INSTRUCTION MANUAL

For

CIRCUIT BREAKER TEST SETS

MODEL CB-8100 SERIES

SERIAL NO.

It is essential that this instruction book be read thoroughly before putting the equipment in service.

Part No. 12460
Rev. 0

IMPORTANT

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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).

Part No. 12460
Rev. 0

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DESCRIPTION of CONTROLS and INSTRUMENTATION

General Description:

Multi-Amp Circuit Breaker Test Sets are portable high current units designed for testing and adjusting low voltage circuit breakers and other current actuated devices. The units incorporate a variable high current ac output, solid state output initiating and timer initiation circuitry, electronic digital timer, multi-range memory ammeter and circuitry to monitor contact closure or opening. The units are self protected against overloads and short circuits.

Controls & Instrumentation:

OUTPUT CONTROLS: Adjustment of the output is accomplished by the combination of the OUTPUT SELECTOR Switch and VERNIER CONTROL.

OUTPUT SELECTOR Switch: This is a multi-position switch which provides coarse adjustment of the output. Position 1 provides minimum output. The last position provides maximum output. The OUTPUT SELECTOR Switch is interlocked with the output initiating circuit. Depressing the switch to change positions operates the interlock and de-energizes the output.

NOTE: This switch is not present on smaller units.

VERNIER CONTROL: Provides fine adjustment of the output between steps of the OUTPUT SELECTOR Switch.

START Button: Energizes the output.

STOP Button: De-energizes the output when in the MAINT. MODE.

EXT. START (External Initiate Jack): An external switch can be plugged into this jack to provide remote initiation of the test set. The jack is wired in parallel with the START Button.

CONTROL FUSE 1.5A: Provides protection for the control circuits.

TIMER STOP Binding Posts:	These binding posts facilitate connection to a set of contacts on the device under test to monitor contact opening or closure. The timer stops and the output is de-energized when the device operates.
BREAKER CLOSED Panel Lamp and Binding Posts:	These binding posts are wired in series with a panel lamp so that contact action or circuit continuity can be monitored.
Circuit Breaker:	Functions as the input POWER ON/OFF Switch and also provides short-circuit and overload protection.
INPUT ON Panel Lamp:	Indicates when the circuit breaker is ON and input power is available.
OUTPUT ENERGIZED Lamp:	Indicates that the SCR Contactor has gated, the output is energized and output current can now be adjusted.
6 A FUSE:	Protects control and isolation transformers T1 and T6.

<u>MemAmp™ PANEL</u>

DIGITAL AMMETER:	Indicates output current.
AMMETER RANGE Switch:	Selects the desired full scale range of the meter. NOTE: The output current level from the test set must be at least 8 percent of any full scale value before the ammeter will indicate an output reading.
MEMORY/CONTINUOUS Switch:	Selects the mode of the ammeter circuit. In the MEMORY position, the highest measured current is indicated on the ammeter. CONTINUOUS mode permits the ammeter to continually indicate the value of output current. When the ammeter range is set in the 200 amp position, the ammeter will only operate in the continuous mode.

PARALLEL/SERIES Switch:	When operating the unit with the output in series operation, this switch must be in the SERIES position in order for the ammeter to read the correct amount of output current. For details refer to OUTPUT on Page 7.
CA Lamp:	Indicates that the current actuator circuit is activated.

TIMER PANEL

TIMER:	This is a specially designed electronic digital timer for indicating the elapsed time of the test in either seconds or cycles. The timer automatically starts at the beginning of each test and stops when the device under test operates.
CYCLES/SECONDS Switch:	Selects the mode of count either cycles or seconds.
.01/.0001 SECONDS Range Switch:	Selects range of display for seconds mode of operation.
RESET Pushbutton:	Resets timer display to zero.
TIMER OPERATION SELECTOR Switch:	This six-position switch selects which of the three modes of operation is to be used to control the output and timer operation are described below:
(1) C.A. (Current Actuator):	When the device to be tested has no contacts other than those involved in the passing of test current, this type of operation is used. In this position, the timer will run from the initiation of the test until the test circuit is interrupted. This position is the position most commonly used for controlling timer operations.
(2) N.O. (Normally Open):	When it is desired to control the timer from a set of normally open contacts (such as an auxiliary contact) this type of operation may be used. In this position, the timer will run from the initiation of the test until the opening of the contacts connected to the TIMER STOP Binding Posts.
(3) N.C. (Normally Closed):	When it is desired to control the timer from a set of normally closed contacts (such as a multi-pole circuit breaker), this type of operation may be used. In this position, the timer will run from the initiation of the test until the opening of the contacts connected to the TIMER STOP binding posts.

The above three modes of operation can be used in either the MAINT. (maintained or MOM. (momentary) positions.

(1) MAINT. (Maintained):	In this position, when the START Button is pressed, the control circuit is sealed-in to maintain the output of the test set until the device under test operates. This is the normal position for timing tests.
(2) MOM. (Momentary):	In this position, the output of the test set is on for approximately 60 milliseconds. (Should the device under test operate after pushing the START Button, the output will be de-energized). This position is normally used when setting the test current prior to the timing test and providing short high current pulses for instantaneous test. Pushing the STOP Button resets the initiate circuit. The STOP Button must be pressed prior to pushing the START Button for repeat initiation of the output.
EXT. V.M. Binding Posts:	These two binding posts enable the digital voltmeter to measure external a.c. voltages up to 600 Volts. When using the voltmeter to read external voltages, it is necessary that the VOLTMETER CIRCUIT Range Switch be in the proper EXT. range.

VOLTMETER CIRCUIT: The input voltage, output voltage or external a.c. voltage is read on a true rms digital voltmeter. For measuring external voltages, it is necessary to switch the VOLTMETER CIRCUIT Selector Switch to the proper range. If the meter is overranged, the display will flash on and off.

