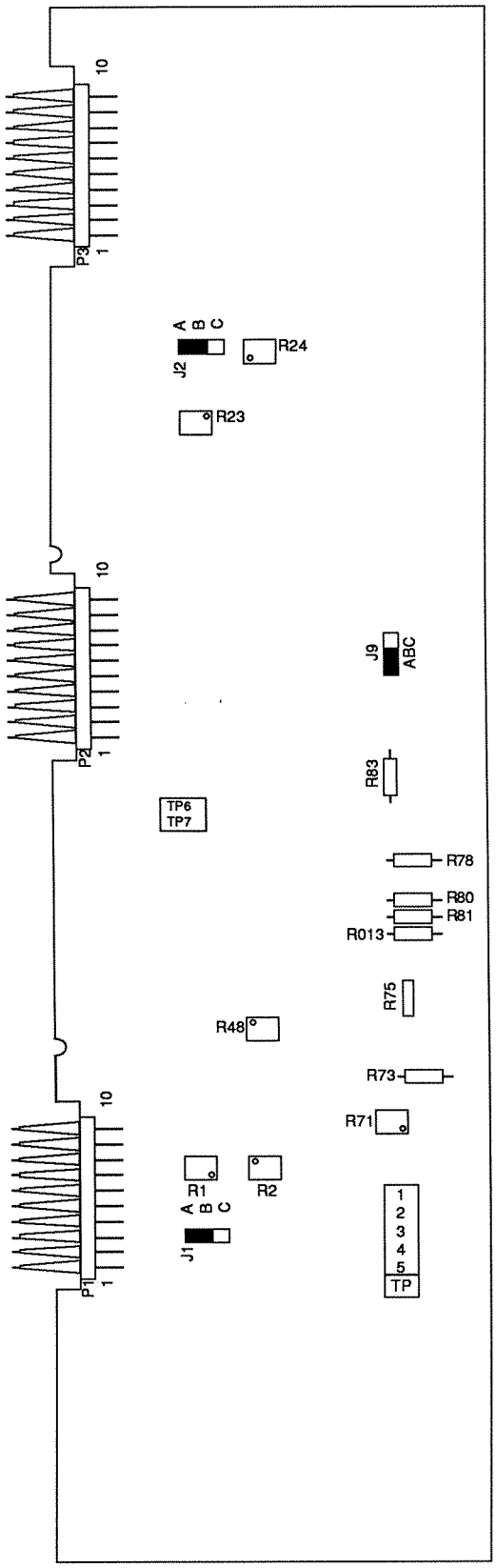


FIGURE 6 Component Location for Calibration and Range Resistors (Voltage Option Board))

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PARTS LIST

M-0188 Syncrocloser® Check Relay

This list includes all electrical and mechanical parts which could conceivably either require replacement or be lost. The **COMPONENT DESIGNATION** is the same as that appearing on schematics or referred to in Instruction Books.

The **BECO NUMBER** refers to an index maintained by the company. This lists the currently available device which may be substituted even though the device originally supplied is obsolete and no longer available. Parts marked by an asterisk* are not available from other sources. Either the original component or a current substitute will be carried in stock by Beckwith Electric.

Parts not marked with an asterisk are normally available from an electronics components house. Those parts or a current substitute will normally be available from Beckwith Electric stock.

In either case, when parts are ordered from Beckwith Electric, we will be responsible for supplying the current replacement in the shortest possible time.

Sufficient detailed description is also given to permit purchasing from an electronics parts house, providing the part is of equal or better quality to insure reliable operation. This may require some interpretation of specifications which may be avoided by direct purchase from Beckwith Electric using the **BECO NUMBER**.

Note that in a few instances, components are selected in final test. Procedures described in the **TEST PROCEDURES** section must be followed in replacing these components.

All resistors are 1/2 W unless noted.

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
		PHASE AND TIME BOARD
	450-00109*	Printed Circuit Board, P-0796
C1,C2	000-00904	Capacitor, Ceramic Disk, 0.01 μF ±20%, 1 kV
C3-C5, C8-C20,C24-C33, C66	000-00939	Capacitor, Ceramic Disk, .0047 μF ±20%, 3 kV
C6,C7,C21,C35	000-00905	Capacitor, Ceramic Disk, 0.05 μF +80/-20%, 600 V
C22	000-00845	Capacitor, Polyester, 0.068 μF ±10%, 250 V
C23,C40-C44,C47,C48, C51,C52,C54,C60,C62	000-00917	Capacitor, Ceramic Disk, 0.01 μF ±20%, 50 V
C34,C65	000-00811	Capacitor, Polyester, 0.1 μF ±10%, 100 V

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
C36,C37	000-00410	Capacitor, Electrolytic, 1900 µF +75/-10%, 50 V
C38,C39,C59	000-00932	Capacitor, Ceramic Disk, 0.1 µF ±20%, 50 V
C45,C46	010-00420	Capacitor, Polycarbonate, 0.022 µF ±10%, 50 V
C49	000-00705	Capacitor, Polyester, 0.27 µF ±10%, 50 V
C50	000-00843	Capacitor, Polyester, 0.39 µF ±5%, 100 V
C53,C55	000-00505	Capacitor, Tantalum, 1 µF ±10%, 50 V
C56	000-00847	Capacitor, Polyester, 10 µF ±10%, 63 V
C57	000-00553	Capacitor, Tantalum, 2.2 µF ±10%, 25 V
C58	0000-00018	Capacitor, Electrolytic, 1.5 µF ±20%, 50 V
C61	000-00934	Capacitor, Ceramic Disk, 0.0047 µF ±10%, 50 V
C63, C64	000-00559	Capacitor, Tantalum, 6.8 µF ±20%, 50 V
D1,D10,D16,D17,D21, D22-D42,D55,D57-D61, D66-D68	400-00224	Diode, 1N4148
D2,D3,D5-D7,D9,D11, D12,D14,D19,D20,D56,	400-00211	Diode, 1N5061
D4,D8,D13,D18	400-00061	Diode, Zener, 36 V ±5%, 1N5365B
D15	400-00004	Diode, Zener, 10 V ±5%, 1N758A
D43-D50,D52,D53	400-00213	Diode, 1N5626
D51,D54	400-00095	Diode, 43 V, 1N5367B
D62,D64,D65	400-00225	Diode, FHD333
D63		Not Used
DS1	400-00743	LED, Panel-Mounted
F1-F8	420-00725	Fuse, Plug-In, 1/2 A, 125 V, Littelfuse 273.500
FH1-FH8	420-00722	Fuse Holder, Plug-In, Vertical

