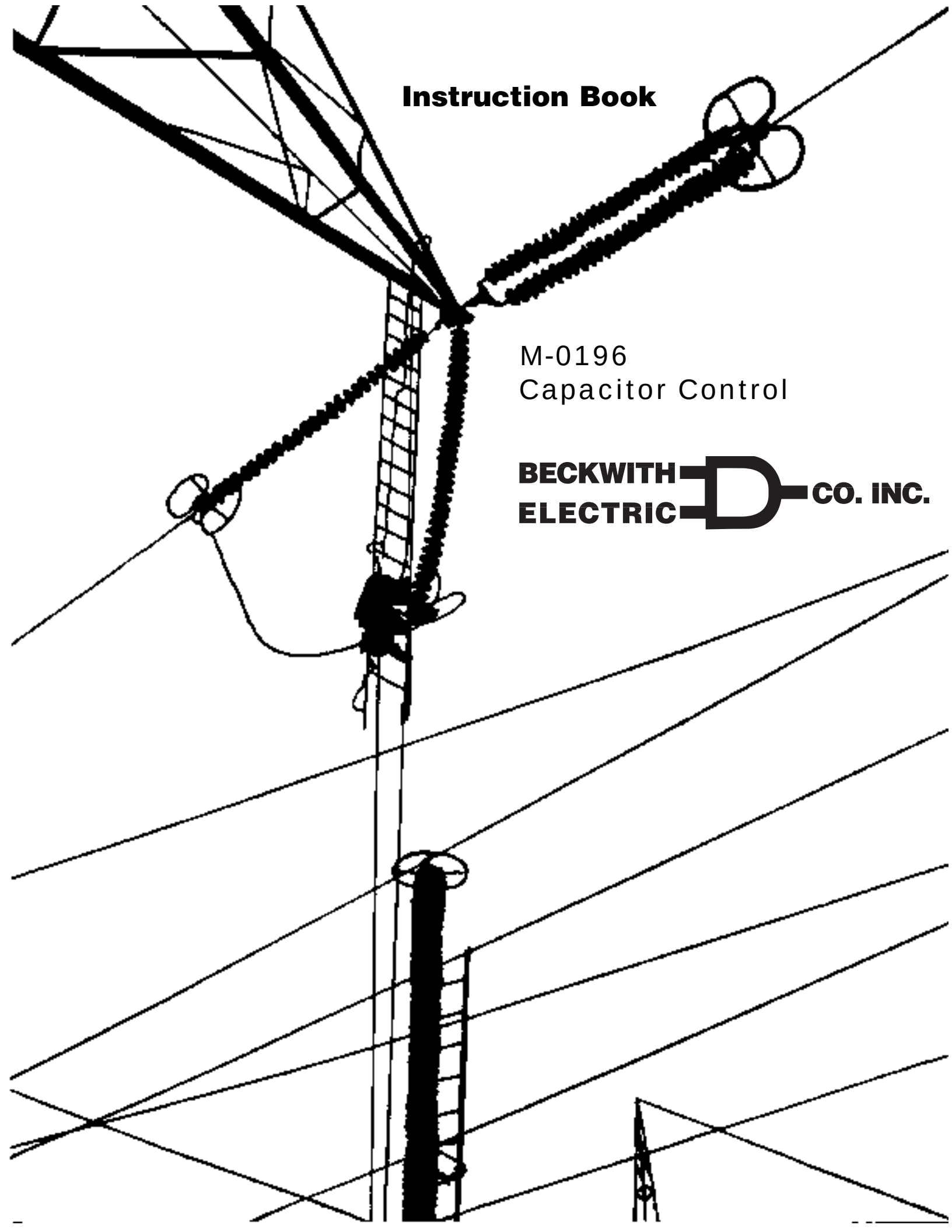
Instruction Book



M-0196
Capacitor Control

BECKWITH ELECTRIC CO. INC.

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Capacitor Control M-0196A

- Highly Stable, Voltage-Responsive Control
- Plug-Connected for Quick Field Changing
- Shape and Size Identical to M-0195 Regulator Control

This simplified solid-state control provides the signals necessary to initiate the addition or removal of capacitor banks. The mounting bracket and socket assembly are designed to be permanently installed on the inside back wall of the existing cabinet. The plug-in control can then be easily installed or removed to facilitate maintenance.

INPUT VOLTAGE

A two-wire voltage input of 105 to 135 V ac nominal is required. A second input, also 105 to 135 V ac nominal with neutral common to the voltage input, is required to power the control. The power consumed by the control is less than 3 W. If a separate power supply is not available, the control may be powered from a common input.

OUTPUTS

Two separate normally open dry output relay contacts are provided. The contacts are rated as follows:

	115 V ac	220 V ac	48 V ac	125 V dc
Carry Continuous	5 A	2 A	5 A	0.5 A
Interrupt Resistive	5 A	1 A	3 A	0.5 A
Interrupt Inductive	0.5 A	0.25 A	0.1 A	0.05 A

CONTROLS

VOLTAGE: The center of the bandwidth may be set to any voltage from 105 to 135 V ac.

BANDWIDTH: The bandwidth can be adjusted from 2 to 12 V ac.

TIME: The timer is adjustable from 0 to 120 seconds. The timer is initiated when the voltages go outside the band and resets within a few milliseconds upon return to the band.

TEST: An uncalibrated dial will lower the input voltage by a maximum of 10% to permit checking the calibration of the M-0196 using a fixed voltage source. Pin jacks are provided on the front panel to measure the test voltage. When set in the **OPERATE POSITION**, the voltage measured is the regulator voltage.

LED INDICATORS

Two band-edge LEDs indicate the excursion of regulator voltage above or below its dead band. A third LED lights if the voltage stays outside the band beyond the time delay setting, indicating that the Raise or Lower output contacts are closed.

RESPONSE TIME

The unit will respond to 5/8% voltage change in 0.2 sec, assuring freedom from hunting on minimum bandwidth.

TRANSIENT PROTECTION

The input will withstand 10/50 µs impulse, 5000 V crest, up to 2 J energy content. Meets ANSI C37.90.1–1989 Surge Withstand Capability Test.

ENVIRONMENTAL

Temperature Range: Stated accuracies are maintained from -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: 10" high X 4-3/4" wide X 5-1/4" deep (25.4 cm X 12.07 cm X 13.34 cm) including mounting bracket.
Approximate Weight: 4 lb 6 oz (1.98 kg).
Approximate Shipping Weight: 5 lb 4 oz (2.38 kg).

WARRANTY

The M-0196 Capacitor Control is covered by a two-year warranty from date of shipment.

Printed in U.S.A.

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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INTRODUCTION

This all solid-state control is designed to provide long, trouble-free performance, using the latest design techniques and modern solid-state components. The control is inherently stable with temperature variations and usage. No temperature compensation is included in the design. All active semiconductors are hermetically sealed, and therefore largely free from performance degradation as a result of being exposed to a variety of environmental conditions.

