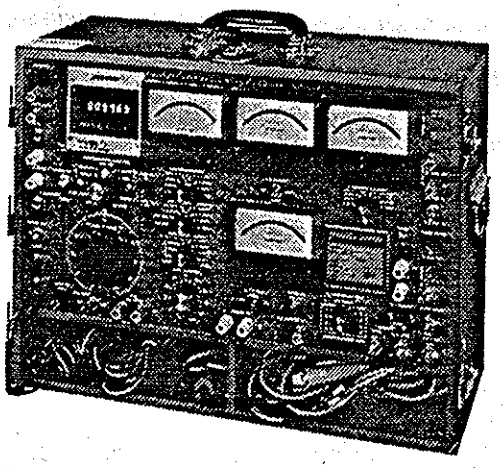
INSTRUCTION MANUAL
MULTI-AMP®
PROTECTIVE RELAY TEST SETS

for testing all types of protective relays



ILLUSTRATED: MODEL SR-51A, ONE-PIECE UNIT

The MULTI-AMP® test instrument described in this manual contributes to the more convenient and accurate field testing of protective relays.

Set-up time, accuracy, safety and a forward step in standardization of testing procedures are among the many benefits.

The following sections describing the use of the MULTI-AMP® relay test instrument will enable the user to utilize it to its fullest extent. Refer to manufacturer's instruction book for the details of the specific device to be tested.

It is recommended that this instruction manual be read thoroughly before proceeding with testing.

NOTE: If the relay test set is not equipped with optional Current Actuator "C.A.", the "Curr. Act" position of the "Timer Operation Selector" switch is not operable.

MODEL NO. SR-51 A SERIAL NO. .....

Please refer to the above serial number when making inquiries regarding this equipment.

multi-amp

4271 Bronze Way Dallas, Texas 75237 U.S.A. Telephone (214) 333-3201 TWX 910-861-9052

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APPRECIATION

We are indebted to the manufacturers of protective relays, who have given their time and advice in the preparation of this instruction book.

And, we also express our gratitude to engineers all over the country for their counsel and encouragement.

IMPORTANT

The information and data contained within this instruction manual are proprietary with MULTI-AMP Corporation. The equipment described herein may be protected by one or more U.S. letters patent. MULTI-AMP specifically reserves to itself all rights to such proprietary information as well as all rights under any such patent, none of which is waived by the submission of this instruction manual to anyone.

The recipient, if a Government Agency, acknowledges that this instruction book and the equipment described were procured with "Limited Rights" to technical data as described in ASPR 9-203(b).

FOREWORD

The MULTI-AMP test instrument described in this manual contributes to the more convenient and accurate testing of current and voltage actuated devices.

Setup time, accuracy, safety, and a forward step in standardization of relay testing are among the many benefits.

This manual presents detailed test procedures for the common types of protective relays. As additional test procedures are developed, they will be added to the manual. Copies of these new procedures will be available upon request.

It is suggested that the relay engineer or technician using the MULTI-AMP test equipment, refer to the relay manufacturer's instruction book for details concerning the characteristics or adjustments for the particular relay under test.

The following publications may be consulted for theory of relay operation and application:

1. "Applied Protective Relaying" (Silent Sentinal)
   Westinghouse Electric Corporation
   Relay-Instrument Division
   Newark, New Jersey

2. "The Art and Science of Protective Relaying"
   by C. Russell Mason, General Electric Company
   published by John Wiley and Sons, Inc., New York, N.Y.

3. "Protective Relays - Their Theory and Practice"
   by A. R. Van C. Warrington, The English Electric Co. Ltd.,
   Stafford, published by John Wiley & Sons, Inc. New York, N.Y.

4. "Electric Power Distribution for Industrial Plants IEEE No. 141

5. MULTI-AMP "The Electrical Tester", Vol. 2, No. 1
   "duPont Coordinates, Tests Protective Relays"
   by T. L. Bourbonnais II, E. I. duPont de Nemours & Co. Inc.

6. MULTI-AMP "The Electrical Tester", Vol. 7, No. 2
   "Effect of Changing Short Circuit Duty on Relay Settings"
   by F. P. Brightman

7. MULTI-AMP INSTITUTE Curriculum
   "Principles of Coordination for Industrial and Commercial
   Power Systems".

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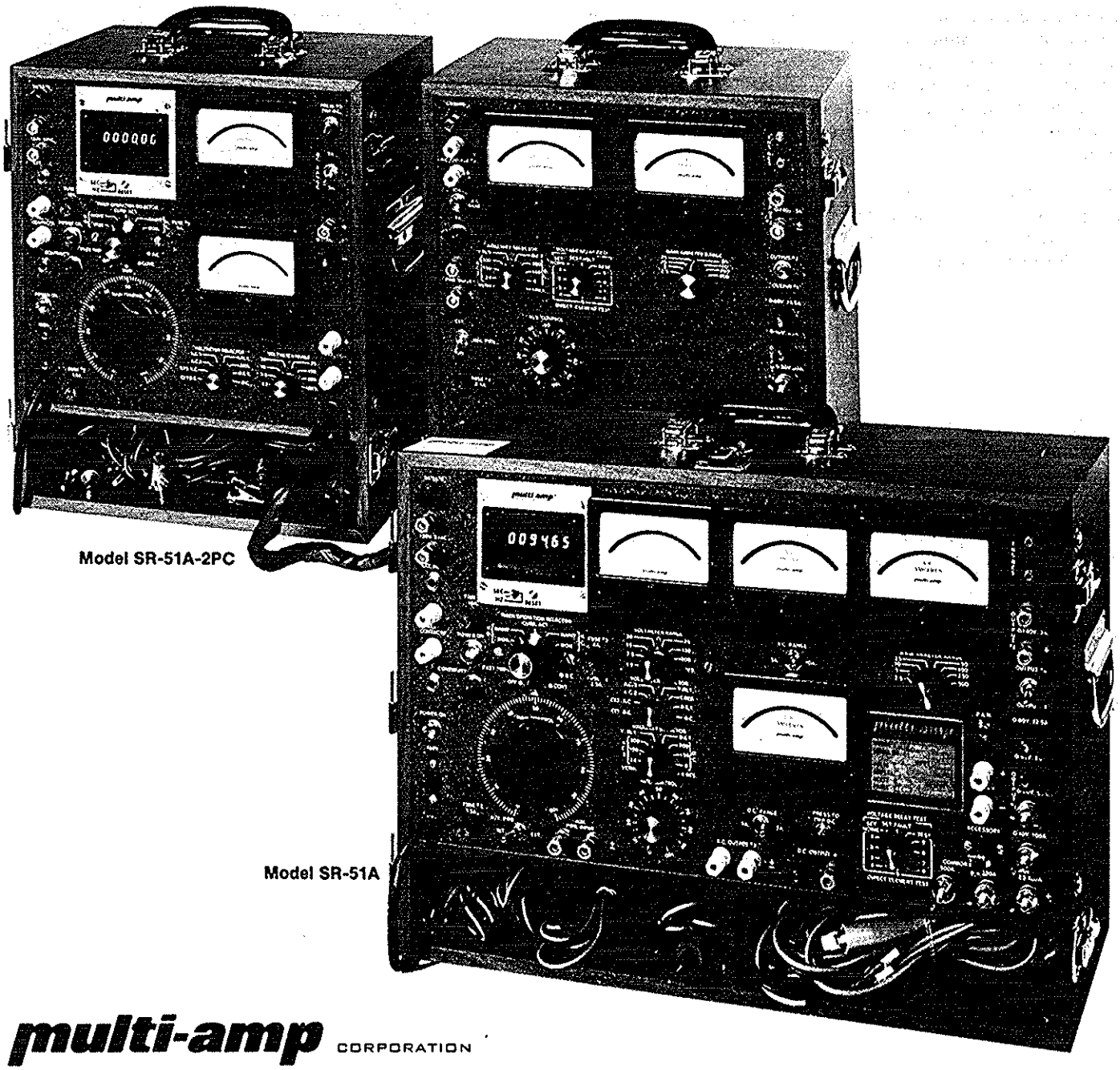
TABLE OF CONTENTS - RELAY TYPES

This table lists alphabetically by type designation, relays covered by test procedures in this instruction manual.

Universal Protective Relay Test Set Model SR-51A



Model SR-51A-2PC

Model SR-51A

multi-amp CORPORATION

4271 Bronze Way Dallas, Texas 75237-1088 U.S.A.
Ph. (214) 333-3201 Telex 163548 MULAM DL Fax (214) 333-3533

Multi-Amp Canada, 445 Finchdene Square, Scarborough, Ontario, M1X 1B7
Ph. (416) 298-6770 Telex 065-25453 Fax (416) 298-7214

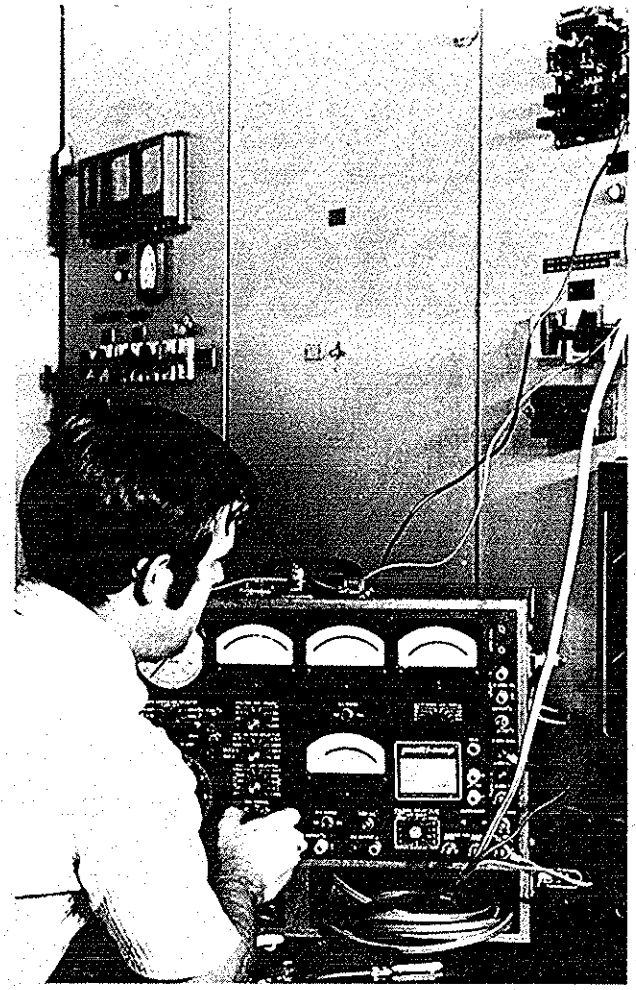
Model SR-51A

General Description

Designed to reduce equipment set-up time, simplify test procedures, and eliminate wiring errors introduced when interconnecting individual components, Multi-Amp Model SR-51A is a self-contained, portable test set incorporating the necessary outputs, control circuitry and instrumentation for testing the "basic" single-phase, single-frequency protective relays. Designed for either field or shop use, this rugged test set is constructed to withstand the rigors of transporation as well as daily field activity.

Among its many outputs are two ac current sources, two ac voltage sources, a dc voltage source, a dc current source and a high voltage source for insulation tests. Of the two (2) dc outputs which are provided, one is used primarily for testing dc auxiliary relays and the other for testing dc targets, operations indicators and seal-in units. Two (2) ac current sources are provided for applications such as testing current unbalance relays or the slope of differential relays. Facilities are provided to utilize and independently adjust two outputs simultaneously; and the test set includes several special test circuits which greatly simplify test procedures and increase efficiency.

Built-in overload relay and fuses protect the test set from damage due to overloads or short-circuits. The input line cord and test leads supplied with each test set are all that is needed for testing essentially all the "basic" protective relays.



Common Test Applications

Relays: Overcurrent, percentage differential, current unbalance, directional overcurrent, thermal, overload, over/under voltage, timing, and ac and dc auxiliary relays. When used in conjunction with a phase shifter such as Multi-Amp Model CS-7B, the Model SR-51A would also be used in testing distance, impedance, mho, reverse power, loss of excitation, and other relays which require control of the phase angle relationship.

Other Applications: Circuit breakers rated up to 50 amperes, current and potential transformer ratios, ammeters, voltmeters.

Specifications

Rating: 1.0 kVA
Input Voltage (specify one): 120 volts, 1ϕ *OR* 240 volts, 1ϕ
Input Frequency (specify one): 60 hertz *OR* 50 hertz
Outputs:

No. 1: Continuously adjustable through 4 ranges to meet a wide variety of test circuit impedances.

- 0-10 volts at 100 amperes
- 0-20 volts at 50 amperes
- 0-40 volts at 25 amperes
- 0-80 volts at 12.5 amperes

Overload (Intermittent) Capabilities of Output No. 1:

When the output voltage is sufficient to "push" higher than rated current through the impedance of the load circuit, the test set may be overloaded for short durations as shown below. The overload capabilities are approximate since output values will vary with regulation.

Per Cent Rated Current	Maximum Time-On	Minimum Time-Off
100%	30 minutes	30 minutes
200%	3 minutes	8 minutes
300%	20 seconds	4 minutes

No. 2: 0-140 volts at 3 amperes ac

No. 3: 0-150/300 volts at 0.5/0.25 amperes ac

No. 4: 0-8 volts at 5 amperes dc for dc current source in testing targets, operations indicators and seal-in units.

No. 5: 0-150/300 volts at 0.3/0.15 amperes dc

No. 6: 1200 volts, current limited to 5 milliamperes ac for insulation resistance tests.

No. 7: 0-24 volts at 10 amperes ac for second current source when testing dual current coil relays.

No. 8: "Directional Element Test" (DET) - A special test circuit to apply a current and voltage which are exactly in phase to determine minimum pick-up of wattmeter elements of complex relays. Four calibrated values are provided as well as five extra positions for special ranges.

No. 9: "Voltage Relay Test" (V. RLY.) - A special circuit for testing over or under or over/under voltage relays. Provides a "normal" voltage holding circuit where the "normal" voltage is adjusted and held while the fault voltage is properly set. Switching to the "Test" position applies the fault voltage and starts the timer simultaneously. Timer stops and voltage is de-energized when relay contacts close.

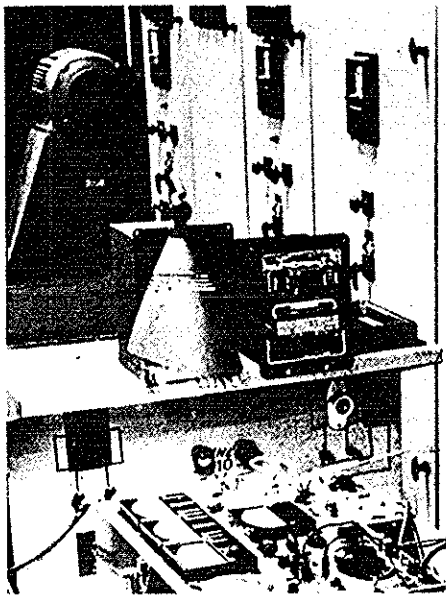
Instrumentation

1. **Main AC Ammeter:** A 4-inch square moving iron vane instrument with non-reflective glass, mirrored scale, knife edge pointer and pointer pre-set mechanism.
   Scales: 5/10/25 amperes
   Ranges: (switch selected): 0-2.5/5/10/25/50/100/250/500 amperes ac
   Accuracy: 1% of full scale
2. **Secondary AC Ammeter:** A 4-inch square moving iron vane instrument with non-reflective glass, mirrored scale and knife edge pointer.
   Scales: 5/10 amperes
   Ranges (switch selected): 0-5/10 amperes ac
   Accuracy: 1% of full scale
3. **DC Ammeter:** A 4-inch square D'Arsonval movement instrument with non-reflective glass, mirrored scale and knife edge pointer.
   Scales: 0.5/5.0 amperes
   Ranges (switch selected): 0-0.5/5.0 amperes dc
   Accuracy: 1% of full scale
4. **Multi-function AC/DC Meter:** A 4-inch square rectifier type instrument with non-reflective glass, mirrored scale and knife edge pointer.
   Scales: 15/30/75 volts ac or dc; 10 megohms
   Ranges (switch selected): 0-1.5/7.5/15/30/75/150/300 volts ac or dc; 10 megohms
   Accuracy: 1% of full scale
5. **Solid-State Digital Timer:** A specially designed Multi-Amp® solid-state digital timer is incorporated to measure the elapsed time of the test in either seconds or cycles. It has extensive shielding and noise suppression circuitry to ensure accurate and reliable operation under the most demanding field conditions. Incorporating a crystal-controlled oscillator, accuracy of the timer is independent of the power line frequency. The readout display appears as continuous, solid, unbroken digits with no gaps between the segments to impair readibility. The high brightness to contrast ratio of the display ensures excellent readability even in high ambient light conditions, including direct sunlight. The flat, planar design of the display allows a full 130° viewing angle without distortion.

   Display: .375-inch (9.53 mm) flat, planar characters using high intensity, gas-discharge technology.

   Ranges (switch-selected):
   (a) 0-9999.99 seconds
   (b) 0-999999 cycles

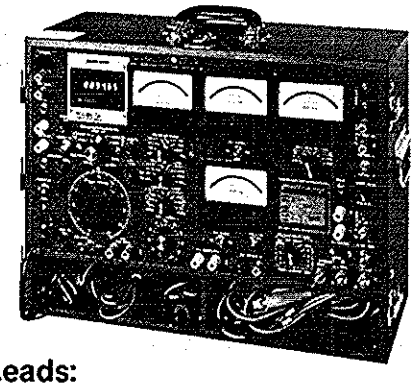
   Accuracy: Seconds Mode: ± least significant digit or 0.0025% of reading, whichever is greater.
   Cycles Mode: ± 1 Cycle



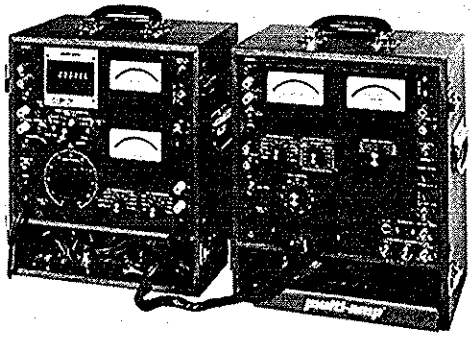
Housing:

Test set is housed in a tough, heavy-duty formica enclosure with carrying handles on both top and ends and has a removable, hinged protective cover. Available in either a one-piece enclosure, or for increased portability, in a two-piece enclosure with a single, multi-conductor interconnecting cable with appropriate plugs.

One-piece enclosure Model SR-51A
Dimensions: 16½"H, 22"W, 11"D
Net Weight: 86 lbs. (39 kg.)



Two-piece enclosure Model SR-51A-2PC
Dimensions: 16½"H, 14"W, 11"D Each
Net Weight: 43 lbs. (19.5kg.) and 48 lbs. (21.8 kg.)



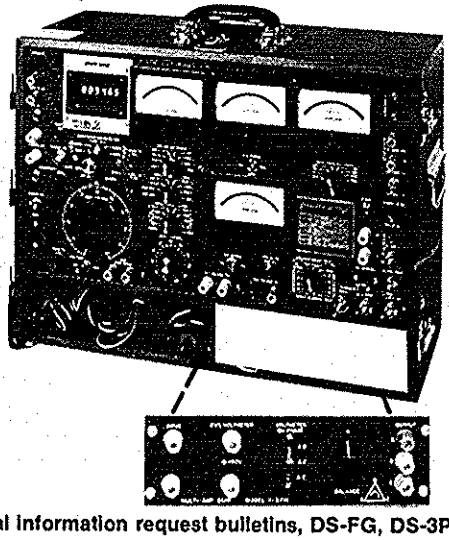
Test Leads:

- One (1) pair No. 6 welding cables with insulated alligator clips and spaded lug Part No. 1285
- Two (2) pair No. 18 utility leads Part No. 1282
- One (1) pair continuity test leads Part No. 1283
- One (1) set of high-voltage test leads Part No. 1125
- One (1) 10-foot 3-conductor input lead Part No. 2708
- One (1) pair #10, 20 feet long output leads Part No. 2040

Standard Features:

- Provided with two instruction manuals, each containing approximately 150 pages of detailed, step-by-step procedures for testing protective relays as well as operating instructions for the test set. Manuals also include maintenance instructions, schematic diagram and parts list.
- High current outputs of the test set are obtained using standard 120-volt convenience outlet for input power. No special high current power source required.
- Output control circuit permits momentary, "pulsed" application of output to avoid damage or overheating of relay when setting test current. Also, output is automatically de-energized when relay under test stops timer.
- Built-in overload and short circuit protection.
- Facilities to initiate the test set from a remote location.
- Facilities to utilize the test set's voltmeter to measure external AC or DC voltages.
- Continuity test circuit to indicate contact action.
- An auxiliary channel, completely independent of the main output channel is incorporated and may be fed from the common primary source or from an external phase shifter or frequency generator.
- Facilities are provided for efficient use of Multi-Amp accessory units such as the Model 1-3PH three-phase synthesizer (shown below), as well as a phase shifter or frequency generator. For additional information on these accessory models, please contact the factory.

Model 1-3PH



For additional information request bulletins, DS-FG, DS-3PH, DS-CS.

GENERAL DESCRIPTION

MULTI-AMP relay test sets are portable, variable current and/or variable voltage units suitable for testing and calibrating electrical protective or indicating devices. They are capable of testing all single phase protective relays that do not require a change in frequency or a specified phase angle relationship between a voltage and a current or between two currents or two voltages. They may also be used to test any three phase protective relay that may be tested one phase at a time. The test sets are dual channeled; each channel controlled independent of the other. The main channel provides test facilities for AC current actuated or AC voltage actuated devices with a continuously variable output.

The second or Auxiliary channel supplies continuously variable outputs of AC or DC for current actuated or voltage actuated devices; provides special circuitry for testing undervoltage relays, directional units, and, in addition, for performing an insulation resistance test on all protective relays.

Accessories are available to be used in conjunction with the MULTI-AMP relay test sets when special facilities are required:

a - change of frequency

b - a specified phase angle relationship between two circuits

c - three phase voltage

Detailed descriptions of the controls are given in the following pages. The numbers ( ) refer to those shown on Figure 1.

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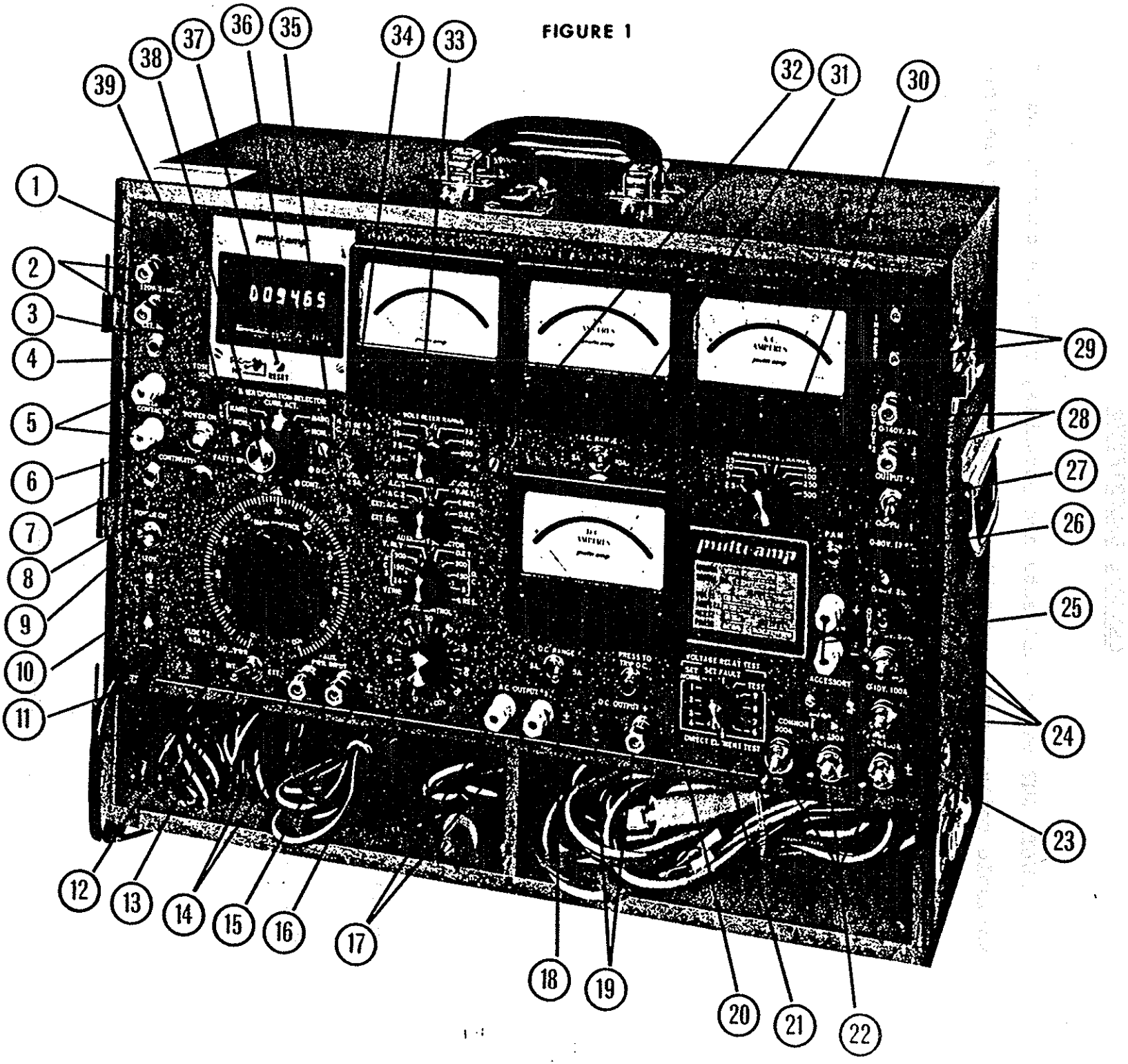
FIGURE 1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CONTROL DEVICE FUNCTIONS

INITIATING SWITCH (1)	This switch serves to start operation of the test set.
120V SYNCH TERMINALS (2)	120 volts is present on these terminals whenever the unit is initiated. This voltage may be used as a control source to initiate an external unit such as MULTI-AMP Model 1010/RB Reactor Booster.
EXT. INITIATE JACK (3)	Closing a circuit plugged into this jack will allow the test set to be initiated from a remote position.
FUSE NO. 1 (4)	This fuse protects the entire unit.
"RELAY CONTACTS" BINDING POSTS (5)	The trip circuit contacts of the device under test are to be connected to these posts.
"POWER ON" LIGHT (6)	This light indicates that the main switch is closed.
CONTINUITY JACK (7)	A 6.3 volt circuit is wired in series
CONTINUITY LIGHT (8)	with a green light (8) so that contact action of relay under test or circuit continuity can be checked.
POWER SWITCH (9)	This is the main input switch controlling all power except to the "120V" outlet (10).
120V OUTLET (10)	This convenience outlet is wired directly across the line cord so that power for auxiliaries such as trouble lights, etc. is available whenever the test unit is plugged in.