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
J1-J3	420-00286	Socket, Rt. Angle, 0.156 Ctrs, 10 Pos.
J4-J8		Not Used
J9,J10,J12	420-00232	Header, 36 Position, 0.1 Ctrs
J11		Not Used
K1-K7, K9,K10	430-00151	Relay, SPDT, 24 V dc, American Zettler AZ4UP-E-1C-24D
K8	430-00153	Relay, 24 V dc, Coil, Unsealed
L1-L4	410-00521	Choke, 180 MHz
P1,P2	030-00040	Header, 6 Position, AMP 641832-1
Q1-Q6	400-00300	Transistor, 2N1711
R1	180-00271	Resistor, Carbon Comp, 270 Ω ±5%, 1/4 W
R2	180-00222	Resistor, Carbon Comp, 2.2 K ±5%, 1/4 W
R3,R6,R47,R57,R87	180-00103	Resistor, Carbon Comp, 10 K ±5%, 1/4 W
R4	330-00518	Resistor, Metal Film, 15.0 K ±1%, 1/4 W
R5,R73	330-00469	Resistor, Metal Film, 5.11 K ±1%, 1/4 W
R7,R8	330-00579	Resistor, Metal Film, 64.9 K ±1%, 1/4 W
R9	330-00502	Resistor, Metal Film, 10.2 K ±1%, 1/4 W
R10,R14,R18,R21	330-00566	Resistor, Metal Film, 47.5 K ±1%, 1/4 W
R11,R17,R77,R78	330-00401	Resistor, Metal Film, 1 K ±1%, 1/4 W
R12	330-00406	Resistor, Metal Film, 1.13 K ±1%, 1/4 W
R13,R19,R29	330-00501	Resistor, Metal Film, 10.0 K ±1%, 1/4 W
R15,R16,R67-R69	180-00203	Resistor, Carbon Comp, 20 K ±5%, 1/4 W
R20	-	See **SELECTED RESISTORS**
R22,R23,R28	330-00602	Resistor, Metal Film, 102 K ±1%, 1/4 W

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R24,R25,R33,R34,R66	180-00104	Resistor, Carbon Comp, 100 K ±5%, 1/4 W
R26,R27	180-00473	Resistor, Carbon Comp, 47 K ±5%, 1/4 W
R30	-	See **SELECTED RESISTORS**
R31	330-00385	Resistor, Metal Film, 750 Ω ±1%, 1/4 W
R32,R38	330-00473	Resistor, Metal Film, 5.62 K ±1%, 1/4 W
R35,R51,R52	180-00102	Resistor, Carbon Comp, 1 K ±5%, 1/4 W
R36	200-00244	Resistor, Carbon Comp, 240 K ±5%
R37	330-00485	Resistor, Metal Film, 7.5 K ±1%, 1/4 W
R39	330-00270	Resistor, Metal Film, 52.3 Ω ±1%, 1/4W
R40	-	See **SELECTED RESISTORS**
R41,R65	180-00273	Resistor, Carbon Comp, 27 K ±5%, 1/4 W
R42	-	See **SELECTED RESISTORS**
R43	-	See **SELECTED RESISTORS**
R44	180-00101	Resistor, Carbon Comp, 100 Ω ±5%, 1/4 W
R45,R46	180-00393	Resistor, Carbon Comp, 39 K ±5%, 1/4 W
R48,R54	330-00414	Resistor, Metal Film, 1.37 K ±1%, 1/4 W
R49,R55	330-00310	Resistor, Metal Film, 124 Ω ±1%, 1/4 W
R50,R53	370-00010	Resistor, Carbon Comp, 4.7 Ω ±5%, 2W
R56	360-00130	Potentiometer, 2 K ±10%, 1/4 W, Bourns 3266W-1-202
R58	180-00200	Resistor, Carbon Comp, 20 Ω ±5%, 1/4 W
R59	180-00513	Resistor, Carbon Comp, 51 K ±5%, 1/4 W
R60,R61,R72	330-00501	Resistor, Metal Film, 10 K ±1%, 1/4 W
R62	-	See **SELECTED RESISTORS**
R63	330-33481	Resistor, Metal Film, 6.81 K ±1%, 1/4 W
R64	-	See **SELECTED RESISTORS**

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R70	180-00622	Resistor, Carbon Comp, 6.2 K ±5%, 1/4 W
R71	360-00140	Potentiometer, 10 K, ±10%, 1/4 W Bourns 3266W-1-103
R74, R75	360-00119	Potentiometer, Cermet, 50 K ±10%, Allen-Bradley 73B1G040S503W
R76	360-00141	Potentiometer, 20 K ±10%, 1/4 W, Bourns 3266W-1-203
R79-R81,R84	370-00020	Resistor, 0 Ω (Jumper)
R82	-	See **SELECTED RESISTORS**
R83		Not Used
R86,R88	180-00913	Resistor, Carbon Comp, 91 K ± 5%, 1/4 W
T1,T2	410-00031*	Transformer, Input, U-0086
TB1	420-00052	Terminal Block, Right Angle, 28 Position, R.D.I. 6PCR-28-001
TB2	420-00066	Terminal Block, 2 Position, Curtis CBP-2C
TB3	420-00051	Terminal Block, 8 Position, TRW 14ZY-355-18-08-001
TP1-TP6	420-00232	Header, 36 Position, 0.1 Center
TP7-TP11	420-00232	Header, 36 Position, 0.1 Center
U1-U3	400-00620	Op Amp, LF255H
U4,U6	400-00639	Quad Op Amp, Fairchild μA4136DM
U5	400-00670	Quad Gate, Exclusive OR, Motorola MC-14070BCL/BAL
U7	400-00636	Quad AND Gate, MC14081
VR1,VR3,VR11-VR14, VR16	400-00724	Varistor, 250 V
VR2,VR4	400-00718	Varistor, 1 kV
VR5-VR10,VR15, VR17-VR21	400-00713	Varistor, 40 V
VR22	560-00008	Voltage Regulator, Adjustable, LM317T