CONSTRUCTION

The entire control is housed in a rugged die-cast aluminum box that is anodized for long life. All circuit components are mounted on a double-sided printed circuit board with plated-through holes. Components are mounted on either side of this board. The board is fastened to the front cover and held 5/8" behind it by metal bushings. Holes are provided to view the light emitting diodes located on the printed circuit board. The shafts of two potentiometers project from the front panel and rotate against marked scales. Both controls are adjusted by knobs having edge indicators. Holes are provided on the cover for screwdriver adjustment of the **TIME** and **BANDWIDTH** functions. Also mounted to the back of the cover are pin jacks to measure the test voltage as well as the normal operating voltage. The cover is held to the box by six screws. The wire cable from the printed circuit board and the components mounted to the front cover is routed to a relay-type connect plug mounted at the back of the box underneath the printed circuit board. A mounting plate is fastened to the bottom end of the box and the connector plug projects through it. The mounting plate has four 1/4-turn stainless steel fastener studs, held by retainers mounted near its corners.

TRANSIENT PROTECTION

Provision is made throughout the design to limit or bypass the undesirable and, at times, hazardous voltages which are developed due to transients associated with external input and output signals. In general, ceramic disc and solid tantalum capacitors provide isolation of high frequency voltage transients from the sensitive solid-state components. Metal oxide varistors are connected across power inputs and outputs since they exhibit non-linear voltage-dependent resistance and therefore clamp the short-duration high voltage pulses. Varistor Q9 will clamp any voltage on the chassis to a safe 40 V from neutral. High voltage circuits are fused for safer operation.

STABILITY

Excellent stability is achieved for an operational range of -40° to +80° C (-40° to +176° F). This is made possible by the use of components and circuits inherently stable with time and environmental variations. A conservative design approach assures that components will operate well below their rated parameters and hence their operating life will be prolonged. By keeping power dissipation and therefore the temperature rise to a minimum, the initial settling or warm-up time has been made negligible.

In critical voltage sensing and reference voltage circuits, military grade metal film resistors are used. Cermet potentiometers and trimmers are used for setting the various control levels. A rugged I.C. voltage regulator, two precision resistors and an operational amplifier provide well regulated and stable +15 and -15 V supplies. Operational amplifiers provide precise voltage gains and in other circuits are connected as comparators to discriminate between voltages as close as .01 V dc.

A precise active full-wave rectifier and filter circuit, which also acts as a summing amplifier for additional inputs, is formed by Q1A, Q2A and their associated components. The effect of temperature on a conventional rectifier circuit due to temperature variable diode drop is thereby eliminated in this circuit. In addition, the conventional voltage sensing transformer is also eliminated in this versatile circuit.

Stable mylar capacitors are used to yield temperature stable timer circuits. The capacitor charging current and the time adjustment voltage are derived from regulated voltage sources, resulting in a repeatable time delay for a given setting. Tantalum capacitors are also used in attenuating any high frequency noise. The filter capacitor in the power supply circuit is chosen for superior performance at the temperature extremes.

Light Emitting Diodes are used to indicate various circuit conditions. These have a projected life far exceeding the anticipated life of the control itself and work off low dc voltages. Signal diodes are chosen for low leakage and designed into circuits where their forward drop is of no consequence. Rugged diodes, having reverse breakdown voltage and forward current well exceeding the design requirements, are used in high voltage circuits.

All active semiconductors are hermetically sealed to ensure sound performance under adverse environmental conditions. Capacitors, resistors, trimmers, potentiometers and diodes used are among the best available. After testing each control, the printed circuit board is coated on both sides with a non-conductive coating to guard against corrosion of copper foil or formation of conductive paths on the board surface.

APPLICATION

GENERAL

The Capacitor Control is intended to provide proper initiation of power system devices to insert or remove a capacitor bank from the power system. It is offered as a compact, versatile control which is easily installed in the control circuitry.

VOLTAGE BAND DETECTOR

Refer to Figure 1 Block Diagram and Figure 6 Schematic.

Resistors R28, R22, potentiometer R17 and trimmer R20 form a voltage divider network across +15 V. Trimmer R20 is factory adjusted to compensate for the initial tolerances of the voltage-sensing circuit. **VOLTAGE** control potentiometer R17 provides a voltage whose range corresponds to a sensing voltage of 105 to 135 V ac. Resistors R21, R23 and R25 produce a voltage band across R21 and R23 corresponding to 2 to 12 V ac; with R21 set for the desired voltage band. The center of the voltage band is determined by the setting of R17. The reference voltages are compared with the voltage across C8, corresponding to the potential input, by Q2A and Q2B connected as voltage comparators.

If the input voltage falls inside the deadband established by the **VOLTAGE** control R17 and the **BANDWIDTH** control R21, the outputs of Q2A and Q2B remain switched to 14 V. As the input voltage increases slightly above the upper band limit, the non-inverting input of Q2A exceeds the inverting input causing its output to switch to +14 V. The high output of Q2A will light the **LOWER** LED D12 indicating the voltage has moved above the band. Similarly if the input voltage moves below the lower end of the deadband, Q2B output switches to +14 V and the **ON** LED is lit. Positive feedback is used to obtain decisive switching of Q2A and Q2B outputs and, in the process, yields a precise 0.2 V ac hysteresis at the band edges. This, coupled with the slight time delay incorporated in the voltage-sensing circuit, assures freedom from hunting at even the minimum bandwidth setting.

TIMER

Two independent but identical integrating time circuits are used to advantage by assuring that each circuit is already reset at the start of the timing cycle. When Q2A output switches high to +14 V as a result of the input voltage moving above the band edge, this precise voltage supplies charging current to the capacitor C9 through resistors R30 and R31. The capacitor voltage is compared with the voltage at the wiper of the **TIME** adjusting trimmer R36 by the voltage comparator Q2C whose output is initially at –14 V. As the capacitor voltage exceeds the reference voltage, Q2C voltage switches to +14 V, developing about 28 V across the coil of the Lower relay K1 which is thereby picked up. One set of the relay contacts is used for the external Lower output contacts from J1-9 to J1-5. The second set of K1 contacts short R31 and R29, causing a large charging current to flow through C9 and increasing C9 voltage instantaneously. This enables the relay K1 to pick up decisively once Q2 output begins to switch high. It also provides hysteresis in relay switching and thereby makes the circuit immune to noise. If the input voltage returns to band before the time delay is completed, C9 voltage discharges at the same rate it was charging previously due to the circuit symmetry and the fact that K1 contacts across R31 are open. Therefore, a truly integrating timer is achieved. Relay K1 will pick up only when the input voltage stays above the band more than it stays in the band by a time interval exceeding the timer setting.