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FUSE NO. 2 (11) — This fuse protects the control transformer.

MAIN CONTROL KNOB (12) — This knob controls the setting of the main variable autotransformer.

AUX. POWER INT-EXT SWITCH (13) — Selects energizing of second channel of test set from internal or external source.

AUXILIARY POWER INPUT TERMINALS (14) — These terminals are for connecting a second source of power (not over 120 volts) from a phase shifter or frequency generator so that relays requiring control of phase relationship or frequency may be tested.

AUXILIARY SELECTOR SWITCH (15) — This switch selects the output to be adjusted by the auxiliary control (16). In the "VERNIER" Position, the Auxiliary Control acts as a fine adjustment for the Main Control (12).

AUXILIARY CONTROL KNOB (16) — This knob controls the setting of the auxiliary autotransformer to change the magnitude of the output selected by the "Auxiliary Selector" Switch.

AC OUTPUT #3 TERMINALS (17) — Binding posts where AC output associated with second channel of MULTI-AMP test set is picked up.

DC RANGE SWITCH (18) — This switch selects the range of the DC Ammeter (0.5A or 5A).

DC OUTPUT TERMINALS (19) — Binding posts where DC outputs of MULTI-AMP test set are picked up.

"PRESS TO TRIP DC" SWITCH (20)

This switch (NC Momentary Contact) opens the DC supply.

VOLTAGE RELAY TEST D.E.T. (Directional Element) TEST SWITCH (21)

This switch is used when running timing tests on voltage relays or minimum pickup of directional units on directional overcurrent relays.

"SET NORM" Position - When used with "Voltage Relay Test" circuitry, this position connects AC Output #3 terminals (17) to output of Channel 1 of the test set.

"SET FAULT" Position - Switches voltmeter to output of second channel of test set while allowing AC Output #3 terminals of test set to remain connected to output of Channel 1 of the test set.

"TEST" Position - Connects AC Output #3 terminals to output of Channel 2 of test set and starts timer.

Position #1 through 4 are factory wired with resistors to provide specific values of voltage and current at zero phase angle to test pickup of directional element.

Position #5 through 9 are left unwired to permit addition of resistors to produce values common to the user's system.

OUTPUT #1 TERMINALS 22 and 24	AC Output #1 is available from these terminals and is adjusted by the Main Control in four (4) ranges.
ACCESSORY SOCKET (23)	This socket is connected to the 0 to 140 volt, 3 amp output of the autotransformer and can be used to supply a soldering iron or similar accessory.
EXTERNAL VOLTMETER TERMINALS (25)	These terminals enable the voltmeter to be used for external voltage measurements.
PAM JACK (26)	This jack enables a phase angle meter current coil or external 5-ampere ammeter to be inserted in series with the main ammeter.
OUTPUT #1 & OUTPUT #2 SWITCH (27)	This switch makes available Output #1 (Current) or Output #2 (Voltage) from Channel 1 of the test set.
OUTPUT #2 TERMINALS (28)	AC Output #2 is available from these terminals and is adjusted by the Main Control.
INSULATION RESISTANCE JACKS (29)	These jacks accept the high voltage test leads provided with the unit.
MAIN AMMETER RANGE SWITCH (30)	This switch selects the range of the main ammeter. The ammeter range must correspond to the appropriate Common of Output #1.
AC RANGE SWITCH (31)	This switch is an ammeter range switch. (5 or 10 amperes)

VOLTMETER SELECTOR SWITCH (32)

By means of this switch, the voltmeter can be connected to any one of several output circuits.

VOLTMETER RANGE SWITCH (33)

This switch selects the voltage range for the voltmeter.

FUSE NO. 3 (34)

This fuse protects the main autotransformer.

FUSE NO. 4 (35)

This fuse protects the auxiliary (VERNIER) autotransformer.

TIMER (36)

Measures elapsed time of test in cycles or seconds. Ranges (switch-selected):
(a) 0-999.99 seconds
(b) 0-999999 cycles

TIMER RESET BUTTON (37)

This push-button resets timer to zero.

TIMER OPERATION SELECTOR SWITCH (38 & 39)

The timer operation selector switch (38 and 39) mounted immediately below tne timer on the panel of the MULTI-AMP relay tester is a dual section switch. Each section is controlled by a separate operating device. The first section of the switch reads against the nomenclature below the switch. It has five positions and is referred to below as the "LOWER" switch (39). The second section is controlled by a knob. It also has five positions and reads against the nomenclature above the switch. This switch is referred to below as the "UPPER" switch (38). By proper selection of positions, many varieties of tests can be run with the MULTI-AMP relay tester.

In order to best explain the operation of this dual switch, its function, as most commonly used in relay testing, is first described.

With the "LOWER" switch (39) set at "TIMER", the "UPPER" switch (38) may be set at any one of its five positions and operation of the test set will be as follows:

A. "N.O. MOM" (Normally Open Momentary) - When the relay under test has normally open contacts which are connected to the "Relay Contact" terminals (5), the test unit may be initiated by depressing the Initiating Switch (1). The selected output of the MULTI-AMP will remain energized as long as the initiating switch is held depressed or until the contacts of the device under test close. If the Initiating Switch is held depressed after the contacts of the device under test close, the cycle will repeat itself.

B. "N.O. MAINT" (Normally Open Maintained) - The function of this position is exactly the same as above except that the Initiating Switch need be depressed only momentarily to lock in the internal control relay. The timer will stop and the output of the MULTI-AMP relay test set de-energized upon contact closure of the device under test.

C. "C.A." (Current Actuated) - A third type of timer operation may be provided as an optional feature. The center position marked "CA" on the timer operation selector switch is inoperative unless a Current Actuator is supplied.

The operation of the Current Actuator is as follows:

The output current of the test set passes through a current transformer(s) on the output common bus(es). The secondary of the current transformer(s) is rated 5 amperes and is connected to a series circuit containing the operating coil of the indicating ammeter and the primary coil of a second current transformer. The secondary circuit of this second current transformer is used to energize the grid of a 2D21 Thyratron tube. When a minimum pre-determined amount of current passes through the output terminals of the test unit, the Thyratron tube "fires", locking the test unit's main contactor closed until current flow ceases. The "CA" Position is used when the device to be tested has no contacts other than those involved in the passing of test current (such as single pole circuit breakers). In this position, the timer will run from the initiation of the test unit until current flow from the output of the test unit is interrupted.

D. "N.C.MAINT." (Normally Closed Maintained) - In this position, the unit may be initiated by depressing the Initiating Switch (1) momentarily, provided the contacts of the device under test are in closed position and are connected to the "Relay Contact" terminals (5). The selected output will be energized and the timer will run until the contacts of the device under test open, at which time the output will be de-energized and the timer will stop.

E. "N.C. MOM" (Normally Closed Momentary) - The operation in this position is exactly the same as in "D" above except that the output will be energized and the timer will run only as long as the initiating switch is held depressed.

The selection of other positions on the "LOWER" switch (39) will affect the operation of the relay tester in the following manner:

F. DC - In this position, the "Relay Contacts" (5) binding posts are connected to the "DC 8" output of the test set for convenience in testing target and seal-in units on relays. (Note that the Auxiliary Selector Switch (15) must be in "DC-8" position.)

The timer will not run and closure of the contacts of the device under test will not de-energize the test set.

Only the positions "N.O. MOM" and "N.O.MAINT" of the UPPER Switch (38) may be used for this position of the "LOWER" Switch (39).

G. "CONT" (Continuity) - In this position the "Relay Contacts" binding posts (5) are connected to the 6.3 volts continuity circuit of the test unit. Therefore, contact operations of a relay under test may be observed by watching the continuity light.

H. "TIMER" - This operation has been described above.

I. "OFF" - With the "LOWER" switch (39) set to the OFF position, the timer motor and clutch are de-energized.

J. "FAST TRIP" - In this position of the "LOWER" switch (39), the operation of the timer selector and initiating circuits are as follows:

MUST BE USED WITH "UPPER" SWITCH IN "N.O. MOM" POSITION.

With the Normally Open Contacts of the device under test connected to the "Relay Contacts" (5) binding posts, the unit may be initiated by depressing and holding the Initiating Switch (1). The closing of the contacts of the device under test will stop the Timer (36) upon their first closure. The output of the MULTI-AMP test unit will continue as long as the Initiating Switch is held depressed. In this way, devices may be tested whose contact closure occurs faster than the Initiating Switch can be released.

WARNING!!!

IT SHOULD BE NOTED THAT THE OUTPUT OF THE UNIT WILL CONTINUE UNTIL THE INITIATING SWITCH IS RELEASED. THEREFORE, TO PREVENT DAMAGE TO THE DEVICE UNDER TEST, RELEASE INITIATE SWITCH (1) AS SOON AS THE MAGNITUDE OF TEST CURRENT HAS BEEN DETERMINED.

CURRENT METERING CIRCUIT (AMMETER)

The main ammeter on the MULTI-AMP test set is equipped with an adjustable Pointer Stop or "Pointer Pre-Set", by means of which the ammeter pointer may be preset to any position on the scale and held there with no current flowing through the meter. This is a purely mechanical operation, easily accomplished by means of an insulated knob on the meter front. It is used to overcome the inertia of the moving system of the meter so that currents of short duration can be read or set accurately.

In use, the pointer is mechanically set approximately 1/2 scale division below the desired current reading. The load is connected, the timer operation selector switch is placed in either "N.O. MOM" or "N.C. MOM" position, and the main power control is slowly rotated clockwise while the initiating switch is periodically pulsed.* Some quivering of the pointer will be seen as the output current approaches the pre-set value. In continuing to advance the Main Power Control, the meter pointer will lift off the "Pointer Pre-Set" to desired current.

*NOTE: DO NOT MOVE THE CONTROL WHILE CURRENT IN EXCESS OF THE TAP RATING IS FLOWING.

I-M-P-O-R-T-A-N-T

ALWAYS MAKE CERTAIN THAT THE AMMETER IS SET ON A RANGE HIGH ENOUGH SO THE OUTPUT CURRENT WILL NOT DRIVE THE POINTER OFF SCALE.

NOTE: The ammeter position selected must be within the range of the "Common for Ammeter" tap selected.

SELECTION OF OUTPUT TAPS

The MULTI-AMP test set may be operated most advantageously by using the tap with the Lowest Voltage* rating consistent with being able to obtain the desired current. In this way, finer adjustment can be obtained by making maximum use of the auto-transformer range. With a low impedance load, even small currents may be obtained from the Low Voltage, High Current tap. When the impedance of the load is too high to obtain the desired test current with the low voltage tap, it becomes necessary to use a higher voltage tap.

IT SHOULD BE NOTED THAT THERE IS NO RELATION BETWEEN THE AMMETER RANGES AND THE CURRENT TAPS. ANY AMMETER RANGE CAN BE USED ON ANY TAP.

Current taps are provided to adapt the test set output to a wide range of load impedances.

Ammeter ranges are provided to facilitate more accurate reading over a wider range of current values.

*When making a timing test on an overcurrent relay, it is suggested that the 80 volt tap be used. Its use will tend to nullify the effect of relay core saturation. When the relay is in good adjustment, test time obtained will match the relay manufacturer's published curves within allowable tolerances.

SHORT TIME RATING

The MULTI-AMP equipment is rated at a certain kva output and is equipped with one or more output taps each capable of supplying the rated kva. The total load kva rating of the unit may be exceeded as noted below.

The continuous rating in kva is based on a 50% load factor of 1/2 hour FULL LOAD followed by 1/2 hour at NO LOAD.

The MULTI-AMP test set can also be used for continuous duty of 100% ON provided the load current is limited to 70.0% of the output tap value.

For Example:

Rating:	1.0 kva
Output Taps:	10 volts at 100 amperes or 20 volts at 50 amperes or 40 volts at 25 amperes or 80 volts at 12.5 amperes

(a) Consider the 10 volt tap. 100 amperes may be drawn at any voltage from 0 to 10 volts for 1/2 hour provided a 1/2 hour NO LOAD condition persists before load is re-applied.

(b) The 100 ampere tap may be used to supply a continuous (100% duty factor) load current of 70.7 amperes (70.7% of tap value) at any voltage from 0 to 10 volts.

(c) The 100 ampere tap may be used to supply the following load currents for the time ON indicated, followed by the indicated OFF period and at any voltage from 0 to maximum. The maximum output voltage available when the rated current is exceeded (overload), will be less than the rated value due to the regulation of the transformers in the test set. For example, when drawing 200 amperes from the 100 ampere tap, the maximum voltage available is approximately 8.0 volts.

Current	Time ON	Time OFF
100 A	Continuous*	----------
200 A	3 minutes	8 minutes
300 A	20 seconds	4 minutes

*Continuous duty is defined as 30 minutes ON and 30 minutes OFF

USE OF PHASE SHIFTER AND PHASE ANGLE METER

WITH MULTI-AMP Models SR-21 and SR-51

The complete testing of certain relays requires control of the phase relationship between the two sources of energy utilized in the test. To facilitate testing of these relays, provisions have been made for connecting a Phase Shifter and Phase Angle Meter to the MULTI-AMP relay test sets.

PROCEDURE (Models CS-5 or CS-6)

1. Connect Phase Shifter to a suitable input power source.

2. Connect Phase Shifter terminals marked "Phase Shifter Output" to the "Aux. Power" input terminals on relay test set. Observe polarity. Connect terminals marked "±" together.

3. Plug in the telephone type plug into the "P.A.M." jack on relay test set. Connect the leads from the plug to the Phase Shifter terminals marked "Current Coil Input". Observe polarity. Connect black lead to terminal marked "±".

4. Turn "Aux. Pwr." Switch on relay test set to "EXT".

5. Turn "AUX." Selector Switch on relay test set to "AC3-24", "AC3-150" or AC3-300.

6. Depending on voltage level required for test, set voltmeter selector switch to "AC3".

7. The Phase Angle Meter will now read the angle between "Output #1" and "AC Output #3" of the relay test set. The Phase Shifter may be used to change this angle to any desired value. "Output #1" is varied in magnitude by the "Main Control" and read on the "Main Ammeter". "AC Output #3" is varied in magnitude by the "Aux. Control" and read on the voltmeter.

   NOTE: If two (2) current sources are desired with variable phase relationship and magnitude, the above procedure may be used with the "Aux."Selector Switch set at "AC3-24". The second current is read on the 5/10 ammeter.

PROCEDURE (Model CS-7)

See Instruction Manual for MODEL CS-7.

PROTECTIVE RELAYS
Principle of Operation

Protective relays are used as sensing devices in a power circuit. Their operation activates a control circuit to effect operation of a circuit breaker(s) located in the power circuit. For their operation, practically all protective relays employ either one or a combination of two basic principles:

a. Electromagnetic attraction

b. Electromagnetic induction

When the electromagnetic attraction principle is employed, the protective relay consists of an iron core surrounded by a coil of wire, an armature or plunger to which is attached a contact (known as the moving contact since it moves as the armature or plunger moves), and a fixed contact attached to the body of the relay. These two contacts are connected into the circuit breaker trip coil circuit. The contacts are maintained in their de-energized position by action of a spring or gravity. When the magnetic field is sufficiently strong, the armature or plunger moves and causes a relay operation. This, in turn, energizes a circuit through the trip coil of the breaker and opens the breaker. Normally, the operation of this relay has no intentional time delay. The principle of electromagnetic attraction may be used equally well on either AC or DC and it is responsive to DC transient offset.

When the electromagnetic induction principle is employed, the protective relay is essentially a small induction motor and, therefore, this relay may only be used on AC circuits. This type relay consists of a flat disc, cylinder or cup which is free to rotate, an iron core surrounded by a coil of wire, a moving contact attached

to the shaft of the rotating element, and a fixed contact located in the body of the relay. The rotating disc (cylinder or cup) is suspended between the pole pieces of the electromagnet and employs a spiral spring to return the moving contact to its de-energized position. As voltage is applied or current is passed through the electromagnet coil, a magnetic field is produced which develops a torque on the disc. When the magnetic field and resultant torque becomes strong enough to overcome friction in the bearings and tension in the spiral spring, the disc rotates moving a contact. Eventually, the moving and fixed contacts will make and energize the trip coil of the circuit breaker. When this is a single phase relay, some means of splitting the phase must be employed so that a rotating magnetic field is produced. These relays employ shading coils, polarized coils, wattmetric principles or tuned circuits. In some electromagnetic induction relays, the distance the moving contact travels may be controlled; these relays provide a <u>time delayed</u> operation.

Protective relays may be constructed so that they respond to faults in a specified section of a circuit (percentage differential), changes in current flow (overcurrent), fluctuations in applied voltage (over or under voltage), frequency changes (over or under frequency). More sophisticated protective relays may distinguish between allowable overloads and faults on a circuit or they may be employed to sectionalize a system.

Since the protective relay is a sensing device connected to the power circuit through either current transformer or

potential transformers, it may be used to protect circuits of any known voltage level or current capacity. Circuit breakers that are operated by protective relays may be built with interrupting ratings measured in millions of volt-amperes.

Types of Relays

Although there are many models of relays, most fall within three (3) types:

1. Overcurrent and Voltage Relays
   a. Greatest number in use
   b. Involve a single coil which is either voltage or current actuated.

2. Bus, Generator or Transformer Differential and Current Balance Relays
   a. Have two (2) or more circuits which act jointly upon an electromagnetic structure to provide contact action.

3. Distance, Directional and Impedance Relays
   a. These are "Complex Type" relays
   b. Have several components any one of which may require definite voltage, current and phase angle relationship for operation.

With the exception of the instantaneous relays, most of the above devices work on the induction principle.

PREPARATION FOR RELAY TESTING

Relay testing should be kept to a minimum. It should be remembered that the purpose of testing is to prove that the relay will work and not to unnecessarily check all the details. Relay testing should be streamlined to as nearly approach actual conditions as possible in a minimum of time and effort. The following are some of the points to be considered:

1. PLAN

   a. Set up program to fit system's needs.

   b. The technician should confer with operating personnel to work out procedures to be followed should a circuit be inadvertently tripped.

      If the relay technician makes a mistake and trips a circuit, he should admit it immediately. This admission may save many hours of work trouble shooting the control circuit looking for non-existent problems. It should be remembered that one of the reasons for planned maintenance and testing is to build confidence in the protective system.

2. SCHEDULING

   a. Test program should be set up on a regular schedule.

   b. Test periods vary with system requirements. Annual inspection and test schedules are common practice.

   c. Operating personnel should be fully informed of the maintenance schedule and the work to be performed. Operating personnel should be notified in advance, and, if possible, operations should be shifted so that the circuits may be de-energized. However, if circuits cannot be de-energized, the technician should proceed with caution, bearing in mind that all the time a relay is out of the circuit, some of that circuit's protection is removed. Therefore, a relay job should never be started unless it can be finished before leaving the work area. It is imperative that any relay work be done in a very thorough manner. A job should not be rushed or left half-done.

3. SAFETY

   Safe work habits and use of good common sense cannot be over-emphasized. Metal ladders or step stools should never be used around switchgear. If safety helmets are required, a fiber or plastic helmet should be worn. Loose key chains, tool pouches, or pieces of wire should never be allowed to hang from the body. Rings and metal watchbands should be removed.

Whenever possible, power circuits should be de-energized and properly tagged to conform with approved procedures. It must not be assumed that circuits are de-energized.

Test personnel should be familiar with the "shock hazard". Since MULTI-AMP test units are all designed with output isolated from input, the "shock hazard" is at an absolute minimum. However, certain outputs of high value should be handled with proper caution. Voltages present in testing contribute to the very dangerous hazard of ventricular fibrillation.

4. KNOW CONTROL CIRCUIT

It is important to know the pecularities of the control circuit associated with the relay being maintained; such as the trip circuit being interlocked with a cubicle door; or that removal of potential from the relay operating coil before opening the trip circuit results in tripping the power circuit breaker.

Identification of Circuits

Double-check the identification of the relays on the panel. This can be complicated when work on relay terminals must be done behind the board and there are a large number of similar boards.

5. CURRENT TRANSFORMERS

The current transformer is a vital part of the electrical protective system. It is this device that reduces the current in the power circuit to a value that can be handled by the protective relay, and insulates the relay from the power circuit. There is danger associated with a current transformer. Under no circumstances should the secondary of a current transformer be opened while the primary is carrying current.

6. TARGET OR OPERATIONS INDICATOR

When a breaker trips under fault, this device indicates the type of fault and the phase which faulted. This information is important and, therefore, a target should never be reset without the supervisor's knowledge and permission.

7. READ AND UNDERSTAND MANUFACTURER'S INSTRUCTION LITERATURE

Many relays have been damaged in testing by incorrect procedures, unfamiliarity with the relay, or improper connections. The engineer in charge should specify test values and conditions.

8. RECORD

a. Good records are very important.

b. An individual card for each device is recommended.

c. Using the information recorded during "As Found" and "As Left" inspections and tests, can result in an economic schedule for performing protective relay maintenance.

Suggested record forms are shown below.

Date	Settings			Relay Tests								Test Operator	
	Tap	Time Dial	Inst.	Time Element		Timing Point		Instant. Element		Time Oper. Indic. Amps.	Inst. Oper. Indic. Amps.		
				Zero Adjust.	Pick-Up	Value	Time	Pick-Up	Drop-Out				
													Specified
													As Found
													As Left

RELAY INSPECTION

Tools and Equipment

Before the job is started, the technician should have the required test data, settings, record cards, test equipment, leads and relay tools on hand.

The following tools are necessary to inspect and adjust protective relays:

1 regular blade straight tweezer
1 curved blade tweezer
1 heavy duty straight tweezer
3 thin open-end wrenches, 3/16", 11/32", 3/8"
1 screw holding screwdriver
1 thin blade screwdriver (6" shank 3/16")
1 Phillips screwdriver
1 Optician's screwdriver
1 pair needle nose pliers
1 burnishing tool
1 magnet cleaner
4 spintite wrenches, 3/16", 5/16", 11/32", 3/8"
1 dental mirror
1 small bulb syringe
1 soft 1" flat paint brush (insulated ferrule)
1 bullseye spirit level
1 offset boxwrench 5/16"
1 offset screwdriver

VISUAL INSPECTION

A. Remove cover from relay case

WARNING The trip circuit is a live circuit and, on some relays, it is possible to cause an instantaneous trip while removing the relay cover.

1. Inspect the cover gasket.

2. Check glass for tightness in the frame, cracks, etc.

3. Clean glass inside and outside.

B. Remove relay from case

1. To eliminate uncertainties, short the CT secondary by jumpering the CT terminals on the back of the relay case. This jumper should be clipped on with square jaw clips such as crocodile clips.

2. Open trip circuit by opening the Red handled switch in the Westinghouse relay or removing the connection block in the General Electric relay.

3. Open the rest of the black handled switches on the Westinghouse relay.

4. Open the latches that hold the relay in the case and carefully remove relay from case. Remember that the switch blades attached to the case in the Westinghouse relay as well as the bars in the bottom of both the Westinghouse and the General Electric case are still "hot". If extreme care is not exercised, the breaker may be tripped. With capacitor trip, high voltages are present in the trip circuit; these voltages may be as high as several hundred volts.

C. Foreign material such as dust or metal particles should be removed from the relay case and relay. This foreign material can cause trouble, particularly in the air gaps between the disc and magnet.

D. Dust can be removed by blowing air from a small hand syringe.

E. Remove any rust or metal particles from disc or magnet poles with a magnet cleaner or brush.

F. Hold relay up to the light to make sure disc does not rub and has good clearance between magnet poles.

G. Inspect relay for the presence of moisture. If free moisture is present or rust spots are noted, report this condition to supervisor. This condition may indicate that the relay is in the improper atmosphere and presents a design problem.