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
VR23	560-00010	Voltage Regulator, Adjustable, LM337T
VR24	400-00644	Voltage Reference, National LH0070-1H
REV A		

VOLTAGE OPTION BOARD

	450-00110*	Printed Circuit Board
C1,C6	000-00841	Capacitor, Polycarbonate, 0.18 µF ±5%, 100 V
C2,C5	000-00842	Capacitor, Polycarbonate, 0.68 µF ±5%, 250 V
C3,C9,C19	000-00903	Capacitor, Ceramic Disk, 100 pF ±10%, 1 kV
C4,C7,C8,C10-C16,C18	000-00917	Capacitor, Ceramic Disk, 0.01 µF ±20%, 50 V
C17	010-00445	Capacitor, Polycarbonate, 0.1 µF ±10%, 100 V
C20-C22	000-00555	Capacitor, Tantalum, 4.7 µF ±20%, 25 V
D1-D4,D7-D10,D13-D16, D27	400-00225	Diode, Fairchild FHD333
D5,D6,D11,D12,D17-D25, D28-D31	400-00224	Diode, 1N4148
D26	400-00239	Diode, Schottky, Hewlett-Packard 5082-2810
DS1-DS8	400-00729	LED, Red, Rt. Angle PC Mount, IDI
DS9	Not Used	
J1,J2,J9	420-00232	Header, 36 Position, 0.1 Centers
J3-J8		Not Used
P1-P3	420-00287	Header, Rt. Angle, 10 Position, 0.156 Centers, Molex 26-48-2106 Series 41672
R1,R23	360-00140	Potentiometer, 10 K ±10%, 12 Turn, Bourns 3266W-1-103

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R2,R24,R71	360-00141	Potentiometer, 20 K ±10%, 12 Turn, Bourns 3266W-1-203
R3,R4,R11,R13,R14,R22	330-00568	Resistor, Metal Film, 49.9 K ±1%, 1/4 W
R5-R8,R15,R16,R20,R21	330-00601	Resistor, Metal Film, 100 K ±1%, 1/4 W
R9,R17,R51-R53,R72	330-00701	Resistor, Metal Film, 1 M ±1%, 1/4 W
R10,R18,R49,R57,R58, R74,R92,	330-00401	Resistor, Metal Film, 1 K ±1%, 1/4 W
R12,R19	330-00589	Resistor, Metal Film, 82.5 K ±1%, 1/4W
R25,R39,R54	330-00501	Resistor, Metal Film, 10 K ±1%, 1/4 W
R26	330-00526	Resistor, Metal Film, 18.2 K ±1%, 1/4 W
R27,R38,R83,R94	330-00473	Resistor, Metal Film, 5.62 K ±1%, 1/4 W
R28,R30,R33,R34	180-00395	Resistor, Carbon Comp, 3.9 M ±5%, 1/4 W
R29,R31,R32,R35,R65, R79,R97	180-00622	Resistor, Carbon Comp, 6.2 K ±5%, 1/4 W
R36	330-00513	Resistor, Metal Film, 13.3 K ±1%, 1/4 W
R37	330-00518	Resistor, Metal Film, 15 K ±1%, 1/4 W
R40-R46	340-00030	Resistor, 20 K ±0.05%, 1/8 W
R47	340-00001	Resistor, 10 K ±0.1%, 1/4 W
R48	-	See **SELECTED RESISTORS**
R50	-	See **SELECTED RESISTORS**
R55	330-00454	Resistor, Metal Film, 3.57 K ±1%, 1/4 W
R56	180-00302	Resistor, Carbon Comp, 3.0 K ±5%, 1/4 W
R59,R87	180-00304	Resistor, Carbon Comp, 300 K ±5%, 1/4 W
R60-R63,R89,R90	180-00104	Resistor, Carbon Comp, 100 K ±5%, 1/4 W
R64,R84,R86,R96	180-00105	Resistor, Carbon Comp, 1 M ±5%, 1/4 W
R66,R88	180-00103	Resistor, Carbon Comp, 10 K ±5%, 1/4 W
R67	180-00204	Resistor, Carbon Comp, 200 K ±5%, 1/4 W

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R68	330-00647	Resistor, Metal Film, 301 K ±1%, 1/4 W
R69,R70,R75,R85,R91	360-00119	Potentiometer, Cermet, 50 K ±10%, Allen-Bradley 73B1G 040S503W
R73	-	See **SELECTED RESISTORS**
R76	330-00385	Resistor, Metal Film, 750 Ω ±1%, 1/4 W
R77	330-00449	Resistor, Metal Film, 3.16 K ±1%, 1/4 W
R78	-	See **SELECTED RESISTORS**
R80	-	See **SELECTED RESISTORS**
R81	-	See **SELECTED RESISTORS**
R82,R93	330-00516	Resistor, Metal Film, 14.3 K ±1%, 1/4 W
R87	180-00304	Resistor, Carbon Comp, 300 K ±5%, 1/4 W
R99-R102,R104		Not Used
R103	370-00020	Resistor, 0 Ω (Jumper)
TP1-TP5	420-00232	Header, 5 Position, 0.1 Ctrs.
TP6,TP7	420-00232	Header, 2 Position
U1,U6	400-00665	Quad Op Amp, LM224J
U2	400-00639	Quad Op Amp, 4136DC
U3,U4,U11	560-00011	Op Amp, LM108J8
U5,U10	560-00012	Op Amp, MC1741
U7,U9	400-00636	Quad AND Gate, MC14081
U8	540-00056	Exclusive OR Gate, MC14049