VOLTMETER CIRCUIT Selector Switch: When placed in the INPUT position, the digital voltmeter will read the voltage at the input plugs of the test set. When placed in the OUTPUT position, the digital voltmeter will indicate the output voltage regardless if the output is in series or parallel operation. When in the EXT. position, the digital voltmeter will indicate the voltage applied to the EXT. V.M. binding posts.

CAUTION

To avoid damage to the voltmeter, the polarity of the EXT. V.M. binding posts must be observed. If one side of the circuit to be measured is connected to ground, it must be identified prior to testing it.

AMMETER CIRCUIT: The output current of the Multi-Amp Circuit Breaker Test Sets is read on a digital ammeter connected to the output circuit by appropriate current transformers and an AMMETER RANGE Switch. The desired full scale value of the ammeter is selected by means of the AMMETER RANGE Switch.

It is necessary to have an output current level from the test set of at least eight (8) percent of any full scale value before the ammeter will indicate a current value. When setting output in either MEMORY or CONTINUOUS MODE, it is necessary to adjust the magnitude of output current up to at least 8 percent of any full scale value before the accuracy of the ammeter is within rated full scale accuracy.

The MEMORY mode of operation allows currents of very short duration to be accurately measured. When setting test currents, it is recommended that the operator "jog" the output current with the ammeter in MEMORY mode and continually increase output current to desired level. When the ammeter is in the 200 ampere range, the ammeter will not hold the reading. It is recommended that the CONTINUOUS mode be used for currents below 200 amperes.

To initiate the output of the test set when the TIMER OPERATION SELECTOR Switch is in the C.A. MAINT. (Maintained) position, it is necessary to reset the timer by depressing the RESET pushbutton on the timer.

GND INTERLOCK OPEN Lamp: A special ground interlock circuit is incorporated which verifies that the test set chassis is connected to system ground before the output of the test set can be energized. If not properly grounded, the Lamp will light and prevent the test set from energizing.

INPUT AND OUTPUT CIRCUITS

INPUT:

INPUT VOLTAGE: The Multi-Amp Circuit Breaker Test Sets are designed to operate on a single phase voltage source. If the nominal rated voltage source is not available, or if use at various locations requires the capability to operate the test set from several different input voltages an optional input autotransformer may be used (see Bulletin in Section I for description).

INPUT LEADS: Due to the wide variation in individual user requirements with regard to wire size, terminations and length of leads, all units are supplied with input sockets and matching plugs only. The plug will accept a wide range of wire sizes more than adequate for the duty required. The power source must have sufficient capacity, and the input leads must be large enough to maintain RATED input voltage at the INPUT terminals of the test set. Although the test sets are designed to operate satisfactorily at 95-105% of rated voltage, any drop in voltage below RATED at the input terminals will result in a proportional decrease in the maximum available output.

NOTE: To achieve published output currents, the rated input voltage must be maintained at the test set terminals during the test.

GROUNDING: For safety, ground wires must be connected to the test set chassis in order to energize the test set. One ground lead must be connected to the ground terminal located just below the input plug to system ground. The size of the conductor should be not less than 1/2 the cross-section of the current carrying input leads. Due to the special ground interlock circuit, a second lead must be connected from the green GND binding post to the same system ground. This will insure that a ground has been achieved and allow the test set to be energized.

SAFETY PRECAUTIONS:

CAUTION

For safety of the operator, it is absolutely essential that the test set be properly and effectively grounded.

SELECTION OF INPUT LEADS: When utilizing maximum output from the test set, the input line currents may be a high as 400% of nameplate rating. the following table has been prepared to aid in selecting the proper wire size for the input leads. To use the table, follow these four steps:

1. Determine the rated input current from the nameplate on the test set. Be sure to choose the correct current for the input voltage being used.
2. Multiply this value by four.
3. Determine the length of input lead required. This is in circuit-feet, therefore it is the one-way distance from the test set to the power source.
4. Select the proper wire size from the table using factors 2 and 3 above.

NOTE: For input currents exceeding 600 amperes, it is recommended that 2/0 cable be used and not exceed 50 feet in length.

SELECTOR CHART FOR INPUT LEADS

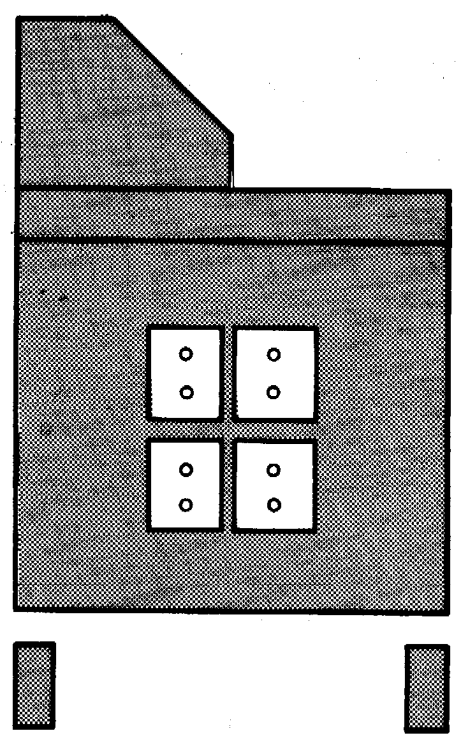
FOUR (4X) TIMES RATED INPUT CURRENT	LENGTH OF INPUT LEADS DISTANCE FROM TEST SET TO POWER SOURCE (FEET) — MINIMUM WIRE SIZE A.W.G.						
	20	40	60	80	100	120	140
50	8	8	8	8	8	8	8
75	8	8	8	8	8	8	6
100	8	8	8	8	6	6	4
125	8	8	8	6	6	4	4
150	8	8	8	6	4	4	2
175	8	8	6	4	4	2	2
200	8	8	6	4	4	2	2
225	8	8	6	4	2	2	1
250	8	6	4	4	2	2	1
275	8	6	4	2	2	1	1/0
300	8	6	4	2	2	1	1/0
325	8	6	4	2	1	1	2/0
350	8	4	2	2	1	1/0	2/0
375	8	4	2	2	1/0	2/0	2/0
400	8	4	2	1	1/0	2/0	
425	8	4	2	1	1/0	2/0	
450	8	4	2	1	2/0		
475	6	4	2	1/0	2/0		
500	6	4	2	1/0	2/0		
525	6	2	1	1/0	2/0		
550	6	2	1	1/0			
575	6	2	1	2/0			
600	6	2	1	2/0			

THE WIRE SIZES IN THIS CHART WILL RESULT IN VOLTAGE DROPS OF TEN VOLTS OR LESS.