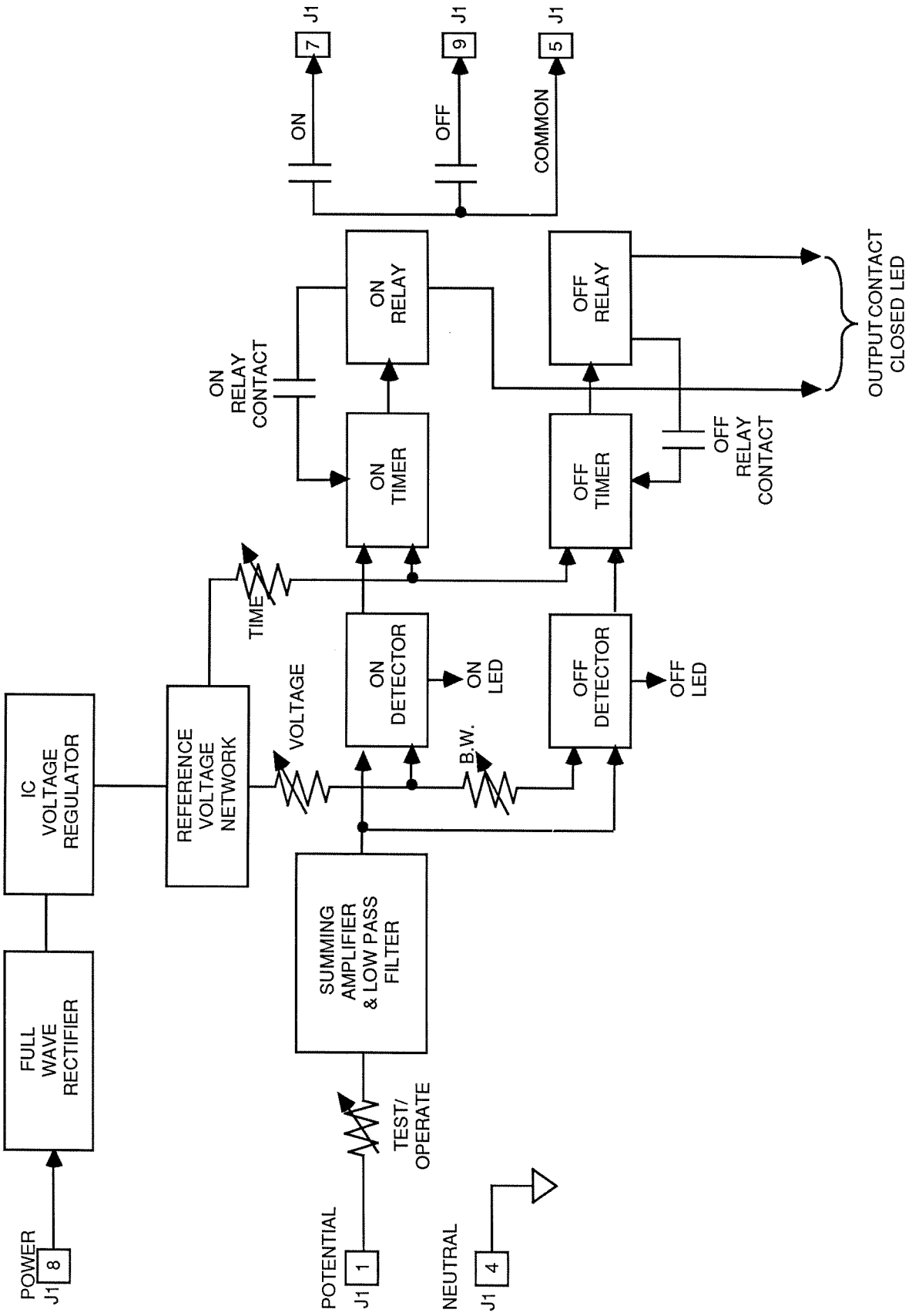


FIGURE 1 Block Diagram

The On timing circuit duplicates this sequence when the voltage input is moved below the band. Diodes D14 and D17 limit the voltage across timing capacitors C9 and C10 to 15 V. **ON** LED D16 indicates the low voltage condition and starting of the timing cycle.

The current through K1 or K2 relay coil passes through the **OUTPUT CONTACTS CLOSED** LED D22 and lights it, indicating the closing of the output contacts of the respective relay. If D12 is already lit, it means that the Lower relay is energized. Similarly, if D16 is already lit, it indicates the energizing of the Raise relay. Diodes D19 and D20 across K1 and K2 relay coils absorb the inductive kick when the relay drops out. When the voltage returns inside the band after the timing is completed, the timing capacitors discharge immediately and the circuit is reset. Trimmer R36, the **TIME** control, is common to both timing circuits and can be set for any time delay up to 120 seconds.

SELF-CHECKING FEATURE

The **TEST/OPERATE** control R5 should be set in the counterclockwise or **OPERATE POSITION** for normal operation. By plugging a high impedance (greater than or equal to 500 ohms per volt) ac voltmeter into Test Jacks J3 and J4, the regulator voltage can be monitored. With the **OPERATE/TEST** switch in the maximum counterclockwise position (switch detent) the Test Jacks (J3 and J4) on the M-0196 front panel can be used with low impedance instruments (up to 60 VA) to monitor the P.T. voltage. When the **OPERATE/TEST** switch is not in the maximum counterclockwise position, the test jacks J3 and J4 can only be used for high impedance (greater than or equal to 500 ohms per volt) instrumentation. When a variable ac voltage is not available, the calibration and proper functioning of the control can be checked by setting the **VOLTAGE** control at about 10 V max. below the available voltage source. The **OPERATE/TEST** control can be moved clockwise and the voltages, when the **ON** and **OFF** LEDs light, can be read on the voltmeter plugged into the Test Jacks. The center voltage will be halfway between the two voltages. The **TIME** setting can be verified by determining the time it takes for the **OUTPUT CONTACTS CLOSED** LED to light after the **ON** or **OFF** LED is lit.

▲ **CAUTION: After the test is completed, and during operation, make sure that the OPERATE/TEST control is set at its most counterclockwise or OPERATE POSITION.**

● **WARNING: Voltage applied at Test Jacks may energize the capacitor bank.**

Death or severe electrical shock can occur.

Do not connect any voltage source at the test jacks.

INSTALLATION

MOUNTING

The control, as shown in Figure 2, is intended to be mounted inside a control cabinet. A U-bracket with two connector sockets assembled to it is provided separately. The bracket should be mounted inside the control cabinet by four screws. Complete the external connections to the two sockets as shown in Figure 3. Fastened to the bracket are four 1/4 turn receptacles that correspond to the studs on the mounting plate described above. The M-0196 Control connector plug should be aligned with the socket and pushed in as far as it will go. By turning the 1/4 turn fastener studs with a screwdriver until they catch, the control is now properly mounted. The control may be plugged in and out with the circuit hot if proper care is taken in aligning the plugs with the sockets and making sure that the user's body does not come in contact with the hot circuit. Also it should be made certain that any hand tools do not inadvertently connect the hot circuit to the chassis.

VOLTAGE INPUTS

The external connections are shown in Figure 3. The measuring potential input should be obtained from a potential transformer having a nominal 120 V ac output. The burden of this input is 0.4 VA. The power to the control unit may be supplied from the same potential transformer since the internal power for the unit is approximately 5 VA.

OUTPUTS

The On and Off outputs should be connected to the respective interposing relays in the capacitor bank switching circuit if more than one step of capacitor compensation is available. If only one step of compensation is to be used, these outputs may be inserted into the normal breaker control scheme. These output relay contacts are rated as follows:

	115 V ac	220 V ac	48 V dc	125 V dc
Carry Continuous	5 A	2 A	5 A	125 A
Interrupt Resistive	5 A	1 A	3 A	0.5 A
Interrupt Inductive	0.5 A	0.25 A	0.1 A	0.05 A

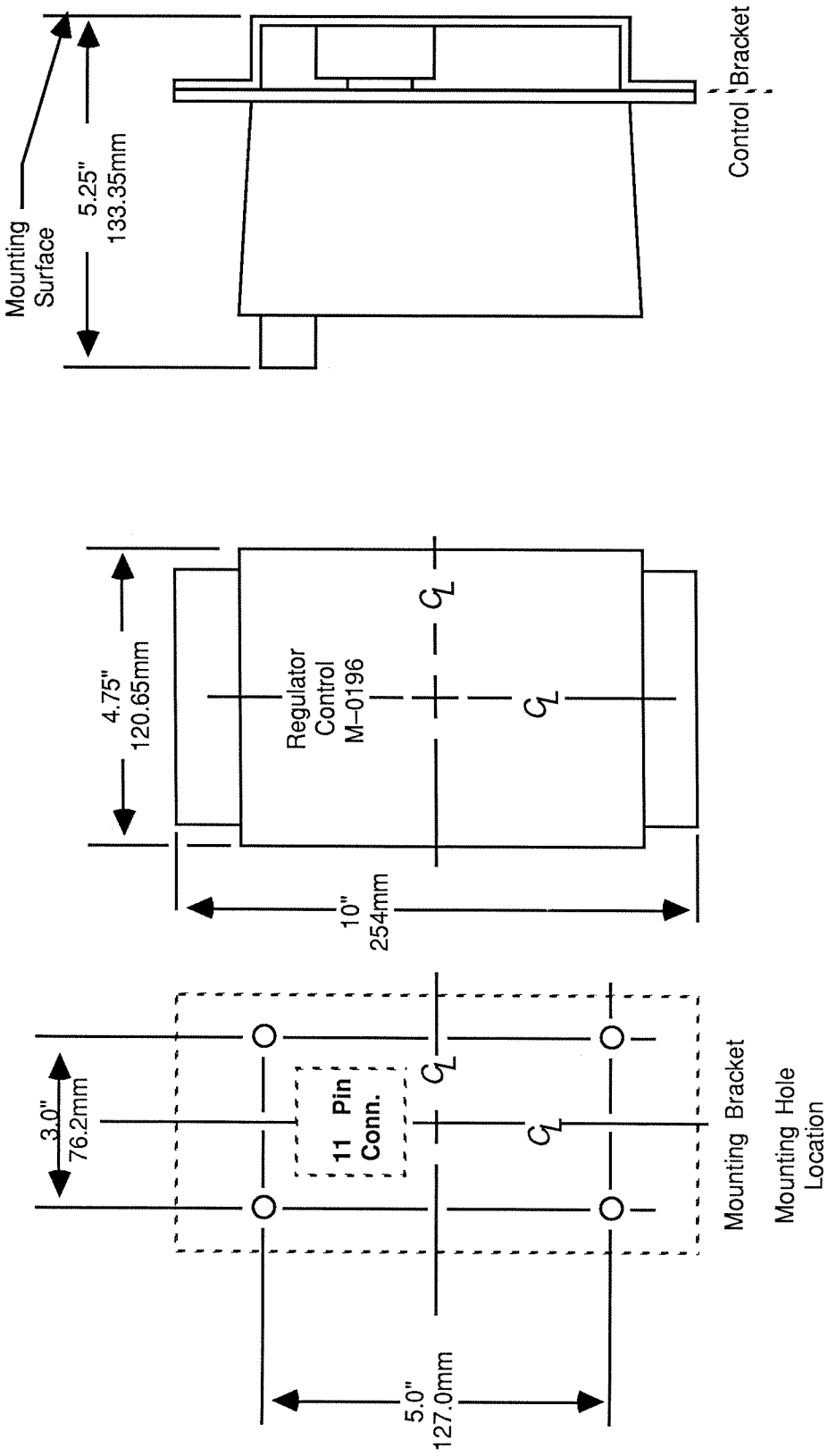


FIGURE 2 Mounting and Outline Dimensions

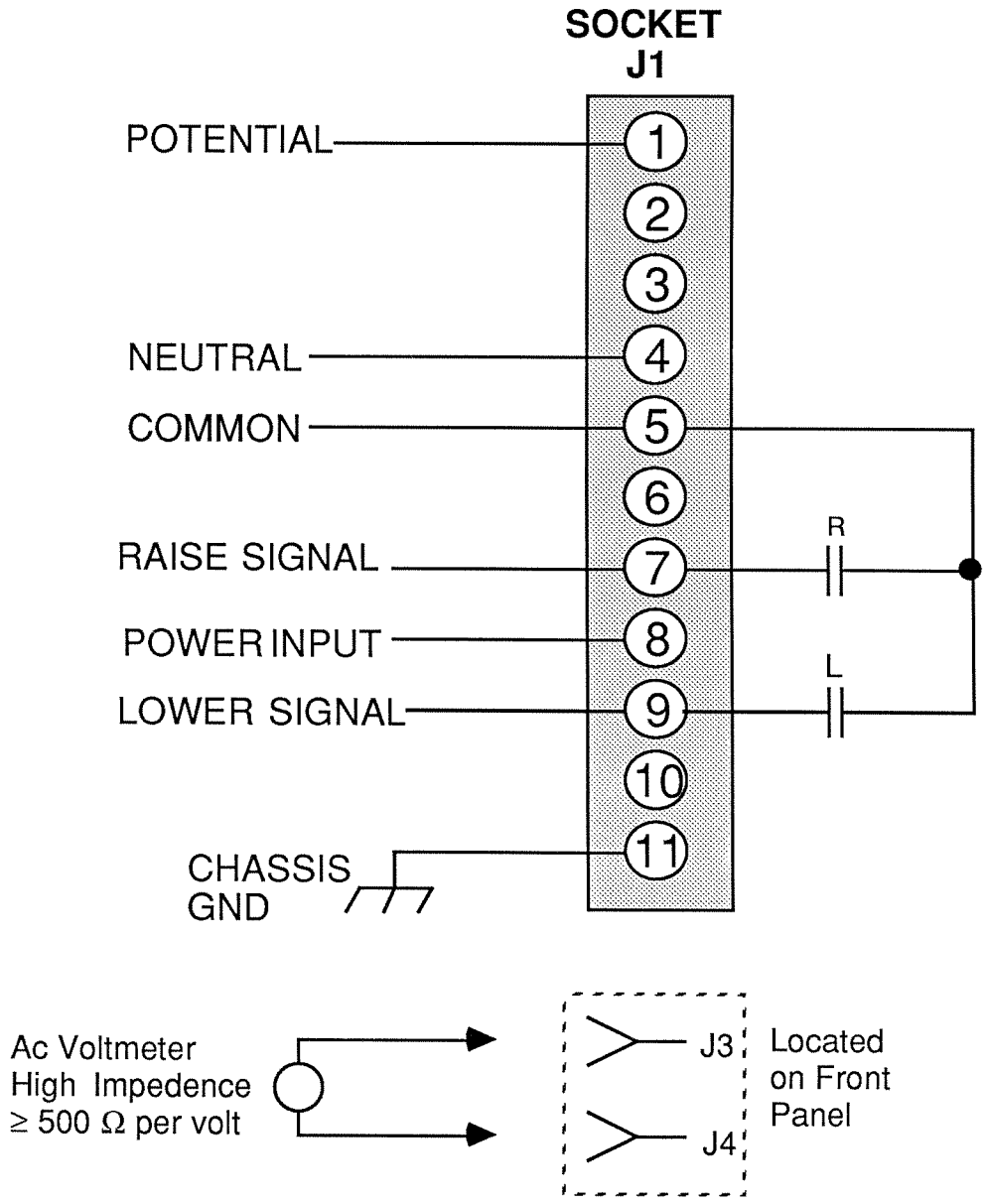


FIGURE 3 External Connections

ADJUSTMENT

Refer to the M-0196 front cover for controls. Adjustments should be made as follows.

Adjust the **VOLTAGE** control to the desired voltage bandcenter.

Adjust the **BANDWIDTH** control with a screwdriver to the desired voltage band. The unit is factory calibrated at 120 V bandcenter and 4 V total bandwidth. When setting for a different voltage, R20 will have to be readjusted. When setting for a different bandwidth, R20 and R21 will have to be readjusted.

Adjust the **TIME** control with a screwdriver to the time delay required between excursion of voltage outside the band and energizing of the Raise or Lower relay. The integrating timer circuit provides good regulation of the voltage and the time delay can be set higher than in a conventional timing circuit.

Lock the **TEST/OPERATE** switch in the maximum counterclockwise or **OPERATE POSITION**. It should remain in this position at all times during operation. With the **TEST/OPERATE** switch locked in the maximum counterclockwise position (switch detent), the test points on the M-0196 front panel (J3 and J4) can be used for low impedance recording devices or instruments with burdens up to 60 VA.

CHECKOUT PROCEDURE

POWER

Connect a high impedance voltmeter (greater than or equal to 500 Ω/V) into the front panel test jacks. Connect a variac between J1-1 and J1-4 in order to obtain a variable voltage source. Apply power to the variac and to the M-0196. Adjust the **VOLTAGE** control to 120 V and the variac to 135 V. The **OFF** LED will illuminate and, after the time delay determined by the **TIME** setting, the **OUTPUT CONTACTS CLOSED** LED will illuminate. Using an ohmmeter, the actual closing of contacts J1-9 and J1-5 can be verified. Next, adjust the variac to approximately 105 V. The **ON** LED will illuminate and, after the time delay, the **OUTPUT CONTACTS CLOSED** LED will illuminate. Using an ohmmeter, the actual closing of contacts J1-7 and J1-5 can be verified.

