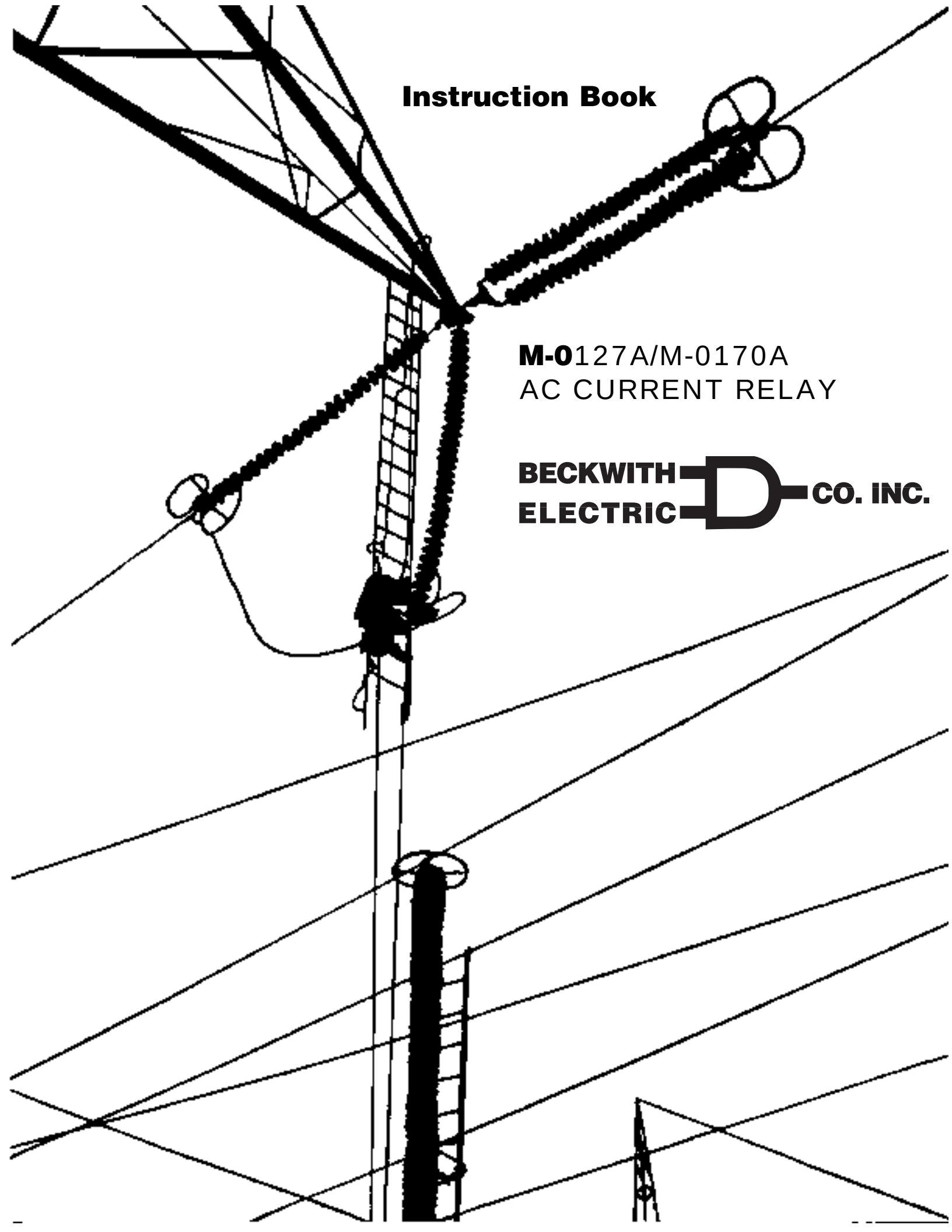
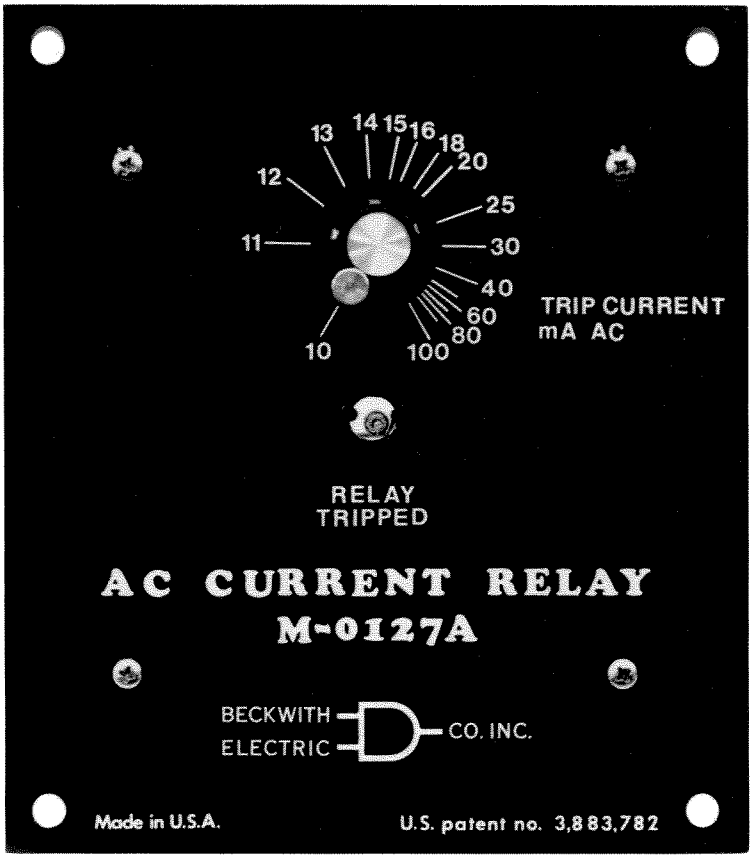
# Instruction Book



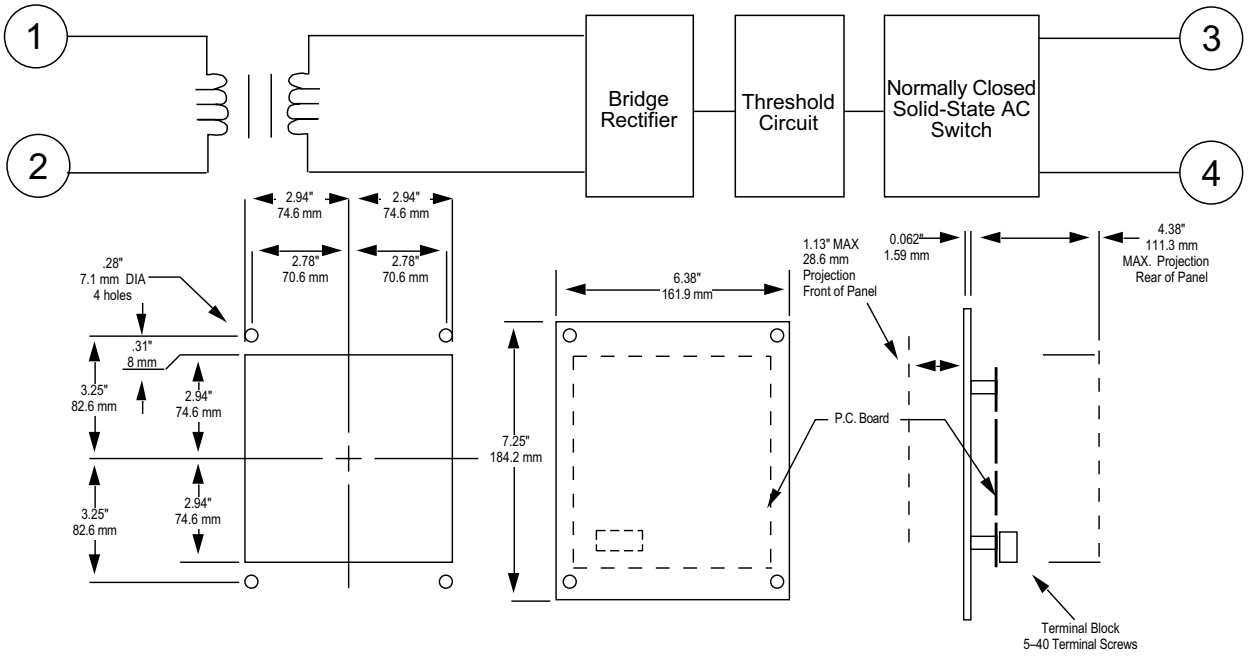
## **M-0**127A/M-0170A
## AC CURRENT RELAY

BECKWITH ELECTRIC CO. INC.

# AC Current Relay M-0127A/M-0170A




- M-0127A intended for use in 0.2 A circulating current circuit of paralleled LTC transformers to guard against damaging excessive circulating current
- M-0170A prevents damage to LTC transformer's switching mechanism under excessive loads
- Available in:
  M-0127A: 0.01 to 0.1 Amps
  M-0170A: 0.2 to 0.4 Amps
- Both relays can be used in other current and voltage-sensing applications




**CUTOUT DIMENSIONS** **OUTLINE DIMENSIONS**

## INPUT

- All solid–state design, transient protected.
- Two terminal input, transformer isolated from the output.
- Current setting adjusted with a calibrated dial.

M-0127A: 10 mA to 100 mA ac current range. 50/60 Hz, will withstand 2.5 A for one second.
M-0170A: 200 mA to 400 mA ac current range. Withstand 10 A for one second.

## INPUT BURDEN

M-0127A: 100Ω to 500Ω dependent upon setting.
M-0170A: 2 Ω.

## OUTPUT

Two terminal ac switch (triac), normally conducting. Opens on input current above threshold setting. Rated 1 A at 120 V ac. Transient and overload protected. Load must not be highly capacitive. Auxiliary relay can provide parallel alarm function. Open circuit impedance: 20 K.

## TEMPERATURE RANGE

Unit will operate properly from -40° C to +85° C.

## PHYSICAL

Size: 7-1/2" high x 6-6/16 wide x 4-3/8 deep (19.05 cm x 16.19 cm x 11.13 cm).
Approximate Weight: 1.4 lbs. (0.6 kg).
Approximate Shipping Weight: 3 lbs. (1.4 kg).

## PATENT

U.S. Patent 3,883,782.

## WARRANTY

The M–0127A/M–0170A is covered by a five year warranty from date of shipment.

ISO 9001:1994 Registered

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# 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.

## TABLE OF CONTENTS

## M-0127A/M-0170A AC Current Relay Instruction Book



In our efforts to provide accurate and informative technical literature, suggestions to improve the clarity or to correct errors will receive immediate attention. Please contact the Marketing Services Department, specifying the publication and page number.

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## 1.0 Application

The M-0127A AC Current Relay is primarily designed for use in the circulating current circuit of load tapchanging transformers to prevent damaging circulating current to flow should the transformer controls fail to keep the transformers on essentially the same taps when using the circulating current method of paralleling. Its range permits the maximum circulating current to be set from 5% to 50% of the rated full load current.

Other relays used for this purpose have an impedance exceeding 5,000 ohms which may cause the main CT to saturate, making the entire circulating current scheme operate poorly. The low impedance of the M-0127A relay avoids this problem.

The output should be connected in series with the common lead of the motor starter relay. When used with the Beckwith Electric M-0067 control, the M-0127A output contacts will be in series with the lead that would otherwise have gone directly to terminal TB1-8 of the M-0067. Polarity of the M-0127A input and output can be ignored.

The M-0170A AC Current Relay is intended to be used in the load current circuit to prevent the tapchanger from changing taps on excessive load current. Its range permits the current setting from 100% to 200% of the rated Full Load current. The relay should be connected in the same manner as the M-0127A.

### Other Applications

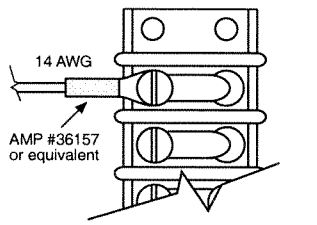
The M-0127A and M-0170A can be used wherever an adjustable, low burden AC relay is required. They have virtually no time delay, a very small hysteresis and a normally closed output for use on AC only; factors that must be considered in their application.

By adding external series resistors, the relays may be used for voltage sensing. For example, with a 10 K series resistor, the M-0127A is adjustable from 100 to 140 Vac, using 10 to 14 mA current setting range. Use of a 10K, 10W wire-wound resistor is suggested.

The relay output draws approximately 6 mA of in-phase current through a 120 Vac load when open. The application should be such that this current can be tolerated.

## 2.0 UL-Listed Terminal Block Connections

The M-0127A and M-0170A AC Current Relays are listed to UL Standards for Safety by Underwriters Laboratories Inc. (UL). To fulfill requirements for UL listing, terminal block connections must be made as illustrated in Figure 1 below. The wire should be No. 14 AWG inserted in an AMP #36157 (or equivalent) connector, and the screw tightened to 4.8 inch-pounds torque.




Recommended Wire Terminations

*Tighten to 4.8 inch-pounds*

**FIGURE 1 Wire Terminations for External Connections**

## 3.0 Description

### Electrical

The novel circuit shown in Figure 2 uses commutation voltage changes on the controlled AC output circuit to turn on a sensitive gate AC triac when no input current flows. Input current above an adjustable threshold effectively shorts the triac gate to main terminal 1. This both shorts the commutation transients and renders the triac insensitive to turn on by high levels of noise from other sources.

One way of thinking of the circuit is that R16 forms a regenerative feedback which causes triac Q4 to turn on at each half cycle. Transistors Q2 and Q3 short the feedback voltage when they are turned on by the voltage comparitor Q1 when it switches to the **HIGH** state.

The input current through terminals TB1-1 and TB1-2 is stepped down by the current transformer TI and converted to the single polarity current by the bridge rectifier consisting of diodes DI through D4. This current flows through the non-linear burden of the temperature-compensated zener diode D6 and the resistor network composed of variable resistors R2, R3 and R4. The voltage developed across D6 is 6.2 V dc while the voltage $V_C$ is dependent upon the settings of the variable resistors R2 through R4 and the magnitude of the current flowing through them. The voltage $V_C$ is filtered by R5 and CI to provide a dc voltage $V_S$ representing the current. Potentiometer R2 is the main control and determines the current threshold of the relay. Trimpot R4 sets the upper range of the relay, while trimpot R3 is trimmed to set the lower range of the relay. The voltage $V_{REC}$ developed across the bridge rectifier is filtered by RI and C2 to provide the operating power to the operational amplifier Q1. This voltage is also scaled down by the voltage divider resistors R6 and R7 to a dc voltage $V_R$ that determines the switching point of the voltage comparator QI.

As the current increases from zero, voltage $V_R$ increases at a constant rate determined by the resistors R6 and R7. Voltage $V_S$ stays at zero until the zener diode D6 saturates at 6.2 V, and then the balance of the voltage will appear as $V_S$. The rate of voltage $V_S$ rise is steeper than that of $V_R$. Since $V_S$ is initially smaller than $V_R$, Q1 remains switched **LOW**, and consequently the transistors Q2 and Q3 are turned off and triac Q4 conducts due to the commutating action of R16. When $V_S$ exceeds $V_R$, Q1 switches **HIGH** and turns on transistors Q2 and Q3; thereby collapsing the commutating voltage $V_G$ at the triac gate to nearly zero with respect to its main terminal 1. The triac is turned off and the output opens from its normally closed condition.

Resistor R8 determines the input bias current of Q1 and is chosen to cause a very small voltage drop across R5 so that most of the voltage $V_C$ appears as $V_S$ with very low ripple. Resistor R9 sinks approximately the same amount of current into Q1 when the latter is switched LOW as Q1 will source into the transistors Q2 and Q3 bases when it switches into the HIGH state. This eliminates the sudden change in the load current drawn from the power supply. Fuse F1 protects triac Q4 by opening on excessive output load. Varistor Q5 suppresses the high voltage transients that may develop across the main terminals of the triac

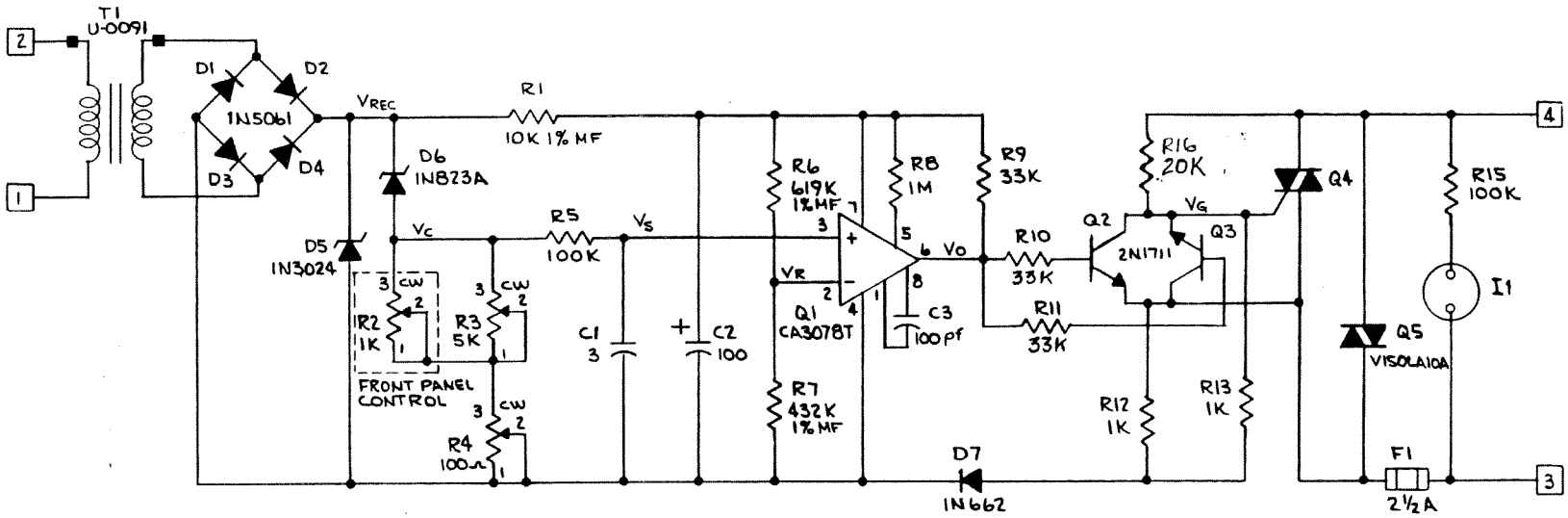



FIGURE 2 Schematic



■ NOTE: Component values shown above are for the M–0127A. Refer to Parts List for Components specific to the M–0170A.

⬢ **WARNING: Any attempt to measure resistances between points on the circuit board is likely to cause damage to the unit.**

when it is not conducting. Zener diode D5 limits the peak value of the voltage $V_{REC}$ to 15 V to protect Q1 from excessive voltage under overcurrent or current transient conditions. During normal operation, D5 does not conduct and draws practically no current. The relay exhibits an excellent stability from -40°C to +85°C.

When the relay output is used on a 120 V ac circuit, a neon light I1 will indicate an overcurrent condition. The lamp and other circuits draw approximately 6 mA through the otherwise open-circuited load.

## 4.0 Mechanical

### Mounting

The unit is designed for panel mounting as shown in the Specifications. The mounting width is consistent with the M-0067 control, permitting use of the M-0124 Surface Mounting Adapter kit for surface mounting when required. The mounting and cutout are consistent with panel-mounted devices of other manufacturers.

### Output

The output is normally closed (with input current below threshold). The current carrying capability is as follows:

| Air Temperature Around Relay | Maximum Continuous AC Current |
|---|---|
| 25° C | 1.6 A |
| 40° C | 1.2 A |
| 60° C | 0.8 A |
| 80° C | 0.4 A |

**TABLE 1 Output Current Carrying Capability**

This current can be exceeded in controllers where the triacs do not conduct continuously as long as the product of current times duty cycle does not exceed the values in the above table.

For very short times, the surge current limit is as follows:

| Time Duration: Cycles, 60 Hz | Non-Repetitive Surge: Amps |
|---|---|
| 1 | 25 |
| 4 | 16 |
| 10 | 11 |
| 100 | 6 |

**TABLE 2 Output Surge Current Limit**

**▲ CAUTION: A capacitor must not be tied across the output or across output load as this will damage the triac in spite of fuse F1. The output is capable of handling a NEMA size 1 or smaller reversing-type motor starter.**

The output will draw approximately 6 mA of in-phase current through a 120 V ac load when the current exceeds the threshold. This will not be sufficient to hold in a NEMA-type starter. When used with old motor starters, a test should be made to make certain this small amount of current will not hold the relay closed. If it does, the air gap on the relay should be increased or other adjustments made so it will properly drop out.

## 5.0 Adjustment

The only adjustment required is to set the current sensitivity to the desired level. Trimpots R3 and R4 are factory adjusted to match the calibration of the front panel control. If extreme accuracy is required, use of an ammeter to measure the current is suggested.

When the M-0127A is used in a circulating current circuit of LTC transformers and no ammeter is available, the following trial and error procedure is suggested:

1. Determine an allowable number of differences in tap steps. This must be at least two steps, with lock out at that point.
2. With the transformers on manual control, set them at the step difference where lock out is desired (two steps, for example).
3. Temporarily connect a light bulb in series with the M-0127A output to a 120 V ac source.
4. Adjust the current sensitivity to the point where the light bulb just goes out.
5. Change the taps to a difference of one.
6. Adjust the current sensitivity to the point where the light bulb just goes out.
7. Make a final setting midway between these points.

Note that circulation current may vary somewhat with transformer loading, and the calibration of the M-0127A relay will, of course, vary slightly with temperature. Tap differences of one will occur with normal operation. To avoid false lock out with this normal difference, the above adjustment should be made with higher tap position differences than 1 and 2, whenever it is possible to do so, and still properly protect the transformer.

**Alarm**

An alarm relay can be used in series with the output to obtain an alarm contact when the AC Current Relay has locked out the control. See Figure 3 for alarm connections.

The following relay and socket are recommended.

| | |
|---|---|
| Relay: | Potter & Brumfield KRP11AG<br>120 V ac, DPDT contacts rated 10 A<br>8-pin plug |
| Socket: | Potter & Brumfield 27E122<br>8-pin industrial type with screw terminals for surface mounting. |

■ **NOTE**: *Both are available from Beckwith Electric Company, Inc.*

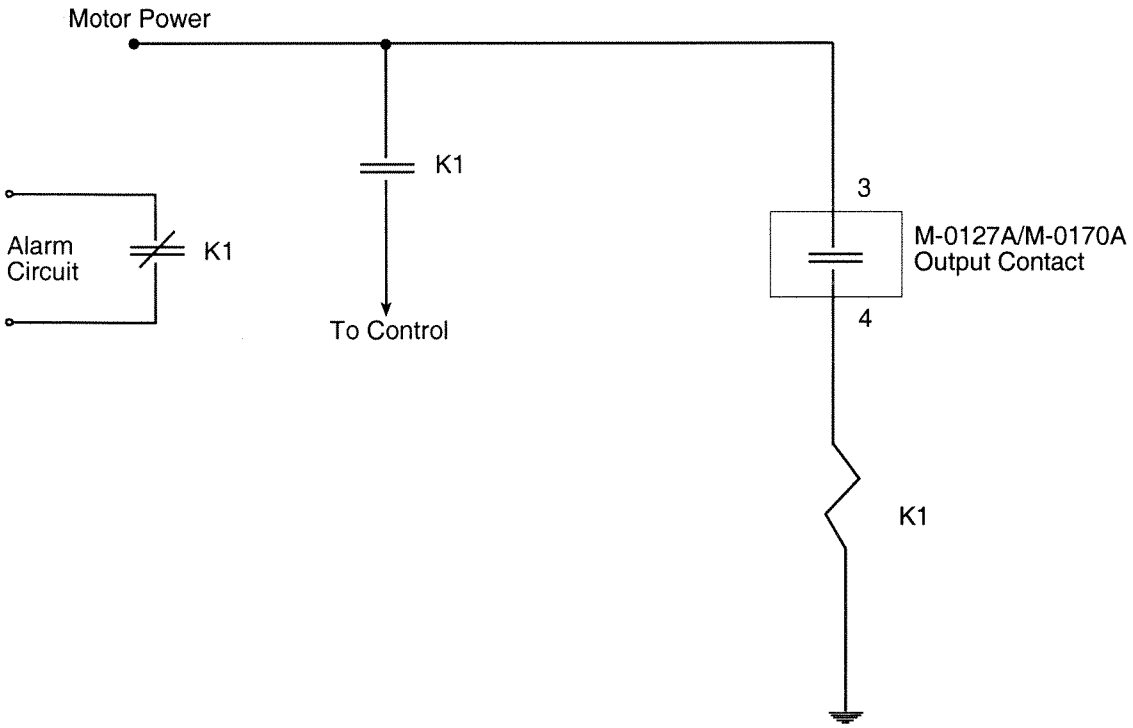



**FIGURE 3 Alarm Contact Detail**

## 6.0 Maintenance

All units are fully calibrated at the factory prior to shipment; there is no need to recalibrate 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 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 unit 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.

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.

## 7.0 Test Procedures

### Equipment Required

1. AC current supply capable of supplying 500 mA.
2. Digital voltmeter, Fluke model 8000A DMM or equivalent.
3. Light bulb.
4. 120 Vac source.
5. AC milliammeter.

### Test Setup

Make the connections to the AC Current Relay as shown in Figure 4.

### Procedure

First check the typical readings from Table 3A or 3B. The readings were taken referenced to ground with the unit calibrated to 20% accuracy. If the readings do not match, calibrate the unit according to the procedures in the **CALIBRATION** section.

### Typical Voltages

Use right (–) side of C2 for ground as shown in Figure 5, Component Location.

| M-0127A Front Panel Setting | Input | $V_{REC}$ | $V_C$ | $V_S$ | $V_R$ | $V_O$ | $V_G$ | $I_1$ |
|---|---|---|---|---|---|---|---|---|
| 10 | 5 | 6.6 | 0.98 | .97 | 1.79 | 0.65 | 0.3 | Off |
| 10 | 15 | 9.82 | 3.89 | 3.85 | 2.62 | 5.88 | 0.67 | On |
| 20 | 15 | 7.66 | 1.85 | 1.83 | 2.13 | 0.67 | 0.3 | Off |
| 20 | 25 | 9.55 | 3.58 | 3.55 | 2.50 | 5.59 | 0.66 | On |
| 100 | 90 | 8.60 | 2.48 | 2.46 | 2.29 | 0.67 | 0.3 | Off |
| 100 | 110 | 9.23 | 2.07 | 2.04 | 2.48 | 5.53 | 0.66 | On |
| in mA | in Volts dc 5%* | | | | | | | |

*Table 3A M-0127A Typical Voltages*

| M-0170A | Input | $V_{REC}$ | $V_C$ | $V_S$ | $V_R$ | $V_O$ | $V_G$ | $I_1$ |
|---|---|---|---|---|---|---|---|---|
| 200 | 100 | 7.9 | 1.8 | 1.8 | 2.11 | .64 | .3 | Off |
| 200 | 250 | 9.4 | 3.22 | 3.20 | 2.5 | 5.7 | .7 | On |
| 300 | 250 | 8.3 | 2.2 | 2.19 | 2.3 | .64 | .3 | Off |
| 300 | 350 | 9.4 | 3.16 | 3.10 | 2.5 | 5.7 | .7 | On |
| 400 | 350 | 8.5 | 2.26 | 2.23 | 2.3 | .64 | .3 | Off |
| 400 | 410 | 8.9 | 2.7 | 2.67 | 2.4 | 5.4 | .7 | On |

*Table 3B M-0170A Typical Voltages*

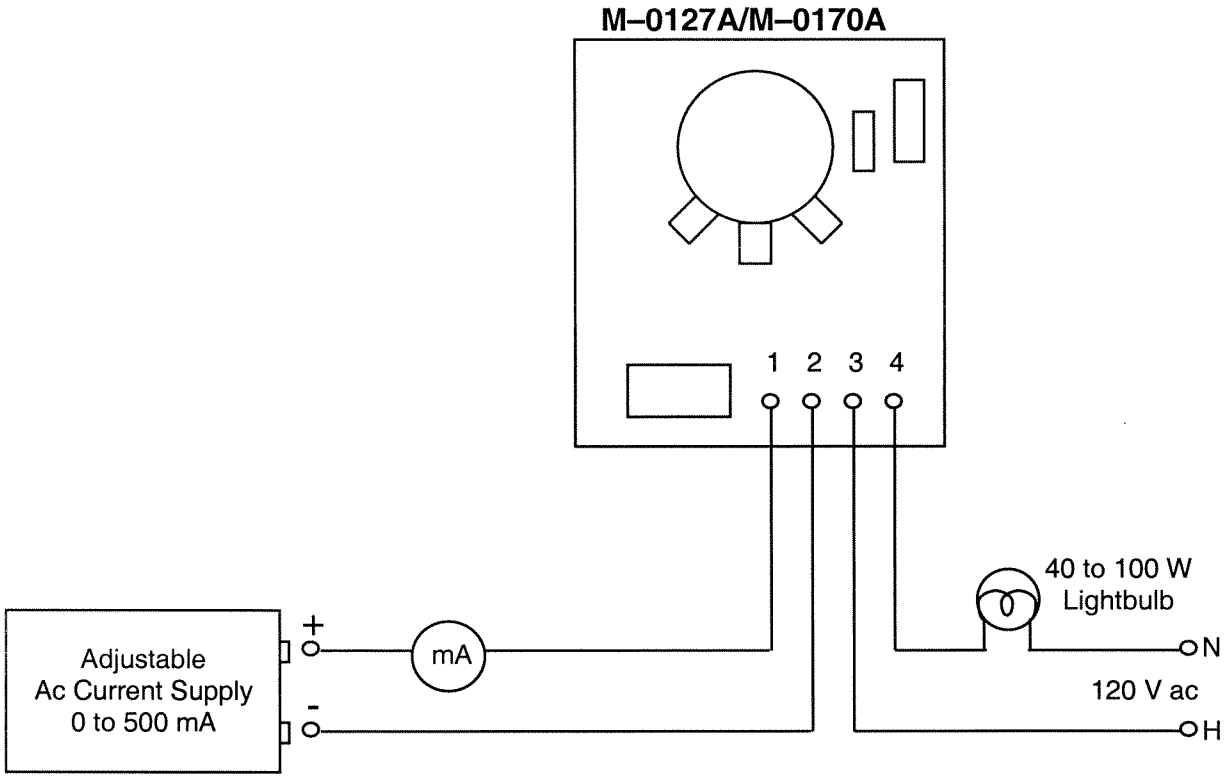



**FIGURE 4 Test Setup**

## 8.0 Calibration

Refer to Figure 5, Component Location.

■ **NOTE:** *Always calibrate the unit at the point where the relay trips during an increasing current. When the relay trips, the **RELAY TRIPPED** lamp (I1) on the front panel will light.*

1. Turn the front panel **TRIP CURRENT** control to maximum setting (fully clockwise).
2. Adjust R4 for relay trip equivalent to this setting.
3. Position the **TRIP CURRENT** control to the minimum setting (fully counterclockwise).
4. Adjust R3 for relay trip equivalent to this setting.
5. Repeat these procedures until both minimum and maximum settings are calibrated.

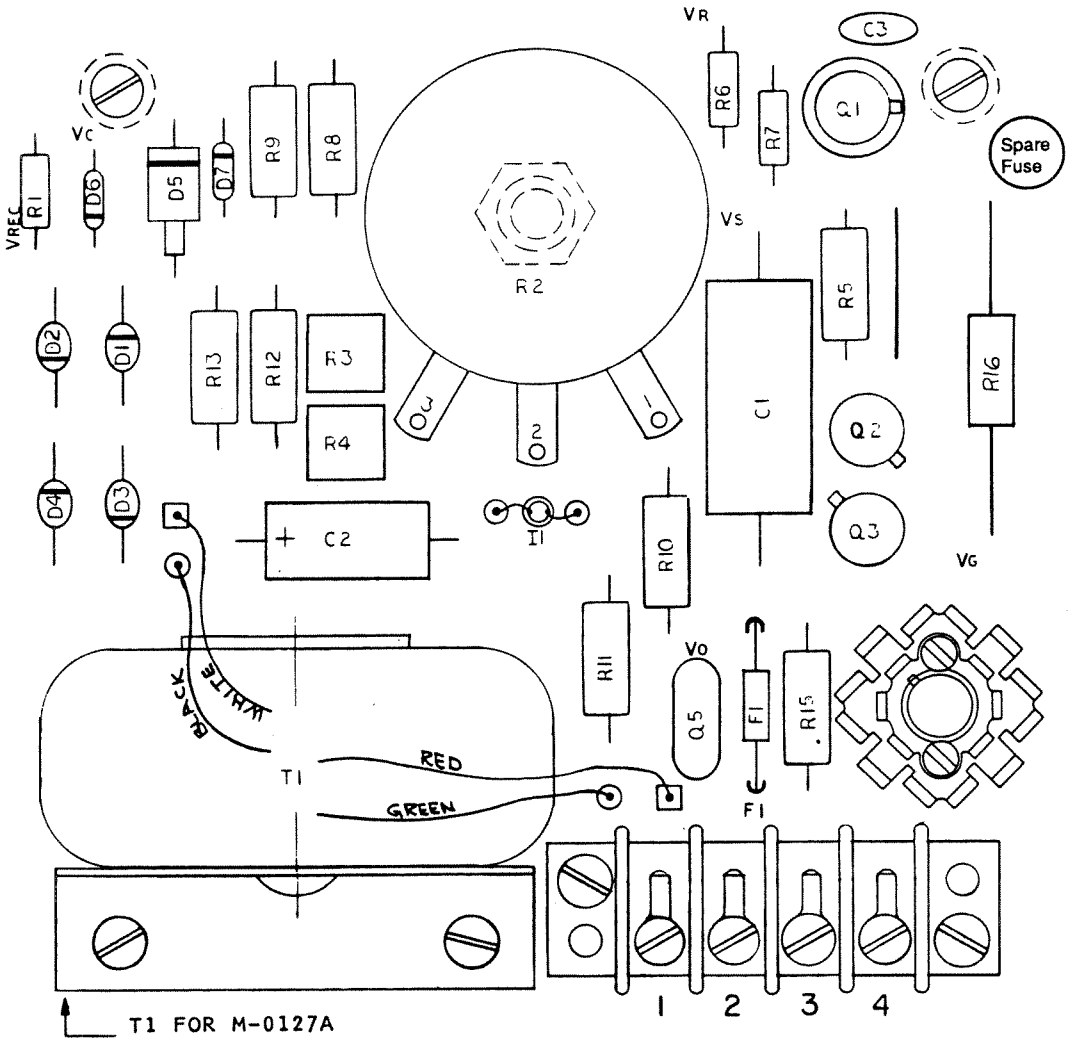





**FIGURE 5 Component Location**

## 9.0 Design Changes

Beckwith Electric maintains a system whereby our customers can be aware of design changes in any of our units. Full documentation on any unit is kept on file by Model Number and Serial Number.