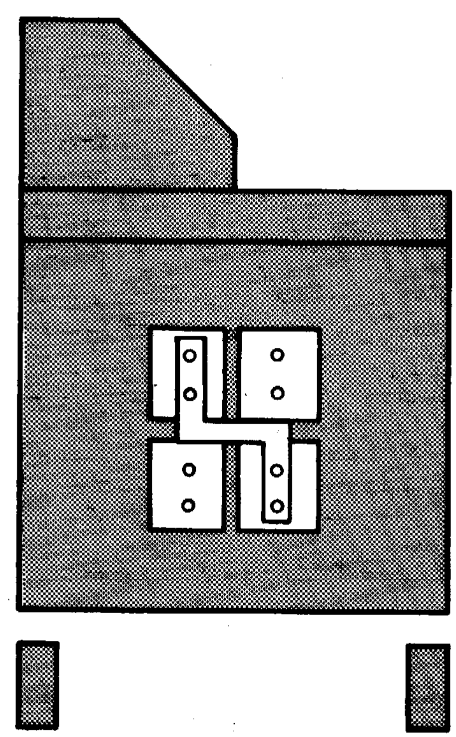
OUTPUT:

SELECTION OF OUTPUT CONNECTIONS: Two output connections, parallel and series, provide various voltage and current ratings to adapt Multi-Amp Circuit Breaker Test Sets to a wide variety of test circuit impedances.

The test sets can be operated most efficiently by utilizing the parallel connection, which provides the HIGHEST CURRENT rating consistent with being able to obtain the desired test current. In this way, finer adjustment can be obtained by making maximum use of the variable autotransformer range. Even the smallest currents can be obtained from the parallel connection. The series connection should be used only when testing high impedance devices where the parallel connection does not have sufficient voltage to "push" the desired test current through the device. The operator should start with the parallel connection and move to the series connection only when necessary. To operate the test set in the parallel connection does not require any changes be made by the operator. However the test set in series requires that a special adapter be placed on the output stab adapter boards to complete the series connection. See figures below.



PARALLEL



SERIES

OUTPUT CONNECTIONS: All model CB-8100 Series Test Sets are equipped with Multi-Amp Stab Adapter Board and Multi-Amp CBS-1 and CBS-2 Stab Sets which accommodate direct engagement of many drawout type circuit breakers to the test set without the use of leads. Additionally, stabs are available for breakers not accommodated by the CBS-1 and CBS-2 stabs. Contact the factory for further details or refer to the specification section.

When testing devices which cannot be connected directly to the stabs of the CB-8100 Series Test Sets, it will be necessary to use test leads. When using high current test leads, it may be necessary to connect the output of the test set in series (see previous section on PARALLEL AND SERIES OPERATION). The following information on the selection of output leads will provide the user with a guide for choosing the proper test leads for his application.

Due to the voltage drop from the inductive reactance of the test circuit, a significant loss of current will result for each inch of test lead. Therefore, when choosing test leads, the length and size of leads chosen will determine the maximum available test current. It is worthwhile to sacrifice cross section of test leads for the sake of reducing length. Every inch of lead that can be eliminated provides worthwhile increase in available test current. Heating is not a significant problem in testing, even though the leads become hot. The use of 4/0 welding or motion picture cable is convenient for constructing test leads. Paralleling of sufficient cables provides higher test currents. Each cable can be fitted with a compression lug on each end, then bolted to the output terminals or stab board of the test set and the breaker.

The two cables between the test set and the breaker should be twisted together or bundled with tape or cord to maintain the close proximity which minimizes inductive reactance.

It is sometimes necessary to use buss bar in order to obtain the desired maximum current. When using bus bar, the buses should be run parallel and kept as close to one another as possible.

DUTY RATINGS AND OVERLOAD CAPACITIES:

Multi-Amp™ equipment is rated on a continuous duty basis as described by NEMA for test equipment in intermittent service; that is, 30 minutes ON followed by 30 minutes OFF. In other words, the equipment can supply rated output current for a maximum period of 30 minutes ON provided a 30 minute cooling OFF period follows. This is a satisfactory basis of rating for testing of circuit breakers and primary injection testing of relay and current transformers. When Multi-Amp™ equipment is being used for heat runs on cables, busbars, terminations, etc., the 30 minute ON time will be exceeded. In such cases the output current should be limited to 70 percent of the rated output current and may be continued for an indefinite time.

In addition to the continuous duty rating defined above, all units have considerable short-time overload capability. Duration of the overload is governed by thermal considerations within the test set. The maximum current available is determined essentially by the impedance of the load. The duty cycles of the CB-8100 series is as follows:

DUTY CYCLES ON CB-8100 SERIES 60 HZ
CIRCUIT BREAKER TEST SETS
(Current Rating Through Circuit Breaker)

CB-8115

CURRENT	TIME ON	TIME OFF
2,240 A	Continuous	N/A
3,200 A	30 min.	30 min.
4,500 A	15 min.	45 min.
7,500 A	1 min.	12 min.
15,000 A	3 sec.	3 min.