If a variac is not available, proper functioning of the unit can be verified by adjusting the **VOLTAGE** control to the low end of the range. This will result in the **OFF** LED being illuminated and the **OUTPUT CONTACTS CLOSED** LED being illuminated after a time delay. Adjust the **VOLTAGE** control to approximately 120 V and the **OPERATE/TEST** control to full clockwise position. The **ON** LED will illuminate and the **OUTPUT CONTACTS CLOSED** LED will illuminate after a time delay. To return the unit to service, reset the **VOLTAGE** control to its initial setting and return the **OPERATE/TEST** control to the **OPERATE POSITION** (fully counterclockwise, switch detent).

■ NOTE: The Capacitor Control is calibrated at 120 V ac and has a scale accuracy at that point of ±0.5 V. Other scale markings are approximate only, and a voltmeter should be used in setting the voltage control.

■ NOTE: With the **OPERATE/TEST** switch in the maximum counter clockwise position (switch detent), the Test Jacks (J3 and J4) on the M-0196 front panel can be used with low impedance instruments (up to 60 VA) to monitor the P.T. voltage. When the **OPERATE/TEST** switch is not in the maximum counterclockwise position, the test jacks J3 and J4 can only be used for high impedance (greater than or equal to 500 Ω/V) instrumentation.

● **WARNING: Voltage applied at Test Jacks may energize the capacitor bank.**

Death or severe electrical shock can occur.

Do not connect any voltage source at the test jacks.

MAINTENANCE

Due to the extremely sophisticated nature of the circuitry in the M–0196, 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 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 blow 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–0196 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. 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 PROCEDURE** 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 PROCEDURE

POWER SUPPLY

Connect the Hot side of 120 V ac to terminals J1-1 and J1-8, and Neutral to terminal J1-4. Check to see that the following dc voltages are obtained (reference at TP4).

R1 Right	+22 V dc ±2 V	Unregulated
D3 Anode	+22 V dc ±2 V	Unregulated
C13 (+)	+15.2 V ±0.5 V	Regulated
C14 (-)	-15.2 V ±0.5 V	Regulated

VOLTAGE AND BANDWIDTH

Connect a high impedance (greater than or equal to 500 Ω/V) ac voltmeter to test jacks J3 and J4. Use a regulated and variable ac voltage source, if available.