REV B

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
		SELECTED RESISTORS
R20	330-00406	Resistor, Metal Film, 1.13 K ±1%, 1/4 W
	330-00481	Resistor, Metal Film, 6.81 K ±1%, 1/4 W
R30	330-00469	Resistor, Metal Film, 5.11 K ±1%, 1/4 W
	330-00439	Resistor, Metal Film, 2.49 K ±1%, 1/4 W
	330-00387	Resistor, Metal Film, 787 Ω ±1%, 1/4 W
	330-00374	Resistor, Metal Film, 576 Ω ±1%, 1/4 W
R40	330-00475	Resistor, Metal Film, 5.90 K ±1%, 1/4 W
	330-00447	Resistor, Metal Film, 3.01 K ±1%, 1/4 W
	330-00401	Resistor, Metal Film, 1.0 K ±1%, 1/4 W
	330-00385	Resistor, Metal Film, 750 Ω ±1%, 1/4 W
	330-00509	Resistor, Metal Film, 12.1 K ±1%, 1/4 W
R42	330-00701	Resistor, Metal Film, 1 M ±1%, 1/4 W
	330-00658	Resistor, Metal Film, 392 K ±1%, 1/4 W
R43	330-00605	Resistor, Metal Film, 110 K ±1%, 1/4 W
R48	360-00142	Potentiometer, 12-Turn, Top Adjust, 50 K ±10%, 1/4 W, Bourns 3266W-1-503
	360-00140	Potentiometer, 12-Turn, Top Adjust, 10 K ±10%, 1/4 W, Bourns 3266W-1-103
	360-00141	Potentiometer, 12-Turn, Top Adjust, 20 K ±10%, 1/4 W, Bourns 3266W-1-203
R50	180-00184	Resistor, Carbon Comp, 180 K ±5%, 1/4 W
	180-00913	Resistor, Carbon Comp, 91 K ±5%, 1/4 W
R62	330-00522	Resistor, Metal Film, 16.5 K ±1%, 1/4 W
	330-00567	Resistor, Metal Film, 48.7 K ±1%, 1/4 W
	330-00501	Resistor, Metal Film, 10.0 K ±1%, 1/4 W
R64	330-00511	Resistor, Metal Film, 12.7 K ±1%, 1/4 W
R73	330-00626	Resistor, Metal Film, 182 K ±1%, 1/4 W
	330-00539	Resistor, Metal Film, 24.9 K ±1%, 1/4 W
	330-00583	Resistor, Metal Film, 71.5 K ±1%, 1/4 W
	330-00554	Resistor, Metal Film, 35.7 K ±1%, 1/4 W
R78	330-00427	Resistor, Metal Film, 1.87 K ±1%, 1/4 W
R80	330-00473	Resistor, Metal Film, 5.62 K ±1%, 1/4 W
R81	330-00505	Resistor, Metal Film, 11 K ±1%, 1/4 W
R82	-	Open or Jumper