CB-8130

CURRENT	TIME ON	TIME OFF
3,000 A	Continuous	N/A
4,500 A	30 min.	30 min.
6,000 A	15 min.	45 min.
15,000 A	2 min.	60 min.
30,000 A	5 sec.	12 min.

CB-8160

CURRENT	TIME ON	TIME OFF
4,500 A	Continuous	N/A
6,250 A	30 min.	30 min.
10,000 A	15 min.	45 min.
30,000 A	2 min.	60 min.
60,000 A	5 sec.	12 min.

THERMAL SET POINTS*

Normal: 72° to 80°F

Warning: 150 to 180°F

Shutdown: 220 to 248°F

*Temperature measured at output stabs adapter plates.

DUTY CYCLES ON CB-8100 SERIES 50 Hz
CIRCUIT BREAKER TEST SETS
(Current Rating Through Circuit Breaker)

CB-8116/8117

CURRENT	TIME ON	TIME OFF
2,223 A	Continuous	N/A
3,162 A	30 min.	30 min.
4,446 A	15 min.	45 min.
7,410 A	1 min.	12 min.
14,820 A	3 sec.	3 min.

CB-8131/8132

CURRENT	TIME ON	TIME OFF
2,964 A	Continuous	N/A
4,446 A	30 min.	30 min.
5,928 A	15 min.	45 min.
14,820 A	2 min.	60 min.
29,640 A	5 sec.	12 min.

CB-8161/8162

CURRENT	TIME ON	TIME OFF
4,446 A	Continuous	N/A
6,175 A	30 min.	30 min.
9,880 A	15 min.	45 min.
29,640 A	2 min.	60 min.
59,280 A	5 sec.	12 min.

THERMAL SET POINTS*

Normal: 22.2 to 26.7°C

Warning: 65.6 to 82.2°C

Shutdown: 104.4 to 120°C

*Temperature measured at output stab adapter plates.

TEST PROCEDURES FOR
TESTING OF MOTOR OVERLOAD RELAYS

Always refer to the manufacturer's literature applicable to the particular overload relay before testing. The test operator should be familiar with the operating characteristics of the relay, the tolerances applicable to the operating characteristics and any means of adjusting the relay.

The test usually performed on these devices is to verify the time delay characteristics of the relay when subjected to an overload. One test point is usually suggested to establish whether the relay is operating correctly and within the band of the time-current curve for the relay. The suggested test current is three times (3x) the normal current rating of thermal overload relays or three times (3x) the pick-up current (setting) of magnetic overload relays.

It is, of course, easiest to make the connections and perform the tests on the relays if they are removed from the starter. However, it is not necessary to remove the relay as long as the power circuit is de-energized and the test leads can be connected to the device. The high current leads from the test set to the relay under test should be kept as short as possible and should be twisted to minimize losses caused by inductive reactance.

Run the test and note the time required for the overload relay to trip. If the tripping time exceeds the desired value, or if the relay does not trip at all, the relay may not be protecting the motor properly. If the relay operates too quickly, it may result in unnecessary nuisance trips. It should be remembered that these devices operate over a wide band and precise results should not be sought. A tolerance of $\pm$ 15% is usually acceptable for electromechanical devices.

If a thermal overload relay is not operating properly, tripping too soon or too late, remove the heater element. Note its type, rating, etc., and compare with manufacturer's data for operating characteristics of the motor. If correct for the application, substitute a new heater of the same rating and retest. If either under- or over-sized heater elements are being used, replace with the proper size heater and retest.

If a magnetic overload relay is not operating properly, refer to the relay manufacturer's literature for instructions on making adjustments of the time delay. If the relay is operating improperly, it also may be desirable to verify the pickup point (minimum operating point) of the relay. To perform this test, it is necessary to disengage the time delay feature of the overload relay. Refer to the manufacturer's literature for detailed instructions.

SETUP OF CONTROLS BEFORE TESTING:

CONTROL	POSITION
Circuit Breaker	OFF

OUTPUT SELECTOR Switch	1 (Disregard for units without this switch)
VERNIER CONTROL	Zero (counterclockwise)
TIMER OPERATION SELECTOR Switch	N.C. MOM.
Ammeter MODE Switch	MEMORY
AMMETER RANGE Switch	So that test current can be read in the proper range of the ammeter
Ammeter PARALLEL/SERIES Switch	To appropriate position depending on OUTPUT CONNECTION
VOLTMETER CIRCUIT Selector Switch	To desired position depending on voltage to be measured

TESTING OF TIME DELAY:

1. Connect the test set to a suitable source of power. Be sure that the circuit breaker on the test set is off.

2. Make sure the motor circuit is de-energized.

3. Connect the output of the test set to the terminal of the heater of operating coil to be tested (see SELECTION OF OUTPUT CONNECTION).

4. Connect a set of light leads from the binding posts marked TIMER STOP to the control circuit contacts of the relay being tested.

5. Turn test set's circuit breaker "ON". The INPUT ON light should glow.

6. Select proper ammeter range.

7. Set the desired test current by rotation of the VERNIER CONTROL, and then pressing the START button (for details see following note).

   NOTE: Depending on the position of the OUTPUT SELECTOR Switch (smaller units do not have this switch), the current may be increased by either clockwise or counter clockwise rotation of the VERNIER CONTROL (refer to chart of OUTPUT RANGES). For example, if the desired test current is 7500 amperes, the proper procedure would be to start with the OUTPUT SELECTOR Switch in position 1 and increase the VERNIER CONTROL from "0" toward "100". However, if the impedance of the device is such that you cannot get 7500 amperes at "100" on the VERNIER CONTROL, switch the OUTPUT SELECTOR Switch to position number 2. To *increase* the output current, rotate the VERNIER CONTROL *counterclockwise* toward "0". If at full rotation of the VERNIER CONTROL, the desired current is not obtained, turn the OUTPUT SELECTOR Switch to the next higher position and repeat the procedure until the desired test current is reached. Since the TIMER OPERATION SELECTOR Switch is in the MOM. position, the output will only stay energized for 60 milliseconds. The memory ammeter will hold the reading of the amperage set (*). If at the last position the desired test current is not reached, connect the output of the test set in series (See SELECTION OF OUTPUT CONNECTION). Switch the Ammeter PARALLEL/SERIES Switch to the SERIES position, return the OUTPUT SELECTOR Switch to position 1 and repeat procedure.

8. Reset timer to zero by pressing RESET button.

9. Place ammeter MODE Switch in CONTINUOUS position.

10. Wait several minutes to allow the overload relay to cool or the plunger to settle in the dash pot.

11. Change TIMER OPERATION SELECTOR Switch to N.C. MAINT. position.

12. Initiate unit by pressing START button. The timer will stop and the output will automatically de-energize when the overload relay operates.

    NOTE: Check the ammeter reading during the test for accuracy. Minor adjustments may be made with the OUTPUT CONTROL while the test is in progress.

13. Record the results and compare them to the manufacturer's specifications.

(*)If the ammeter range switch is set in the 200 amp position, the memory ammeter will not hold the reading. It is recommended that the CONTINUOUS mode be used for currents below 200 amperes.

TEST PROCEDURE FOR
TESTING OF MOLDED CASE AND LOW
VOLTAGE POWER CIRCUIT BREAKERS

Always refer to the manufacturer's literature applicable to the particular circuit breaker before testing. The test operator should be familiar with the operating characteristics of the circuit breaker, the tolerances applicable to the operating characteristics and any means for adjusting the circuit breakers.

Molded case breakers are usually tested for verification of the time delay characteristics and the minimum operating point (pick-up point) of the instantaneous element. Low voltage power breakers with solid state or electro-mechanical trip devices are usually tested for verification of the time delay characteristics of the long time delay and short time delay elements and for the minimum operating point (pick-up point) of the instantaneous element. Each breaker pole should be tested independently so that all trip devices are tested.

One test point is usually sufficient to establish whether the long time delay or short time delay element is operating properly and within the band width of its time-current characteristics. For molded case breakers the suggested test current of the time delay element is three times (3x) the current rating of the breaker; for low voltage power circuit breakers, suggested test current is three times (3x) the pick-up setting of the long time delay element and one and one half times (1.5x) the short time delay setting where the type of trip characteristics is incorporated on the trip device.

On both molded case and low voltage power breakers, the instantaneous element is tested to verify the minimum current necessary to cause the breaker to consistently trip instantaneously.

When testing instantaneous trip elements, run the test to find the minimum current required to trip the breaker instantaneously and compare to the setting. Remember the instantaneous elements have an operating tolerance of from ± 10% to ± 25% of setting, depending on the particular trip device. On molded case circuit breakers, it is suggested that the time delay elements be tested before any instantaneous tests are performed.

Most modern low voltage power circuit breakers are of the "draw-out" type. These breakers should be tested using Multi-Amp Model CB-8100's equipped with the appropriate stabs to directly connect the breaker to the test set. When testing molded case breakers or any other breaker where leads are required to connect it to the test set, the leads should be as short as possible and twisted to minimize losses. See section on Output Leads.

SETUP OF CONTROLS BEFORE TESTING:

CONTROL **POSITION**

Circuit Breaker	OFF
OUTPUT SELECTOR Switch	1 (Disregard for units without this switch)
VERNIER CONTROL	Zero (counterclockwise)
TIMER OPERATION SELECTOR Switch	C.A. MOM. (Momentary) If desired, the N.0. or N.C. position may be used to control timer operation.
AMMETER RANGE Switch	Select a range such that the test current can be read as near full scale as possible.
Ammeter MODE Switch	MEMORY
Ammeter PARALLEL/SERIES Switch	PARALLEL
VOLTMETER CIRCUIT Selector Switch	To desired position depending on voltage to be measured.

TESTING OF TIME DELAY:

1. Connect the test set to a suitable source of power. Be sure that the circuit breaker on the test set is OFF.

2. Make sure the line side circuit of the breaker to be tested is de-energized or disconnected. Close the breaker to be tested.

3. Connect the test set output terminals to one pole of the breaker to be tested (see SELECTION OF OUTPUT CONNECTION).

4. If the N.O. or N.C. positions are used, connect a set of light leads from the TIMER STOP binding posts to another pole of the breaker under test or the desired auxiliary contact.

5. Turn test set circuit breaker ON. INPUT ON light should glow.

6. Verify proper ammeter range.

7. Set the desired test current by rotation of the VERNIER CONTROL, and then pressing the START button (for details see following note).

   NOTE: Depending on the position of the OUTPUT SELECTOR Switch (smaller units do not have this switch), the current may be increased by either clockwise or counterclockwise rotation of the VERNIER CONTROL (refer to chart of

OUTPUT RANGES). For example, if the desired test current is 7500 amperes, the proper procedure would be to start with the OUTPUT SELECTOR Switch in position 1 and increase the VERNIER CONTROL from "0" toward "100". However, if the impedance of the device is such that you cannot get 7500 amperes at "100" on the VERNIER CONTROL, switch the OUTPUT SELECTOR Switch to position number 2. To *increase* the output current, rotate the VERNIER CONTROL *counterclockwise* toward "0". If at full rotation of the VERNIER CONTROL the desired current is not obtained, turn the OUTPUT SELECTOR Switch to the next higher position and repeat the procedure until the desired test current is reached. Since the TIMER OPERATION SELECTOR Switch is in the MOM. position, the output will only stay energized for 60 milliseconds. The memory ammeter will hold the reading of the amperage set (*). If at the last position the desired test current is not reached, connect the output of the test set in series (See SELECTION OF OUTPUT CONNECTION). Switch the Ammeter PARALLEL/SERIES Switch to the SERIES position, return the OUTPUT SELECTOR Switch to position 1 and repeat procedure.

(*) If the ammeter range switch is set in the 200 amp position, the memory ammeter will not hold the reading. It is recommended that the CONTINUOUS mode be used for currents below 200 amperes.

8. Reset timer to zero by pressing the RESET button.

9. Place ammeter mode switch in CONTINUOUS position.

10. Change TIMER OPERATION SELECTOR Switch to C.A. MAINT. (or N.C. MAINT. if another pole of the breaker is used to timer control).

11. Initiate unit by pressing START button. The timer will stop and output will automatically de-energize when the circuit breaker operates.

    NOTE: Check the ammeter reading during the test for any change in output setting. Minor adjustments may be made with the output control while the test is in progress.

12. Record the results and compare them to the manufacture's specifications.

TESTING OF INSTANTANEOUS PICK-UP:

NOTE: To set up controls, see "SETUP OF CONTROLS BEFORE TESTING" beginning on page 14."

1. Connect the test set to a suitable source of power. Be sure that the circuit breaker on the test set is OFF.

2. Make sure the line side circuit of the breaker to be tested is de-energized or disconnected. Close the breaker to be tested.

3. Connect the output of the test set to one pole of the breaker to be tested (see SELECTION OF OUTPUT CONNECTION).

4. Connect a set of light leads from the binding post marked TIMER STOP to another pole of the breaker being tested.

   NOTE: Not applicable when testing single-pole breakers using the C.A. Mode.

5. Turn test set circuit breaker ON. INPUT ON light should glow.

6. Select the proper ammeter range so that the instantaneous pick-up current of the instantaneous element can be read as near to full scale as possible.

7. Place the ammeter mode switch in the MEMORY position.

8. Rotate VERNIER CONTROL while alternately pressing the STOP button then the START button until the circuit breaker under test trips instantaneously. Pushing the STOP button resets the initiate circuit. The STOP button must be pressed prior to pushing the START button for repeat initiation of the output. Read ammeter for value of current required to trip breaker.

   If breaker does not trip instantaneously with VERNIER CONTROL fully rotated, turn OUTPUT SELECTOR Switch to next higher position and repeat procedure (refer to procedure NOTE under TESTING OF TIME DELAY).

   If at the last position the required test current still is not reached, connect the test set's output in series (see SELECTION OF OUTPUT CONNECTION). Switch the ammeter PARALLEL/SERIES Switch to the SERIES position and repeat the procedure.

MAINTENANCE OF MOTOR OVERLOAD RELAYS

APPLICATION:

The prime function of the motor overload relay is to prevent operation of a motor for too long a period of time when an overload condition exists.

In general, motor starters are applicable to a given horsepower range of motors. The voltage and current requirements of the application will "size" the starter under NEMA requirements, but the actual starting current, running current, ambient temperature and severity of atmospheric conditions will determine the overload relay rating required to protect the motor without nuisance tripping.

Selection of the properly rated overload relay heater or coil can be made by reference to tables or charts supplied by the manufacturer of the overload relays. Whenever a motor trips out it is poor practice to indiscriminately install a larger heater or coil, since the motor may actually be working under an overload condition or the overload relay may be operating improperly. Installing a larger heater or coil could allow an overloaded motor to continue to run, resulting in deterioration of the motor insulation and reduction of motor life. Therefore, careful analysis should be made as to the cause of the trip before changing the rating of the overload relay heater. Operating characteristics of the motor overload relay should be verified at regular intervals. The inspection and test interval can vary widely depending on the type of service involved, the importance of the motor to process or production, and environmental conditions.

TYPES:

Motor overload relays incorporate an element which actuates a set of contacts connected to the motor control circuit. These contacts open the circuit of the holding coil in the motor starter and interrupt the power to the motor.

In general, there are three types of motor overload relays in use:

1. Thermal - melting alloy or solder pot
2. Thermal - bimetallic strip
3. Electromagnetic

In thermal type relays, time-current characteristics are obtained by the thermal properties of the melting alloy or bimetallic strip. In the magnetic type, a damped plunger or moving iron device is used to produce time delays.

1. Thermal - melting alloy or solder pot:
   In this type, tripping is the result of heat generated by the motor overload current passing through a "heater" in the overload relay. This overload relay consists of a brass shaft which is surrounded by solder. Fixed to one end of the shaft is a small ratchet wheel. As long as the solder is solid, this assembly is immobile. When the motor control circuit contacts are closed, a spring in the motor overload relay is

held compressed by the immobility of the ratchet wheel. An overload condition in the motor increases the current through the heater, thus melting the solder allowing the ratchet wheel to move, and releasing the energy in the spring. This interrupts the circuit of the holding coil in the motor starter and shuts down the motor.

The starter may be reset only after the heater has cooled sufficiently to permit the solder to solidify and again make the ratchet and shaft immobile. Reset is usually accomplished by an external pushbutton on the face of the starter. Many motor overload relays offer a selection of either manual or automatic reset.

2. Thermal - Bimetallic strip:

   This type uses a bimetallic strip---two pieces of dissimilar metal bonded together. An increase in heat will cause movement of the bimetallic unit and eventually open a set of contacts in the motor control, thus opening the holding coil circuit and shutting down the motor.

   The principle of operation is the same as the melting alloy type. When the bimetallic element has cooled sufficiently, the motor control circuit may be reset either manually or automatically.

3. Electromagnetic:

   In this type of motor overload relay, a damped plunger or moving iron device is used to produce the delays required and initiate the trip signal to the interrupting device. In the most common type of magnetic relay, movement of an armature or piston rod is delayed by a dashpot.