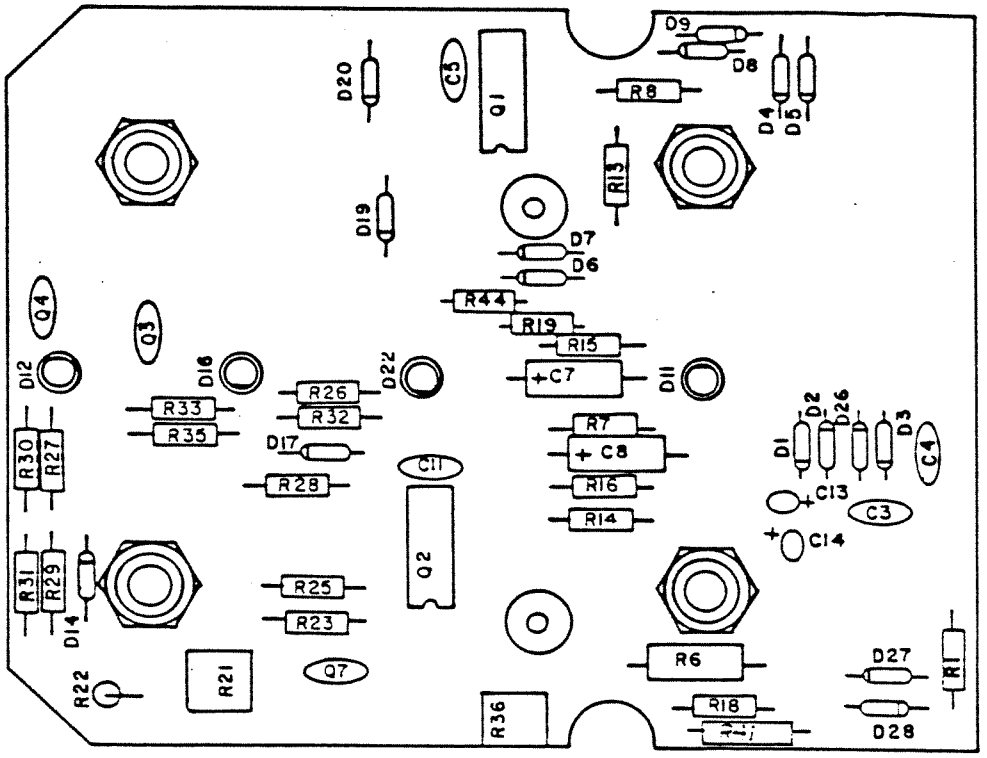
Set the **VOLTAGE** control at 120 V. Vary the uncalibrated **OPERATE/TEST** knob and see that the **ON** and **OFF** lights are lit at some voltages and that there is a dead band where both lights are extinguished. Adjust the **BANDWIDTH** trimmer R21 to obtain 4 V bandwidth. Next adjust R20 trimmer so that 120 V is the center of the band.

TIMER

Set the **TIME** control at minimum. Move the voltage outside the band so that the **OFF** LED is lit. Observe that the **OUTPUT CONTACTS CLOSED** LED lights approximately 4 seconds later and is extinguished, along with the **OFF** LED, when the voltage returns to band. Set the **TIME** control at maximum and observe that 120 seconds elapses between the time when the voltage goes outside the band and the **OUTPUT CONTACTS CLOSED** LED lights. Check minimum and maximum time delays when the voltage goes below the band.

OUTPUT

Connect terminal J1-8 to J1-5. Connect on 100 W lamp from J1-9 to J1-4 (Neutral) and another from J1-7 to Neutral. Let the timer time out and make sure that the respective lamps are lit. If the voltage source is regulated and cannot deliver 100 W of power, use smaller lamps or relays as the load.



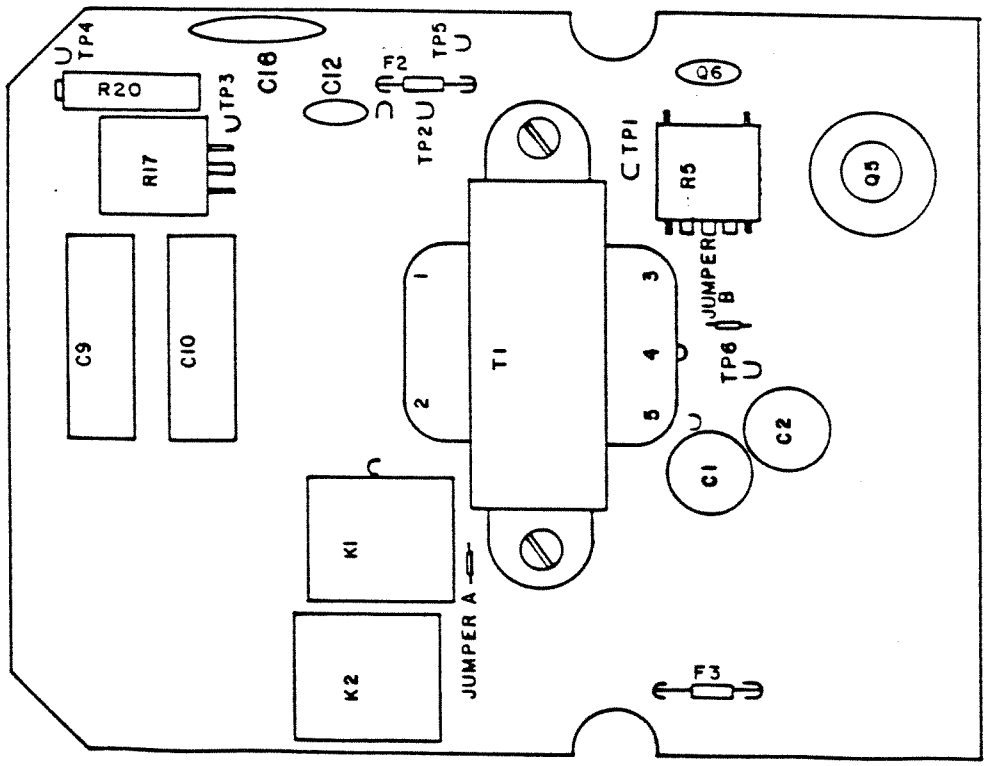


FIGURE 4 Component Location

TYPICAL VOLTAGES

The following voltages were measured with a Data Precision Model 248OR digital multimeter and wave shapes taken with a Tektronix Model T922 oscilloscope. In making the measurements, a regulated variable ac voltage source was used. The Neutral was connected to terminal J1-4 and the hot side of the voltage supply connected to J1-1 and J1-8. The **OPERATE/TEST** control was in the maximum clockwise position.

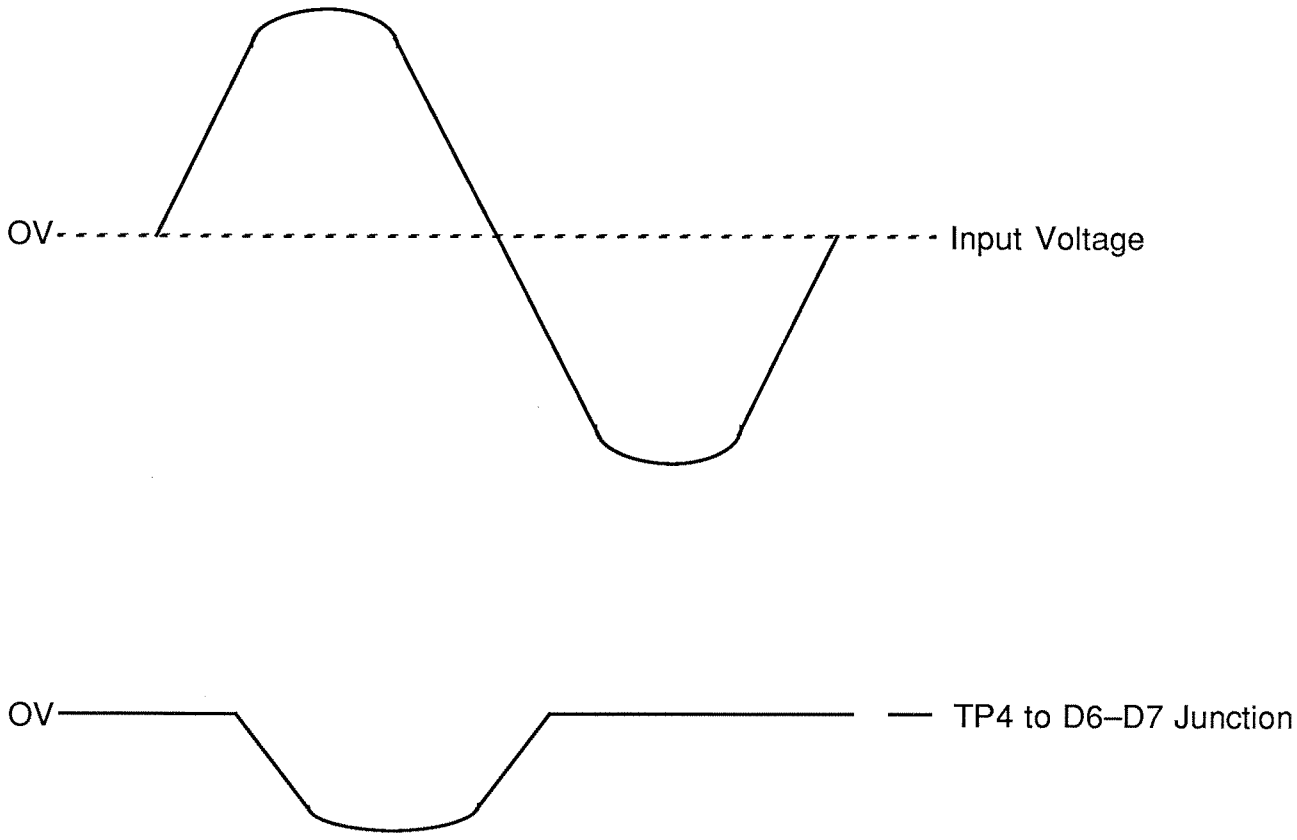
FROM	TO	CONDITION	VOLTAGE
J3	J4	Input 120 V ac	103 to 107 V ac

For subsequent measurements, move **OPERATE/TEST** control to the maximum counter clockwise or **OPERATE POSITION.**

Jumper B	TP4	Input 100 to 140 V ac	+15 V dc, ac ripple 1 mV pp.
D22-C & C11 Junction	TP4	Input 100 to 140 V ac	-15 V dc, ac ripple 1 mV pp.
		Input 105 V ac	18.4 V dc ±5%
D27 Cathode	D27 Anode	Input 120 V ac	21.6 V dc ±5%
D28 Cathode	D28 Anode	Input 135 V ac	24.6 V dc ±5%
		Input 100 to 140 V ac	ac ripple 1.0 V pp.
TP4	TP1	Input 105 V ac	+5.07 to 5.28 V dc
		Input 120 V ac	+5.80 to 6.04 V dc
		Input 135 V ac	+6.52 to 6.80 V dc
		Input 100 to 140 V ac	ac ripple 5 mV pp.
D6 Cathode	TP4	Input 105 V ac	-0.5 V dc to -7 V dc*
		Input 120 V ac	-0.5 V dc to -8 V dc*
		Input 135 V ac	-0.5 V dc to -9 V dc*

* ■ **NOTE:** See Figure 5 for waveshapes

FROM	TO	CONDITION	VOLTAGE
R27-R30 Junction	TP4	Input voltage above the band	+13.5 V dc
		Input voltage in band or below the band	-13.5 V dc
R32-D16 Junction	TP4	Input voltage below the band	+13.5 V dc
		Input voltage in band or above the band	-13.5 V dc
TP5	TP4	R36 maximum clockwise	+7.5 V dc



■ **NOTE:** If waveshape is different than shown above, Q1 or a related component may be defective.

FIGURE 5 Waveshapes

PARTS LIST

M-0196 Capacitor Control

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
C1,C2	000–00421	Capacitor, Electrolytic, 220 µF +50/-10%, 50 V
C3-C5, C11	000–00928	Capacitor, Ceramic Disc, 0.01 µF ±20%, 100 V
C6		Not Used
C7	000–00549	Capacitor, Tantalum, 6.8 µF ±10%, 35 V
C8	000–00544	Capacitor, Tantalum, 15 µF ±10%, 20 V
C9,C10	000–00813	Capacitor, Polyester, 4.7 µF ±10%, 100 V
C12	000–00927	Capacitor, Ceramic Disc, 0.01 µF ±20%,1 kV
C13,C14	000–00556	Capacitor, Dip Tantalum, 10 µF ±10%, 35 V
D1–D3,D26	400–00232	Diode, 1N4004
D4-D9	400–00224	Diode, 1N4148

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
D10, D11		Not Used
D12,D16,D22	400–00722	Diode, Light Emitting, Hewlett-Packard 5082-4658
D13		Not Used
D14,D17	400–00228	Diode, Fairchild FDH300
D15,D18		Not Used
D19,D20	400–00211	Diode, 1N5061
D21,D23-D25		Not Used
D27,D28	400–00085	Diode, Zener, 28 V, IN5362B
F1		Not Used
F2	420–00843	Fuse, 1/2 A, 125 V, Littelfuse 275.500
F3	420–00848	Fuse, 1/16 A, 125 V, Littelfuse 275.062
F4	420–00850	Fuse, 1 A, 125 V, Littelfuse 275.001
K1,K2	430–00138	Relay, 18 V dc, American Zettler AZ-420-V50-4H
Q1	400–00639	Quad Op Amp, Fairchild µA4136DC
Q2	400–00678	Quad Op Amp, Texas Instrument TL084MJ
Q3,Q4	400–00728	Varistor, 275 V, G.E. V275LA2
Q5	400–00675	Voltage Regulator, ±15 V, Raytheon RC4195T
Q6,Q7	400–00709	Varistor, 250 V, G.E. V250LA2
R1	200–00155	Resistor, Carbon Film, 1.5 M ±5%
R2–R4		Not Used
R5	360–00105*	Potentiometer and Switch, 5 K ±10%, 2 W Allen Bradley 73LIN132P502W
R6	230–00473	Resistor, Carbon Film, 47 K ±5%, 1 W
R7,R8	330–00647	Resistor, Metal Film, 301 K ±1%, RN60E