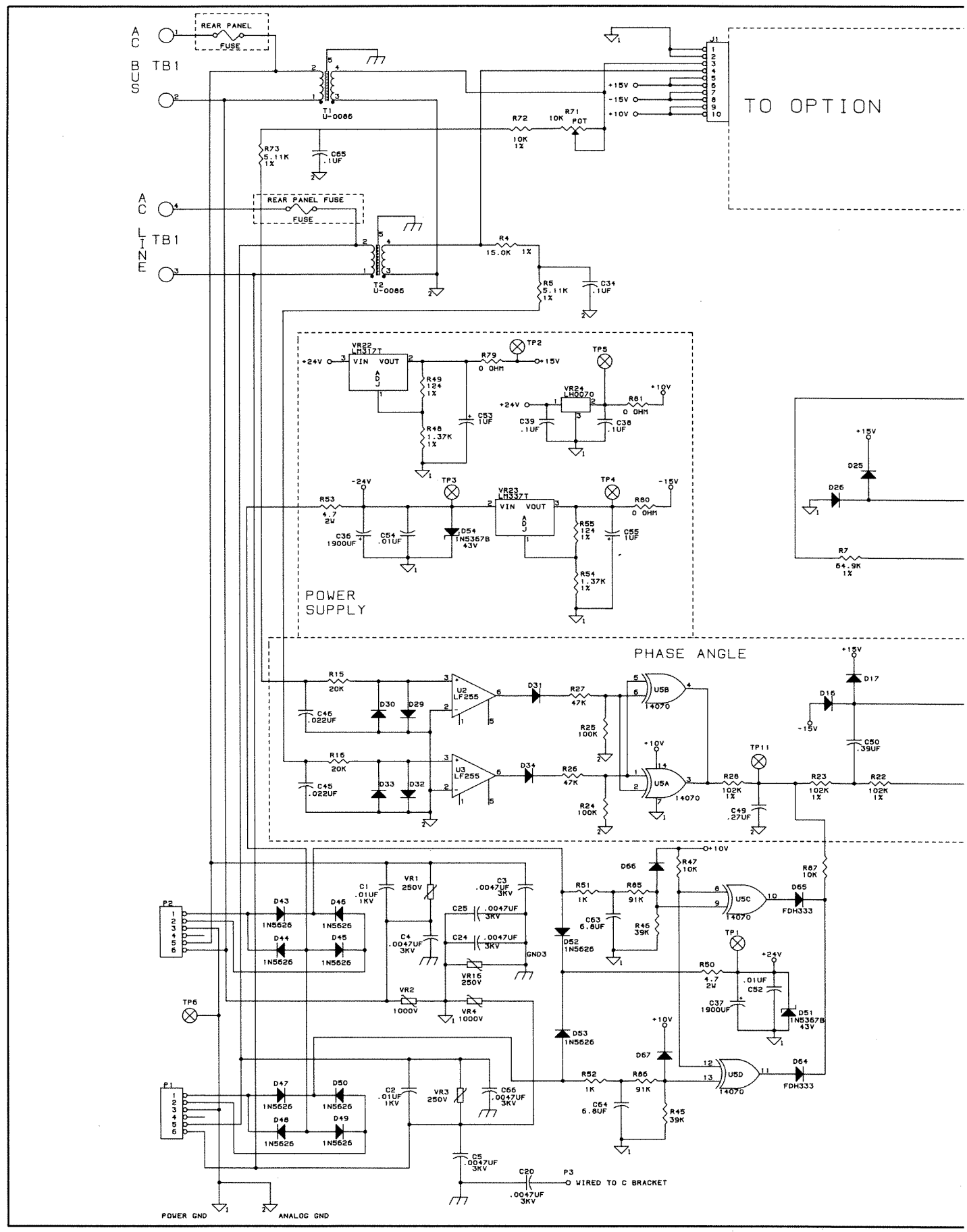


FIGURE 7a Phase and Time Board Schematic

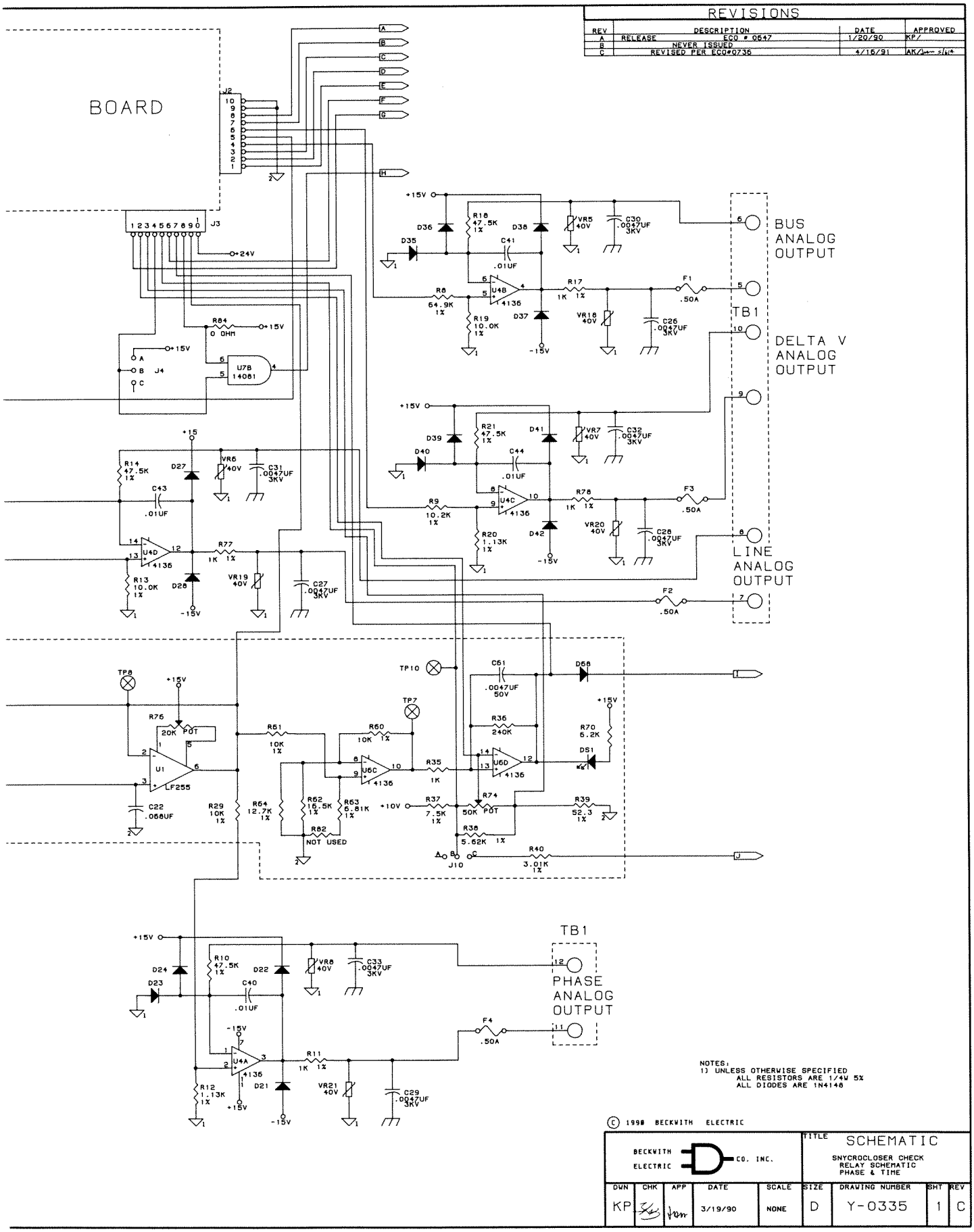


FIGURE 7b Phase and Time Board Schematic

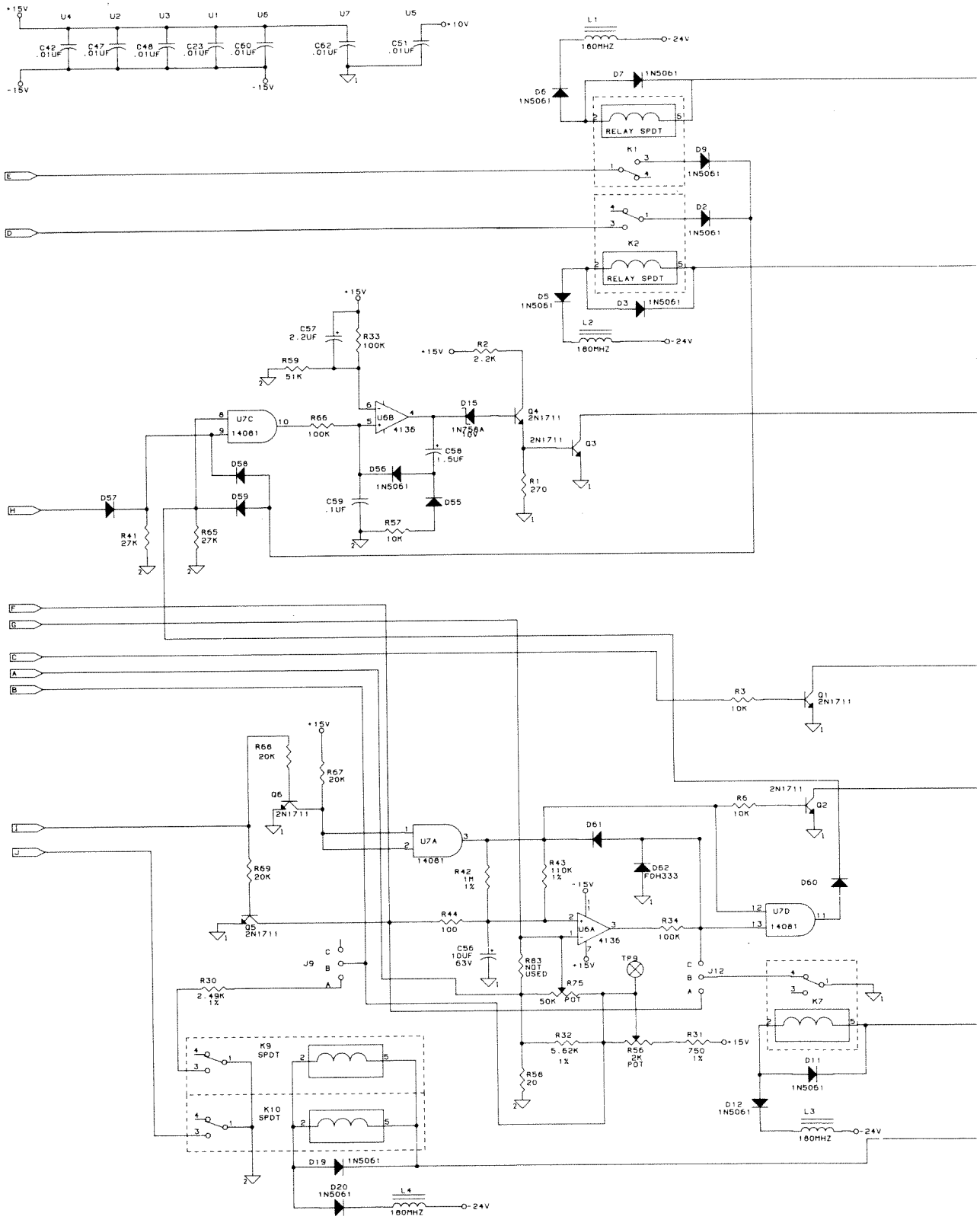


FIGURE 7c Phase and Time Board Schematic

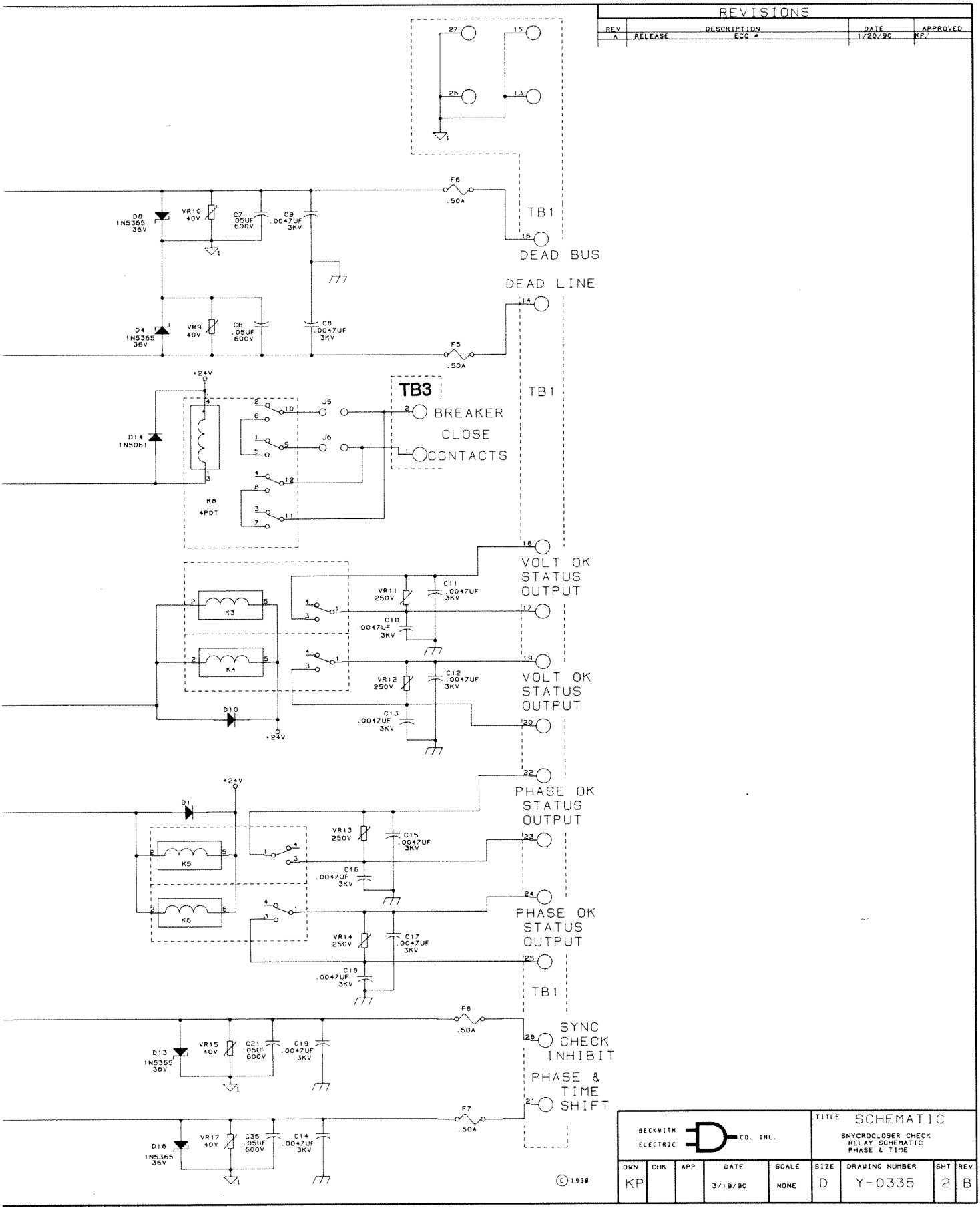


