ALLIS-CHALMERS

BWX-6678-1

STATIC OVERCURRENT TRIP DEVICE

* MODELS A-1, A-2, AG, AG-1, D, D-1, DG

ILLUSTRATIONS



*Throughout the text any reference to:

A-1 is also applicable to A-2
AG is also applicable to AG-1
D is also applicable to D-1

www . ElectricalPartManuals . com

www . ElectricalPartManuals . com

# INSTRUCTIONS FOR STATIC OVERCURRENT TRIP DEVICES

## SECTION 1 - GENERAL

BWX-6678-1

### 1-A INTRODUCTION

These instructions describe the ALLIS-CHALMERS STATIC OVERCURRENT TRIP DEVICES as applied to Type "LA" Low Voltage Power Circuit Breakers, and provide information necessary for their correct use.

The overcurrent trip devices described here are completely static; that is, there are no moving parts or contacts. Extensive use is made of such components as semi-conductors, capacitors, transformers, etc. The circuits are designed for conservative loading of components, to provide long life with negligible maintenance.

### 1-B APPLICATION

These static overcurrent trip devices are designed primarily for use with type "LA" low voltage power circuit breakers, but are not limited to that class of circuit breaker. They perform the same functions customarily provided by electro-mechanical series overcurrent trip devices, but do so with greater accuracy and versatility.

Static overcurrent trip devices operate to open the power circuit breaker when the circuit current exceeds a preselected current-time relationship. Tripping may be instantaneous or time delayed, depending on the selected settings.

Energy to operate the tripping system is obtained solely from the circuit being protected. No batteries or other separate power sources are required.

### 1-C FUNCTIONAL DESCRIPTION

The complete static overcurrent trip system consists of three parts - primary circuit current transformers, the static overcurrent trip device, and a magnetically held circuit breaker latch release device. These parts are described in more detail in the following paragraphs.

#### Current Transformers

Toroid transformers similar to standard bushing current transformers are mounted one per phase on the primary studs of the circuit breaker. They provide a signal to the static trip device in relation to the condition of the primary circuit, and are used solely for that purpose. They are not used for other functions. The transformers selected for a specific circuit breaker establish the current rating of that circuit



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

1-C (continued)

breaker. Each transformer usually provides a choice of five ratings, which are listed on the circuit breaker rating plate. A typical rating plate is shown in Figure 4.

Static Trip Device

The static trip device receives the signal from the current transformers. It monitors the signal, senses overloads and faults and determines the required action in accordance with preselected instructions. It is the "intelligence" unit of the tripping system.

The static trip device is housed in a small metal box that is a part of the circuit breaker. It contains the various electronic circuits, and on the front a calibration plate containing the various adjusting means.

Several variations of the static trip device are available, as described later in detail. All are similar in size and appearance as shown in Figure 3.

Magnetic Latch Release

When the static trip device senses a circuit condition that requires the circuit breaker to open, it produces an output that is fed to the magnetic latch release device. The magnetic latch release device then causes the circuit breaker contacts to open and isolate the circuit.

The magnetic latch release, mounted on the circuit breaker, is held in a charged position by a permanent magnetic circuit. It contains a coil which is energized by the output of the static trip device. When energized, the coil causes the magnetic flux to shift to a new path, thereby releasing the stored energy of a spring contained within the magnetic latch release. The spring provides the energy needed to trip the circuit breaker.

Several styles of the magnetic latch release are in use, and details are covered in the specific circuit breaker instruction books. Figure 1 illustrates two typical styles.

1-D DESCRIPTION OF STATIC TRIP DEVICES

These instructions describe four models of static trip devices. All are similar in many respects and differ only in the kind of end use function that they provide. All use the same current transformer inputs and provide output signals to the magnetic latch release as previously described.



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

1-D (continued)

Dual Model A1

Furnished with one non-adjustable current-time curve. The curve may be either for the minimum, the intermediate, or the maximum curve as shown in Figure 12. Time delay up to fifteen times pick-up is standard, as is instantaneous tripping between five and fifteen times pick up by adjustment. It monitors the current in each of the three phases.

Dual Model AG

Same as the Model A1 except that the circuit is arranged to monitor current in two phases and current in the neutral of the primary current transformers. This device is thus able to provide normal overload and short circuit protection, and also to detect ground fault currents as low as 20% of the current required to operate the phase circuits.

Selective Model D

This static overcurrent trip device is furnished with three long time delay curves and three short time delay curves, any combinations of which may be selected by settings on the front plate of the device. Selectivity between coordinated circuit breakers can be maintained throughout the full interrupting range of the circuit breakers. The Model D device monitors the currents in each of the three phases. The arrangement of the current-time curves is shown in Figure 13.

Selective Model DG

Same as the Model D except that the circuit is arranged to monitor current in two phases and current in the neutral of the primary current transformers. This device is thus able to provide normal overload and short circuit protection, and also to detect groung fault currents as low as 20% of the current required to operate the phase circuits.

1-E OPERATION OF STATIC TRIP SYSTEM

The basic functional operation of static trip devices can be understood in adequate detail for most applications without going into the technical areas of semi-conductor devices. Those that desire a more technical description are referred to Section 3 of this Instruction Book, where circuit diagrams are discussed in detail.

Figure 2 is a functional block diagram arranged to show the operation of the Models A1, A2, AG, AG-1, D, D1, DG static overcurrent trip systems. The minor differences between the models are also indicated in this figure.



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

1-E (continued)

Referring to Figure 2, there are three current transformers on the circuit breaker, one for each phase of the primary circuit. The current transformers supply a signal to the static trip device which is proportional to the current in the primary circuit. This signal passes through the power supply transformers to establish the self-contained regulated power supply for operating the static trip device and for tripping the circuit breaker. The signal then goes to the auxiliary transformers where it is modified by the pick-up adjustment potentiometers. The pick-up adjustment is the means by which a specific pick-up current is selected by referring to the breaker rating plate (Figure 4).

The three individual AC signals then go to the signal rectifier and filter circuit where they are combined into a single DC signal, which is compared to a standard pre-set value. If the signal is below the pre-set value nothing further happens and the static trip device continues to monitor it. If the signal exceeds the pre-set value, the trigger circuit is immediately turned on. This in turn allows the timing circuit to start functioning.

Meanwhile, the signal is also being fed into the time shaping circuit, so named because it determines the shape and slope of the current-time curve. The output of the time shaping circuit is stored in the timing circuit until the proper time delay has been reached - depending on the magnitude of the signal. At that time, the timing circuit will cause the static switch to turn on and energize the circuit breaker trip coil.

When the circuit breaker opens, the signal to the static trip device disappears and the static trip device automatically resets itself and turns off the trigger circuit.

If the signal exceeds a value established by the preselected adjustments, it will by-pass the timing circuit entirely and go directly to the static switch, turn it on, and trip the circuit breaker. This is the instantaneous trip feature on Models AI and AG, as shown on the current-time curve (Figure 12).

The Model D does not have an instantaneous trip feature. Instead it has selective short-time delay curves. The circuits shown in dotted outline on Figure 2 establish the timing characteristics for the short-time function. The signal will automatically activate either the long-time or the short-time trigger circuit, depending on the magnitude of the signal and the setting of the pre-selected adjustments. The short-time circuits do not require a time shaping circuit because they are constant-time curves as shown in Figure 13.



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

1-E (continued)

The Model DG operates exactly like the Model D except that one set of transformers and pick-up adjustment are located in the neutral circuit of the primary current transformers, and are designed to provide a more sensitive response compared to that of the individual phase circuits.

The Model AG operates exactly like the Model A1 except that one set of transformers and pick-up adjustment are located in the neutral circuit of the primary current transformers, and are designed to provide a more sensitive response compared to that of the individual phase circuits.

In all models, the specific amount of time delay is controlled by the values of components in the timing circuit. These components determine the location on the time scale of the minimum, intermediate and maximum time bands. The components are fixed on Models A1, A2, AG, AG-1 to provide one time band while on the Models D, D1, DG can be adjusted on the static trip device to provide a choice of any long-time band plus any short-time band.

As noted in an earlier paragraph, the trigger circuit is turned on when the signal exceeds a pre-set standard value, and allows timing to take place. If, during a timing operation, the signal should decrease as a result of the primary current fault or overload being reduced to less than about 95% of the selected pick-up value, the trigger will shut off and the timing circuit will revert to its original steady-state condition. Thus, loss of the fault or overload before the static trip device has completed its timing function, will cause the device to reset and the circuit breaker will not receive a tripping signal. This resetting action defines the term "resettable time" used in connection with the Model D, D1, DG static trip device.

## 1-F SELECTION OF SETTINGS

The static overcurrent trip devices have a number of knobs and switches which can be arranged to select the specific conditions that will cause the circuit breaker to open. The selection of settings is usually made when the circuit breaker is placed in service, and will not require later changes unless load condition or other primary circuit changes are made. The following paragraphs describe the various selections that may be made.

**CAUTION:** ALL SELECTION KNOBS ARE EQUIPPED WITH SHAFT LOCKS TO ENSURE PERMANENCE OF SETTINGS. TURNING A KNOB ON A LOCKED SHAFT WILL CAUSE LOSS OF CALIBRATION. THE SECTION ON MAINTENANCE DESCRIBES HOW TO RESTORE CALIBRATION IF THIS SHOULD HAPPEN.

www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

1-F (continued)

Pick-Up Selection

The three knobs arranged vertically on the right hand side of the static trip device (Figure 3) are for selection of the current at which a time delay tripping operation will start. This is the pick-up current. One Knob is provided for each phase (except Models AG and DG, where the middle knob is used to select ground current pick-up).

The pick-up selection dials are marked with the letters "A" through "E". The pick-up current defined by each letter is listed on the circuit breaker rating plate (Figure 4). This is the minimum primary circuit current which will cause the circuit breaker to open.

EXAMPLE: A circuit breaker has a rating plate as shown in Figure 4. The pick-up settings are at point "A". Therefore, the circuit will carry up to 200 Amps without tripping the circuit breaker. Above 200 Amps a trip operation will occur.

The pick-up selection is continuous and may be set between marks if desired. