TECHNICAL REPORT

REPORT NO.: 86-I02-8294

SHEET NO.: 1 of 2 Sheets

LOCATION: Central Laboratories Services Branch

SUBJECT: Isolating Devices - Fault Tests

DATE OF WORK: 8/11/86

DATE OF REPORT: 8/12/86

COPIES SENT TO: H. Styles, M. Duncan, RIMS, W. Robertson

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Introduction

The Central Laboratories Services Branch (CLSB) was requested to perform fault tests on two devices: Robert Shaw Isolation Amplifier and General Electric Transmitter. The purpose was to determine if any credible events occur at the input while applying various faults on the output. These tests were requested by H. Styles, Office of Engineering, Electrical Engineering Branch, W8A32C-K.

Results

Regardless of output fault, no electrical event could be observed on the input signal or supply lines of the Robert Shaw Isolator. On the G. E. unit very small spikes were seen in the input signal line when the output load was reconnected during the open output fault test. Oscillograph recordings are bulky and will be transmitted in a package that is separate from this report to the Electrical Engineering Branch.

Procedure

All measurements were performed by instruments that are certified in accordance with the approved Laboratory Quality Assurance Program. These instruments have documented traceability to offically recognized standards. Specific tests performed are contained in this report.

The circuit shown in Figure 1 was used for testing the Robert Shaw Model 572-C2 (S/N 7727040) isolation amplifier and the General Electric Type 550 Code No. 7343-43J027-001) transmitter. Functional tests were first performed on each device to ensure proper operation. An operational check was made after each fault test to ensure that no damage was incurred, except for the 120v fault test in which case damage was apparent on both devices. Isolator output measurements for functional tests are given in millivolts measured across R1 of the output network and may be converted to milliamps using the measured value of this resistor.

Pre-Fault Functional Test Results

Isolator input	Robert Shaw Output	G.E. Output
0% of range 10 ma.	99 mv	99 mv
50% of range 30 ma.	297 mv	297 mv
100% of range 50 ma.	494 mv	495 mv

Input current was provided by a battery-resistor supply to ensure total isolation. On the oscillograph recordings the Robert Shaw full-range input appear as a 5v trace, the resultant voltage drop across the input resistance with 50 ma. current flow. The G.E. input appears as approximately 60 mv due to the lower input resistance. All fault conditions were applied directly to the isolator output terminals, Nos. 7 and 8 on the Robert Shaw and Nos. 10 and 11 on the G.E.

Test No. 1

Instrument output load was removed and reconnected several times and then left open approximately five minutes.

Result: The Robert Shaw oscillograph recording for this test showed no effect on either the supply voltage or signal input line of the Robert Shaw isolator. No visual effects were observed and a functional check of this unit showed that it was fully operational. The G.E. unit was not affected on the supply voltage line. Close inspection of the input trace will reveal very small negative spikes (approximately 1 to 2 mv.) as the output load is reconnected. No visual effects were observed and a functional check of this unit showed that it was fully operational.

Test No. 2

Instrument output short circuit was applied and removed several times and then left shorted approximately five minutes.

Results: The oscillograph recordings for this test showed no effect on the supply or signal inputs of either the Robert Shaw or G.E. isolator. No visual effects were observed and a functional check of each unit after this test showed both to be fully operational.

Test No. 3

Application of a 120 vac, 20 amp supply to isolator output.

Results: Oscillograph recordings from this test show no effect on the monitored inputs of either the Robert-Shaw or G.E. units. In both cases the 10r output resistor (R1, Figure 1) burned open the instant the fault was applied. No visual effects were seen on the Robert Shaw unit but inspection after the test revealed R18 on the circuit board had overheated and some of its coating broken off. The G.E. unit began to smoke heavily approximately one minute into this test until approximately one minute later when the smoke abated somewhat. About four minutes into the test the smoke stopped. After the test, inspection revealed that the 300r resistor on the circuit board mounted on the chassis bottom had severely overheated and burnt a section of the board. One end of the resistor had detached from its solder terminal presumably as the solder heated to its melting point. Because of the obvious damage sustained as a result of this test, no functional test was attempted on either unit.

GAE:CG
Attachment: Figure 1

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TECHNICAL REPORT

DIVISION OF POWER SYSTEM OPERATIONS

REPORT NO.:	86-I02-8294
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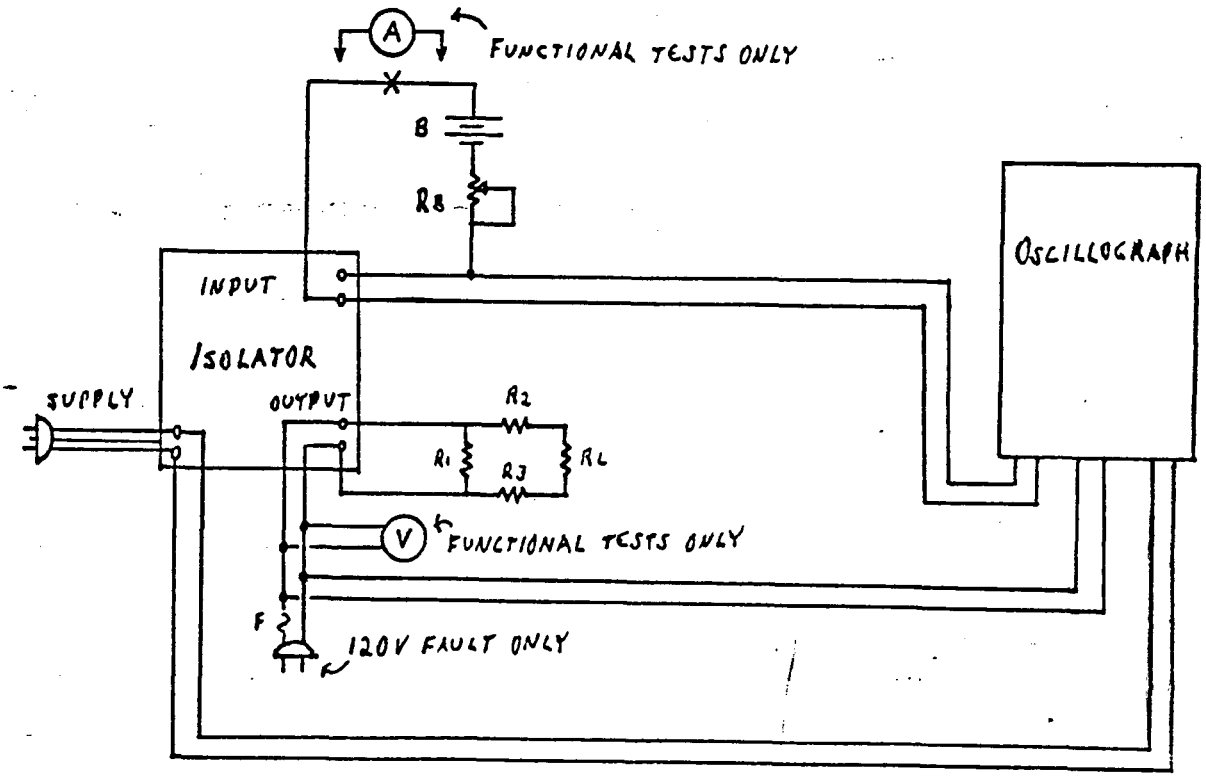
FIGURE 1



R1 - 10Ω ¼W. CARBON FILM RESISTOR, MEASURED VALUE 9.9Ω

R2 - 5KΩ ¼W. 1% TOL. METAL FILM RESISTOR

R3 - SAME AS R2

RL - 1MΩ 1% RESISTOR

R8 - 5KΩ W.W. POT.

B - 12V 1.2 AH NICAD BATTERY

A - KEITHLEY 197 DMM US-TVA 548492

V - KEITHLEY 197 DMM US-TVA 548496

F - 20 AMP FUSE

OSCILLOGRAPH SOLTEC 5M28 US-TVA 512797

ISOLATION TESTS ON
WESTINGHOUSE TYPE AR RELAYS
(SUPPLEMENTAL TESTING)

TEST PROCEDURE
EQTP(84)-019, REVISION 2, ADDENDUM I

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1.0 OBJECTIVE

The objective of this supplemental testing is to further verify the isolation capabilities of the AR Relays. Westinghouse type AR Relays are used as isolation devices between 1E and non-1E circuits. Initial isolation testing was performed at Westinghouse Nuclear Services Integration Division (WNSID) ITTC facility in Monroeville, Pennsylvania in November 1984. The relays were tested for isolation between contacts and coil and between contacts as documented in EQTR(84)-019, Revision 2 (September 1985).

Supplemental testing was performed at Westinghouse Seco Road facility in Monroeville, Pennsylvania in December 1986. The relays were tested for the isolation capability between the contacts and coil in 1) open contact (high voltage) mode and 2) closed contact (high current) mode while the coil was being monitored for any induced coil voltage.

2.0 EQUIPMENT TESTED

Testing was performed on Westinghouse Type AR Relays identified as follows:

Quantity	# Poles	Catalog #	Style
2	4	AR440AR	766A025G09

3.0 TEST REQUIREMENTS

3.1 General

Engineering bench tests were conducted at Westinghouse Seco Road Assembly and Test Facility. Two (2) relays were tested for isolation between contacts (non-1E Circuits) and coil (1E Circuits).

The insulation resistance of each relay between all contacts (connected in parallel) and coil (terminals connected together) was measured and recorded using a megometer (500 VDC) before tests.

Each relay was subjected to a preliminary dielectric test where 1000 VAC was applied between contacts and coil. Alarms were set on the hypot tester at 1mA.

Open Contact Mode (High Voltage Testing)

Test voltages of 120 VAC, 240 VAC and 580 VAC were applied in turn to the open contacts (Figure 1) for one (1) minute and the coil was monitored for any induced voltage.

Closed Contacts (High Current Testing)

A test voltage of 120 VAC was applied to the closed contacts (connected in series). A 12.4 ohm series resistive load (heater) and a fuse (15A) were used to limit the current through the closed contacts (Figure 2). The coil was again monitored for one (1) minute.

3.2 Test Equipment

A list of test equipment used for the isolation testing is included in the test log book and is provided in Table 1.

3.3 Monitoring Requirements

The following parameters were measured and recorded:

- Insulation resistance between contacts and coil (@ 500 VDC)
- Applied test voltage
- Input current
- Induced coil voltage

4.0 TEST PROCEDURE

4.1 Test Sequence

Data is provided in Table 2.

4.1.1 Measure insulation resistance (at 500 VDC) between contacts and coil (de-energized).

4.1.2 Apply 120 VAC to open contacts (Figure 1)

4.1.3 Record parameters after one (1) minute (Table 2)

4.1.4 Repeat 4.1.2 and 4.1.3 at 240 VAC

4.1.5 Repeat 4.1.2 and 4.1.3 at 580 VAC

4.1.6 Apply 120 VAC to closed contacts (Figure 2)

4.1.7 Record parameters after one (1) minute (Table 2) or until fuse blows.

5.0 REQUIRED TEST DATA

5.1 A listing of all equipment used for test (Table 1).
5.2 All test recordings (Table 2).
5.3 Log book recording start of test, completion of test steps, abnormal occurrences, deviations from test procedure, etc.

6.0 ACCEPTANCE CRITERIA*

Insulation resistance of greater than 1 megohm (at 500 VDC) between contacts and coil.

Dielectric test - leakage current not to exceed 1mA.

7.0 TEST RESULTS

The AR Relays were tested according to the isolation test procedures in Sections 3 and 4.

- Insulation resistance measurements were made on the relays (between contacts and coil) at 500 VDC prior to testing. The insulation resistance was greater than 100 megohms which greatly exceeded the acceptance criteria of 1 megohm.

  A preliminary dielectric test was performed by applying 1000 VAC across the open contacts and the coil. Alarms were set at 1mA on the Hypot tester. None of the Alarms were activated, indicating that the leakage current between contacts and coil was less than 1mA.

- Open Contact Mode (High Voltage) Testing

  A test voltage of 120 VAC was applied to the open contacts (Figure 1) for one (1) minute. An induced coil voltage of 1.15 E-06 volts was recorded. (Data Sheet 1).

  A test voltage of 240 VAC was applied to the open contacts (Figure 1) for one (1) minute. An induced coil voltage of 1.15 E-06 volts was recorded. (Data Sheet 2).

  A test voltage of 580 VAC was applied to the open contacts (Figure 1) for one (1) minute. An induced coil voltage of 1.17 E-06 volts was recorded. (Data Sheet 3).

* Derived from EIA Standard RS-407-A, (July 1978), Testing Procedures for Relays for Electrical and Electronic Equipment

Closed Contact Mode (High Current) Testing

A test voltage of 120 VAC was applied across the closed contacts for one (1) minute. The current obtained through the contacts was 8.93 Amps. The coil voltage after one (1) minute was 4.98mV. After this test, the relays were disassembled and the contacts were visually inspected. No signs of deterioration of the contacts were observed as a result of this test (Data Sheet 4).

Additional High Current Testing

The relays were subjected to a series of test voltages. For Relay #2, the voltage was adjusted to 140 VAC to obtain a current of 10.38 Amps. The voltage was then increased to obtain current steps of approximately 1 amp each (Data Sheet 5). After the final current step (290 VAC to obtain 19.8 Amps), Relay #2 was disassembled. Visual inspection of the contacts showed 25% of contacts had deterioriated (pitted) and all remaining contacts had discolored. However, the contacts did not burn open.

Relay #1 was also subjected to a series of test voltages to obtain current steps of approximately 5 Amps each step (Data Sheet 5). After the final current step (265 VAC, 19.8 Amps), the relay was disassembled. Visual inspection of the contacts showed discoloration of the contacts. However, no pitting was observed. It is believed that pitting occurred on Relay #2 contacts because the contacts were subjected to the higher currents for a longer period of time.

8.0 SUMMARY

In conclusion, Westinghouse Type AR Relays have been tested as isolation devices with testing documented in EQTP(84)-019, Revision 2 "Isolation Tests for Westinghouse Type AR Relays Used in Auxiliary Relay Racks" and EQTR(84)-019, Revision 2, Addendum I, "Isolation Tests on Westinghouse Type AR Relays (Supplemental Testing)". Testing has demonstrated that under abnormal voltage and current conditions (faults) occurring on the contact side of the relay, there was no gross failure of coil/contact isolation capabilities. The coil voltage was monitored throughout all phases of testing and, although the induced voltages were quite small, evaluation of their ultimate acceptability should be based on the specific application of the AR relays.

TABLE I

TEST TOOLS AND CALIBRATION

EWO # 861.050, Revision 0 TEST COMPLETION DATE 12/15/86

Manufacturer	Model (Description)	Last Calibration Date
Fluke	Temperature Probe	12/12/86
Fluke	Digital Multimeter	6/12/86
Keithley	Digital Multimeter	9/24/86
Simpson	Ampmeter	7/10/86
Westinghouse	Ampmeter	7/10/86
Westinghouse	Test Bench	8/5/86
N/A	Resistive Load (Heater)	N/A
A&R	Hpot Tester	7/8/86

TABLE 2
AR RELAY ISOLATION TEST
DATA SHEET 1 – 120 VAC TEST (OPEN CONTACTS)

	RELAY NO.1	RELAY NO.2
INSULATION RESISTANCE (MEGOHMS)	>100	>100
APPLIED VOLTAGE (VAC)	120	120
INPUT CURRENT (uA)	4.71	5.24
INDUCED COIL VOLTAGE (uV)	1.14	1.15

TABLE 2 (continued)
AR RELAY ISOLATION TEST
DATA SHEET 2 – 240 VAC TEST (OPEN CONTACTS)

	RELAY NO.1	RELAY NO.2
INSULATION RESISTANCE (MEGOHMS)	>100	>100
APPLIED VOLTAGE (VAC)	240	240
INPUT CURRENT (uA)	9.51	9.85
INDUCED COIL VOLTAGE (uV)	1.14	1.15

TABLE 2 (continued)
AR RELAY ISOLATION TEST
DATA SHEET 3 – 580 VAC TEST (OPEN CONTACTS)

	RELAY NO.1	RELAY NO.2
INSULATION RESISTANCE (MEGOHMS)	>100	>100
APPLIED VOLTAGE (VAC)	580	580
INPUT CURRENT (uA)	23.07	23.68
INDUCED COIL VOLTAGE (uV)	1.17	1.17

TABLE 2 (continued)
AR RELAY ISOLATION TEST
DATA SHEET 4 - 120 VAC TEST (CLOSED CONTACTS)

	RELAY NO.1	RELAY NO.2
APPLIED VOLTAGE (VAC)	120	120
INPUT CURRENT (Amps)	8.93	9.16
INDUCED COIL VOLTAGE (mV)	4.98	3.48

TABLE 2 (continued)
AR RELAY ISOLATION TEST
DATA SHEET 5 – HIGH CURRENT TESTS (CLOSED CONTACTS)

RELAY NO.1

APPLIED TEST VOLTAGE	INPUT CURRENT	INDUCED COIL VOLTAGE
70 VAC	5.28 Amps	2.35mV
135 VAC	10.11 Amps	5.06mV
200 VAC	15.13 Amps	7.03mV
265 VAC	19.80 Amps	8.63mV

RELAY NO.2

APPLIED TEST VOLTAGE	INPUT CURRENT	INDUCED COIL VOLTAGE
140 VAC	10.38 Amps	2.57mV
150 VAC	11.0 Amps	2.80mV
165 VAC	12.0 Amps	3.26mV
180 VAC	13.0 Amps	4.50mV
190 VAC	14.0 Amps	6.05mV
210 VAC	15.0 Amps	6.75mV
215 VAC	16.0 Amps	7.44mV
230 VAC	17.0 Amps	7.93mV
290 VAC	19.8 Amps	8.50mV

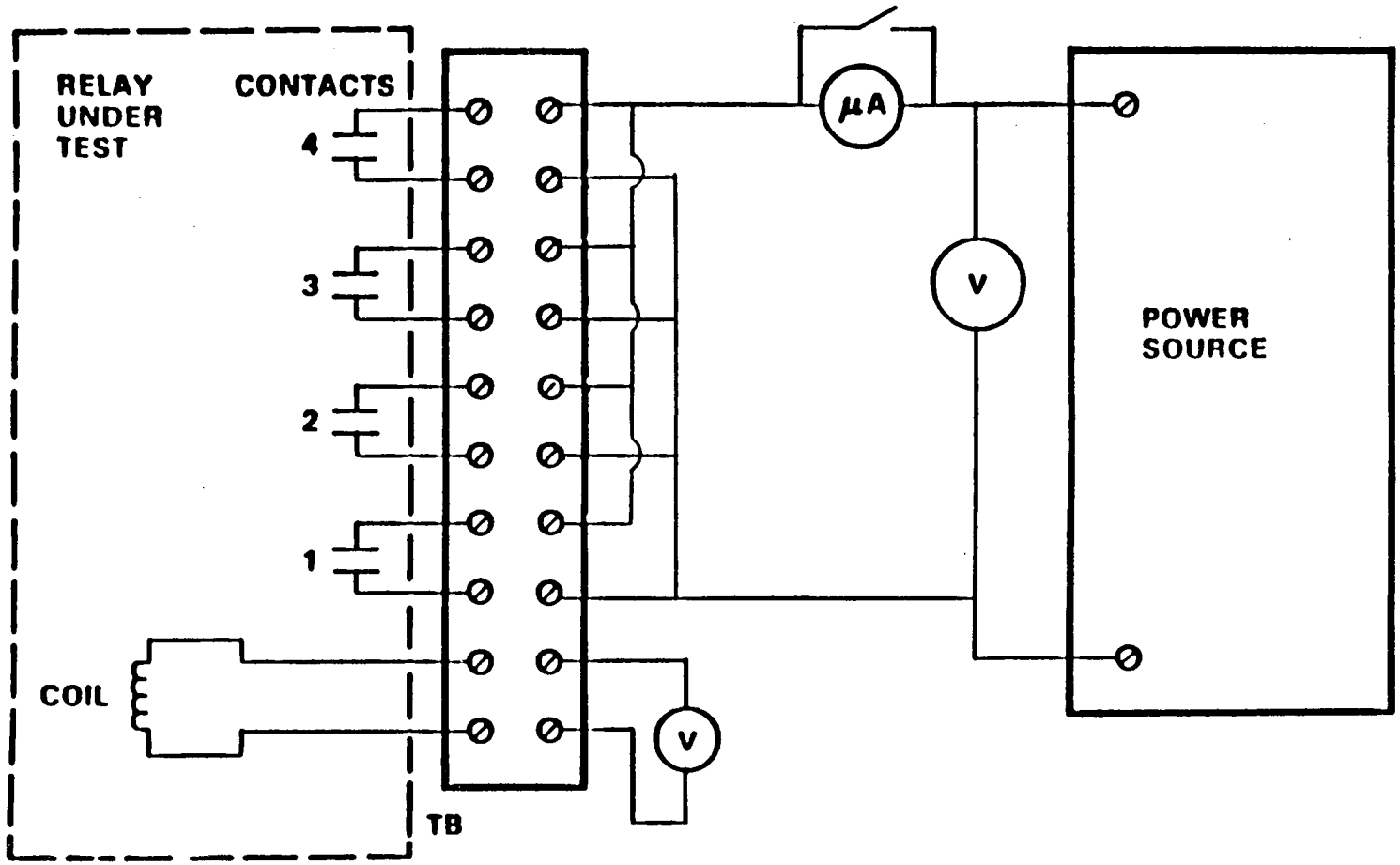

FIGURE 1: ELECTRICAL CONNECTIONS(OPEN CONTACTS)

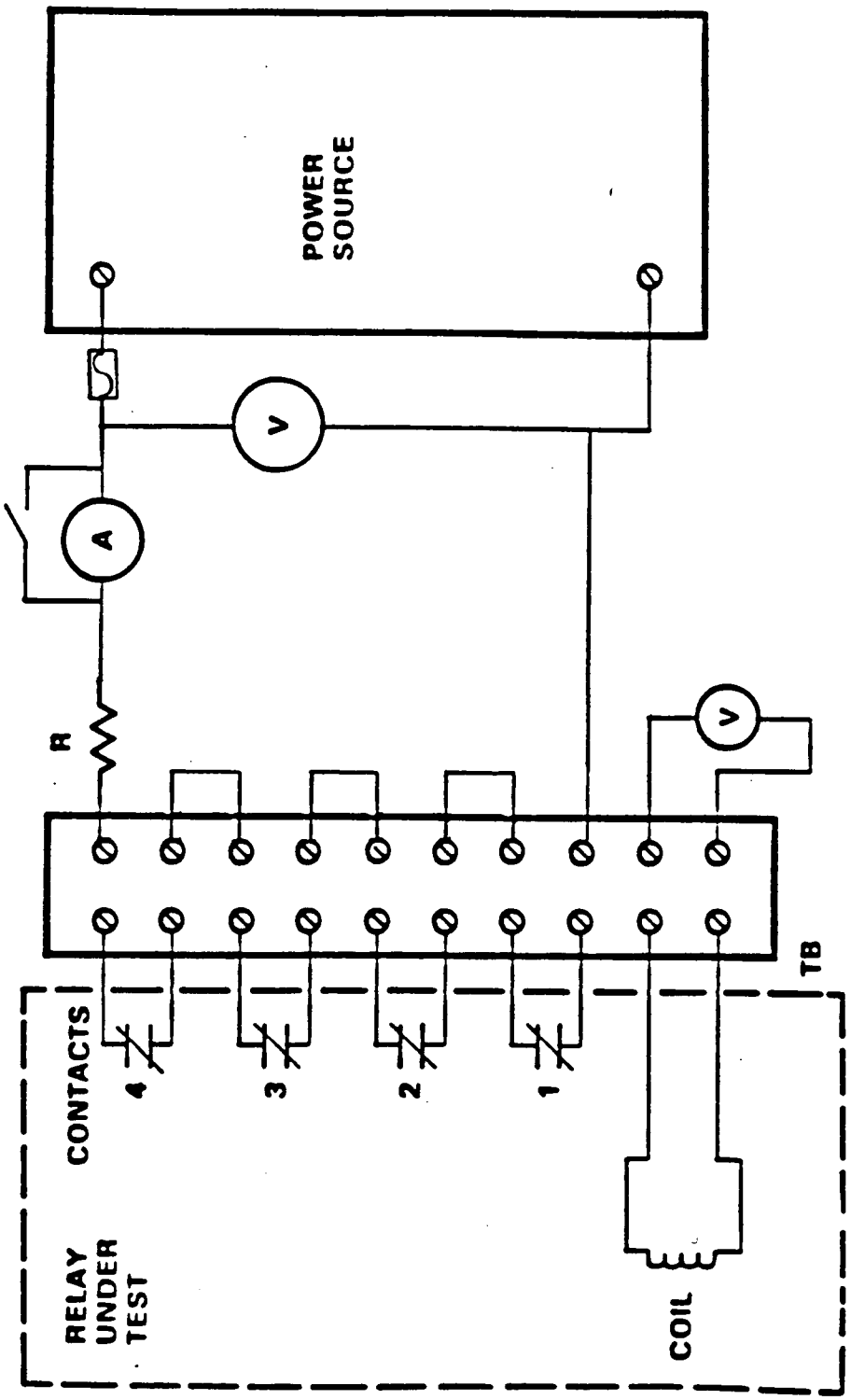

FIGURE 2: ELECTRICAL CONNECTIONS(CLOSED CONTACTS)