FIGURE 7d Phase and Time Board Schematic

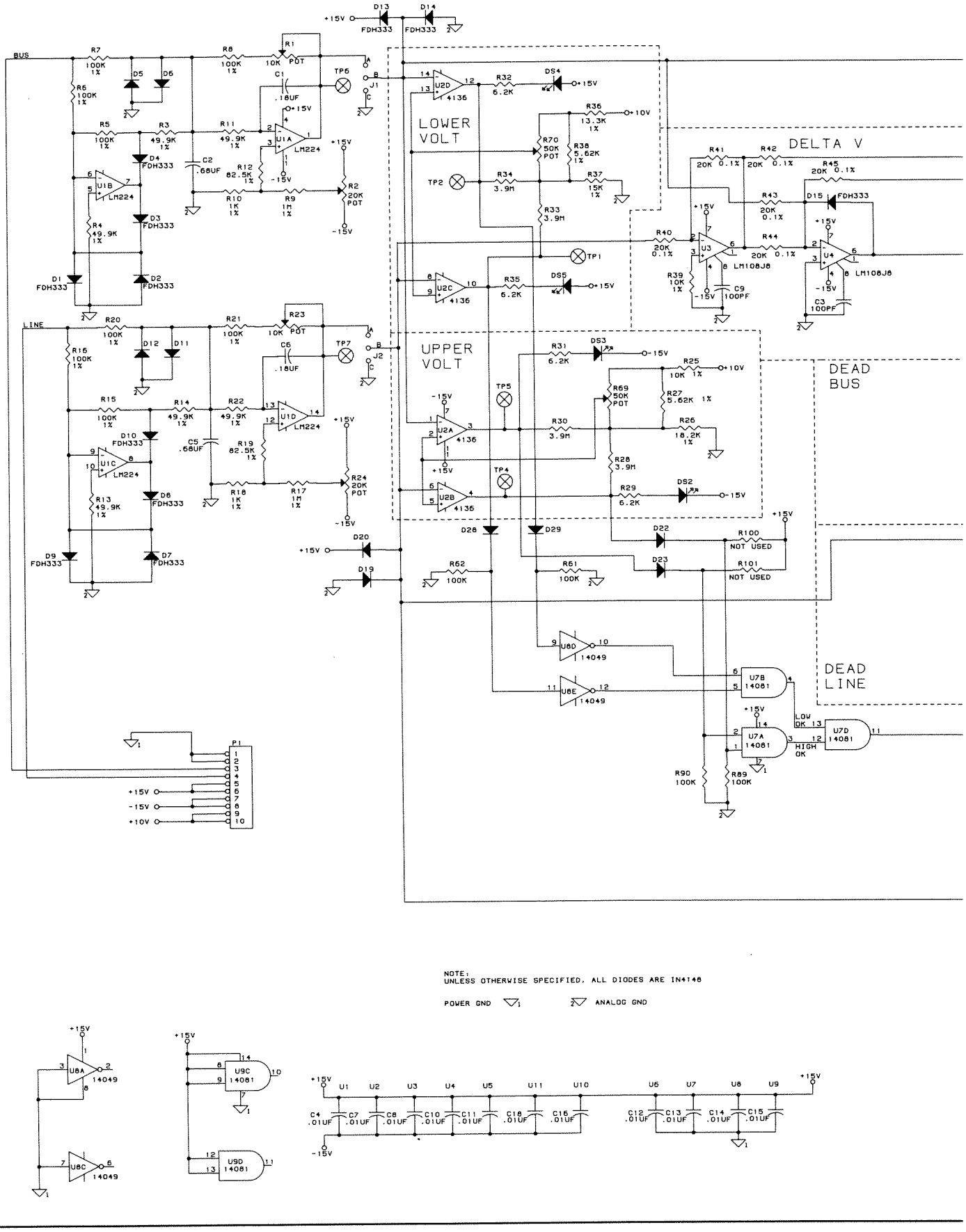
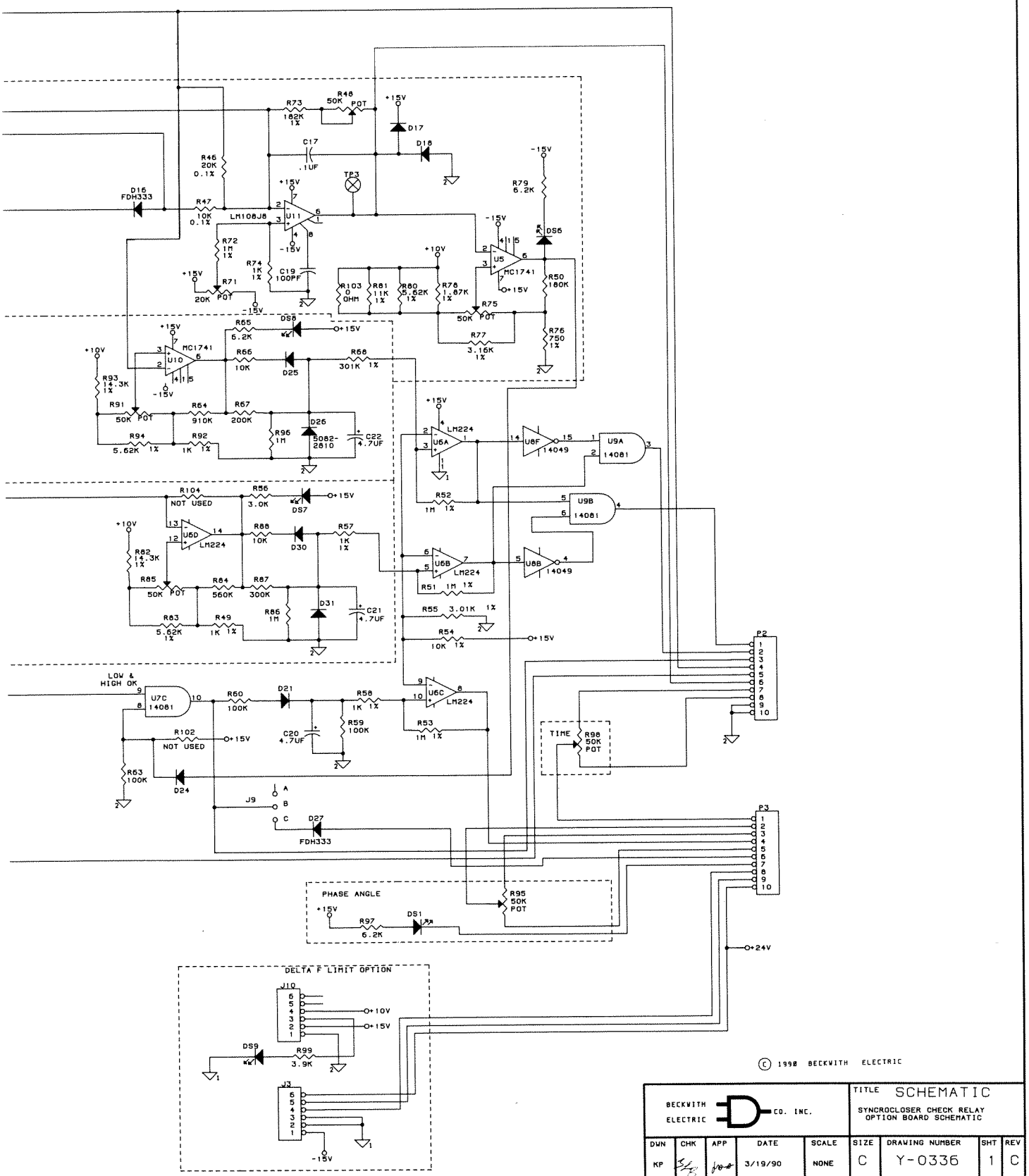