   When the electromagnetic field produced by the operating coil is strong enough, the piston in the dashpot moves through the oil to trigger the opening of the relay contacts, shutting down the motor. Usually, magnetic overload relays with oil dashpots have facilities which permit adjusting their minimum operating current (pick-up point) and their time delay characteristics.

PLANNED MAINTENANCE PROGRAM:

A scheduled program for maintenance of motor overload relays consists primarily of "good housekeeping" in conjunction with visual inspections, tightening of electrical connections, and electrical testing. A brief outline is given below:

1. CLEAN - All types of motor overload relays should be cleaned periodically to ensure continued, reliable operation. It is possible for dirt or dust created by conditions in the plant to prevent parts of the relay from moving. Also, these same conditions can prevent the proper dissipation of normal heat, resulting in unnecessary operation of thermal type overload relays.

2. TIGHTEN CONNECTIONS - This is particularly important in thermal overload relays. Loose electrical connections can cause extra heat which may result in a nuisance operation of the relay.

3. INSPECT HEATER SIZE - Determine that the specified heater is used in thermal overload relays. Too often, oversized heaters are arbitrarily installed to eliminate unexplained trips. Actually, the original heaters may have oxidized over a period of time, becoming smaller in cross section. Then, the heat required to operate the relay is provided by a smaller amount of current than that intended by the original design. This may make the relay trip prematurely and the heater appear undersized.

4. INSPECT SETTINGS (Where applicable) - Most magnetic overload relays have adjustable settings for minimum operating current and time delay characteristics. These should be adjusted to the specified settings.

5. TEST - The motor overload relay should be subjected to a simulated overload and the tripping time measured. This time should be compared to the manufacturer's specifications of the relay's time-current curves to make certain that the relay is operating properly. A tolerance of ± 15% is usually acceptable. If the relay's curves or specifications are not available, it is suggested that the Heat Damage Curve of the motor be used as a guide for maximum trip time at 300% of motor full load current.

MAINTENANCE OF MOLDED CASE CIRCUIT BREAKERS

DESCRIPTION:
The molded case circuit breaker essentially consists of two separate elements. One element is a set of contacts and suitable mechanical linkage for manual operation of the breaker as a switch in an electric circuit. The other element is a device to sense and react to an overload or short circuit. Normally, the time delay overload device is thermal and the instantaneous overload device, when supplied, is magnetic. Some newer styles include solid-state trip elements and operate very similar to low voltage power circuit breakers.

The thermal element uses a bimetallic strip---two pieces of dissimilar material bonded together. An overload causes an increase in heat which will result in moving the bimetallic unit, releasing a latching spring which trips the circuit breaker.

A small percentage of molded case circuit breakers achieve their time delay through the use of an electromagnet, whose operation is opposed by a fluid filled dash pot.

The magnetic element operates with no intentional time delay to provide instantaneous protection against high magnitude faults.

In small molded case circuit breakers, the instantaneous element is not adjustable as it is factory set and sealed. In larger molded case breakers, the instantaneous pickup of the trip may be adjustable and is set with an adjustment screw. This type breaker may be shipped from the factory with the instantaneous element set at maximum if the setting is not specified by the purchaser; therefore, it is necessary to check these adjustable instantaneous settings before putting the breaker in service.

PLANNED MAINTENANCE PROGRAM:
A scheduled program for maintenance of molded case circuit breakers consists primarily of "good housekeeping" in conjunction with visual inspections, tightening of connections and electrical testing. A brief outline is given below:

1. CLEAN - All types of molded case circuit breakers should be externally cleaned periodically so that the heat produced in normal operation can be dissipated properly. It is possible for dirt or dust caused by normal plant conditions to accumulate and prevent proper dissipation of heat, resulting in a nuisance operation of the breaker.

2. TIGHTEN CONNECTIONS - This is particularly important, because loose electrical connections will cause deterioration of the breaker terminals and an eventual phase to phase or phase to ground fault.

3. TEST - The molded case circuit breaker should be subjected to a simulated overload and the tripping time measured. This is important because after a period of inactivity, the overload device may become stiff or inoperable. The only way to determine this condition and eliminate the stiffness is to electrically operate the breaker on a periodic basis. Manually opening and closing the main contacts of the breaker does not move any of the mechanical linkage associated with the overload device. Testing may be as

often as every 6 months or as long as every 3 or 4 years, depending upon conditions where the breaker is installed.

MAINTENANCE OF LOW VOLTAGE POWER CIRCUIT BREAKERS

APPLICATION:
The low voltage power circuit breaker has a wide application and may be used to protect circuits up to 600 volts ac or 250 volts dc. These devices are essentially two separate elements. One element is a set of contacts with suitable mechanical linkage for operating the breaker as a switch. The other element is a device to sense and react to an overload or short circuit condition. Low voltage power circuit breakers are manufactured with either electro-mechanical or solid state trip devices.

SOLID STATE TRIP ELEMENTS - This type of breaker uses a sample of the load current to supply a signal to an electronic sensing element. When an overload or short circuit condition exists, the solid state sensing element sends a signal to a solenoid which releases the latching mechanism and trips the circuit breaker. This type eliminates the magnetic coil and dashpot mechanism of the electro-mechanical trip device.

ELECTRO-MECHANICAL TRIP ELEMENTS - Series tripped, direct acting low voltage power circuit breakers are tripped by the movement of an armature which strikes the trip bar of the breaker. The trip bar operates a latch which releases stored energy to rapidly open the breaker contacts. The armature of the trip unit is attracted to a pole piece through the magnetic field set up by current through a coil. The current through the coil is either the actual load current or the secondary output of a current transformer. For time delay the armature is restrained mechanically. Tripping time is a function of magnitude of current through the breaker.

Low Voltage Power Circuit Breakers are available with three types of tripping characteristics:

1. LONG TIME DELAY - The long time delay characteristic provides overload protection with typical time delays of approximately 10 -60 seconds at 300% of pickup.

2. SHORT TIME DELAY - The short time delay characteristic provides protection for short circuit or fault conditions. It is used whenever a small delay is necessary for coordination or selectivity with other protective devices. Typical delays of this type characteristics are approximately 6-30 cycles.

3. INSTANTANEOUS - The instantaneous trip characteristic is used for short circuit or fault protection and has no intentional time delay.

PLANNED MAINTENANCE PROGRAM:
A scheduled program for maintenance of low voltage power circuit breakers consists primarily of "good housekeeping" in conjunction with visual inspection, tightening all connections and non-pivotal joints, and electrical testing.

1. CLEAN AND TIGHTEN - Low voltage power circuit breakers should be periodically cleaned, tightened and inspected. The manufacturer's instruction book for the breaker should be read thoroughly and his recommendations for lubricating and clearances should be followed closely.

2. TEST - The voltage power circuit breaker should be subjected to simulated overload conditions to verify that the breaker is operating within its specifications and tolerances. This is important because, after a period of time, vibration and environmental conditions can render the breaker inoperable. Manually opening or closing the main contacts of the breaker does not "exercise" the overload trip device.

SUGGESTED RECORD FORMS
INSPECTION AND TEST RESULTS

INSPECTION

Circuit No ______________________ Trip Device Mfg. ______________________

Location ______________________ Trip Device Type ______________________

Breaker Mfg. ______________________ Long Time Delay Range ______________________

Breaker Type ______________________ Short Time Delay Range ______________________

Instantaneous Range ______________________

Date						
Process Clearance						
Circuit De-energized						
Circuit Properly Tagged						
Breaker Removed						
Primary Fingers						
Arc Chutes						
Contacts						
Clean						
Aligned						
Pressure						
Mechanical Operation						
Proper Lubrication						
Racking Device						
Rollers						
Trip Mechanism						
Tightened Bolted and Screwed Connections						
Trip Bar						
Trip Arm						
Electrical Tests						
Inspector						

TEST RESULTS

Circuit No. ______________________ Trip Device Type ______________________

Circuit Location ______________________ Long Time Delay Range ______________________

Breaker Mfg. ______________________ Short Time Delay Range ______________________

Breaker Type ______________________ Instantaneous Range ______________________

Mfg. Serial No. or Shop Order No. ______________________

Date				Specified						
SETTINGS	PH. A		L.T.D.							
			Std/Inst							
	PH. B		L.T.D.							
			Std/Inst							
	PH. C		L.T.D.							
			Std/Inst							
TEST RESULTS	PHASE A	LTD	Curr							
			Time							
		STD	Curr.							
			Time							
			Inst. Curr.							
	PHASE B	LTD	Curr.							
			Time							
		STD	Curr.							
			Time							
			Inst. Curr.							
	PHASE C	LTD	Curr.							
			Time							
		STD	Curr.							
			Time							
			Inst. Curr.							

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SERVICE DATA

Servicing

The test set utilizes straightforward circuits and components which require little or no service except for routine cleaning, tightening of connections, etc. The test set should be serviced in a clean atmosphere away from energized electrical circuits. The following maintenance is recommended:

1. Open the unit every six months and examine for:

    a. dirt/dust

    b. moisture

    c. corrosion

2. Remove dirt/dust with dry, compressed air.

3. Remove moisture as much as possible by putting test set in a warm, dry environment.

4. As corrosion may take many forms, no specific recommendations can be made for its removal.

5. Check cable connections for solid connections (look for loose pin connections) and printed circuit boards for tightness.

Service and Repair Order Instructions

If factory service is required or desired, contact the factory for return instructions.

A Service & Repair Order (SRO) number will be assigned for proper handling of the unit when it arrives at the factory.

If desired, a letter with the number and instructions can be provided.

Provide the factory with model number, serial number, nature of the problem or service desired, return address, your name, and where you can be reached should the factory need to contact you.

A purchase order number, cost limit, billing, and return shipping instructions may also be provided if desired.

National Bureau of Standards traceable calibration and certification of two types is available, if desired, at additional cost.

Class One: A certificate is provided verifying the traceability and calibration of the equipment.

Class N: That which is required for nuclear power plants. A certificate of traceability and calibration along with "as found" and "as left" data are provided.

If an estimate is requested, provide the name and contact information of the person with approval/disapproval authority.

Pack the equipment appropriately to prevent damage during shipment. If a reuseable crate or container is used, the unit will be returned in it if in suitable condition.

Put the SRO number on the address label of the shipping container for proper identification and faster handling.

NOTE: Ship the equipment *without* instruction manuals or nonessential items such as test leads, spare fuses, etc. These items are not needed to conduct repairs. *Do* ship the equipment with *all* interconnect cables, etc. which make the unit operational.

Preparation for Reshipment

Save the shipping container that your unit came in. The shipping container your unit came in is designed to withstand the normal bumps and shocks of shipping via common commercial carrier. For example, you may wish to reship your unit to Multi-Amp for annual calibration certification.

Warranty Statement

Multi-Amp Corporation warrants to the original purchaser that the product is free from defects in material and workmanship for a period of one (1) year from date of shipment. This warranty is limited and shall not apply to equipment which has damage, or cause of defect, due to accident, negligence, unauthorized modifications, improper operation, faulty installation by purchaser, or improper service or repair by any person, company or corporation not authorized by the Multi-Amp Corporation.

Multi-Amp Corporation will, at its' option, either repair or replace those parts and/or materials that it deems to be defective. Any costs incurred by the purchaser for the repair or replacement of such parts and/or materials shall be the sole responsibility of the original purchaser.

THE ABOVE WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED ON THE PART OF THE MULTI-AMP CORPORATION, AND IN NO EVENT SHALL THE MULTI-AMP CORPORATION BE LIABLE FOR THE CONSEQUENTIAL DAMAGES DUE TO THE BREACH THEREOF.