H. Connections, especially taps, should be checked for tightness. Tighten all screws, nuts and bolts that are not pivotal joints.

I. Sluggish bearings may be detected by noting smoothness of relay reset. Rotate the disc manually to close the contacts and observe that operation is smooth. Allow the action of the spiral spring to return the disc to its normal de-energized position. If the bearings appear bad or operation of the relay is questionable, this condition should be reported to the supervisor. It may be that the relay should be returned to the manufacturer for overhaul. On an instantaneous plunger type relay, occasionally a burr or groove may develop on the plunger which would cause the relay to "hang-up".

J. Check mechanical operation of targets by lifting the armature and observe showing of target.

K. Observe that the relay coils have not been subjected to high currents for a prolonged period by smelling or squeezing between thumb and fingers.

L. Components of the relay that touch when the relay is in a "normal" position and part as the relay "operates", should be cleaned. These parts may become dirty and prevent the relay from operating properly on relatively low overloads.

M. Pitted or burned contacts should be cleaned with a contact burnisher. Never use a solvent on these contacts or touch with fingers as the residue left on the contacts may cause improper operation.

ELECTRICAL TESTING

The Test Equipment

The purpose of relay test equipment is to provide the relay with a load that will simulate operating conditions, and to meter electrical quantities with accuracy and simplicity. The test tools for common relays include time and current measuring instruments and loading devices as provided by the MULTI-AMP relay testers. For more complex relays, a phase shifter and phase angle meter are required for complete results. (See MULTI-AMP specifications for Models CS-5, CS-6 and CS-7 Phase Shifter and Phase Angle Meter units.

Proper Setup

Careless setups can use valuable time and often result in erroneous data. Attention should be given to proper setup of controls as given in MULTI-AMP test procedures, and proper connections to devices under test as given in manufacturer's literature.

A. Test Methods

1. Testing with the relay disconnected from the power and trip circuits.

2. Testing across the secondary of the current transformer with primary de-energized (secondary injection).

    a. This method may be used whenever it is possible to de-energize power circuit being tested.

    b. This test includes checking the operation of circuit breaker, presence of energy to trip breaker, etc.

    c. Testing is done by introducing the test current at the secondary terminals of the instrument transformer (s). This test checks the relay connections as well as the relay.

3. Primary Circuit Test - high current, low voltage (Primary Injection)

   a. Complete system is checked including the current transformers.

   b. This method requires that caution and safety practices be closely observed, as test connections are made on the primary conductors.

   c. This test simultaneously checks current transformer ratio, secondary wiring, polarity, relay operation and identity of each phase on the switchboard.

   d. This test is valuable for initially checking bus differentials where many current transformers are paralleled at the relay.

B. Test Connections

1. Relays with draw-out construction

   a. Whenever possible and practical, the relay should be tested in place, disconnected from the power and trip circuits. The use of the proper test plug is convenient.

   b. If the relay cannot be tested in place, carefully remove it from case and proceed to set up at a convenient location. Care should be exercised to ascertain that the relay is level. If possible, a spare case should be procured and used to hold the relay during the test.

2. Relays permanently fixed to panel.

   a. Usually these relays have test facilities installed to disconnect the relay from the power and trip circuits and to permit access to the relay circuits from the front of the board.

   b. If such facilities do not exist, it is necessary to test from rear of panel.

C. Types of Tests

1. Insulation resistance

2. Zero check

3. Pickup (induction disc and/or instantaneous unit)

4. Time characteristics (when applicable)

5. Target and seal-in operation

6. Special tests that are peculiar to the specific type of relay such as through fault, reach, drop-out, etc.

Insulation Resistance

A test that may be run on all types of relays to determine the condition of the insulation. In this test, 1200 volts AC is applied between the relay connections that are brought to the outside of the relay and the frame of the relay. If a finite quantity is read on the megohmmeter, look for trouble.

Zero Check

A test conducted on any relay that has a time dial. The purpose is to determine the time dial reading when the relay's fixed and moving contacts are closed by the manual rotation of the time dial towards zero.

Pickup

A test conducted on relays to determine the minimum or maximum current, voltage, power, or frequency that will allow relay operation and closure of the relay contacts.

Time Characteristics

A test run to determine the elapsed time for relay operation with a specific abnormal quantity of current, voltage, power or frequency.

Target and Seal-In Operation

A test to determine minimum current required in the trip circuit for an operation of the target and/or seal-in unit.

INDUCTION DISC OVERCURRENT RELAYS

(Westinghouse Type CO) (General Electric Type IAC)

GENERAL

The overcurrent relay is designed to detect abnormal conditions of current in a circuit. If the abnormal condition is an overload, usually there will be a time delay operation. Time current characteristics are inverse. A short circuit or fault will cause an instantaneous operation of the relay providing the relay is equipped with such a unit.

The time delay overcurrent relay is an induction disc relay. The action of the spiral spring is to keep the relay trip circuit contacts open. The spiral spring action is opposed by torque produced as current is passed through the relay's current actuated operating coil. Thus, the higher the current, the faster the disc rotates.

The following procedures describe the use of the MULTI-AMP units in testing time overcurrent relays. There are many variations within this type. However, they all operate on similar principles. It is recommended that details of relay circuits be obtained from the manufacturer's instruction book as well as other pertinent data concerning procedures.

These test procedures are designed so that a specific test can be made without performing all tests on the relay. See following test procedure for "Complete Test of an Overcurrent Relay" which outlines the most efficient manner to consecutively perform all tests.

TEST PROCEDURES

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

Type of Tests

Pickup

Time Current Characteristics

Instantaneous Trip

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON"	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MOM" LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	"EXT. A.C."
"Aux. Selector" Switch	"VERN"
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A (not SR-21)
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that desired test current will be read on upper 1/3 of meter scale.
"Voltage Relay Test"("Direct. Element Test")Switch	SET NORM
"Output #1-#2" Switch	Output #1

Testing Pickup

1. Connect the MULTI-AMP relay tester to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect induction unit operating coil to right-hand Common and 80 volt tap of "Output #1".

3. Connect light leads from binding posts marked "Relay Contacts" to induction disc unit trip circuit contact terminals of the relay.

4. Select proper Main Ammeter range. Expected value of pickup should be read in upper 1/3 of ammeter scale.

5. Adjust "Timer Operation Selector" Switch --UPPER to "N.O. MAINT", LOWER to "CONT".

6. Turn "Power ON" Switch ON. "Power ON" light should glow.

7. Initiate unit by pressing "Initiate" Switch.

8. Rotate "Main Control" (clockwise) to increase output until relay induction unit trip circuit contacts close and the Continuity light flickers. The "Aux. Control" may be used as a fine adjustment for "Main Control".

9. Read current on Ammeter. Record.

Testing Time Current Characteristics

1. Connect the SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect relay induction unit operating coil to right-hand Common and 80 volt tap of "Output #1". (Note: Test current should not exceed 25 amperes. If relay tap exceeds 8, move tap to 4 or 5 position for this test)

3. Select ammeter range so that test current will be read in UPPER 1/3 of meter scale. Preset ammeter needle using "Pointer PreSet". Set to 1/2 division below desired current value.

4. Adjust "Timer Operation Selector" Switch, UPPER to "N.O. MOM", LOWER to "CONT.".

5. Turn "Power ON" Switch ON. "Power ON" light should glow.

6. Initiate unit by pressing "Initiate" Switch.

7. Set test current desired by jogging unit with "Initiate" Switch and rotating "Main Control" (clockwise) to increase output until the ammeter needle quivers. Hold in "Initiate" Switch and rotate "Aux. Control" as a fine adjustment to the "Main Control" until test current is read on ammeter.

8. Connect light leads from binding posts marked "Relay Contacts" on the SR-51 to trip circuit contact terminals on relay induction unit.

9. Set "Timer Operation Selector" Switch, UPPER to "N.O.MAINT." (or "N.C.MAINT." if relay is of circuit opening type), LOWER to "TIMER".

10. Reset timer to zero with "Timer Reset" button.

11. Initiate unit by pressing "Initiate" Switch. Timer will run and test current will flow. The relay tester will automatically cut off, and the timer will stop when relay contacts make (or break).

12. Read timer. Time shown is total time of test. Record time.

13. If desired, reset "Timer Operation Selector" Switch --UPPER to "N.O. MOM", LOWER to "CONT.". Proceed from Step 6 to obtain another point on relay curve.

14. When test is concluded, return "Main Control" knob to zero setting. Replace relay tap in proper position.

NOTE: Check Ammeter while test is on for accurate reading. Minor adjustment may be made with "Aux. Control".

Testing Instantaneous Trip

1. Connect the MULTI-AMP relay tester to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect relay instantaneous unit operating coil (with heavy leads) to "Output #1" of the relay tester. Connect to appropriate Common for ammeter range to be utilized and "10V-100Amp" tap.

3. Select Ammeter Range so that desired test current will be read in upper 1/3 of meter scale.

4. Connect light leads from binding posts marked "Relay Contacts" on the relay unit to trip circuit contact terminals on the relay instantaneous unit.

5. Set "Timer Operation Selector" Switch --UPPER to "N.O. MOM", LOWER to "FAST TRIP".

6. Turn "Power ON" Switch ON. "Power ON" light should glow.

7. Initiate unit and hold in "Initiate" Switch.

8. Rotate "Main Control" (clockwise) to increase current until timer stops. Make sure this is minimum setting on "Main Control" where instantaneous unit of relay will consistently pick up as the "Initiate" Switch on the test set is alternately opened and closed.

9. Rapidly read this value of current and release "Initiate" Switch.

   WARNING!!! CURRENT IS FLOWING THROUGH THE RELAY COIL UNTIL "INITIATE" SWITCH IS RELEASED. Therefore, it is important to READ THE VALUE OF CURRENT RAPIDLY.

10. Record ammeter reading.

COMPLETE TEST OF AN OVERCURRENT RELAY

The following procedure outlines the most efficient manner to consecutively perform all tests on an overcurrent relay. This procedure involves the least possible number of changes in the connecting test leads and test set controls.

TYPES OF TESTS

Zero Check
Pickup-Induction Unit
Timing- Induction Unit
D.C. Target & Seal-In - Pickup
Instantaneous Pickup

SET UP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power On"	OFF
"Timer Operation Selector" Switch	UPPER - "N.O. MOM" LOWER - "CONT"
"Main Control	Zero (counterclockwise)
"Aux. Power" Switch	"INT"
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	EXT. A.C."
"Aux. Selector" Switch	"VERN."
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A (Not on SR-21)
"DC Range" Switch	5A
"MAIN Ammeter Range" Switch	To read test current on upper 1/3 meter scale
"Voltage Relay Test"("Direct. Element Test"-SR-51) Switch	SET NORM
"Output #1-#2" Switch	Output #1

ZERO CHECK

This test is to determine that the relay contacts close when the dial is set to zero. For this test, the continuity light of the MULTI-AMP relay tester is used. Consult manufacturer's instruction leaflet to identify current terminals and contact terminals.

Procedure

1. Connect the MULTI-AMP test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect light leads from binding posts marked "Relay Contacts" to trip circuit contact terminals of the relay induction unit.

3. Turn "Power ON" Switch ON. "Power ON" light should glow.

4. Manually rotate time dial on the relay toward zero until the continuity light glows. Record reading on time dial.

5. Reset time dial as specified, adjust for any irregularities uncovered in the Zero Check test.

6. Turn "Power ON" Switch OFF.

PICKUP - INDUCTION UNIT

This test is to determine the minimum operating current of the relay; that is, the minimum current needed to close the relay contacts for any particular tap setting. Pickup value should be equal to tap value $\pm$ 5%.

7. Connect relay induction unit operating coil to right-hand Common and 80 volt tap of "Output #1".

8. Select Main Ammeter range so that relay tap value of current may be read on upper 1/3 of ammeter scale.

9. Adjust "Timer Operation Selector" Switch UPPER to "N.O. Maint", LOWER to "CONT.".

10. Turn "Power ON" Switch ON.

11. Initiate unit by pressing "Initiate" Switch.

12. Rotate "Main Control" (clockwise) to increase output until relay picks up and Continuity light flickers. "AUX. Control" may be used for fine adjustment.

13. Read current on ammeter. Record.

14. Turn "Power ON" Switch OFF.

Timing Test - Induction Unit

NOTE: If relay tap exceeds 8, move to 4 or 5 tap for this test. This should prevent test current from exceeding 25 amperes.

15. Return both "Main Control" and "Aux. Control" to zero.

16. Adjust "Timer Operation Selector" Switch, UPPER - "N.O.MOM.", LOWER - "CONT.".

17. Select main ammeter range so that test current will be read in upper 1/3 of meter scale. Use ammeter Pre-Set so that ammeter needle is approximately 1/2 division below desired current.

18. Turn "Power ON" Switch ON. "Power ON" light should glow.

19. Initiate unit by pressing "Initiate" switch.

20. Set test current desired by jogging unit with "Initiate" Switch and rotating "Main Control" (clockwise) to increase output until ammeter needle quivers. Hold in "Initiate" Switch and rotate "Aux. Control" to make final current adjustment.

21. Set "Timer Operation Selector" Switch, UPPER - "N.O. MAINT." (or "N.C.MAINT." if relay is of circuit opening type), LOWER - "TIMER".

22. Reset timer to zero with "Timer Reset" button.

23. Initiate unit by pressing "Initiate" Switch. Timer will run and test current will flow. The relay tester will automatically cut off and the timer will stop when relay contacts make (or break).

24. Read timer. Time shown is total time of test. Record time.

25. If desired, reset "Timer Operation Selector" Switch, UPPER - "N.O.MOM", LOWER - "CONT.". Proceed from Step 15 to obtain another point on relay curve.

26. When test is concluded, return "Main Control" knob to zero setting.

NOTE: Check ammeter while test is on for accurate reading. Minor adjustment may be made with "Aux. Control".

Testing DC Target and Seal-In

27. Adjust "Timer Operation Selector" Switch UPPER - "N.O.MAINT.", LOWER - "DC".

28. Adjust "Aux. Selector" to "DC-8"

29. Adjust Main Ammeter range switch so that a current value approximately 150% of relay tap value may be read in UPPER 1/3 of meter scale.

30. Choose proper range for DC Ammeter.

31. Turn "Power ON" Switch ON.

32. Initiate test unit by pressing "Initiate" Switch.

33. Rotate "Main Control" clockwise to energize relay induction unit operating coil with a value of current equal to approximately 150% relay tap value.

34. When relay induction unit trip circuit contacts close, rotate "Aux. Control" clockwise to energize relay target coil with DC. When target drops, read and record DC amperes.

35. Rotate "Main Control" counterclockwise to zero. If DC circuit is energized when relay induction unit trip circuit contacts open, the Seal-In unit is working properly.

36. Return "Aux. Control" to zero and turn test set OFF.

Testing Instantaneous Pickup

37. Connect relay instantaneous unit operating coil to right-hand Common and 10 volt tap of test set "Output #1".

38. Connect relay instantaneous unit trip circuit contacts to "Relay Contacts" binding posts of test set.

39. Select Main Ammeter range so that desired test current will be read in UPPER 1/3 of meter scale.

40. Adjust "Aux. Selector" to "VERN.".

41. Set "Timer Operation Selector" Switch, UPPER - "N.O. MOM.", LOWER - "FAST TRIP".

42. Turn "Power ON" Switch ON. "Power ON" light should glow.

43. Initiate unit by holding in "Initiate" Switch.

44. Rotate "Main Control" (clockwise) to increase current until timer stops. Make sure this is minimum setting on "Main Control" where instantaneous unit of relay will consistently pick up as the "Initiate" Switch is alternately opened and closed.

45. Rapidly read this value of current and release "Initiate" Switch.

WARNING!!! CURRENT IS FLOWING THROUGH THE RELAY COIL UNTIL "INITIATE" SWITCH IS RELEASED. THEREFORE, IT IS IMPORTANT TO READ THE VALUE OF CURRENT RAPIDLY.

46. Record ammeter reading.

47. Turn test set OFF.

CURRENT PHASE BALANCE RELAYS
(General Electric IJC) (Westinghouse CM)

The Current Phase Balance Relay operates to trip a circuit breaker when the phase currents in a circuit become unbalanced by some predetermined amount. This relay compares the three phase currents of a line.

General Electric Type IJC

The General Electric IJC relay is composed of three individual induction discs with two coils per disc. One coil produces a contact closing torque on the disc and is called an operating coil. The second coil produces a contact opening torque on the disc and is called a restraint coil. These two coils see currents from different phases of the circuit and the relay will operate when the phase currents become sufficiently unbalanced. The trip circuit contacts associated with all three induction discs are connected in parallel.

Testing

Always refer to manufacturer's literature before testing.

Types of Tests

1. Pickup
2. Timing
3. Slope
4. Target and Seal-In

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O. MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	"AC EXT."
"Aux. Selector" Switch	"VERN."
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5.0A
"Main Ammeter Range" Switch	So test current may be read in upper 1/3 of scale
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1

Testing Pickup

1. Connect SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect current operating coil for one unit of the relay to "Output #1" of the SR-51.

3. Turn "Power ON" Switch ON. "Power ON" light should glow.

4. Initiate unit by pressing "Initiate" Switch.

5. Slowly increase current by rotating "Main" and "Aux." controls clockwise until disc moves and contacts are almost closed. Then decrease current until disc remains stationary at this point.

6. Record this value of current as Pickup.

7. Repeat for operating coils of the other two relay units.

Testing Timing

1. Repeat Steps 1 and 2 under "Pickup".

2. Set Main Ammeter Pointer Pre-Set to 1/2 division below desired test current.

3. Adjust "Timer Operation Selector" Switch, UPPER-"N.O.MOM", LOWER-"CONT.".

4. Set test current desired by jogging with "Initiate" Switch and rotating Main Control clockwise. Fine adjustment may be made by rotating "Aux." Control clockwise.

5. Using a pair of light leads, connect relay trip circuit contact terminals to "Relay Contacts" binding posts on the SR-51.

6. Adjust "Timer Operation Selector" Switch to UPPER-"N.O. MAINT.", LOWER-"Timer".

7. Reset Timer to zero. Make sure relay trip circuit contacts are fully open.

8. Initiate test unit by pushing "Initiate" Switch.

9. Observe and record time for relay trip circuit contacts to close.

10. Repeat Steps 1-9 for operating coils of the other two relay units.

Testing Slope

1. Repeat Steps 1 and 2 under "Pickup" test.

2. Connect restraint coil for same relay unit that was used in Step 2 under "Pickup Test" to "AC Output #3".

3. Adjust "Timer Operation Selector" Switch to UPPER-"N.O.MAINT.", LOWER-"CONT.".

4. Turn "Aux. Selector" Switch to "AC3-24".

5. Turn "Power ON" Switch ON. "Power ON' light should glow.

6. Initiate unit by pressing "Initiate" Switch.

7. Rotate "Main Control" clockwise to energize operating coil of relay unit under test.

8. Rotate "Aux. Control" clockwise to energize restraint coil of relay unit under test.

9. Regulate the two currents until the disc of the relay under test is stopped with that unit's trip circuit contacts. (About halfway between full open position and trip position.)

10. Record both values of current and calculate slope.

11. Repeat Steps 1-10 for the other relay units.

Westinghouse Type CM Relay

The Westinghouse Type CM relay has two individual induction discs. Each disc has two current coils. One coil produces torque to move the disc to the left and the other coil produces torque to move the disc to the right. As long as the currents energizing the two coils are equal, the torques cancel and the disc remains stationary. In connecting the relay in the circuit, the coil producing rotation to the right on one disc is in "A" Phase, while the coil producing rotation to the left on the same disc is in "B" Phase. The other disc is connected left rotation "B" Phase, right rotation "C" Phase. Each unit of the relay has a moving contact attached to the disc shaft and two stationary contacts, one on the right and one on the left. When the relay is energized with balanced 3-phase currents, the moving contacts of both relay units should be midway between the left and right stationary contacts. An unbalance of the phase currents will cause either or both of the discs to rotate with subsequent closing of the relay trip circuit contacts. The relay trip circuit contacts are connected in parallel.

Types of Tests

1. Electrical Balance
2. Minimum Trip Setting
3. Operating Curve
4. Time Curve

Testing

Always refer to Manufacturer's literature before testing.

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MOM" LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	"EXT. AC"
"Aux. Selector" Switch	"VERN."
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that desired test current will be read in UPPER 1/3 of meter scale
"Voltage Relay Test"(DET) Switch	Set "NORM"
"Output #1-#2" Switch	Output #1

Testing Electrical Balance

1. Connect Model SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
2. Connect front operating coil of one induction disc unit to Output #1 terminals of the SR-51.
3. Connect rear operating coil of the same induction disc unit to "AC Output #3" terminals of the test set.
4. Adjust "Aux. Selector" Switch to "AC-3 24".
5. Adjust "Timer Operation Selector" Switch to UPPER-"N.O.MAINT.", LOWER-"CONT.".
6. Turn "Power ON" Switch ON. "Power ON" light should glow.

7. Initiate unit by pressing "Initiate" Switch.

8. Rotate "Main Control" clockwise to obtain a reading of 6 amperes on Main Ammeter.

9. Rotate "Aux. Control" clockwise to obtain a reading of 6 amperes on the second AC Ammeter on test set.

10. The moving contact of the induction disc unit under test should be in a balanced position as described in relay manufacturer's literature.

11. Turn "Power ON" Switch OFF.

Minimum Trip Setting

1. Repeat Steps 1 through 7 under testing "Electrical Balance".

2. Connect light leads from "Relay Contacts" binding posts on test set to the trip circuit contacts of the relay.

3. Rotate "Main Control" clockwise to obtain a reading of one ampere on "Main Ammeter".

4. Adjust left stationary contact until it just makes with the moving contact as indicated by glowing of the Continuity light.

5. Return "Main Control" to zero.

6. Rotate "Aux. Control" clockwise to obtain a reading of one ampere on second AC Ammeter of test set.

7. Adjust right stationary contact until it just makes with moving contact, as indicated by glowing of Continuity light.

Operating Curve

1. Connect light leads from "Relay Contacts" binding posts on the test set to the trip circuit contacts of the relay.

2. Repeat Steps 1-8 under "Testing Electrical Balance".

3. Rotate the "Aux. Control" clockwise until the moving contact and the right stationary contact just make, as indicated by flickering of the Continuity light. Record readings of both ammeters.

4. Slowly decrease current output of "AC Output #3" by rotating the "Aux. Control" counterclockwise until the moving contact and lefthand stationary contact just makes, as indicated by flickering of Continuity light. Record readings of both ammeters.

Time Curve

1. Repeat Steps 1-6 under "Testing Electrical Balance".
2. Connect a pair of light leads from "Relay Contacts" binding posts of the test set to trip circuit contact terminals of the relay.
3. Jog "Initiate" Switch and rotate "Main Control" to obtain a reading of 10 amperes on main ammeter.
4. Manually set moving contact to "Balance" position.
5. Adjust "Timer Operation Selector" Switch, UPPER-"N.O.MAINT.", LOWER-"TIMER".
6. Initiate test set by pressing "Initiate" Switch.
7. Read and record time for closure of moving contact and left stationary contact.
8. Adjust "Timer Operation Selector" Switch UPPER-"N.O.MOM", LOWER-"CONT.".
9. Return "Main Control" to zero.
10. Jog "Initiate" Switch and rotate "Aux. Control" to obtain a reading of 10 amperes on second AC Ammeter.
11. Manually set moving contact to "Balance" position.
12. Adjust "Timer Operation Selector" Switch to UPPER-"N.O.MAINT.", LOWER-"TIMER".
13. Initiate test set by pushing "Initiate" Switch.
14. Read and record time for closure of moving contact and right stationary contact.

Repeat all four tests, i.e. Electrical Balance, Minimum Trip Setting, Operating Curve and Time Curve for the other induction disc unit.

VOLTAGE RESTRAINT OVERCURRENT RELAY

(GENERAL ELECTRIC TYPE IJCV)

GENERAL

The IJCV contains an induction disc which is influenced by the magnetic fields of two electromagnets. The current actuated electromagnet produces torque on the disc to close the relay trip circuit contacts and is known as the operating coil. The potential actuated electromagnet produces torque on the disc to open the relay trip circuit contacts and is known as the restraint coil. When the voltage applied to the restraint coil decreases, a smaller amount of current is required to operate the relay and close the trip circuit contacts. This relay may operate to close trip circuit contacts even though the voltage applied to the restraint coil may remain at full system voltage.

The IJCV relay is normally used to protect a generator against bus faults.

Testing

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

Type of Tests

Pickup of overcurrent unit, zero voltage restraint
Pickup of overcurrent unit, system voltage restraint
Timing of overcurrent unit, zero voltage restraint
Timing of overcurrent unit system, voltage restraint

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power On" Switch	OFF
"Timer Operation Selector" Switch	UPPER - "N.O. MAINT." LOWER - "CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT"
"Voltmeter Range"Switch	So that desired test voltage may be read on upper 1/3 of meter scale.
"Voltmeter Selector" Switch	"AC-3"
"Aux. Selector" Switch	"AC-3-150"

CONTROL	POSITION
"Aux. Control"	Zero (counterclockwise)
"A.C. Range" Switch	10A
"D.C. Range" Switch	5A
"Main Ammeter Range" Switch	So that desired test current may be read on upper 1/3 of meter scale.
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1 - #2" Switch	Output #1

Testing for Pickup - Zero Volts Restraint

1. Connect the Test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
2. Connect relay voltage restraint coil terminals to test set binding posts marked "A.C. Output #3".
3. Connect the relay current operating coil terminals to the test set "Output #1" right-hand Common on 80 volt tap.
4. Connect test set binding posts marked "Relay Contacts" to the relay trip circuit contacts terminals.
5. Turn "Power On" Switch ON. "Power ON" light should glow.
6. Initiate unit by pressing "Initiate" Switch.
7. Increase current through operating coil of relay to a value 50% above relay tap by rotating "Main Control" clockwise.
8. When relay contacts close, Continuity light will glow.
9. Slowly decrease current by rotating "Main Control" counter-clockwise until Continuity light flickers. Record this value of current as "Pickup - zero volts restraint".
10. Return "Main Control" to zero and turn "Power ON" switch off.

Testing for Pickup - System Volts Restraint

Repeat steps 1 - 6 above.

7. Apply system voltage to voltage restraint coil of relay by rotating "Aux. Control" clockwise.
8. Repeat steps 7 - 10 above.

Testing Timing - Overcurrent Unit - Zero Volts Restraint

1. Connect the test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
2. Connect relay voltage restraint coil terminals to "AC Output #3" binding posts of the test set.
3. Connect the relay current operating coil terminals to the test set "Output #1" right-hand Common and 80 volt tap.
4. Connect the test set "Relay Contacts" binding posts to the relay trip circuit contact terminals.
5. Pre-set Main Ammeter needle 1/2 division below desired test current.
6. Adjust "Timer Operation Selector" Switch UPPER to "N.O. MOM", LOWER to "CONT.".
7. Turn "Power ON" Switch ON. "Power ON" light should glow.
8. Initiate unit by pressing and holding "Initiate" Switch.
9. Set test current to desired value by rotating "Main Control (clockwise) while jogging "Initiate" Switch.
10. Set "Timer Operation Selector" Switch UPPER to "N.O. MAINT.", LOWER to "TIMER".
11. Reset timer to zero with "Timer Reset" button.
12. Initiate unit by pressing "Initiate" Switch. Timer will run and test current will flow until the relay trip circuit contacts close.
13. Read timer. Time shown is total time of test. Record time.
14. Turn "Power ON" Switch OFF.

Testing Timing Overcurrent Unit - System Voltage Restraint

1. Repeat Steps 1 - 8 above - "Timing Test".
2. Rotate "Aux. Control" clockwise to increase applied voltage to a value equal to system voltage.
3. Repeat Steps 9 - 14 above - "Timing Test".

VOLTAGE CONTROLLED OVERCURRENT RELAY

(WESTINGHOUSE TYPE COV)

GENERAL

The COV relay contains an induction disc overcurrent unit and an instantaneous undervoltage unit. The undervoltage unit supervises the operation of the overcurrent unit. Regardless of the amount of current passing through the operating coil of the overcurrent unit, no operation takes place unless the undervoltage unit has "dropped out". This means that the overcurrent unit may be set to operate on less than full load current when the voltage falls below a predetermined value. Conversely, the overcurrent unit will not operate as long as the voltage is above the predetermined value.

This relay is normally used to protect a generator against a bus fault.

Testing

Typical Tests

Pickup - undervoltage unit
Dropout - undervoltage unit
Voltage control of overcurrent unit
Pickup - overcurrent unit
Time current characteristics - overcurrent unit.

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power On"	OFF
"Timer Operation Selector" Switch	UPPER -"N.O. Maint." LOWER -"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	So that desired test voltage may be read in upper 1/3 of scale
"Voltmeter Selector" Switch	"AC-3"
"Aux. Selector" Switch	"AC-3 150"
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A

CONTROL	POSITION
"DC Range" Switch	5A
"Main Ammeter Range" Switch	"500"
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	Output #1

Testing Pickup and Dropout of Undervoltage Unit

1. Connect the test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
2. Connect the "AC Output #3" binding posts of the test set to the undervoltage unit operating coil terminals.
3. Connect a pair of light leads from the "Relay Contacts" binding posts of the test set to the relay so that operation of the undervoltage unit contacts may be observed.
4. Turn "Power ON" Switch ON. "Power ON" and "Continuity" lights should glow.
5. Initiate test set by pushing "Initiate" switch.
6. Rotate "Aux. Control" (clockwise) to increase voltage applied to undervoltage unit operating coil until the Continuity light just goes out. Read and record this value of voltage as "pick-up of undervoltage unit."
7. Continue to rotate "Aux. Control" clockwise to increase applied voltage until relay rated voltage is read on test set voltmeter.
8. Rotate "Aux. Control" counterclockwise to decrease applied voltage until the Continuity light just lights. Read and record this value of voltage as "drop out of the undervoltage unit."
9. Return "Aux. Control" to zero and turn test set "Power ON" switch OFF.

Testing Voltage Control of Overcurrent Relay

1. Connect the test set to a suitable source of power as indicated on the nameplate and ground. BE SURE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
2. Connect the "AC Output #3" binding posts of the test set to the undervoltage unit operating coil terminals.
3. Connect "Output #1" terminals of the test set to the overcurrent unit operating coil terminals.

4. Adjust "Main Ammeter Range" switch so that the desired test current may be read on the upper 1/3 of the meter scale.

5. Connect light leads from the test set binding posts marked "Relay Contacts" to the relay trip circuit contacts terminals.

6. Adjust "Timer Operation Selector Switch" - UPPER to"N.O. MAINT." LOWER to "TIMER".

7. Initiate test set by pushing "Initiate" switch.

8. Rotate "Aux. Control" clockwise until relay rated voltage is read on voltmeter.

9. Rotate "Main Control" clockwise until the value of current read on the main ammeter is approximately 4 times tap value of the overcurrent unit.

10. The overcurrent unit should <u>not</u> operate to close the relay trip circuit contacts.

11. Rotate "Aux. Control" counterclockwise to reduce voltage until undervoltage unit "drops out".

12. The overcurrent unit should operate to close the relay trip circuit contacts. This stops timer and de-energizes the relay.

<u>Testing Pickup of Overcurrent Unit</u>

<u>SETUP OF CONTROLS BEFORE TEST</u>

CONTROL	POSITION
"Power On"	OFF
"Timer Operation Selector" Switch	UPPER - "N.O. MOM" LOWER - "CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	"EXT. A. C."
"Aux. Selector" Switch	"VERN"
"Aux. Control" Switch	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A

CONTROL	POSITION
"Main Ammeter Range" Switch.....	So that desired test current will be read in upper 1/3 of meter scale.
"Voltage Relay Test" (DET) Switch.....	Set "NORM"
"Output #1 - #2" Switch.....	Output #1

Testing Pick-Up

1. Connect the test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect overcurrent unit operating coil to righthand Common and 80 volt tap of "Output #1".

3. Connect light leads from binding posts marked "Relay Contacts" to trip circuit contact terminals of the relay.

4. Adjust "Timer Operation Selector" Switch - UPPER to "N.O. MAINT.", LOWER to "CONT.".

5. The undervoltage unit contacts must remain closed.

6. Turn "Power ON" Switch "ON". "Power ON" light should glow.

7. Initiate unit by pressing "Initiate" switch.

8. Rotate "Main Control" (clockwise) to increase output until relay picks up and Continuity light flickers. The "Aux. Control" may be used as a fine adjustment for "Main Control".

9. Read current on Ammeter and record.

Testing Time Current Characteristics - Overcurrent Unit

1. Connect the test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECH THE "POWER ON" LIGHT.

2. Connect relay overcurrent unit operating coil to righthand Common and 80 volt tap of "Output #1". (NOTE: Test current should not exceed 40 amps. If relay tap exceeds 8, move tap to 4 or 5 position for this test.)

3. Select ammeter range so that test current will be read in upper 1/3 of meter scale. Pre-set ammeter needle using "Pointer Pre-set". Set to 1/2 division below desired current value.

4. Adjust "Timer Operation Selector" Switch - UPPER to "N.O. MOM", LOWER to "CONT.".

5. Turn "Power ON" switch "ON". Power "ON" light should glow.

6. Initiate unit by pressing "Initiate" switch

7. Set test current desired by jogging unit with "Initiate" switch and rotating "Main Control" (clockwise) to increase output until required test current is reached. "Aux. Control" may be used for fine adjustment.

8. The undervoltage unit contacts must remain closed.

9. Connect light leads from binding posts marked "Relay Contacts" on the test set to trip circuit contact terminals on relay overcurrent unit.

10. Set "Timer Operation Selector" Switch - UPPER to "N O. MAINT", LOWER to "TIMER".

11. Reset timer to zero with "Timer Reset" button.

12. Initiate unit by pressing "Initiate Switch. Timer will run and test current will flow. The test set will automatically cut off, and the timer will stop when relay contacts make.

13. Read timer. Time shown is total time of test. Record time.

INDUCTION DISC OVER, UNDER OR OVER/UNDER VOLTAGE RELAYS

(Westinghouse Type CV) (General Electric Type IAV)

GENERAL

The voltage relay is a load balancing relay and is not intended to clear a fault in the power system. In most applications it is used as an undervoltage device and is designed to de-energize the power circuit whenever voltage falls below a predetermined value. Time of operation may be instantaneous or delayed.

The time delay undervoltage relay is also an induction disc relay. The action of the spiral spring is to keep the relay contacts trip circuit closed. The torque produced when voltage is applied to the relay's voltage actuated coil opposes the spring action. Thus, as the applied voltage decreases, the disc rotates to close the relay trip circuit contacts.

The overvoltage relay has the opposite operation. The spring action keeps the relay trip circuit contacts open whenever voltage in the circuit is normal or below normal. A higher than normal voltage produces operating torque on the relay disc.

TEST PROCEDURES

Type of Tests

Pickup

Timing

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-N.O.MAINT" LOWER-"CONT."
"Main Control".	Zero (counterclockwise)
"Aux. Power" Switch	"INT"
"Voltmeter Range" Switch	So that desired test voltage will be read in UPPER 1/3 of scale
"Voltmeter Selector" Switch	"V.RLY."
"Aux. Selector" Switch	"V.RLY".
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A (not on SR-21)

CONTROL	POSITION
"DC Range" Switch	5A
"Main Ammeter Range" Switch	500
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #2"

Testing for Pickup

1. Connect the relay test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
2. Connect relay operating coil to terminals marked "AC Output #3" on relay tester.
3. Connect light leads from binding posts marked "Relay Contacts" to trip circuit contact terminals of the relay.
4. Turn "Power ON" Switch ON. "Power ON" light should glow.
5. Initiate unit by pressing "Initiate" Switch.
6. Rotate "Main Control" (clockwise) to increase voltage until Continuity light flickers.
7. Record this value of voltage as pickup of the relay.

Testing Timing

1. Connect the relay tester to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
2. Connect relay operating coil to terminals marked "AC Output #3" of the relay tester.
3. Turn "Power ON" Switch to ON. "Power ON" light should glow.
4. Initiate unit by pressing "Initiate" Switch.
5. Set normal relay voltage (see relay nameplate) by rotating "Main Control" (clockwise) to increase output. Read voltage on voltmeter.
6. Connect light leads from binding posts marked "Relay Contacts" to trip circuit contact terminals on the relay.
7. Adjust "Timer Operation Selector" Switch, UPPER to "N.O.MAINT", LOWER to "TIMER".

8. Turn "Voltage Relay Test" Switch to "Set Fault" position.

9. Set fault relay voltage (over or under normal) by rotating "Aux. Control" (clockwise) to increase output. Read voltage on Voltmeter. (NOTE: Rotate "Aux. Control" until voltage read on Voltmeter is approximately 2 volts higher than desired test voltage.

10. Reset timer to zero.

11. Turn "Voltage Relay Test" Switch to "Test" position.

    NOTE: The fault voltage (over or under normal) as set in Step 9, will be impressed on the relay operating coil instantaneously. The timer will automatically start.

12. When relay trip circuit contacts make, the timer will stop. Read timer. Time shown indicates time in which the relay contacts closed after impressing fault voltage. Record this time.

13. If desired, turn "Voltage Relay Test" Switch back to "NORMAL". Remove one lead from "Relay Contacts" binding post. Initiate unit by pressing "Initiate" Switch. Replace lead in "Relay Contacts" binding post. Repeat Steps 8 through 12 for other values of fault voltage.

TYPICAL TESTS FOR INSTANTANEOUS VOLTAGE RELAYS
(Westinghouse Type SV, SV-1) (General Electric Type PJV)

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

Type of Tests

Pickup
Dropout

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	So that desired test voltage may be read in upper 1/3 of scale
"Voltmeter Selector" Switch	"A.C. 2"
"Aux. Selector" Switch	"VERN."
"Aux. Control"	Zero (counterclockwise)
"A.C. Range" Switch	10A (Not on SR-21)
"DC Range" Switch	5A
"Main Ammeter Range" Switch	500
"Voltage Relay Test"(DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #2"

Testing for Pickup

1. Connect SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect relay operating coil terminals to "AC Output #2" binding posts of the test set.

3. Connect light leads from test set binding posts marked "Relay Contacts" to the relay trip circuit contact terminals.

4. Turn "Power ON" Switch ON. "Power ON" light and continuity light should glow.

5. Initiate test set by pressing "Initiate" Switch.

6. Rotate "Main Control" clockwise until continuity light is just extinguished. The "Aux. Control" may be used for fine adjustment.

7. Read pickup voltage on voltmeter. Record.

8. Continue to rotate "Main Control" clockwise until relay normal voltage (on relay nameplate) is read on voltmeter.

9. Rotate "Main Control" counterclockwise to decrease voltage until the continuity light just glows. The "Aux. Control" may be used as a fine adjustment.

10. Read and record this value of voltage as dropout.

11. Turn test set OFF.

TESTS FOR
GENERAL ELECTRIC PHASE SEQUENCE AND UNDERVOLTAGE RELAY (TYPE ICR)
OR
WESTINGHOUSE REVERSE PHASE RELAY (TYPE CP)

GENERAL

Westinghouse Type CP and General Electric Type ICR relays are three-phase voltage induction disc relays used to protect for undervoltage or phase reversal in AC systems.

The CP and ICR relay electromagnets contain three (3) coils. When the three (3) coils are energized, out-of-phase fluxes are produced causing the disc to rotate toward closure of the high voltage contact. The out-of-phase fluxes produced when a phase is reversed, cause the disc to rotate to close the low voltage contacts. Low voltage with proper phase rotation may not produce enough torque on the disc to overcome mechanical tension in a spring and the low voltage contacts will close. Pickup, Dropout and Operating Time of the relay may be varied by adjustments.

TYPE OF TESTS

Pickup - Minimum voltage to close Normally Open contact
Dropout - Maximum voltage at which Normally Closed contacts will close
Loss of One Phase
Phase Sequence
Timing

EQUIPMENT REQUIRED

Model SR-51 Relay Tester
1-3PH Synthesizer Accessory
NOTE: If Model CS-7 Phase Shifter and Phase Angle Meter unit is supplied, 1-3PH Synthesizer is not required. Refer to instructions on testing of these relays in CS-7 instruction manual.

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
SR-51	
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	150
"Voltmeter Selector" Switch	"EXT. AC"
"Aux. Control"	Zero (counterclockwise)
"Aux. Selector" Switch	AC Output #3 150V
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	500
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	Output #1
1-3PH Accessory	
"Balance"	Red Dot

Testing Pickup

1. Connect the SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect "AC Output #3" (yellow) terminals to yellow terminals marked "Input" on 1-3PH accessory unit.

3. Connect white terminals "EXT.VM." on SR-51 to white terminals marked "EXT. VOLTMETER 0-150" on 1-3PH accessory unit.

4. Using #18 flexible leads, make the following connections between the 1-3PH accessory and the relay under test:

   a - red terminal "A" to relay terminal for Phase 1 or A
   b - yellow terminal "B" to relay terminals for Phase 2 or B
   c - blue terminal "C" to relay terminal for Phase 3 or C

5. Connect two #18 flexible leads from white terminals on SR-51 marked "Relay Contacts" to relay terminals which will permit observation of operation of relay Normally Open contacts.

6. Turn "Power ON" Switch to ON. Amber pilot light should glow.

7. Initiate SR-51 test set. Press red "Initiate" Switch. Red light in switch should glow.

8. Rotate "Aux. Control" clockwise until continuity light flickers.

9. Check AB-AC-BC switch positions for balance of voltage. Readjust Balance of 1-3PH as necessary to get the three voltages as close as possible.

10. Record the average of the three voltages (AB-AC-BC) as pickup.

11. Turn "Power ON" Switch OFF. Return "Aux. Control" to zero.

Testing Dropout

1. Repeat Steps 1-4 above

2. Connect two #18 flexible leads from white terminals on SR-51 marked "Relay Contacts" to relay terminals which will permit observation of operation of relay Normally Closed contacts.

3. Throw "Power ON" Switch ON. Amber pilot light and green continuity light should glow.

4. Press "Initiate" Switch. Red light in switch should glow.

5. Rotate "Aux. Control" clockwise until continuity light extinguishes

6. Check AB-AC-BC switch positions for balance of voltages. Readjust balance of 1-3PH as necessary to get the three voltages as close as possible.

7. Record the average of the three voltages as dropout.

Testing Loss of One Phase

1. Repeat Steps 1-4 under "Testing Dropout".

2. Rotate "Aux. Control" clockwise until rated voltage has been applied to relay coils. Continuity light should be extinguished.

3. Check AB-AC-BC switch positions for balance. Adjust as necessary.

4. Carefully remove lead from red terminal "A" on 1-3PH accessory. After a few seconds, the green continuity light should glow.

5. Turn "Power ON" Switch OFF. Return "Aux. Control" to zero.

Testing Phase Sequence

1. Repeat Steps 1-3 under "Testing Loss of One Phase".
2. Carefully interchange the connections on the 1-3PH accessory. Lead connected to red terminal "A" should be moved to yellow terminal "B" and lead on yellow terminal "B" moved to red terminal "A".
3. The movable contact on the relay should make the low voltage contact. The green continuity light should glow.
4. Replace "A" and "B" test leads in proper sequence.
5. Turn "Power ON" Switch OFF. Return "Aux. Control" to zero.

Testing Timing

1. Repeat Steps 1-4 under testing "Dropout".
2. Adjust "Aux. Selector" switch on test set to "V.Rly" position.
3. Change "Output #1-#2" toggle switch to "Output #2" position.
4. Turn "Aux. Control" fully counterclockwise to zero.
5. Turn "Power ON" Switch ON. Amber light should glow. Green continuity light should glow.
6. Initiate unit by pressing red "Initiate" switch. Red light should glow in switch.
7. Rotate "Main Control" clockwise until rated voltage is impressed across relay. Check balance and readjust if necessary. Green light will be extinguished.
8. Reset timer to zero with reset button.
9. Adjust "Timer Operation Selector" Switch LOWER to "Timer" position.
10. Turn "Voltage Relay Test" switch to "Test" position.
11. When timer stops, test is complete. Read timing value on timer and record.
12. Turn "Power ON" switch to OFF.
13. Remove all test leads.

PERCENTAGE DIFFERENTIAL RELAYS
(Westinghouse Type CA) (General Electric Type IJD)

GENERAL

This relay compares two similar currents in a circuit, i.e. primary and secondary current of a transformer. Since the relay compares two currents, it is connected to two current transformers. That portion of the circuit between the two CT primaries is referred to as the relay's "zone of protection". The percentage differential relay operates to close its trip circuit contacts and trip a circuit breaker(s) whenever it senses an abnormal condition within the "zone of protection". The degree of unbalance or abnormality the relay may tolerate is a function of the relay's design. (i.e. 5%, 10%, 25% or 50% differential)

The simple percentage differential relay has two restraint coils and one operating coil. The operating coil is common to the two restraining coil circuits. Under normal conditions, the currents in the operating coil produce torques that are equal in magnitude but opposite in direction and thus cancel.

Under fault conditions, these currents in the operating coil become unequal and produce an operating torque on the disc. When the differential current reaches a predetermined amount, as governed by relay design, the relay trip circuit contacts close.

TEST PROCEDURES

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

Type of Tests

Pickup
Time Current Characteristics
Through Fault
Slope (Cannot be performed with SR-21)

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MOM" LOWER-"CONT"
"Main Control"	Zero (counter-clockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	300

CONTROL	POSITION
"Voltmeter Selector" Switch	"EXT. A.C."
"Aux. Selector" Switch	"VERN."
"Aux. Control"	Zero (counterclockwise)
"A.C. Range" Switch	10A (Not on SR-21)
"D.C. Range" Switch	5A
"Main Ammeter Range" Switch	So that desired test current may be read in UPPER 1/3 of meter scale
"Voltage Relay Test"("Direct. Element) Switch	Set "NORM"
"Output #1-#2" Switch	Output #1

Testing Pickup

1. Connect the MULTI-AMP relay tester to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect operating coil and one restraint coil of relay to "Output #1" of the test unit. Connect to right-hand Common and 10 volt tap.

3. Connect light leads from binding posts marked "Relay Contacts" to trip circuit contact terminals of the relay.
   NOTE: This relay usually has one moving contact and two fixed contacts. Use terminals for moving contact and one of the fixed contacts.

4. Select proper ammeter range so that expected pickup current will be read in UPPER 1/3 of Main Ammeter scale.

5. Set "Timer Operation Selector" Switch UPPER to "N.O. MAINT.", LOWER to "CONT.".

6. Turn "Power ON" Switch ON. "Power ON" light should glow.

7. Initiate unit by pressing "Initiate" Switch.

8. Rotate "Main Control" (clockwise) to increase output until relay picks up and Continuity light flickers. "Aux. Control" may be used for fine adjustment. Read and record current.

9. Move one light lead to relay terminal for other fixed contact of the relay and repeat Steps 4 through 8.

Testing Time Current Characteristics

1. Connect the MULTI-AMP relay tester to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect operating coil and one restraint coil of relay to "Output #1" of the tester. Connect to right-hand Common and 10 volt tap.

3. Select proper ammeter range. Set ammeter Pre-Set mechanism 1/2 division below desired test current. (See "Current Metering Circuit")

4. Turn "Power ON" Switch ON. "Power ON" light should glow.

5. Set test current desired by jogging unit with "Initiate" Switch and rotating "Main Control" (clockwise) to increase output. Use "Aux. Control" for fine adjustment. (See "Current Metering Circuit")

6. Connect light leads from binding posts market "Relay Contacts" to trip circuit contact terminals of the relay (terminals for moving contact and one of the fixed contacts).

7. Set "Timer Operation Selector" Switch UPPER-to "N.O.MOM", LOWER-"FAST TRIP".

8. Reset timer to zero with "Timer Reset" button.

9. Initiate unit by pressing and holding "Initiate" Switch. As soon as timer stops, release "Initiate" Switch.

10. Read timer. Time shown is total time of test.

11. Disconnect lead from the restraint coil of relay and connect to the other restraint coil.

12. Repeat Steps 7 through 10.

Testing "Through Fault"

1. Connect the MULTI-AMP relay tester to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect "Output #1" of relay tester to restraint coil terminals so that current flows through the coils in series. Connect to right-hand Common and 10 volt tap.

3. Select proper Ammeter Range on Main Ammeter.

4. Set "Timer Operation Selector" Switch UPPER to "N.O. MAINT.", LOWER to "CONT.".

5. Turn "Power ON" Switch ON. "Power ON" light should glow.

6. Initiate unit by pressing "Initiate" Switch.

7. Rotate "Main Control" (clockwise) to increase output to desired value. Read current on ammeter (approximately 20 amperes).

8. Manually turn relay disc for evidence of restraint. Turn "Power ON" Switch OFF.

Testing Slope (Cannot be performed with Model SR-21)

1. Connect the MULTI-AMP relay tester to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect "Output #1" of the relay tester to restraint coil terminals so current flows through them in series. Use right-hand Common and 10 volt tap of "Output #1".

3. Connect light leads from binding posts marked "Relay Contacts" to trip circuit contact terminal of the relay. (terminals for moving contact and one of the fixed contacts)

4. Select proper Ammeter Range on "Main Ammeter" for larger currents desired. (20 to 30 amperes depending on percent differential of relay)

5. Turn "Aux. Selector" Switch to "24-AC-3" position.

6. Connect operating coil and one restraint coil of relay to terminals marked "AC Output #3". Instantaneous ± of "Output #1" and "AC Output #3" of the relay tester should be connected to same relay terminal. NOTE: On Westinghouse Type CA relay "AC Output #3" must be connected to operating coil and untapped restraint coil of the relay.

7. Set "Timer Operation Selector" Switch UPPER to "N.O. MAINT.", LOWER to "CONT".

8. Turn "Power ON" Switch ON. "Power ON" light should glow.

9. Initiate unit by pressing "Initiate" Switch.

10. Rotate "Main Control" (clockwise) to increase output from "Output #1" to desired value of larger current. Read current on Main Ammeter.

11. Rotate "Aux. Control" (clockwise) to increase output from "A.C. Output #3" until Continuity light flickers. Read Differential Current on Second Ammeter.

12. If desired, test may be repeated for opposite restraint coil by disconnecting test leads from operating coil terminal and first restraint coil terminal and reconnecting test leads to opposite restraint coil terminal and operating coil terminal.