FIGURE 8a Voltage Option Board Schematic

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED
A	RELEASE ECO #0647	1/20/90	KP/
B	NEVER ISSUED		
C	NEW VALUE R64,R84 ECO#0736	4/16/91	AK/



BECKWITH ELECTRIC CO. INC.	TITLE SCHEMATIC SYNCROCLOSER CHECK RELAY OPTION BOARD SCHEMATIC							
DWN	CHK	APP	DATE	SCALE	SIZE	DRAWING NUMBER	SHT	REV
KP			3/19/90	NONE	C	Y-0336	1	C

FIGURE 8b Voltage Option Board Schematic

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Legal Information

Patent

The units described in this manual are covered by U.S. Patent 4.218.625, with other patents pending.

Buyer shall hold harmless and indemnify the Seller, its directors, officers, agents, and employees from any and all costs and expense, damage or loss, resulting from any alleged infringementof United States Letters Patent or rights accruing thereform or trademarks, whether federal, state, or common law, arising from the Seller's compliance with Buyer's designs, specifications, or instructions.

Warranty

Seller hereby warrants that the goods which are the subject matter of this contract will be manufactured in a good workmanlike manner and all materials used herein will be new and reasonably suitable for the equipment. Seller warrants that if, during a period of two years from date of shipment of the equipment, the equipment rendered shall be found by the Buyer to be faulty or shall fail to peform in accordance with Seller's specifications of the product, Seller shall at his expense correct the same, provided, however, that Buyers shall ship the equipment prepaid to Seller's facility. The Seller's responsibility hereunder shall be limited to replacement value of the equipment furnished under this contract.

Seller makes no warranties expressed or implied other than those set out above. Seller specifically excludes the implied warranties of merchantibility and fitness for a particular purpose. There are no warranties which extend beyond the description contained herein. In no event shall Seller be liable for consequential, exemplary, or punitive damages of whatever nature.

Any equipment returned for repair must be sent with transportation charges prepaid. The equipment must remain the property of the Buyer. The aforementioned warranties are void if the value of the unit is invoiced to the Seller at the time of return.

Indemnification

The Seller shall not be liable for any property damages whatsoever or for any loss or damage arising out of, connected with, or resulting from this contract, or from the performance or breach thereof, or from all services covered by or furnished under this contract.

In no event shall the Seller be liable for special, incidental, exemplary, or consequential damages, including but not limited to, loss of profits or revenue, loss of use of the equipment or any associated equipment, cost of capital, cost of purchased power, cost of substitute equipment, facilities or services, downtime costs, or claims or damages of customers or employees of the Buyer for such damages, regardless of whether said claim or damages is based on contract, warranty, tort including negligence, or otherwise.

Under no circumstances shall the Seller be liable for any personal injury whatsoever.

It is agreed that when the equipment furnished hereunder are to be used or performed in connection with any nuclear installation, facility, or activity, Seller shall have no liability for any nuclear damage, personal injury, property damage, or nuclear contamination to any property located at or near the site of the nuclear facility. Buyer agrees to indemnify and hold harmless the Seller against any and all liability associated therewith whatsoever whether based on contract, tort, or otherwise. Nuclear installation or facility means any nuclear reactor and includes the site on which any of the foregoing is located, all operations conducted on such site, and all premises used for such operations.

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Printed in USA

800-0188A-IB 02/99