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R9–R12		Not Used
R13	330–00518	Resistor, Metal Film, 15 K ±1%, RN60E
R14	330–00485	Resistor, Metal Film, 7.5 K ±1%, RN60E
R15	330–00522	Resistor, Metal Film, 16.5 K ±1% RN60E
R16	200–00272	Resistor, Carbon Film, 2.7 K ±5%
R17	360–00089	Potentiometer, 5 K ±10%, 2 W, Allen Bradley 73BIN124P502W
R18	340–00473	Resistor, Metal Film, 5.62 K ±1%, RN60C
R19,R44	340–00016	Resistor, Carbon Comp, 22 M ±5%, 1/4 W
R20	360–00084	Potentiometer, Cermet, 5 K ±10% Bourns 3009P-1-502
R21,R36	360–00038	Potentiometer, Cermet, 50K ±20% Bourns 3386P-1-503
R22	330–00519	Resistor, Metal Film, 15.4 K ±1% RN60E
R23	330–00501	Resistor, Metal Film, 10 K ±1%, RN60E
R24		Not Used
R25	330–00673	Resistor, 562 K ±1%, RN60E
R26,R29,R31,R33,R35	200–00156	Resistor, Carbon Film, 15 M ±5%
R27	200–00622	Resistor, Carbon Film, 6.2 K ±5%
R28	330–00543	Resistor, Metal Film, 27.4 K ±1%, RN60E
R30,R32	200–00153	Resistor, Carbon Film, 15 K ±5%
R34,R37–R40,R42,R43		Not Used
R41	340–00466	Resistor, Metal Film, 4.75 K ±1%, RN60C
T1	410–00042*	Power Transformer, U-0097
Relay Retainer	430–00121*	
REV C		

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
PARTS MOUNTED TO THE ENCLOSURE		
J3	420–00102	Pin Jack Black, E.F. Johnson 105-0603-001
J4	420–00101	Pin Jack Red, E.F. Johnson 105-0602-001
P1	420–00181	Connector Plug (11-Pin) Amphenol 86 RCP-11
Q9	400–00713	Varistor, 40 V, G.E. V40LA2
Knobs	440–00060*	P–0195
Knurled Thumb Screws	440–00061*	P–0196
Mounting Plate	440–00139*	P–0467
SOCKET ASSEMBLY		
Mounting Bracket	440–00140*	P–0468
J1	420–00180	Connector Socket (11-Pin) Potter & Brumfield 27E123

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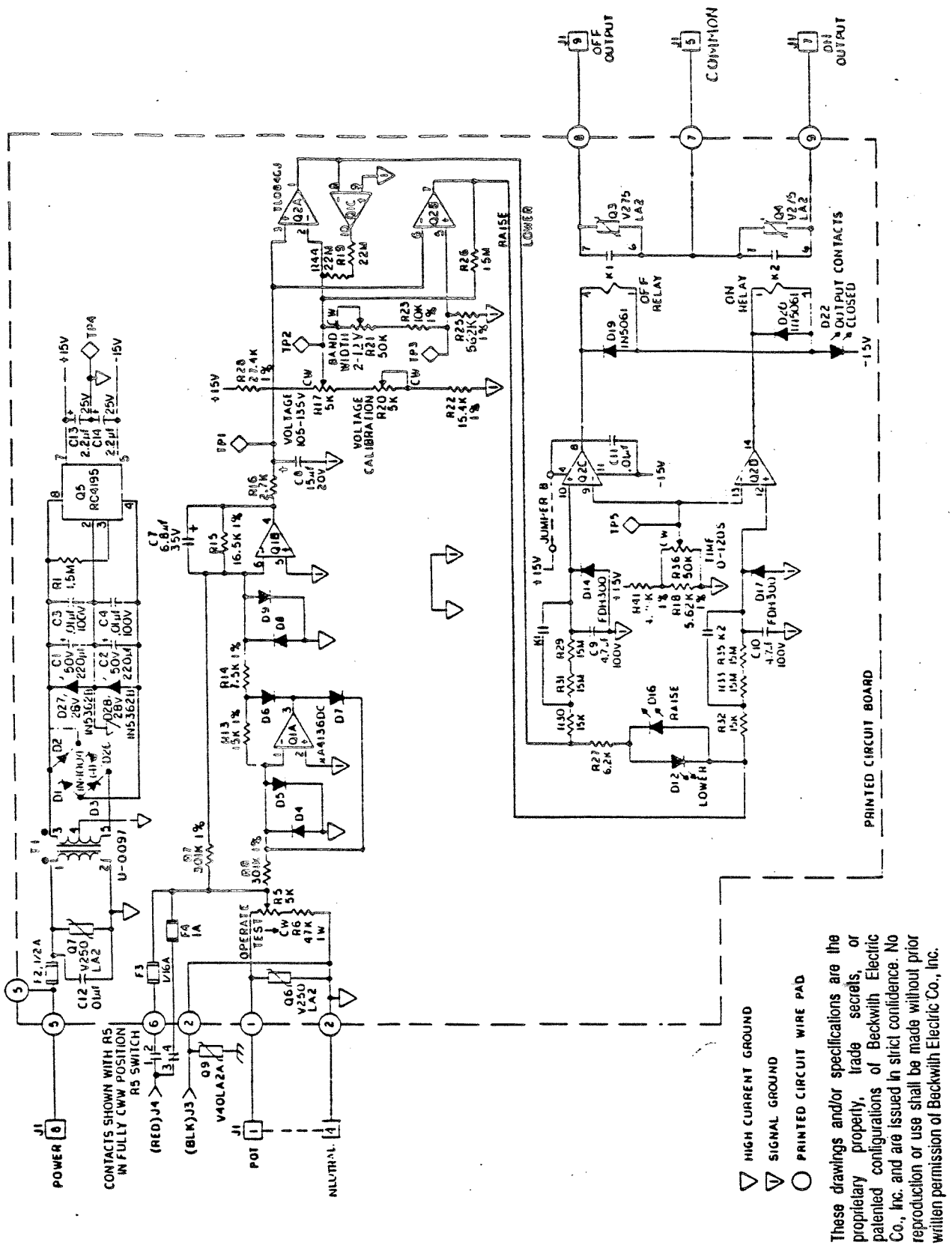

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FIGURE 6 Schematic

Legal Information

Patent

The units described in this manual are covered by U.S. Patents, 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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