All units have a Model Number, consisting of a letter and four numbers. Complex changes are recorded by adding a suffix letter. The rule is that it must be possible to use any later version as a replacement for an eariler version. The opposite may not be true because of features added. If later units are not interchangeable with older units, a change in the Model Number is made.

Some simple changes are recorded by Serial Numbers; for example, changes in the detailed rating or manufacturer of a component where either the new or old part will perform properly.

The following describes the changes that have taken place on the M-0127A/ M-0170A AC Current Relay.

**M–0127A/M–0170A**

The "A" version of these units have additional circuitry to improve accuracy.

# PARTS LIST

## M-0127A and M-0170A AC Current 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 ½ W unless noted.

| COMPONENT DESIGNATION | BECO NUMBER | DESCRIPTION |
|---|---|---|
| | 450–00007* | Printed Circuit Board, P-0421 |
| C1 | 000–00856 | Capacitor, Mylar, 3 µF ±10%, 50 V |
| C2 | 000–00618 | Capacitor, Electrolytic, 100 µF ±10% 25 V |
| C3 | 000–00903 | Capacitor, Ceramic Disc, 100 pF ±10%, 1 kV |
| C4 | | Not Used |
| D1–D4 | 400–00211 | Rectifier, 600 V, 1 A, 1N5061 |
| D5 | 400–00078 | Diode, Zener, 15 V ±10%, 5 W, 1N5352A |
| D6 | 400–00035 | Diode, Zener, 6.2 V ±5%, 400 mW, 1N823A |
| D7 | 400–00200 | Diode, Signal 1N662 |

| COMPONENT DESIGNATION | BECO NUMBER | DESCRIPTION |
|---|---|---|
| F1 | 420–00726 | Microfuse, 3 A, Littelfuse 273003 |
| I1 | 420–00590 | Neon Lamp, 120 V, Alco MNE–3 |
| Q1 | 400–00643 | Op Amp, RCA CA3078T |
| Q2,Q3 | 400–00300 | Transistor, NPN, 2N1711 |
| Q4 | 400–00503 | Triac, with Heat Sink, Raytheon Z0302DG |
| Q5 | 400–00704 | Varistor, 150 V, G.E. V150LA10A |
| R1 | 340–00501 | Resistor, Metal Film, 10 K ±1%, 1/4 W, RN60C |
| R5,R15 | 200–00104 | Resistor, Carbon Film, 100 K ±5% |
| R6 | 340–00677 | Resistor, Metal Film, 619 K ±1%, 1/4 W, RN60C |
| R7 | 340–00662 | Resistor, Metal Film, 432 K ±1%, 1/4 W, RN60C |
| R8 | 200–00105 | Resistor, Carbon Film, 1 M ±5% |
| R9–R11 | 200–00333 | Resistor, Carbon Film, 33 K ±5% |
| R12,R13 | 200–00102 | Resistor, Carbon Film, 1 K ±5% |
| R14 | | Not Used |
| R16 | 350–00062 | Resistor, Wirewound, 20 K ±5%, 5 W, Ohmite 995–5B (95J20K) |
| TB1 | 420–00019 | Terminal Block, 4–position, Cinch–Jones 4–140–Y |
| **PARTS FOR M–0127A ONLY** | | |
| R2 | 360–00076* | Potentiometer, 1 K, Wirewound, U–0031–3 |
| R3 | 360–00059 | Trimmer, Cermet, 5 K ±10%, Bourns 3386P–1–502 |
| R4 | 360–00072 | Trimmer, Cermet, 100 Ω ±10%, Bourns 3386P–1–101 |
| T1 | 410–00038* | Transformer, Current, U–0091 |
| *REV E* | | |

| COMPONENT DESIGNATION | BECO NUMBER | DESCRIPTION |
|---|---|---|
| | | |
| **PARTS FOR M–0170A ONLY** | | |
| R2 | 360–00047* | Potentiometer, Wirewound, 500 Ω, U–0031–1 |
| R3 | 360–00032 | Trimmer, Cermet, 10 K ±10%, Bourns 3386P–1–103 |
| R4 | 360–00073 | Trimmer, Cermet, 500 Ω ±10%, Bourns 3386P–1–501 |
| T1 | 410–00039* | Transformer, Current, U–0092 |

*REV E*

# Legal Information

## Patent

The units described in this manual are covered by U.S. Patent 3.883.782, 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 five 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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