PERCENTAGE DIFFERENTIAL RELAY

(WESTINGHOUSE TYPE CA-5)

GENERAL

The CA-5 Percentage Differential Relay consists of one restraining element with two windings, and one operating element. The operating element is energized through an external auxiliary current transformer. Taps to control the sensitivity of the relay are located in this external transformer.

The unit operates on the induction disc principle with both electromagnets operating on the same disc. The front electromagnet is the restraining element and the rear electromagnet is the operating element.

Testing

NOTE: This test procedure specifically applies to the Westinghouse Type CA-5 relay used for transformer or generator differential. Refer to Westinghouse Bulletin I.L. 41-339.1B for details. This relay is used in conjunction with an auxiliary current transformer. This same auxiliary current transformer must be in the test circuit.

Type of Tests

Pickup - Operating Coil
Percent Slope Characteristics

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power On" Switch	OFF
"Timer Operation" Switch	UPPER -"N.O. MAINT." LOWER -"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT"
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	"EXT. A.C."
"Aux. Selector Switch	"A.C. #3 - 24 V"
"Aux. Control"	Zero (counterclockwise)
"A.C. Range" Switch	10A

CONTROL	POSITION

"D.C. Range" Switch.....5A

"Main Ammeter Range" Switch.....500A

"Voltage Relay Test"(DET) Switch....Set "NORM"

"Output #1-#2" Switch.....Output #1

Testing Pickup

1. Connect the SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect the operating coil of the relay to the "R" terminal of the auxiliary current transformer.

3. Connect the primary winding of auxiliary current transformer (I_o Terminals) in series with one of the relay restraint coils. Connect this series circuit to "AC Output #3" binding posts of the test set. An external milliammeter capable of reading currents between 0.145 and 1.0 ampere must be in this circuit.

4. Connect test set "Relay Contacts" binding posts to relay trip circuit contacts terminals.

5. Set tap on auxiliary current transformer to 19.

6. Turn "Power On" switch "ON". "Power On" light should glow.

7. Initiate test set by pressing "Initiate" switch.

8. Rotate "Aux. Control" clockwise until continuity light flickers.

9. Read and record the value of current indicated on the external milliammeter as pickup.

10. Turn test set off.

Testing Slope Characteristics

1. Connect the SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect the operating coil of the relay to the "R" terminals of the Auxiliary Current Transformer. (NOTE: The Auxiliary Transformer should be positioned so that the "R" terminals are at the top. The right-hand "R" terminal should be connected to the even numbered terminal of the relay operating coil.)

3. Connect the primary winding of Auxiliary Current Transformer (I_o Terminals) in series with one of the relay restraint coils. This series circuit should be connected to "AC Output #3" binding posts of the test set.

4. Connect the relay two restraint coils in series to "AC Output #1" of the test set. NOTE: Polarity (±) terminals from both outputs of the test set should be connected to the same relay restraint coil terminal.

5. Connect test set "Relay Contacts" binding posts to relay trip circuit contacts terminals.

6. Set "Main Ammeter Range" switch so that test current through the relay's two restraint coils may be read in upper 1/3 of scale.

7. Turn "Power On" Switch "ON". Power "On" light should glow.

8. Initiate unit by pressing "Initiate" switch.

9. Rotate "Main Control" clockwise until desired test current is read on main ammeter (suggested 20 amps.)

10. Rotate "Aux. Control" clockwise until continuity light flickers.

11. Read and record currents indicated on both ammeters. Compare to relay manufacturer's specifications.

12. Turn test set off.

PERCENTAGE DIFFERENTIAL RELAY
(Westinghouse Type CA-6)

The CA-6 Percentage Differential relay is usually applied for the protection of multi-circuit buses. The relay operates on the induction disc principle and consists of four (4) electromagnets operating on two discs which are fastened to the same shaft. Three of the electromagnets are restraining elements, each of which has two separate windings connected to receive secondary currents from the various current transformers. The fourth electromagnet is the operating element with its winding connected to receive the differential or unbalance current through an auxiliary current transformer. The sensitivity of the relay is controlled by taps on the auxiliary current transformer.

TEST PROCEDURE

NOTE: This test procedure specifically applies to the Westinghouse Type CA-6 relay used for transformer or bus differential. Refer to Westinghouse Bulletin I.L. 41-337.1 for details. This relay is used in conjunction with an auxiliary current transformer. This same auxiliary current transformer must be in the test circuit.

Type of Tests

Pickup - Operating Coil
Restraint Characteristics

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER - "N.O.MAINT." LOWER - "CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	EXT. AC
"Aux. Selector" Switch	"AC 3-24"
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A

CONTROL	POSITION
"Main Ammeter Range" Switch.....	500A
"Voltage Relay Test" (DET) Switch.....	Set "NORM"
"Output #1-#2" Switch.....	Output #1

Testing Pickup

1. Connect Model SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

NOTE: This is a polarized relay and polarities must be observed. The relay even numbered terminals on the restraint coils are polarity (±). Facing the auxiliary current transformer, the "R" terminals are the secondary winding and the I_o terminals are the primary winding. The right-hand terminals of both "R" and "I_o" are polarity (±). The odd numbered terminal of the relay operating coil is connected to the right-hand terminal of "R" auxiliary current transformer.

2. Connect operating coil of relay to "R" terminals of the auxiliary current transformer. (Observe polarity. See NOTE)

3. Connect the I_o terminals of the auxiliary current transformer to the "AC Output #3" binding posts of the test set. (Observe polarity. See NOTE.). An external milliammeter, capable of reading as low as 0.145 amperes or as high as 1.0 amperes, must be in this circuit.

4. Set tap on auxiliary current transformer to 19.

5. Connect test set "Relay Contacts" binding posts to "Relay Trip Circuit" contacts terminals.

6. Turn "Power ON" Switch ON. "Power ON" light should glow.

7. Initiate unit by pressing "Initiate" Switch.

8. Rotate "Aux. Control" clockwise until continuity light flickers. Read this value of current on milliammeter and record as pickup.

9. Return all controls to zero and de-energize test set. Remove external ammeter. Do not disconnect any other leads.

Testing Restraint Characteristics

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER - "N.O. MAINT." LOWER - "CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	"EXT. AC"
"Aux. Selector" Switch	"AC #3-24V"
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that desired test current may be read on upper 1/3 of scale.
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2"Switch	Output #1

1. Connect SR-51 to a suitable source of power and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect all six relay restraint coils in series. Observe polarity. (See NOTE above)

3. Connect the series circuit of the six relay restraint coils to "AC Output #1" of the test set. "AC Output #1" common terminal (±) to polarity terminal of relay.

4. Connect operating coil of relay to "R" terminals of the auxiliary current transformer. (Observe polarity. See NOTE)

5. Connect the "I_o" terminals of the auxiliary current transformer to "AC Output #3" binding posts of the test set. (Observe polarity. See NOTE.)

6. Set auxiliary current transformer tap to 19.

7. Connect test set "Relay Contacts" binding posts to relay trip circuit contacts terminals.

8. Turn "Power ON" Switch ON. "Power ON" light should glow.

9. Initiate test set by pressing "Initiate" Switch.

10. Rotate "Aux. Control" clockwise to energize relay operating coil circuit with a value of current equal to 1/2 tap setting of auxiliary current transformer. Continuity light should glow.

11. Rotate "Main Control" clockwise to energize the relay restraint coil circuit until the continuity light flickers. Read and record this value of current.

DIFFERENTIAL VOLTAGE RELAY
General Electric Type PVD

GENERAL

This relay is a high speed bus differential relay which contains two operating units connected in parallel. One of the units (known as 87L) is an instantaneous voltage unit having a high impedance operating coil connected across the dc terminals of a full wave rectifier. The rectifier is connected in series with a reactor-capacitor combination tuned for resonance at rated frequency. The other unit (known as 87H) is an instantaneous overcurrent unit with a low impedance operating coil which is connected in series with Thyrite resistor stacks. Both of these units are connected in parallel with the secondaries of all current transformers on all the circuits associated with the bus to be protected. The current transformers should all have the same ratios.

The purpose of the 87L unit is to allow designation of the minimum internal fault that will operate the relay to trip all circuit breakers associated with the protected bus. The purpose of the 87H unit is to provide instantaneous operation for extremely severe internal faults.

Testing General Electric Type PVD11C Relays

Note: Set both the 87L and 87H units in low range.

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

Tests

1. Pickup of 87L element
2. Pickup of 87H element
3. Testing leakage of Thyrite

Testing Pickup of 87L Element

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MOM", LOWER-"CONT"
"Main Control	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	150
"Voltmeter Selector" Switch	AC-3
"Aux. Selector"Switch	AC-3-150

CONTROL	POSITION

"Aux. Control".....Zero (counterclockwise)

"AC Range" Switch.....10A

"DC Range" Switch.....5A

"Main Ammeter Range" Switch.....500A

"Voltage Relay Test"(DET) Switch....Set "NORM"

"Output #1-#2" Switch.....Output #1

1. Connect test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect "AC Output #3" binding posts of the test set to the relay terminals so that the relay 87L unit operating coil circuit may be energized.

3. Jumper the relay terminals so that the relay 87H operating coil circuit is connected in parallel with the 87L operating coil circuit.

4. Connect the "Relay Contacts" binding posts of the test set to the trip circuit contact terminals of the relay.

5. Turn "Power ON" Switch ON. "Power ON" light should glow.

6. Initiate unit by pressing and holding "Initiate" Switch.

7. Rapidly rotate the "Aux. Control" clockwise until the voltmeter indicates an applied voltage approximately 25 volts higher than setting of the relay 87L unit. The Continuity light should glow. Release the "Initiate" Switch.

8. Jog "Initiate" Switch while reducing applied voltage by rotating the "Aux. Control" counterclockwise. Determine minimum voltage which closes the relay 87L trip circuit contacts as indicated by the Continuity light.

9. Record this value of voltage as pickup of 87L element.

Testing Pickup of 87H Element

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT", LOWER-"CONT"
"Main Control	Zero (counterclockwise)
"Aux. Power" Switch	"INT"
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	"EXT. AC"
"Aux. Selector" Switch	VERN
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that test current will be read in upper 1/3 of ammeter scale
"Voltage Relay Test"(DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1"

1. Connect the test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect the test set "Output #1" binding posts to the relay terminals so that the operating coil of the relay 87H unit may be energized with the Thyrite resistor disks out of the circuit

3. Connect the "Relay Contacts" binding posts of the test set to the trip circuit contacts terminals of the relay.

4. Turn "Power ON" Switch ON. "Power ON" light should glow.

5. Initiate unit by pressing "Initiate" Switch.

6. Slowly increase current to the relay operating coil by rotating "Main Control" and "Aux. Control" clockwise until Continuity light glows.

7. Record this value of current as "Pickup" of the 87H unit.

Testing Thyrite Leakage

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT", LOWER-"CONT"
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT"
"Voltmeter Range" Switch	150
"Voltmeter Selector" Switch	DC
"Aux. Selector" Switch	150 DC
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	0.5A
"Output #1-#2 Switch	Output #1
"Main Ammeter Range" Switch	500
"Voltage Relay Test"(DET) Switch	Set "NORM"

1. Connect the test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON LIGHT.

2. Connect the "DC Output" binding posts of the test set to the relay terminals so that the Thyrite resistor disks may be independently energized. A 0-15 milliampere DC meter should be connected in series with this circuit.

3. Turn "Power ON" Switch ON. "Power ON" light should glow.

4. Initiate unit by pressing "Initiate" Switch.

5. Rotate "Aux. Control" (clockwise) to increase output to 120 volts dc.

6. Read current on milliammeter. Compare with relay manufacturer's specifications.

PILOT WIRE RELAY

(General Electric Type CPD)

GENERAL

The CPD relay is a single element pilot wire relay. Two (2) of these relays, one at each end of a power line, and a two-wire pilot wire circuit between the relays, provides protection for both phase to phase and phase to ground faults over the entire length of the power line. The basic components of the relay are the relay unit, a tapped autotransformer and an input transformer.

The relay unit is of the induction cylinder classification. This unit has directional qualities.

The tapped autotransformer transforms three-phase and ground currents into a single phase current which energizes the primary of the input transformer. The secondary voltage of the input transformer is polarized and is applied to the relay unit restraining coils. Any pilot wire current must pass through the relay unit operating coil.

The pilot wire scheme operates on the opposed voltage principle and on normal operation or with a through-fault, no current flows through the pilot wire. For a fault on the power line within the protected section, the voltages at the opposite ends of the pilot wire become additive and relatively large currents pass through the pilot wire relay operating coils to close the relay trip circuit contacts.

Test Procedure

ALWAYS CONSULT MANUFACTURER'S INSTRUCTION LEAFLET FOR PROPER CIRCUIT CONNECTIONS AND INFORMATION ON CHARACTERISTICS BEFORE TESTING.

Type of Tests

Pickup Phase A to Neutral
Pickup Phase A to C
Pickup Phase A to B
Pickup Target and Seal-In

SETUP OF CONTROLS BEFORE TESTS

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	"300"

CONTROL	POSITION
"Voltmeter Selector" Switch.....	"EXT. AC"
"Aux. Selector" Switch.....	"VERN."
"Aux. Control".....	Zero (counterclockwise)
"AC Range" Switch.....	10A
"DC Range" Switch.....	5A
"Main Ammeter Range" Switch.....	So that test current may be read in UPPER 1/3 of scale
"Voltage Relay Test" (DET) Switch.....	Set "NORM"
"Output #1-#2" Switch.....	"Output #1"

Testing Pickup Phase A to Neutral

1. Connect Model SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
2. Connect "Output #1" of SR-51 to relay terminals so as to pass current "Phase A" to "Neutral".
3. Connect Continuity light so as to observe action of front relay trip circuit contacts.
4. Turn "Power ON" Switch ON. "Power ON" light should glow.
5. Initiate unit by pressing "Initiate" Switch.
6. Slowly increase current by rotating "Main Control" and "Aux. Control" clockwise until Continuity light glows. Record this value of current as pickup.
7. Open Continuity light circuit to de-energize relay trip circuit contact holding coil.
8. Adjust "Timer Operation Selector" Switch to UPPER-"N.O.MOM.".
9. Set test current to 125% of value recorded in Step 6 by jogging "Initiate" Switch.
10. Adjust "Timer Operation Selector" Switch to UPPER-"N.O. MAINT.".
11. Reconnect Continuity light to observe closure of relay back trip circuit contacts.
12. Initiate unit. Continuity light should glow.

Pickup Phase A to Phase C

1. Follow Steps 1 through 12 above except "Output #1" of relay test set is connected to relay terminals so as to pass current Phase A to Phase C.

Pickup Phase A to Phase B

1. Follow Steps 1 through 12 above except "Output #1" of relay test set is connected to relay terminals so as to pass current Phase A to Phase B.

Pickup Target & Seal-In

1. Block relay trip circuit contacts closed and follow normal procedure for DC Target pickup.

IMPORTANT NOTE

In testing this relay, it is necessary that the relay terminals connected to the pilot wire isolating transformer should be shorted through a suitable resistor. The value of the resistance should be approximately equal to the resistance of the pilot wire.

PILOT WIRE RELAY

(Westinghouse Type HCB)

GENERAL

The HCB relay is a three-phase high speed pilot wire relay designed for simultaneous tripping at the terminals of a power line. The power line three-phase currents energize the relay operating circuits through current transformers and are converted by a combination positive and zero sequence filter into a single phase output voltage. The single-phase output voltages from the HCB relays which are located at each power line terminal, normally have polarity to cause a circulating current through the pilot wire. When a fault occurs between the terminals of the power line, polarity of the single-phase output voltage from one of the relays will reverse, causing the two single-phase output voltages to oppose each other in the pilot wire. Therefore, the output voltage of each relay is bypassed through the relay operating coil causing relay trip circuit contact closure.

The relay moving contact is attached to a pivoted armature on a magnetic frame which contains both an electro-magnet and a permanent magnet. The electro-magnet has two (2) concentric coils connected in opposition, so that one is used as a restraining winding and the other an operating winding. The restraining winding sets up a magnetic field, which in conjunction with the field from the permanent magnet, holds the contact in the Normal Open position. The operating winding produces a magnetic field which acts to move the armature in the relay trip circuit contact closing direction.

TEST PROCEDURE

ALWAYS CONSULT MANUFACTURER'S INSTRUCTION LEAFLET FOR PROPER CONNECTION AND INFORMATION ON RELAY CHARACTERISTICS BEFORE TESTING.

Type of Tests

Phase to Neutral Pickup
Phase to Phase Pickup
Target and Seal-In Pickup

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	"300"

CONTROL	POSITION
"Voltmeter Selector" Switch	"AC EXT."
"Aux. Selector" Switch	"VERN."
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Output #1-2" Switch	"Output #1"
"Main Ammeter Range" Switch	So that test current may be read in UPPER 1/3 of scale
"Voltage Relay Test" (DET) Switch	Set "NORM"

Testing Phase to Neutral Pickup

1. Connect Model SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
2. Connect "Output #1" of SR-51 to relay terminals so as to pass current "Phase A" to "Neutral".
3. Connect Continuity light to observe action of relay trip circuit contacts.
4. Turn "Power ON" Switch ON. "Power ON" light should glow.
5. Initiate unit by pressing "Initiate" Switch.
6. Slowly increase current by rotating "Main Control" and "Aux. Control" clockwise until Continuity light glows.
7. Record this value of current as pickup.
8. Repeat for "B" to Neutral and "C" to Neutral.

Testing Phase to Phase Pickup

Repeat Steps 1 through 7 above except that "Output #1" of SR-51 is connected to relay terminals so as to pass current Phase B to Phase C in series.

8. Increase current until neon light glows. Record value.
9. Repeat for Phase "C" - "A" and Phase "A" - "B".

Testing Target and Seal-In Pickup

Block relay trip circuit contacts closed and follow test procedures for testing DC Target and Seal-In.

TRANSFORMER DIFFERENTIAL RELAY WITH PERCENTAGE AND HARMONIC RESTRAINT (General Electric Type BDD)

GENERAL

The Type BDD relay is a single-phase transformer differential relay provided with the features of percentage and harmonic restraint and has a sensitive polarized relay as the operating element. Percentage restraint permits accurate determination between internal and external faults at high currents. Harmonic restraint enables the relay to distinguish, by the difference in waveform, between the differential current caused by an internal fault and that caused by transformer magnetizing inrush.

The Type BDD 15 relay is designed to be used for the protection of two-winding power transformers and has two (2) through-current restraint circuits and one (1) differential current circuit.

The Type BDD 16 relay is designed to be used with three-winding power transformers and has three (3) through-current restraint circuits and one (1) differential current circuit.

Type of Tests

Pickup of DHR Unit	Harmonic Restraint
Slope (Not with SR-21)	Pickup of Instantaneous Unit

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	150
"Voltmeter Selector" Switch	DC
"Aux. Selector" Switch	150 DC
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A (Not on SR-21)
"DC Range" Switch	5A

Note: The harmonic restraint and slope tests are written based on testing the relay with all restraint windings set in the 5 tap. If the relay is to be tested with any other tap settings, please refer to the G.E. instruction book under "Periodic Testing".

CONTROL	POSITION
"Main Ammeter Range" Switch.....	So that desired test current may be read on upper 1/3 of scale
"Voltage Relay Test (DET) Switch.....	Set "NORM"
"Output #1-#2" Switch.....	"Output #1"

Testing Pickup (Relay rated 125 volts DC)

NOTE: If the BDD relay is rated for 250 volts DC circuit, adjust "Aux. Selector" to "DC 300". In Step 7, rotate "Aux. Control" clockwise for a reading of 250 volts on the voltmeter.

1. Connect the relay tester to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect "AC Output #1" terminals of the test set to relay terminals so that differential current coil and one through current restraint coil may be energized.

3. Connect leads from "DC" binding posts of the test set to relay terminals across DHR unit Normally Open contacts.

4. Connect leads from "Relay Contacts" binding posts of test set to relay trip circuit contact terminals.

5. Turn "Power ON" Switch ON. "Power ON" light should glow.

6. Initiate unit by pressing "Initiate" Switch.

7. Rotate "Aux. Control" clockwise for reading of 125 volts DC on voltmeter.

8. Rotate "Main Control" clockwise to increase output until relay picks up and continuity light glows. Read current on ammeter. Target on relay "T" should drop.

9. Return "Aux." and "Main" controls to zero. Turn "Power ON" Switch to OFF.

10. Repeat test with "AC Output #1" terminals of the test set connected to relay terminals so that the differential current coil and each of the other current restraint coils may be energized.

Testing Through Current Restraint (Slope)

1. Connect the SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect the 10 volt tap and the right hand common terminals of "AC Output #1" to terminals 4 and 6 of the relay. The common of "AC Output #1" is connected to terminal 6 of the relay.

3. Connect "AC Output #3" terminals of the test set to terminals #5 and #6 of the relay. Connect the polarity (+) terminal of "AC Output #3" to terminal #6 of the relay.

4. Connect leads from test set "Relay Contacts" binding posts to relay terminals across DHR unit Normally Open contacts.

5. Adjust "Timer Operation Selector" switch, UPPER - "N.O. MOM.", LOWER - "FAST TRIP".

6. Adjust "Aux. Selector" switch to "AC3-24", "Voltmeter Range" switch to "300", "Voltmeter Selector" Switch to "Ext. A.C."

7. Turn "Power ON" switch ON. "Power ON" light should glow.

   WARNING

   The relay coils are energized as long as the test set is initiated. Therefore, this test should be conducted as rapidly as possible to prevent damage to relay coils.

8. Initiate unit by pressing and holding "Initiate" Switch.

9. Rotate "Main Control" clockwise until desired current is read on Main Ammeter, as indicated by relay manufacturer's instruction book.

10. Rotate "Aux. Control" clockwise until relay DHR unit Normally Open contacts close. At this point, readjustment of "Main Control" may be necessary to maintain current set in Step 9 and test set timer may restart. Readjust "Aux. Control" until timer stops. Read current values and release "Initiate" switch.

11. For BDD 16, repeat procedure from Step 4. In Step 4, re-connect 10 volt tap of "AC Output #1" to relay terminal #3.

12. Turn test set off.

Testing Harmonic Restraint

1. Connect the SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect the 10 volt tap of "AC Output #1" to the external test rectifier. Connect the other side of the test rectifier to terminal #5 of the relay. Connect the right hand common of "AC Output #1" to terminal #6 of the relay.

3. Short the external test rectifier by placing a jumper across its terminals.

4. Adjust "Aux. Selector" switch to "AC3-24" "Voltmeter Range" switch to "300", and "Voltmeter Selector" Switch to "Ext. A.C."

5. Turn "Power ON" switch ON. "Power ON" light should glow.

6. Initiate unit by pressing "Initiate" switch.

7. Rotate "Main Control" clockwise to increase current output until 9 amperes is read on the Main Ammeter.

8. Turn test set off.

9. Remove jumper from external test rectifier.

10. Connect "AC Output #3" terminals of the test set to terminals #5 and #6 of the relay. Connect the polarity terminal (+) of "AC Output #3" to terminal #6 of the relay. NOTE: "AC Output #3 must not be connected to relay while 9 amperes is being set in Step #7.

11. Adjust "Timer Operation Selector" switch, UPPER - "N.O. MOM.", LOWER - "FAST TRIP".

12. Turn "Power ON" switch ON. "Power ON" light should glow.

13. Initiate unit by pressing and holding "Initiate" switch.

14. Rotate "Aux. Control" clockwise until timer stops. Read value of current required to operate Harmonic Restraint on the Auxiliary Ammeter and release "Initiate" switch.

15. Turn test set off.

Testing Instantaneous Unit

1. Connect the SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Adjust "Voltmeter Range" Switch to "300", "Voltmeter Selector" Switch to "Ext. A.C.", and "Aux. Selector" Switch to "Vern."

3. Connect "AC Output #1" terminals of the test set to relay terminals to energize the differential current coil and one through current restraing coil, i.e.: relay terminals 5 and 6.

4. Connect leads from "Relay Contacts" binding posts of test set to relay trip circuit contact terminals.

5. Turn "Power ON" switch ON. "Power ON" light should glow.

   This test should be conducted as rapidly as possible to avoid damage to the relay coil.

6. Initiate unit by pressing "Initiate" switch.

7. Rotate "Main Control" clockwise until the continuity light glows. Read and record current value on main ammeter.

8. Turn test set OFF.

DIRECTIONAL OVERCURRENT RELAY
(Westinghouse Type CR) (General Electric Type IBC)

GENERAL

A Directional Overcurrent Relay trips a circuit when it senses two abnormal conditions in the following sequence:

1. Current flow must be reversed
2. The reversed current flow must be higher than a prescribed amount, and the flow must continue for a predetermined time.

This relay is composed of two units, a directional unit and an overcurrent unit. The directional unit is similar to a single phase wattmeter. It contains a voltage actuated and a current actuated coil. When these two coils are energized, a torque is produced on the unit's disc. A 180° shift in phase relationship between the voltage and current produces a reverse torque on the disc. Normally, the torque produced holds the directional unit contacts open. When the current flow in the circuit reverses, the unit's disc will rotate to close the directional unit contacts.

The overcurrent unit of the relay is similar to the time delay overcurrent relay. In modern designs, the directional unit contacts must be closed before operating torque will be produced on the induction disc of the overcurrent unit. Thus, the directional overcurrent relay requires reversal as well as a minimum quantity of current flow before it may operate to trip a breaker.

Test Procedures

Type of Tests

Directional Unit
- Minimum Pickup

Overcurrent Unit
- Minimum Pickup
- Time Current Characteristics

The test procedure is arranged to test each element of the relay individually. The directional element contacts must be blocked closed or bypassed to permit complete testing of the overcurrent element.

TESTING DIRECTIONAL ELEMENT FOR MINIMUM PICKUP USING D.E.T. CIRCUIT IN MULTI-AMP MODEL SR-51 RELAY TESTER. (CURRENT AND VOLTAGE IN PHASE)

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	To read voltage in upper 1/3 of scale
"Voltmeter Selector" Switch	"D.E.T."
"Aux. Selector" Switch	"D.E.T."
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that desired current may be read in UPPER 1/3 of scale
"Voltage Relay-D.E.T." Switch	As desired -Positions 1-4 (See Step 4)
"Output #1-#2" Switch	"Output #1"

1. Connect the MULTI-AMP relay tester to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect Polarity terminal $\pm$ of relay directional unit current operating coil to the Polarity terminal of "AC Output #3" ($\pm$) (right-hand binding post). The other relay operating coil terminal should be connected to the desired tap of "AC Output #1". (10 volt)

3. Connect the relay voltage polarizing coil to "AC Output #3" terminals. The polarity terminal "$\pm$" of the relay voltage polarizing coil should be connected to Non-Polarity terminal of "AC Output #3". (left-hand binding post)

4. Turn "D.E.T." (Direct. Element Test) Switch to desired position.
   NOTE: Positions 1, 2, 3, and 4 are factory wired to produce values given below:

POSITION	VOLTS	AMPERES
1	1	4
2	2	4
3	1	8
4	2	8

   Positions 5 through 9 are left unwired to permit their use for any particular values common to the user's system. The installation of a resistor in these unwired positions may produce any reasonable values of current and voltage.

5. Turn "Power ON" Switch ON. "Power ON" light should glow.

6. Initiate unit by pressing "Initiate" Switch.

7. Rotate "Main Control" clockwise to increase output until the relay directional unit contacts close. Read and record the values of voltage and current on the respective meters.

8. Reverse leads from test set to potential coil of relay. Relay directional unit contacts should resist closure.

TESTING PICKUP AND TIME CURRENT CHARACTERISTICS OF OVERCURRENT UNIT

1. Block Directional Unit contacts closed and follow procedure for "Induction Disc Overcurrent Relay".

   NOTE: AT END OF TEST BE SURE TO REMOVE ALL BLOCKING FROM RELAY

TESTING DIRECTIONAL ELEMENT FOR MINIMUM PICKUP USING EXTERNAL PHASE SHIFTER AND PHASE ANGLE METER (MULTI-AMP MODELS CS-5 or CS-6)

SETUP OF CONTROLS BEFORE TEST - Model SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counter-clockwise)
"Aux. Power" Switch	"EXT."
"Voltage Range" Switch	So that test voltage may be read in upper 1/3 of scale
"Voltage Selector" Switch	"AC-3"
"Aux. Selector" Switch	"AC-3 -24"
"Aux. Control"	Zero (counter-clockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	As desired so that test current may be read in upper 1/3 of scale
"Voltage Relay Test" (Direct. Element) Switch	SET NORM
"Output #1-#2" Switch	"Output #1"

SETUP OF CONTROLS BEFORE TESTS (Models CS-5 or CS-6)

"Power ON" Switch	OFF
"Input Voltage" Selector" Switch	As required
"Phase Shift Adjust Coarse"	Any position
Switch (Upper Right)	Phase Shift Output

NOTE: Model CS-7 Phase Shifter and Phase Angle Meter may be used for this test. Please refer to Instruction Book covering tests using MULTI-AMP CS-7.

1. Connect Model CS-5 to a suitable source of 3-phase power or Model CS-6 to a suitable single phase source. Check "Power ON" light. BE SURE THE MAIN SWITCH IS OFF.

2. Connect Model SR-51 relay tester to a suitable source of power as indicated on the nameplate and ground. Check the "Power ON" light. BE SURE THE MAIN SWITCH IS OFF.

3. Using Continuity leads, connect the "P.A.M." jack on the SR-51 to "Current Coil Input" terminals on Model CS-5 or CS-6 . Connect black lead to polarity (±) on CS-5 or CS-6.

4. Using light leads, connect the "Phase Shifter Output" terminals to the "Aux. Power Input" terminals on the SR-51. "±" terminals should be connected together.

5. Using light leads, connect the voltage polarizing coil of the relay directional unit to "AC Output #3" terminals of the SR-51; relay polarity terminal "±" to "AC Output #3" polarity terminal "±".

6. Using regular leads, connect current operating coil of the relay directional unit to "Output #1"; relay polarity terminal "±" to "Output #1" polarity terminal "±".

7. Rotate "Main Control" knob clockwise to desired current value as read on Main Ammeter.

8. Adjust "Coarse" and "Fine" Controls on Model CS-5 or CS-6 to desired phase angle as read on phase angle meter. (This should be angle of maximum torque as determined from manufacturer's instruction bulletin.)

9. Rotate "Aux. Control" clockwise until the relay directional unit contacts close. Read value of voltage on voltmeter.

10. Record values of current, voltage and phase angle at which directional unit contacts close.

POWER DIRECTIONAL RELAYS
(General Electric Type ICW) - (Westinghouse Type CW)

GENERAL

The General Electric Type ICW or Westinghouse Type CW relay is an induction disc relay containing current and voltage operating coils. It is a single-phase wattmeter element equipped with a tap block so that minimum operating watts may be varied. The operation of these relays depends upon both phase angle and the magnitude of the applied voltage and current. Either the ICW or CW relay is available as a 3-phase or 1-phase unit.

The 3-phase relay measures 3-phase watts, and the relay current coil is connected to the secondary winding of a current transformer in one phase. The relay potential coil is connected to the secondary winding of a potential transformer providing line to line voltage. The tap block of this relay is calibrated in 3-phase watts. W=1.73 EI (Power Factor).

The single-phase relay measures single-phase watts. This relay's current and potential coils are connected to the secondaries of current and potential transformers in the same phase. The tap block of this relay is calibrated in single-phase watts.

Testing GE Type ICW 51A Relay (calibrated in 3-phase watts).

Type of Tests

1. Minimum Pickup
2. Timing

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE PROCEEDING WITH TESTS.

SETUP OF CONTROLS BEFORE TEST - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Sw.	UPPER - "N.O.MOM" LOWER-"CONT"
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"EXT"
"Voltmeter Range" Switch	So that test voltage may be read on upper 1/3 of meter scale
"Voltmeter Selector" Switch	"AC Output #3"
"Aux. Selector" Switch	"AC Output #3 150V"
"Aux. Control"	Zero (counterclockwise)

CONTROL	POSITION
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that test current may be read on upper 1/3 of meter scale
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1"

SETUP OF CONTROLS BEFORE TESTS-MODEL CS-5 or CS-6

"Power ON-OFF" Switch	OFF
Input Voltage Selector	As required (Not on CS-6)
Phase Shift Adjust Coarse	Any Position
Phase Shift Adjust Fine	Counterclockwise
Switch (upper right)	Phase Shift Output

Testing Minimum Pickup

1. Connect SR-51 and CS-5 or CS-6 together as described under "Use of Phase Shifter and Phase Angle Meter", Section II.

2. Connect Model SR-51 and CS-5 or CS-6 to suitable sources of power as indicated on test set nameplate. BE SURE "POWER ON" SWITCHES ARE OFF. CHECK THE "POWER ON" LIGHTS.

3. Connect SR-51 "Output #1" binding posts to relay terminals so that the relay current coil may be energized. Observe polarity.

4. Connect SR-51 "AC Output #3" binding posts to relay terminals so that the relay potential coil may be energized. Observe polarity.

5. Connect a pair of light leads from the SR-51 binding posts marked "Relay Contacts" to the relay trip circuit contacts terminals.

6. Turn the SR-51 and CS-5 or CS-6 "Power ON" Switches ON. "Power ON" lights should glow.

7. Adjust "Timer Operation Selector" Switch, UPPER to "N.O. MAINT", LOWER to "CONT".

8. Initiate SR-51 by pressing the "Initiate" Switch.

9. Rotate the SR-51 "Main Control" clockwise to energize the relay current coil, until the Main Ammeter indicates 5 amperes.

10. Adjust the "Coarse" and "Fine" controls on CS-5 or CS-6 until the Phase Angle Meter indicates 90° current lead voltage (270°I lag.)

11. Rotate the SR-51 "Aux. Control" clockwise until the Continuity light flickers. Observe this value of voltage.

12. If the relay is in perfect adjustment, the value of voltage observed in Step 2 should be:

$$E = \frac{\text{Relay Tap Value}}{(1.73)\ (5)} = \underline{\qquad\qquad} \text{Volts}$$

13. Turn both test sets OFF.

Testing Timing

1. Repeat Steps 1-10 above ("Testing Minimum Pickup").

2. Rotate SR-51 "Aux. Control" clockwise until the voltmeter indicates a value of voltage equivalent to:

$$E = \frac{(4)\ (\text{Relay Tap Setting})}{(1.73)\ (5)} = \underline{\qquad\qquad} \text{Volts}$$

   If this value of voltage exceeds the relay voltage rating, rotate SR-51 "Main Control" clockwise to increase current input to relay. Calculate a new voltage corresponding to the new value of current.

3. Turn SR-51 "Power ON" Switch OFF.

4. Adjust "Timer Operation Selector" Switch, UPPER to "N.O.MAINT", LOWER to "TIMER".

5. Reset timer to zero.

6. Turn SR-51 "Power ON" Switch ON.

7. Initiate SR-51 by pressing "Initiate" Switch.

8. When relay trip circuit contacts make, the timer will stop and the relay will be de-energized. Read and record this value of time.

9. Turn both test sets OFF.

Testing Westinghouse Type CW Relay 30° Characteristic (Calibrated in 3-Phase Watts)

Follow exactly same procedure as for General Electric Type ICW51A except as noted below:

1. The Phase Shifter (CS-5 or CS-6) controls should be adjusted until the Phase Angle Meter reads current lead voltage by 30° (330° current lag).

Testing General Electric Type ICW51B or Westinghouse CW Zero Degree Characteristic. (Calibrated in Single-Phase Watts)

Follow exactly same procedure as for Type ICW51A except as noted below:

1. The Phase Shifter (CS-5 or CS-6) controls should be adjusted until the phase angle meter reads zero (voltage and current in phase).

2. In calculating the test voltages, use the formula:

   Watts = (Voltage) (Current)

   Where watts = tap value or multiple thereof

   Current = Reading of Main Ammeter or magnitude of current energizing relay current coil from "Output #1" of SR-51.

LOSS OF EXCITATION RELAY
(General Electric Type CEH)

GENERAL

The Type CEH relay is a single-phase offset MHO type relay which operates on the induction cylinder principle. This relay is designed to detect the loss of excitation of synchronous generators with a sufficient selectivity so as not to function during system short circuits.

The relay contains current operating and voltage polarizing coils and will operate to close its trip circuit contacts whenever the voltage and current "seen by the relay" result in an impedance value within the relay manufacturer's operating characteristics curve. The operating characteristics curve may be changed in size or shifted through relay tap changes or relay adjustments.

TEST PROCEDURES - General Electric Type CEH-11A

PLEASE REFER TO MANUFACTURER'S BULLETIN BEFORE PROCEEDING WITH TEST.

Equipment Required

1. MULTI-AMP Model SR-51 relay tester
2. MULTI-AMP Model CS-5 or CS-6 Phase Shifter and Phase Angle Meter. (Note: See MULTI-AMP CS-7 Instruction Book for procedures using Model CS-7.

Power Required

Input: 3-phase at approximately 200 VA for Model CS-5

120 volts, 60 hertz, 1-phase at approximatly 1.0 kva for Models SR-51 and CS-6

Type of Tests

1. Characteristics of Induction Cylinder Unit
   a. Offset and diameter of circle (Total Ohmic Reach)
   b. Angle of maximum torque
2. Pickup of auxiliary relay ("A")
3. Pickup of target and seal-in unit

Pre-Test Requirements

1. All mechanical maintenance and adjustments should be performed prior to the electrical tests. Follow recommended procedures as outlined in the manufacturer's instruction bulletin (except when "As Found" tests are required).
2. Relay must be level for tests.
3. The MHO unit spiral spring should hold the contact definitely ope

SETUP OF EQUIPMENT BEFORE TEST

1. Place Model CS-5 or CS-6 to the left of Model SR-51.

2. Place the relay at a convenient location so that easy connections can be made to all terminals, or

   Place Model CS-5 or CS-6 and Model SR-51 close to the relay at the switchboard so that the test lead length is kept to a minimum and the relay operation can be observed during testing.

3. If the relay is to be tested on the switchboard, remove connection plug from the bottom of the unit and replace with test plug.

   WARNING!!! During removal of cover and plugs, be careful not to activate the target and seal-in unit contacts as this can cause tripping of the circuit breaker.

4. Make sure that the Main Switch on Models CS-5 or CS-6 and SR-51 are OFF.

5. Connect Model CS-5 to a suitable source of 3-phase power, or Model CS-6 to a suitable 120 volt, single-phase source.

6. Connect Model SR-51 to a suitable source of single-phase power as indicated on the nameplate.

SETUP OF CONTROLS BEFORE TEST - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MOM." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"EXT."
"Voltmeter Range" Switch	So that test voltage will be read in upper 1/3 of scale
"Voltmeter Selector" Switch	"AC Output #3"
"Aux. Selector" Switch	"AC Output #3" 150V
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that test current may be read in upper 1/3 of scale

CONTROL	POSITION
"Voltage Relay Test ("Direct. Element")Switch...	SET NORM
"Output #1-#2" Switch.....	"Output #1"

SETUP OF CONTROLS BEFORE TEST - MODELS CS-5 or CS-6

CONTROL	POSITION
"Power ON" Switch.....	OFF
"Input Voltage Selector"	As required
"Phase Shift Adjust Coarse".....	Any position
"Phase Shift Adjust Fine".....	counterclockwise
Switch (Upper Right).....	"Phase Shift Output"

NOTE: For testing with Model CS-7, please refer to CS-7 instruction book.

Induction Cylinder Unit

The induction cylinder unit belongs to the general classification of MHO units. That is, the unit is composed of a wound field with both current and voltage coils and an armature shaped like a cylinder and acts like a single-phase induction motor. The design is such that the torque may rotate the armature either clockwise or counterclockwise, dependent upon the value of the impressed voltage and current. For certain phase angle relationships, there are no values of voltage and current that will produce a torque on the armature to close the unit's trip circuit contacts. This characteristic gives the relay directional qualities.

Testing Induction Cylinder Unit

A. Offset and Diameter of Circle - (Ohmic Reach)

1. Connect the MULTI-AMP test units to a suitable source of power and ground. BE SURE THE "MAIN SWITCH" IS OFF. CHECK "POWER ON" LIGHTS.

2. Connect Model CS-5 or CS-6 output terminals marked "Phase Shifter Output" to the "Aux. Power" input terminals on Model SR-51. Observe polarity. Connect terminals marked "±" together.

3. Connect "AC Output #3" terminals on SR-51 to relay voltage polarizing coil terminals. Relay polarity terminals (±) should be connected to "AC Output #3" polarity terminal (±).

4. Connect "AC Output #1" of the SR-51 to the relay current operating coil terminals. The relay contains two current coils. A jumper must be used so that the current will

flow through these coils in series. "AC Output #1" polarity terminal (±) must be connected to polarity terminal (±) of one of the operating coils. Non-polarity terminal of that coil is jumpered to polarity terminal (±) of relay second operating coil. Non-polarity terminal of relay second operating coil is connected to non-polarity terminal of "AC Output #1".

5. Insert the telephone type plug into the "P.A.M." jack on Model SR-51. Connect the leads from the plug to the CS-5 or CS-6 terminals marked "Current Coil Input". Observe polarity. Connect black lead from plug to terminal marked (±).

6. Connect the SR-51 continuity light across the relay terminals so as to observe operation of the relay main trip circuit contacts.

7. Block the auxiliary relay (A) trip circuit contacts closed.

8. Select proper Voltmeter and Main Ammeter ranges on the Model SR-51 so that meter readings will be in upper 1/3 of meter scale.

9. Turn "Power ON" in both SR-51 and CS-5 or CS-6. "Power ON" lights should glow.

10. Adjust "Timer Operation Selector" Switch to UPPER-"N.O.MAINT."

11. Initiate Model SR-51 by pressing "Initiate" Switch.

12. Rotate "Main Control" to energize relay current operating coils. (Suggested - 5 amps.)

13. Adjust phase angle by means of "Coarse" and "Fine" Phase Shifter adjustment to 270°. (e.g. 90° current lead voltage or any other specified angle of maximum torque.)

14. Rotate "Aux. Control" (clockwise) to increase voltage until the continuity light lights.

15. Continue to rotate "Aux. Control" (clockwise) to increase voltage until continuity light is extinguished. Continue to rotate "Aux. Control" to increase voltage approximately 10 or 20 volts above point where continuity light was extinguished.

16. Decrease voltage by rotating "Aux. Control" (counterclockwise) until continuity light glows. Record this value of voltage for Maximum Reach Voltage. Continue to decrease voltage until continuity light extinguishes. Record this value of voltage as offset voltage. During this operation, maintain current and phase angle as specified in Steps 12 & 13.

17. Remove blocking from relay.

B. Testing for Angle of Maximum Torque

1. Repeat Steps 1 through 16 above for phase angles of 255° (current lead voltage by 75°) and 285° (current lead voltage by 105°). (15° on either side of angle of maximum torque) Other angles may be used depending upon offset tap setting.

2. Remove all blocking from relay.

Auxiliary or "A" Unit

This unit is an electromagnetic attraction type unit actuated by a DC coil. The purpose of this unit is to prevent false tripping due to vibration should that relay voltage go to zero as the result of a blown fuse in the potential transformer circuit.

Pickup of Auxiliary Relay ("A")

SETUP OF CONTROLS - MODEL SR-51 (CS-5 or CS-6 not required)

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	So that test voltage may be read in UPPER 1/3 of scale.
"Voltmeter Selector" Switch	DC
"Aux. Selector" Switch	DC 150
"Aux. Control"	Zero(counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	0.5A
"Main Ammeter Range" Switch	500
"Voltage Relay Test"("Direct. Element") Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1"

1. Connect SR-51 to a suitable source of power and ground. BE SURE THE "MAIN SWITCH" IS OFF. CHECK "POWER ON" LIGHT.

2. Connect a pair of light leads to relay terminals which will permit energizing auxiliary (A) coil of relay when relay main trip circuit contacts are closed. Connect other end of these leads to SR-51 "D.C. Output".

3. Connect continuity light across relay terminals to observe operation of relay ("A") trip circuit contacts.

4. Block relay main trip circuit contacts closed.

5. Turn "Power ON" Switch ON. "Power ON" light should glow.

6. Push "Initiate" Switch.

7. Rotate "Aux. Control" until continuity light glows.

8. Record these values of DC voltage and current.

Test of Target and Seal-In (Model CS-5 or CS-6 not required)

SETUP OF CONTROLS - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"D.C."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT"
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	"EXT. A.C."
"Aux. Selector" Switch	8 D.C.
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	So that test current will be read in UPPER 1/3 of scale
"Main Ammeter Range" Switch	500
"Voltage Relay Test"(DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1"

1. Connect SR-51 to a suitable source of power and ground. BE SURE MAIN SWITCH IS OFF. CHECK "POWER ON" LIGHT.

2. Connect a pair of light leads to relay terminals which will allow energizing the target and seal-in coil; connect other end of these leads to SR-51 "Relay Contacts" binding posts.

3. Block relay main unit and "A" unit trip circuit contacts closed.

4. Turn "Power ON" Switch CN. "Power ON" light should glow.

5. Initiate unit by pressing "Initiate" Switch.

6. Rotate "Aux. Control" (clockwise) to increase current to target and seal-in coil until target shows. Remove blocking from "A" unit trip circuit contacts. If DC circuit remains energized, the seal-in unit is operating properly.

7. Record this value of current.

8. Remove all blocking from relay.

DIRECTIONAL DISTANCE (REACTANCE) RELAY
(General Electric Type GCX)

GENERAL

The GCX relay is a high-speed directional-distance relay intended for the protection of transmission lines. The relay contains two (2) basic units - MHO and OHM, and may contain some or all of several accessory units, each of which is explained below:

MHO UNIT

The MHO unit belongs to the general classification of induction cup units. That is, the unit is composed of a wound field with both current and voltage coils and an armature shaped like a cup. The unit operates like a single-phase induction motor. The design of this motor is such that the torque may rotate the armature either clockwise or counterclockwise dependent upon value of the impressed voltage, current, and phase angle between the current and voltage. There are certain phase angle relationships where it is impossible to find values of voltage and current that will produce a torque on the armature to close the MHO unit trip circuit contacts. Therefore, the MHO unit has directional qualities.

OHM UNIT

This is also an induction cup unit with both current and voltage coils acting like a single-phase induction motor. However, in this case, regardless of phase angle relationships, values of voltage and current can be found that will produce torque on the armature to close the OHM unit trip circuit contacts. Torque is a function of impressed voltage, current, and phase angle between the current and voltage.

INSTANTANEOUS OVERCURRENT UNIT

This is an electromagnetic attraction type of unit actuated by an AC current coil. The coil of this unit is in series with the MHO and OHM unit current operating coils. The overcurrent unit trip circuit contacts must be closed before this relay can trip a circuit breaker.

"OX" UNIT

This is an electromagnetic attraction type unit actuated by a DC coil. This unit changes potential taps on the "OHM" unit so that the "OHM" unit will respond for either Zone 1 or Zone 2 values of OHMIC reach.

"S" UNIT

This is an electromagnetic attraction type of unit actuated by a DC coil. For certain faults, the MHO unit reset is relatively slow. The "S" unit prevents a false trip signal under these conditions.

Equipment Required

1. MULTI-AMP Model SR-51 Relay Tester

2. MULTI-AMP Model CS-5, CS-6 or CS-7 Phase Shifter & Phase Angle Meter
   NOTE: For testing with Model CS-7, please refer to CS-7 instruction book.

Power Required

Input: 3-phase at approximately 200 VA for Model CS-5
120 volts, 60 hertz, 1-phase at approximately 1.0 kva for Model SR-51 or CS-6

Types of Tests

1. OHM unit tests - First (#1) zone reach and maximum torque angle
2. OHM unit tests - Second (#2) zone reach
3. MHO or starting unit tests - Third (#3) zone reach and maximum torque angle
4. Pickup of "OX" relay
5. Pickup of "S" relay
6. Pickup of overcurrent unit (where applicable)
7. Pickup of target and seal-in unit
8. Overall test

Pre-Test Requirements

All mechanical maintenance and adjustments should be performed prior to the electrical tests. Follow recommended procedures as outlined in the manufacturer's instruction bulletin (except when "As Found" tests are required).

Relay must be level for tests.

The OHM unit (upper) lead-in spring should barely hold the contact against the backstop.

The MHO unit (lower) lead-in spring should hold the contact definitely open.

Set-up of Equipment Before Test

1. Place Model CS-5 or CS-6 to the left of Model SR-51.

2. Place the relay at a convenient location so that easy connections can be made to all terminals, or

   Place Model CS-5 or CS-6 and Model SR-51 close to the relay at the switchboard so that the test lead length is kept to a minimum and the relay operation can be observed during testing.

3. If the relay is to be tested on the switchboard, remove plugs from the top and bottom of the unit and replace them with test plugs. Remove bottom plug first.

WARNING: During removal of cover and plugs, be careful not to activate the Target and Seal-In unit contacts as this can cause tripping of the circuit breaker.

4. Make sure that the "Main Switch" on CS-5 or CS-6 and SR-51 are OFF.

5. Connect Model CS-5 to a suitable source of three-phase power.

6. Connect Model SR-51 and CS-6 to a suitable source of single-phase power as indicated on the nameplate.

Test Procedures

SETUP OF CONTROLS BEFORE TESTS - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MOM." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"EXT."
"Voltmeter Range" Switch	So that test voltage will be read in upper 1/3 of scale
"Voltmeter Selector" Switch	"AC Output #3"
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that test current will be read in upper 1/3 of scale
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1"

SETUP OF CONTROLS BEFORE TEST - Model CS-5 or CS-6

CONTROL	POSITION
"Power ON-OFF" Switch	OFF
Input Voltage Selector	As required (Not on CS-6)
"Phase Shift Adjust Coarse	Any position
"Phase Shift Adjust Fine"	counterclockwise
"Switch" (upper right)	"Phase Shift Output"

Testing OHM Unit (Zone 1) for Reach and Phase Angle

1. Connect Model CS-5 or CS-6 output terminals marked "Phase Shifter Output" to the "Aux. Power" input terminals on Model SR-51. Observe polarity. Connect terminals marked "±" together.

2. Connect Model SR-51 "AC Output #3" to the relay potential coil terminals. Observe polarity.

3. Connect SR-51 "AC Output #1" to relay current coil terminals. The relay current coils should be connected in series. Observe polarity.

4. Plug in the telephone type plug into the "P.A.M." jack on SR-51. Connect the leads from the plug to the CS-5 or CS-6 terminals marked "Current Coil Input". Observe polarity. Connect black lead to terminal marked "±".

5. Connect a pair of light leads from terminals marked "Relay Contacts" to terminals on relay so as to observe operation of OHM unit trip circuit contacts through the "OX" unit NC contacts.

6. Bypass or block the overcurrent unit contacts (if present) and the MHO unit contacts.

7. Select proper AC range on the "Aux. Selector" Switch of the SR-51.

8. Turn Power ON in the Models SR-51 and CS-5 or CS-6. "Power ON" lights should glow.

9. Turn "Timer Selector" Switch to UPPER - "N.O. MAINT.", LOWER-"CONT".

10. Initiate Model SR-51 by pressing the "Initiate" Switch.

11. Adjust current through the current coils of the relay to the desired value by turning the "Main Control" on SR-51 slowly clockwise. (The value of current will be calculated from the impedance settings of the relay and will be provided to the personnel performing the test (suggested value 5 amps.). The continuity light will glow.

12. Adjust the phase angle by means of the "Coarse" and "Fine" phase shifter adjustment on the CS-5 or CS-6. The phase angle utilized will be either the angle of maximum torque of the relay (e.g. 90° current lag voltage) or value as determined from actual operating conditions.

13. Adjust "Aux. Control" on SR-51 until the continuity light extinguishes. Continue to increase voltage for another 10-15 volts.

14. Reduce voltage slowly by rotating "Aux. Control" counterclockwise until the contacts of the OHM unit just close (as shown by the flickering of continuity light).

15. Record the values of current, voltage and phase angle. Compare with values computed and/or calibration data on the relay.

16. Return "Main" and "Aux." controls on SR-51 to zero (maximum counterclockwise).

17. To determine the angle of maximum torque, repeat Steps 11-16 for two other values of phase angle equi-distant from 90° current lag. (e.g. 60° current lag and 120° current lag)

18. Turn "Power ON" Switches on SR-51 and CS-5 or CS-6 to OFF.

Testing OHM Unit - (Zone 2) - For Reach

1. Connect a pair of light leads from binding posts marked "Relay Contacts" to relay terminals to observe closure of OHM unit and "OX" unit Normally Open contacts.

2. Close the "OX" relay contacts by blocking its armature in the closed position. (This is the relay mounted behind the nameplate).

3. Turn Models SR-51 and CS-5 or CS-6 "Power ON" Switches to ON.

4. Initiate SR-51 by pressing "Initiate" Switch.

5. Adjust current through the current coils of the relay to desired value by turning the "Main Control" on SR-51 slowly clockwise. (The value of current will be calculated from the impedance settings of the relay and be provided to the personnel performing the test. (Suggested value 5 amps.)

6. Adjust the phase angle by means of the "Coarse" and "Fine" phase shifter adjustment on the CS-5 or CS-6 to the angle of maximum torque of the relay (e.g. 90° current lag voltage), or value as determined from actual operating conditions. Continuity light should glow.

7. Adjust "Aux. Control" on SR-51 until the continuity light extinguishes. Continue to increase voltage another 10-15 volts.

8. Reduce voltage slowly with "Aux. Control" until the contacts of the OHM unit just close as shown by the flickering of the continuity light.

9. Record the values of current, voltage and phase angle. Compare with values computed and/or calibration data on the relay.

10. Return "Main" and "Aux. Control" on SR-51 to zero (maximum counterclockwise).

11. If desired, Steps 4 through 10 may be repeated at other phase angles.

12. Turn Models SR-51 and CS-5 or CS-6 OFF.

13. Remove blocking of MHO and OX units. Retain blocking on instantaneous overcurrent unit (if present).

Testing MHO Unit - (Starting Unit) - (Zone 3) for Reach and Angle of Maximum Torque

1. Block OHM unit and overcurrent unit (if present) closed.

2. Connect a pair of light leads from "Relay Contacts" binding posts to relay terminals to observe closure of MHO unit terminals.

3. Turn "Power ON" in Models SR-51 and CS-5 or CS-6. "Power ON" lights should glow.

4. Initiate Model SR-51 by pressing the "Initiate" Switch.

5. Adjust current through the current coil of the relay to desired value by turning the "Main Control" on SR-51 slowly clockwise. (The value of current will be calculated from the impedance settings of the relay and will be provided to the personnel performing the test (suggested value 5 amps.).

6. Adjust the phase angle by means of the "Coarse" and "Fine" phase shifter adjustment on CS-5 or CS-6 to the angle of maximum torque of the relay (e.g. 60° current lag) or values as determined from actual operating conditions. Continuity light may be extinguished. If so, follow with first part of Step 7.

7. Rotate "Aux. Control" clockwise on SR-51 until the continuity light glows. Continue to rotate "Aux. Control" until continuity light extinguishes. Continue to increase voltage for another 10-15 volts.

8. Reduce voltage slowly by rotating "Aux. Control" counterclockwise until the contacts of the MHO unit just close (as shown by flickering of the continuity light).

9. Record the values of current, voltage and phase angle.

10. Return "Main" and "Aux." Controls on SR-51 to zero (maximum counterclockwise).

11. To determine angle of maximum torque, repeat Steps 4 - 10 for two (2) other phase angles, equi-distant from 60° current lag. (e.g. 30° current lag and 90° current lag)

12. Turn Models SR-51 and CS-5 or CS-6 OFF.

13. Remove all blocking from the relay.

Testing "OX" Unit (Phase Shifter not required)

SETUP OF CONTROLS BEFORE TEST - Model SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O. MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT"
"Voltmeter Range" Switch	So that test voltage will be read in upper 1/3 of scale
"Voltmeter Selector" Switch	DC
"Aux. Selector" Switch	DC of desired voltage
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5.0A
"Main Ammeter Range" Switch	500
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1"

1. Block MHO, OHM and overcurrent unit contacts closed.
2. Connect a pair of light leads to relay terminals associated with "OX" unit operating coil.
3. Connect the other end of the leads to terminals marked "DC Output" on SR-51.
4. Connect a pair of light leads from terminals marked "Relay Contacts" to terminals of relay to observe opening of "OX" unit trip circuit contacts.
5. Turn "Power ON" Switch to ON. "Power ON" light and Continuity light should glow.
6. Initiate unit by pressing "Initiate" Switch.
7. Advance "Aux. Control" slowly clockwise until the continuity light is extinguished. Observe the voltage on the voltmeter. This is the pickup voltage of the "OX" relay.

8. Return "Aux. Control" to zero (maximum counterclockwise).

9. Reconnect the continuity light to relay terminals to observe closure of "OX" unit contacts. Continuity light is extinguished.

10. Advance "Aux. Control" slowly clockwise until the continuity light glows. Observe the pickup voltage of the "OX" relay on the voltmeter.

11. Turn "Aux. Control" slowly counterclockwise until continuity light is extinguished. Observe the dropout voltage of the "OX" relay on the voltmeter.

12. Return the "Aux. Control" to zero (maximum counterclockwise).

13. Turn Model SR-51 OFF.

14. Remove all blocking from the relay.

Testing "S" Relay - (Phase Shifter and Phase Angle Meter not required)

SETUP OF CONTROLS BEFORE TEST - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	So that test voltage will be read in upper 1/3 of scale
"Voltmeter Selector" Switch	DC
"Aux. Selector" Switch	DC desired voltage
"Aux. Control" Switch	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5.0A
"Main Ammeter Range" Switch	500
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1"

1. Connect a pair of light leads to relay terminals associated with "S" unit operating coil.
2. Connect the other end of the leads to terminals marked "DC Output" on Model SR-51.
3. Connect a pair of light leads from terminals marked "Relay Contacts" to relay terminals so as to observe operation of "S" unit contacts.
4. Turn the "Power ON" Switch ON. "Power ON" light should glow.
5. Initiate unit by pressing "Initiate" Switch.
6. Observe the Continuity light. Light should be extinguished.
7. Advance "Aux. Control" slowly clockwise until the Continuity light glows. Observe the pickup voltage of the "S" relay on the voltmeter.
8. Turn "Aux. Control" slowly counterclockwise and observe the drop-out voltage of "S" relay as indicated when the continuity light is extinguished.
9. Return the "Aux. Control" to zero (maximum counterclockwise).
10. Turn Model SR-51 OFF.

Testing Overcurrent Unit - Phase Shifter and Phase Angle Meter is not required

SETUP OF CONTROLS - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	"EXT.AC"
"Aux. Selector" Switch	"VERN."
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A

CONTROL	POSITION
"DC Range" Switch	5A
"Output #1-#2" Switch	"Output #1
"Main Ammeter Range" Switch	So that test current may be read in UPPER 1/3 of scale
"Voltage Relay Test" (DET) Switch	Set "NORM."

1. Block the OHM and MHO unit trip circuit contacts closed.
2. Connect a set of heavy leads to relay terminals associated with the overcurrent unit operating coil.
3. Connect the other end of these leads to the "Output #1" terminals of SR-51. Use suitable Common for the ammeter range to be utilized and desired output taps. (See "Selection of Output Taps")
4. Connect a pair of light leads from terminals marked "Relay Contacts" to relay trip circuit terminals so as to observe operation of overcurrent unit contacts.
5. Turn "Power ON" Switch ON. "Power ON" light should glow.
6. Initiate unit by pressing "Initiate" Switch.
7. Turn "Main Control" and "Aux. Control" slowly clockwise until instantaneous element picks up. Continuity light should glow.
8. Read current on ammeter. This is the pickup current of the instantaneous overcurrent element.
9. Return "Main Control" to zero (maximum counterclockwise).
10. Turn the SR-51 OFF.
11. Remove all blocking from the relay.

Testing of Target and Seal-In Unit - Phase Shifter and Phase Angle Meter not required.

SETUP OF CONTROLS - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)

CONTROL	POSITION
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	"EXT. AC"
"Aux. Selector" Switch	8 DC
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	So that test current will be read in UPPER 1/3 of scale
"Main Ammeter Range" Switch	500
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2 Switch	"Output #1"

1. Block the OHM, MHO and Instantaneous Overcurrent Element (when supplied) trip circuit contacts closed.

2. Connect a pair of light leads from terminals marked "Relay Contacts" to relay trip circuit terminals so as to observe operation of seal-in contacts.

3. Connect a set of light leads to relay terminals associated with target and seal-in operating coil.

4. Connect other end of the leads to terminals marked "DC Output".

5. Turn "Power ON" Switch ON. "Power ON" light should glow.

6. Initiate unit by pressing "Initiate" Switch.

7. Rotate "Aux. Control" slowly (clockwise) to increase output.

8. Observe Target operation. When Seal-In contacts close, the Continuity light will glow.

9. Read pickup current on DC ammeter.

   NOTE: Target and Seal-In operation can be observed by alternately pressing and holding the "Press to Trip DC" Switch on SR-51 with one hand and resetting the target with the other hand and then releasing the switch.

10. Return the "Aux. Control" to zero (maximum counterclockwise).

11. Turn SR-51 OFF.

12. Remove all blocking from the relay.

OVER-ALL TEST OF GCX RELAY

The following tests provide over-all operational tests of the GCX relay. They verify the integrity of internal connections in the relay, correct polarization between the OHM and the MHO units, and the operation of the "OX" relay.

SETUP OF CONTROLS BEFORE TEST - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	So that test voltage will be read in UPPER 1/3 of scale
"Voltmeter Selector" Switch	"EXT." AC
"Aux. Selector" Switch	150 DC
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that test current will be read in UPPER 1/3 of scale.
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1"

SETUP OF CONTROLS BEFORE TEST - MODELS CS-5 or CS-6

CONTROL	POSITION
"Power ON-OFF" Switch	OFF
"Input Voltage" Selector	As required (Not on CS-6)
"Phase Shift Adjust Coarse"	Any position
"Phase Shift Adjust Fine"	Counterclockwise
Switch (upper right)	Phase Shift Output

1. Connect Model CS-5 or CS-6 output terminals marked "Phase Shifter Output" to relay potential coil terminals. Observe polarity. ± to ±.

2. Connect one set of light leads from terminals marked "DC Output" to relay terminals associated with "OX" unit operating coil.

3. Connect SR-51 "AC Output #1" to the relay current operating coil terminals. Current coils are connected in series. Observe polarity.

4. Plug in the telephone type plug into the "P.A.M." jack on SR-51. Connect the leads from the plug to the CS-5 or CS-6 terminals marked "Current Coil Input". Observe polarity. Connect black lead to terminal marked "±".

5. Connect a pair of light leads from terminals marked "Relay Contacts" to relay trip circuit terminals to observe closure of overcurrent, OHM and MHO unit contacts through circuit with "OX" unit Normally Closed contacts.

6. Select 150V range on the "Voltmeter Range" Switch.

7. Hook up external voltmeter terminals on SR-51 to output terminals of phase shifter.

8. Connect CS-5 or CS-6 to a suitable source of power and SR-51 to 120 volts, single-phase power.

9. Turn "Power ON" Switches in Model SR-51 and CS-5 or CS-6. "Power ON" lights should glow.

10. Initiate Model SR-51 by pressing "Initiate" Switch.

11. Select proper ammeter range on Main Ammeter. The range should be high enough to register the current sufficient to pick up the OHM unit (Zone 1) when phase shifter output voltage is applied to potential coils of relay.

12. Rotate "Main Control" on SR-51 clockwise to pass about 5 amperes through relay current coils. Rotate "Coarse" and "Fine" controls on CS-5 or CS-6 until desired phase angle is read on phase angle meter. (e.g. 90° current lag). Continue to rotate "Main Control" on SR-51 until Continuity light glows. Rapidly read current, voltage and phase angle.

13. Reduce the current to zero by turning "Main Control" to its maximum counterclockwise position.

14. Record the value of current, voltage and phase angle observed in Step 12.

15. Repeat Steps 12 through 14 for another phase angle, if desired.

16. Increase the DC output voltage by turning the "Aux. Control" on the SR-51 slowly clockwise until the "OX" relay picks up as indicated by a clicking noise. This will set up the relay for the second zone operation.

17. Hook Continuity light across relay trip circuit terminals to observe closure of Overcurrent, OHM and MHO unit contacts through circuit with "OX" unit Normally Open contacts.

18. Repeat Steps 12 through 15.

DISTANCE RELAY (MHO)
GENERAL ELECTRIC TYPE GCY

The Type GCY relay is a high speed directional distance relay containing three (3) MHO units known as the M_1 unit, the M_2 unit and the OM_3 unit. Each of these units contains a wound field with both current and voltage coils and an armature shaped like a cup. The units operate like single-phase induction motors. Generally speaking, the voltage coils produce torque to hold the relay trip circuit contacts open while the current coils produce torque to close the trip circuit contacts.

The M_1 unit is used for first zone protection. This unit is an instantaneous unit, has directional qualities and operates independent of any other relay.

The M_2 unit is used for second zone protection. This unit has directional qualities and operates in conjunction with a timing relay. Therefore, a time delayed trip is obtained.

The OM_3 unit may be used for zone 3 protection. This unit has directional qualities; however, its circular impedance characteristics may be offset so as to encompass the origin of the impedance diagram. Thus, this unit may "Reach" backwards. The OM_3 unit is also used in conjunction with a timing relay which results in a time delayed trip.

Testing

PLEASE REFER TO MANUFACTURER'S BULLETIN BEFORE PROCEEDING WITH TEST

Types of Tests

1. MHO Unit M_1 - First (#1) zone Reach and Torque Angle
2. MHO Unit M_2 - Second (#2) zone Reach and Torque Angle
3. MHO Unit OM_3 - Third (#3) zone Reach, Maximum Torque Angle and Offset.

Equipment Required

1. MULTI-AMP Model SR-51 Relay Tester
2. MULTI-AMP Model CS-5 or CS-6 Phase Shifter & Phase Angle Meter

Power Required

Input: 3-phase at approximately 200 VA for Model CS-5
120 volts, 60 hz, 1-phase at approximately 1.0 kva for Models SR-51 and CS-6

NOTE: All mechanical maintenance and adjustments should be performed prior to the electrical tests. Follow recommended procedures as outlined in the manufacturer's bulletin (except when "As Found" tests are required).

Relay must be level for tests.

SETUP OF EQUIPMENT BEFORE TEST

1. Place Model CS-5 or CS-6 to the left of Model SR-51.

2. Place the relay at a convenient location so that easy connections can be made to all terminals, or

2a. Place Model CS-5 or CS-6 and Model SR-51 close to the relay at the switchboard so that the test lead length is kept to a minimum and the relay operation can be observed during testing.

3. If the relay is to be tested on the switchboard, remove plugs from the top and bottom of the unit and replace them with test plugs. Remove bottom plug first.

   WARNING: During removal of cover and plugs, be careful not to activate the Target and Seal-in contacts as this can cause tripping of the circuit breaker.

4. Make sure the Main Switches on CS-5 or CS-6 and SR-51 are OFF.

5. Connect Model CS-5 to a suitable source of 3-phase power.

6. Connect Model SR-51 and CS-6 (when used) to a suitable source of single-phase power as indicated on the nameplate.

SETUP OF CONTROLS BEFORE TEST - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT.", LOWER-"CONT."
"Main Control	Zero (counterclockwise)
"Aux. Power" Switch	"EXT."
"Voltmeter Range" Switch	So that test voltage will be read in upper 1/3 of voltmeter scale
"Voltmeter Selector" Switch	"AC Output #3"
"Aux. Selector" Switch	"AC Output #3 150V"
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that test current will be read in upper 1/3 of ammeter scale
"Voltage Relay Test"(DET)Switch	Set "NORM"
"Output #1-#2" Switch	Output #1

SETUP OF CONTROLS BEFORE TEST - MODEL CS-5 or CS-6

CONTROL	POSITION
"Power ON-OFF" Switch	OFF
Input Voltage Selector	As Required (Not on CS-6)
Phase Shift Adjust Coarse	Any Position
Phase Shift Adjust Fine	Counterclockwise
Switch (upper right)	Phase Shift Output

Testing M_1 Unit (Zone 1) for Reach and Phase Angle

1. Connect Model SR-51 and Model CS-5 or CS-6 together as described in Section 2 under "Use of Phase Shifter and Phase Angle Meter".

2. Connect SR-51 "AC Output #3" binding posts to the relay M_1 unit potential coil terminals. Observe polarity.

3. Connect all the relay current coils in series by jumpering the proper relay terminals. This series circuit is then connected to the SR-51 "Output #1" binding posts. Observe polarity.

4. Connect a pair of light leads from the SR-51 binding posts marked "Relay Contacts" to the relay terminals associated with the relay M_1 unit trip circuit contacts.

5. Turn "Power ON" Switch ON. Both test sets (SR-51 and CS-5 or CS-6) "Power ON" lights should glow.

6. Initiate SR-51 by pressing "Initiate" Switch.

7. Rotate "Main Control" on SR-51 clockwise to energize current coils of relay until the desired value of test current is read on the SR-51 Main Ammeter (suggested 5 amperes). The Continuity light should glow.

8. Adjust the "Coarse" and "Fine" controls on the CS-5 or CS-6 until the phase angle meter indicates the presumed angle of maximum torque for the M_1 unit. (Example: 60° current lag voltage)

9. Rotate the "Aux." Control on the SR-51 clockwise to increase voltage applied to the relay M_1 unit potential coil until the voltmeter indicates a voltage approximately 15-20 volts higher than the voltage where the continuity light extinguishes.

10. Rotate the "Aux." Control on the SR-51 counterclockwise until the Continuity Light flickers. Observe and record the values of voltage, current and phase angle. Calculate "Reach".

11. Return SR-51 "Main" and "Aux." Controls to zero.

12. Repeat Steps 7 through 10 for two other values of phase angle to determine that the presumed angle of maximum torque was really the true angle of maximum torque for the relay M_1 unit. (suggested -15° and $+15^\circ$ from angle chosen in Step 8.

13. Turn "Power ON" Switches OFF on both SR-51 and CS-5 or CS-6.

Testing M_2 Unit (Zone 2) for Reach and Phase Angle

1. Repeat Step 1 above ("Testing M_1 Unit").

2. Connect SR-51 "AC Output #3" binding posts to the relay M_2 unit potential coil terminals. Observe polarity.

3. Repeat Step 3 above. ("Testing M_1 Unit)

4. Connect a pair of light leads from the SR-51 binding posts marked "Relay Contacts" to the relay terminals associated with the relay M_2 unit trip circuit contacts.

5. Repeat Steps 5, 6, 7 for "Testing M_1 Unit".

6. Adjust the "Coarse" and "Fine" Controls on the CS-5 or CS-6 until the Phase Angle Meter indicates the presumed angle of maximum torque for the M_2 unit. (Example: 75° current lag voltage)

7. Repeat Steps 9-13 above. (Testing M_1 Unit)

Testing OM_3 Unit (Zone 3) for Reach, Phase Angle and Offset.

1. Repeat Step 1 "Testing M_1 Unit".

2. Connect SR-51 "AC Output #3" binding posts to the relay OM_3 unit potential coil terminals. Observe polarity.

3. Repeat Step 3 "Testing M_1 Unit".

4. Connect a pair of light leads from the SR-51 binding posts marked "Relay Contacts" to the relay terminals associated with the relay OM_3 unit trip circuit contacts.

5. Repeat Steps 5, 6 and 7 "Testing M_1 Unit".

6. Adjust the "Coarse" and "Fine" Controls on the CS-5 or CS-6 until the Phase Angle Meter indicates the presumed angle of maximum torque for the OM_3 unit. (Example: 75° current lag voltage)

7. Repeat Steps 9 through 12 above. ("Testing M_1 Unit")

8. Repeat Step 7 "Testing M_1 Unit".

9. Adjust "Coarse" and "Fine" Controls on CS-5 or CS-6 until the Phase Angle Meter indicates a shift of 180° from the OM_3 unit angle of maximum torque.

10. Repeat Steps 9 and 10 "Testing M_1 Unit" except the calculation will be Offset of the OM_3 unit.

DISTANCE (IMPEDANCE) RELAY

(Westinghouse Type HZ)

GENERAL

The HZ relay is a high speed zone distance impedance type relay providing either an instantaneous or a time delay trip. The total relay contains five (5) major units, namely, three (3) instantaneous impedance units, a directional unit and a synchronous timer, each of which is described below:

Instantaneous Impedance Units

These units work on the balance-beam principle. A magnetic beam is pivoted between two voltage actuated coils which produce a magnetic pull on one end of the beam, and a current actuated coil which produces a magnetic pull on the other end of the beam. When the pull produced by the current coil exceeds the pull produced by the voltage coils, the beam tips and closes the relay trip circuit contacts. The values of voltage and current required to tip the beam and close relay trip circuit contacts, may be varied through the use of a core screw and taps on the relay current coil.

Directional Unit

This is a polarized electromagnetic unit with a pivoted armature. There are two (2) potential coils and one (1) current coil. The unit is designed so that for all current/voltage phase relationship between current lead 100° to current lag 80° passing through 0° lag, torque is produced to close the unit's contacts. For all the other current/voltage phase relationships, the directional unit's contacts are restrained.

Synchronous Timer

This is a motor driven timing unit that provides a time delay for closing the relay trip circuit contacts in Zones 2 and 3.

TESTS TO BE RUN

Balance - Impedance Unit Zone 1
Balance - Impedance Unit Zone 2
Pickup of Directional Unit
Pickup Impedance Units Zone 1, Zone 2, Zone 3
Timing Test - Zone 2 Impedance Unit
Timing Test - Zone 3 Impedance Unit
Pickup of Target and Seal-In

TEST PROCEDURES

ALWAYS CONSULT MANUFACTURER'S LITERATURE BEFORE STARTING TEST

Balance - Impedance Unit - Zone 1

SETUP OF CONTROLS BEFORE TEST - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	So that test voltage may be read on UPPER 1/3 of scale
"Voltmeter Selector" Switch	"AC-3"
"Aux. Selector" Switch	AC of desired voltage
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that test current may be read on UPPER 1/3 of scale
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	Output #1

1. Connect SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
2. Connect Zone 1 current coil to "Output #1".
3. Connect Zone 1 potential coil to "AC Output 3".
4. Connect Continuity light across terminals on relay so as to observe operation of Zone 1 contacts.
5. Block directional unit contacts closed.
6. Turn "Power ON" Switch ON. "Power ON" light should glow.
7. Initiate unit by pressing "Initiate" Switch.

8. Rotate "Aux. Control" clockwise until 35 volts is applied to voltage coils.

9. Rotate "Main Control" clockwise until Zone 1 contacts close as indicated by glowing of Continuity light.

10. Record this value of current.

11. Return both "Aux. Control" and "Main Control" to zero (counter-clockwise).

12. Rotate "Aux. Control" clockwise until 5 volts is applied to voltage coils.

13. Rotate "Main Control" clockwise until Zone 1 contacts close as indicated by glowing of Continuity light.

14. Record this value of current. It should be approximately 1/7th of value record in Step 10.

15. Remove all relay blocking.

Balance - Impedance Unit Zone 2

1. Same setup of controls and hookup as for Zone 1, except Zone 2 coils and contacts are connected to test unit; Timer Contacts "T_1" are jumpered; directional unit contacts are blocked closed.

2. In Step 8 use 60 volts.

3. In Step 12 use 10 volts.

4. In Step 14 second current should be approximately 1/6th of first current.

5. Remove jumper from "T_1" contact.

6. Remove blocking - directional unit.

Balance - Impedance Unit Zone 3

1. No electrical test recommended. Beam should be balanced when both current and potential coils are de-energized.

Pickup of Directional Unit

SETUP OF CONTROLS - MODEL SR-51 RELAY TESTER

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)

CONTROL	POSITION
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	1.5 or 7.5 depending upon position of "D.E.T." Switch
"Voltmeter Selector" Switch	"D.E.T."
"Aux. Selector" Switch	"D.E.T."
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	5A or 10A depending upon position of "D.E.T." Switch
"Voltage Relay Test" (DET) Switch	Position 1-4 (as desired)
"Output #1-#2" Switch	"Output #1"

1. Connect SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect Polarity terminal (±) of relay direction unit current operating coil to the Polarity terminal (±) of "AC Output #3". The other relay operating coil terminal should be connected to the desired tap of "Output #1".

3. Connect the relay voltage polarizing coil to "AC Output #3" terminals. The Polarity terminal (±) of the relay voltage polarizing coil should be connected to Non-Polarity terminal of "AC Output #3".

4. Connect Continuity light so as to observe operation of directional unit contacts. If necessary, block other contacts to allow this observation.

5. Turn "Power ON" Switch ON. "Power ON" light should glow.

6. Initiate unit by pressing "Initiate" Switch.

7. Rotate "Main Control" clockwise until relay directional contacts close as indicated by glow of Continuity light.

8. Read and record values of voltage and current.

9. Remove blocking from relay.

Pickup Impedance Units Zone 1, Zone 2, Zone 3

Test Equipment Required
Model SR-51 Relay Tester
Model CS-5, CS-6 or CS-7 Phase Shifter & Phase Angle Meter
Note: Please refer to CS-7 instruction book when testing with Model CS-7

SETUP OF CONTROLS - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"EXT."
"Voltmeter Range" Switch	So that test voltage may be read on UPPER 1/3 of scale
"Voltmeter Selector" Switch	"AC-3"
"Aux. Selector" Switch	"AC-3 150"
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that test current may be read on UPPER 1/3 of scale
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1"

SETUP OF CONTROLS - Model CS-5 or CS-6

CONTROL	POSITION
"Power ON-OFF" Switch	OFF
"Input Voltage Selector"	As required (Not on CS-6)
"Phase Shift Adjust Coarse"	Any position
"Phase Shift Adjust Fine"	Counterclockwise
Switch (upper right)	"Phase Shift Output"

1. Connect SR-51 "AC Output #1" to relay current operating coil terminals. The relay current coils should be connected in series. Observe polarity.

2. Connect all relay potential polarizing coils in parallel and across "AC Output #3" binding posts. Observe polarity.

3. Connect Continuity light so as to observe operation of Impedance Unit #1 trip circuit contacts.

4. Turn "Power ON" Switches ON. "Power ON" lights should glow.

5. Initiate unit by pushing "Initiate" Switch.

6. Adjust current through operating coils of relay to the desired value by rotating the "Main Control" on the SR-51 clockwise. (suggested 5 amps.)

7. Adjust Phase Shifter to desired Phase Angle. (suggested relay angle of maximum torque.) Continuity light should glow.

8. Increase applied voltage by rotating "Aux. Control" on SR-51 clockwise until Continuity light is extinguished. Increase voltage 10-15 volts above this point. Then slowly decrease voltage by counterclockwise rotation of "Aux. Control" on SR-51 until the Continuity light glows. Record these values of current, voltage and phase angle as pickup of Zone 1 Impedance Unit.

9. Return "Main Control" and "Aux. Control" to zero positions.

10. Jumper relay timer contacts.

11. Connect Continuity light to observe operation of Impedance Unit #2 trip circuit contacts.

12. Repeat Steps 6-9 above. Record the values of current, voltage and phase angle as pickup of Zone 2 Impedance Unit.

13. Connect Continuity light to observe operation of Impedance Unit #3 trip circuit contacts.

14. Repeat Steps 6-9 above. Record the values of current, voltage and phase angle as pickup of Zone 3 Impedance Unit.

15. Turn test sets OFF and remove all relay blocking and jumpers.

Timing Test - Zone 2 Impedance Unit

SETUP OF CONTROLS BEFORE TEST - MODEL SR-51

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER - "N.O. MOM" LOWER - "CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"EXT."
"Voltmeter Range" Switch	So that test voltage will be read on UPPER 1/3 of scale
"Voltmeter Selector" Switch	"AC EXT."
"Aux. Selector" Switch	"DC 150V"
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that test current will be read on UPPER 1/3 of scale
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1"

SETUP OF CONTROLS BEFORE TEST - MODEL CS-5 or CS-6

CONTROL	POSITION
"Power ON-OFF" Switch	OFF
"Input Voltage Selector"	As required (Not on CS-6)
"Phase Shift Adjust Coarse"	"A"
"Phase Shift Adjust Fine"	Counterclockwise
Switch (upper right)	"Phase Shift Output"

1. Connect SR-51 "AC Output #1" to relay current operating coil terminals. The relay current coils should be connected in series. Observe polarity.

2. Connect all relay potential polarizing coils in parallel and to "Phase Shifter Output" terminals of CS-5 or CS-6. Observe polarity.

3. Connect a pair of light leads from "Phase Shifter Output" terminals on CS-5 or CS-6 to "External Voltmeter" terminals on SR-51.

4. Connect "DC Output" binding posts on SR-51 to relay terminals so that lower contact switch of relay may be energized.

5. Rotate "Aux. Control" 1/2 turn clockwise.

6. Turn "Power ON" Switches ON. "Power ON" lights should glow.

7. Set Pointer Pre-Set on Main Ammeter to 1/2 division below desired test current. This value of current should be high enough to pick up Zone 2 Impedance Unit. It may be calculated from relay settings and voltage available from "Phase Shifter Output".

8. Rotate "Main Control" clockwise to increase current to desired value. Jog "Initiate" Switch. Set CS-5 or CS-6 to desired phase angle.

9. Connect "Relay Contacts" binding posts on SR-51 to relay terminals so that closure of "Timer 1" contacts may be observed.

10. Adjust "Timer Operation Selector" Switch, UPPER-"N.O. MAINT.", LOWER - "TIMER".

11. Initiate unit by pressing "Initiate" Switch.

12. Record time to trip.

Timing Test - Zone 3 Impedance Unit

Repeat Steps 1 through 12 above except that in Step 9, connect so as to time closure of Timer 2 contacts.

Pickup of Targets

See DC Target and Seal-In test procedure.

TYPICAL TESTS FOR DC AUXILIARY RELAYS
Model SR-51 Only

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

Type of Tests

Pickup
Dropout

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT" LOWER-"CONT".
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT"
"Voltmeter Range" Switch	So that desired test voltage will be read in upper 1/3 of scale
"Voltmeter Selector" Switch	DC
"Aux. Selector" Switch	150 or 300 DC
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Output #1-#2" Switch	"Output #1"
"Main Ammeter Range" Switch	500
"Voltage Relay Test"(DET) Switch	Set "NORM"

Testing Pickup and Dropout

1. Connect Model SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect relay operating coil terminals to "DC Output" binding posts of test set.

3. Connect light leads from test set binding posts marked "Relay Contacts" to trip circuit contact terminals of the relay.

4. Turn "Power ON" Switch ON. "Power ON" light should glow.
5. Initiate unit by pressing "Initiate" Switch.
6. Rotate "Aux. Control" clockwise to increase output until continuity light glows.
7. Read pickup voltage on voltmeter. Record.
8. Rotate "Aux. Control" counterclockwise to decrease output until continuity light extinguishes.
9. Read dropout voltage on voltmeter. Record.
10. Turn test set OFF.

TESTING DC TARGET AND SEAL-IN UNITS (Operations Indicator)

The operating coil of the Target and Seal-In unit is usually located in the same circuit as the relay trip circuit contacts. Therefore, when using the relay's trip circuit terminals as a connection to energize the Target unit operating coil, the relay's trip circuit contacts must be closed or shunted.

Testing

Always refer to manufacturer's literature before testing.

Type of Test

1. Pickup

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER- "DC"
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	300
"Voltmeter Selector" Switch	"EXT. AC"
"Aux. Selector" Switch	8 VDC
"Aux. Control"	Zero (counterclockwise)
"AC Range Switch"	10A
"DC Range" Switch	As desired
"Main Ammeter Range" Switch	"500"
"Voltage Relay"(DET) Switch	Set "NORM"
"Output #1-#2" Switch	"Output #1"

1. Connect Model SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect light leads from binding posts marked "Relay Contacts" to operating coil of Target and Seal-In units.

3. If necessary, close relay trip circuit contacts. This may be done electrically or mechanically. To close these contacts electrically, energize the proper operating coil from "Output #1" or "Output #2" of the test set. When "Output #1" is used, it will be necessary to adjust the test set Main ammeter switch so that the current required to close the relay trip circuit contacts may be read on the upper 1/3 of ammeter scale.

4. Turn "Power ON" Switch ON. "Power ON" light should glow.

5. Initiate unit by pressing "Initiate" Switch.

6. When relay trip circuit contacts are closed electrically, rotate "Main Control" clockwise to energize proper operating coil.

7. Rotate "Aux. Control" slowly (clockwise) to increase output until Target shows or Seal-In picks up.

8. Observe DC amperes on DC Ammeter and record.

9. Open relay trip circuit contacts. The DC trip circuit should remain energized through the Seal-In contacts.

TESTING INSULATION RESISTANCE

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER-"N.O.MAINT." LOWER-"OFF"
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT."
"Voltmeter Range" Switch	"INS. RES."
"Voltmeter Selector" Switch	"INS. RES."
"Aux. Selector" Switch	"INS. RES."
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	500
"Voltage Relay Test"(DET) Switch	Set "NORM."
"Output #1-#2" Switch	"Output #1"

Testing

1. Connect the SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
2. Connect high voltage test leads to terminals marked "INS. RES."
3. Throw "Power ON" Switch to ON. "Power ON" light should glow.
4. Initiate unit by pressing "Initiate" Switch.
5. Make sure test probes are separated.
6. Increase "Aux. Control" (clockwise) until reading of infinity is obtained on megohm scale of voltmeter on SR-51.
7. Apply test probes to the equipment to be tested. The relay components will not be harmed as long as one probe is applied to relay frame and the other to all external terminals of the relay. If the relay insulation is good, the megohmmeter should continue to read in upper 10% of scale.

CAUTION

TEST PROBES HAVE 1200 VOLTS AC IMPRESSED ON THEM. CARE SHOULD BE TAKEN IN HANDLING

TYPICAL TEST FOR HEATER TYPE THERMAL MOTOR OVERLOAD RELAYS

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power On" Switch	OFF
"Timer Operation Selector"	UPPER - "N.C. MOM", LOWER - "CONT"
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT"
"Voltmeter Range" Switch	"300"
"Voltmeter Selector" Switch	"EXT. AC"
"Aux. Selector" Switch	"VERN"
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that test current may be read on upper 1/3 of scale.
"Voltage Relay Test"(DET) Switch	Set "NORM"
"Output #1-#2" Switch	Output #1

Test Procedure

1. Refer to manufacturer's literature for connection points and TIME-CURRENT Curves of the device to be tested.
2. Connect the test set to a suitable source of power as indicated on the nameplate. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.
3. Connect operating coil or heater of device to be tested to "Output #1" of the test set.
4. Connect relay contacts of device being tested to "Relay Contacts binding posts of test set.
5. Preset main ammeter needle 1/2 division below desired test current through the use of the pointer pre-set.

6. Turn "Power ON" Switch ON. "Power ON" light should glow.

7. Jog test set with "Initiate" switch and rotate "Main Control" clockwise to increase current to desired value.

8. Set "Timer Operation Selector" Switch, UPPER - "N.C. MAINT", LOWER - "TIMER".

9. Reset timer to zero.

10. Initiate unit with "Initiate" Switch and run test.

11. If minor adjustments in current are necessary, use "Aux. Control".

12. Timer stops and test set will de-energize when device under test trips.

13. Read timer and record results. Compare to manufacturer's specifications.

THERMAL OVERLOAD RELAYS

(Westinghouse Type BL-1) (General Electric Type TMC)

GENERAL

The Westinghouse Type BL-1 is a thermal overload relay basically designed to provide overload running protection of a motor. The relay may be used anywhere if the current transformer ratio is such that at full load current of the motor, the relay receives between 2.5 - 5.0 amperes. The relay setting is changed by moving an indicator on a sliding scale and/or changing the position of short-circuiting links. When the scale pointer is set to one of the indicated current values (motor full load current), the relay contacts will close in approximately 60 minutes if the current increases to 125% of motor full load current. (NOTE: The full load current must have been flowing long enough for the temperature rise to reach a constant value.)

The General Electric Type TMC is a thermal relay also providing overload running protection for motors. The range of adjustment of the relay is from 2.01 - 5.09 amperes (current transformer secondary currents). However, the relay rating is changed through the use of 10 interchangeable operating coils. The relay is provided with a screw adjustment to vary the setting of each operating coil from 90% to 110% of the rated coil current.

Both the BL-1 and TMC relays are ambient compensated and are equipped with instantaneous elements for short circuit protection of a motor.

Testing

Type Of Tests

Time Current Characteristics
Instantaneous Pickup

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER "N.O. MOM" LOWER "CONT."
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	INT
"Voltmeter Range" Switch	"300"

CONTROL	POSITION
"Voltmeter Selector" Switch.....	"EXT. AC"
"Aux. Selector" Switch.....	VERN
"Aux. Control".....	Zero (counterclockwise)
"AC Range" Switch.....	10A
"DC Range" Switch.....	5A
"Main Ammeter Range" Switch.....	So that test current may be read in upper 1/3 of scale.
"Voltage Relay Test" (DET) Switch...	Set "NORM"
"Output #1-#2 Switch.....	Output #1

Testing for Time Current Characteristics

1. Refer to manufacturer's literature for connection points and TIME-CURRENT curves of the relay to be tested.

2. Connect the SR-51 to a suitable source of power as indicated on the nameplate. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

3. Connect the relay thermal unit operating coil terminals to the test set "AC Output #1" terminals.

4. Turn "Power On" switch "ON". "Power On" light should glow.

5. Use main ammeter pre-set to set the main ammeter needle approximately 1/2 scale division below desired test current.

6. Jog the test set by alternately pressing and releasing the "initiate" switch. At the same time rotate the "Main Control" clockwise, until the main ammeter needle moves off the pre-set and indicates the desired amount of test current.

7. Connect test set "Relay Contacts" binding post to the relay trip circuit contact terminals associated with the relay thermal element.

8. If necessary allow the relay coil to cool down to approximately room temperature.

9. Set "Timer Operation Selector" Switch, UPPER - "N.O. Maint", LOWER - "TIMER".

10. Reset timer to zero.

11. Initiate unit with "Initiate" switch and run test.

12. If minor adjustments in current are necessary, use "Aux. Control."

13. Timer will stop and test set will de-energize when thermal unit trip circuit contacts of relay close.

14. Read timer and record results. Compare to manufacturer's specifications.

Testing Instantaneous Trip

1. Connect the SR-51 to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect instantaneous unit operating coil of the relay to "Output #1" of the test set.

3. Connect light leads from binding posts marked "Relay Contacts" on the test set to instantaneous unit trip circuit contact terminals on the relay.

4. Set "Timer Operation Selector" Switch, UPPER - "N.O. MOM", LOWER - "FAST TRIP".

5. Turn "Power ON" Switch ON.

6. Initiate unit by holding in "Initiate" Switch.

7. Rotate "Main Control" (clockwise) to increase current until timer stops.

8. Rapidly read this value of current and release "Initiate" switch.

   WARNING !!! CURRENT IS FLOWING THROUGH THE RELAY COIL UNTIL "INITIATE" SWITCH IS RELEASED. THEREFORE, IT IS IMPORTANT TO READ THE VALUE OF CURRENT RAPIDLY.

9. Decrease setting of "Main Control" about 10% and jog the "Initiate" switch. Determine minimum setting of "Main Control" where relay instantaneous trip circuit contacts of the relay consistently close when the test set "Initiate" switch is pressed.

10. Read and record pickup current.

11. Turn test set off.

TESTING ROWAN MAGNETIC OVERLOAD RELAYS

1. Types of Tests

   a. Pick-up
   b. Timing

   NOTE: The pick-up test is not normally performed unless it is desired to change the setting, or it is suspected that the setting has been changed.

Pick-up

1. Remove dashpot from the relay by releasing retainers and bearing pin. Set dashpot aside in an upright position.

2. Secure proper calibrating weight from manufacturer and suspend from lower control arm attached to relay armature.

3. Follow test set setup of controls and steps (1) through (4) under "Typical Tests for Heater Type Thermal Motor Overload Relays."

4. Turn"Power ON" Switch ON. Power ON light and continuity light should glow.

5. Initiate test set by pressing "Initiate" switch.

6. Rotate "Main Control" clockwise until continuity light is extinguished.

7. Read and record this value of current as pick-up.

Timing

1. Remove calibrated weight and re-install dashpot if disconnected previously. Operate armature by hand several times to reset piston and oil.

2. Follow entire procedure for "Typical Test for Heater Type Thermal Motor Overload Relays."

TESTING MULTI-POLE MOLDED CASE CIRCUIT BREAKERS

ALWAYS REFER TO MANUFACTURER'S LITERATURE BEFORE TESTING

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER - "N.C. MOM", LOWER - "OFF"
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	INT
"Voltmeter Range" Switch	"300"
"Voltmeter Selector" Switch	EXT AC
"Aux. Selector" Switch	"VERN"
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that desired test current may be read on upper 1/3 of scale.
"Voltage Relay Test"(DET) Switch	Set NORM
"Output #1-#2" Switch	Output #1

Testing

1. Connect test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF. CHECK THE "POWER ON" LIGHT.

2. Connect one pole of circuit breaker to be tested to "Output #1" terminals of the test set.

3. Connect another pole of circuit breaker to be tested to "Relay Contacts" binding posts of the test set.

4. Preset main ammeter needle 1/2 division below desired test current through the use of the pointer preset.

5. Turn "Power ON" Switch "ON". "Power ON" light should glow.

6. Close circuit breaker under test.

7. Jog test set with "Initiate" switch and rotate "Main Control" (clockwise) to obtain desired test current.

8. Adjust "Timer Operation Selector" Switch - UPPER - "N.C. MAINT", LOWER - "TIMER".

9. Reset timer to zero.

10. Initiate unit with "Initiate" Switch and run test.

11. If minor adjustments in current are necessary, use "Aux. Control".

12. Timer stops and test set de-energizes when circuit breaker under test trips.

13. Read timer and record results. Compare to manufacturer's specifications.

TESTING SINGLE POLE MOLDED CASE CIRCUIT BREAKERS

NOTE: The MULTI-AMP test set must be equipped with a Current Actuator (optional accessory) to use this test procedure.

SETUP OF CONTROLS BEFORE TEST

CONTROL	POSITION
"Power ON" Switch	OFF
"Timer Operation Selector" Switch	UPPER - "N.O. MOM" LOWER - "OFF"
"Main Control"	Zero (counterclockwise)
"Aux. Power" Switch	"INT"
"Voltmeter Range" Switch	"300"
"Voltmeter Selector" Switch	"EXT. AC"
"Aux. Selector" Switch	"VERN"
"Aux. Control"	Zero (counterclockwise)
"AC Range" Switch	10A
"DC Range" Switch	5A
"Main Ammeter Range" Switch	So that desired test current may be read on upper 1/3 of scale.
"Voltage Relay Test" (DET) Switch	Set "NORM"
"Output #1-#2" Switch	Output #1

Testing

1. Connect test set to a suitable source of power as indicated on the nameplate and ground. BE SURE THE MAIN SWITCH IS OFF.
2. Connect single pole circuit breaker to be tested to "Output #1" terminals of the MULTI-AMP.
3. Preset main ammeter needle 1/2 division below desired test current through the use of the pointer preset.
4. Turn "Power ON" Switch "ON". "Power ON" light should glow.
5. Close circuit breaker under test.

6. Jog test set with "Initiate" Switch and rotate "Main Control" (clockwise) to obtain desired test current.

7. Adjust "Timer Operation Selector" Switch, UPPER - "N.O. MOM" LOWER - "TIMER".

8. Reset timer to zero.

9. Initiate unit with "Initiate" switch and run test.

10. If minor adjustments in current are necessary, use "Aux. Control".

11. Timer stops and test set de-energizes when circuit breaker under test trips.

12. Read timer and record results. Compare with manufacturer's specifications.

SERVICE DATA

Your MULTI-AMP test set basically uses straightforward circuits and components requiring little or no routine servicing except for cleanliness.

The following maintenance is recommended:

1. Open the unit every six months and examine for:
   a. dirt
   b. moisture
   c. corrosion
   d. condition of relay contacts
2. Remove dirt with dry compressed air.
3. Remove moisture by opening unit as much as possible and putting it in a warm dry environment.
4. As corrosion may take many forms, no specific recommendations can be made for its removal.
5. The contacts on relays and contactors should be examined for pitting and burning. The contacts on control relays and contactors may be burnished with a diamond dressing tool if not too badly damaged. If excessive pitting or burning has occurred, the relay or contactor should be replaced.

Current Actuator

The minimum amount of output current which will cause the Thyratron tube to "fire" and operate the relay is between 10% and 20% of full scale on the ammeter. This point is factory set and may be adjusted in the field by means of the potentiometer on the control chassis. This potentiometer is located next to the Thyratron tube and has a screwdriver slot and shaft lock.

Adjustment:

1. Set the controls on the unit so that output may be obtained.
2. Set "Main Control" at zero and put a short circuit across the output of the unit. The lowest voltage, highest current tap and "Common for Ammeter" is used.

3. Set controls for "CA" operation.

4. Set "Ammeter Range" switch to any position.

5. Turn power ON and rotate "Main Control" until the ammeter indicates 20% of full scale.

6. Adjust the potentiometer until the timer hands just start running at this point.

Notes:

1. If attempt is made to make the "CA" pick up at too low a current value, the unit will chatter when the load circuit is broken.

2. The sensitivity of the "CA" circuit will vary slightly due to the phase angle of the load and aging of the Thyratron tube.

3. If the "CA" refuses to operate, the 2D21 tube should be replaced first.

14130D

EASI FILE CORP. IRVINE, CA EFH22

5

4	18769 12-7-86	2	10602 10-8-87	DWG. NO. 14130
5	20052 11-19-86	3	14227 2-2-88	1

S4 AUX SELECTOR

POS.	1-VERN	6-DET.
	2-24	7-300
	3-150 AC #3	8-150 DC
	4-300	9-8
	5-V RLY	10-I.RES

S5-TIMER OPER. SELECTOR

KNOB	LEVER
POS. 1-MOM. N.O.	POS. 1-DC
2-MAINT. N.O.	2-CONTINUITY
3-CURR. ACT.	3-TIMER
4-MAINT. N.C.	4-OFF
5-MOM. N.C.	5-FAST TRIP
SECTIONS i,j,k,l,m,n,o,p	SECTIONS a,b,c,d,e,f

S7-VOLT-RELAY TEST-DET

POS.	1-SET NORM	7-6
	2-SET FAULT	8-5
	3-TEST	9-4
	4-9	10-3
	5-8	11-2
	6-7	12-1

S8-VOLTMETER SELECTOR

POS.	1-EXT. DC	5-V RLY
	2-EXT. AC	6-I. RES
	3-AC-2	7-D.E.T.
	4-AC-3	8-DC

S9-VOLTMETER RANGE

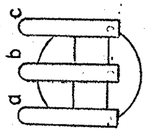
POS.	1-1.5	5-75
	2-7.5	6-150
	3-15	7-300
	4-30	8-I. RES

SI3-MAIN AMMETER RANGE

POS.	1-2.5	5-50
	2-5	6-100
	3-10	7-250
	4-25	8-500

DRAWING SYMBOLS-PER USAS Y32.2-1967

- BRIDGE RECTIFIER
- VARIABLE AUTO TRANSFORMER
- FUSE
- CAPACITOR
- RESISTOR
- (X1) RELAY COIL
- ⊥ RELAY CONTACTS N.O.
- ⊤ RELAY CONTACTS N.C.
- SWITCH OR (DOUBLE BREAK)
- S4 d / 3 TYPICAL SWITCH IDENTIFICATION
- S4=SWITCH NUMBER
- d= SWITCH SECTION
- 3= POSITION IN WHICH CONTACTS ARE CLOSED



VOLTMETER CIRCUIT

VOLTAGE RELAY & DIRECTIONAL ELEMENT TEST SWITCH

NOTES
1- □=TERMINALS ON CURRENT ACTUATOR.
2- T8 IS FITTED ON 240V MODEL ONLY.
3- FOR PARTS LIST SEE DWG. 14131B
4- ONE COLOR=SOLID COLOR.
W =WHITE WITH TRACER.
WB =WHITE/BLACK WITH TRACER
5- HV WIRE
6- RELAYS X1, X5 & X6 ARE SINGLE POLE SEE SKETCH AT RIGHT FOR MULTI POLE RELAY LAYOUT (X2,3,4)
7 ⬡ BINDING POST.

multi-amp CORPORATION 4271 BRONZE WAY, DALLAS, TEXAS 75237 (214) 333-3201			
TOLERANCES: DECIMAL ±.010 FRACTIONAL ±1/64 UNLESS NOTED	DWN. RMD	APPD.	SCALE N
	CHK'D.	DATE 7-13-77	SHT. 1 OF 1
TITLE SCHEMATIC MODEL SR-51A		DWG. NO. 14130 D	REV. 5
PART NO. W/ DIGITAL TIMER			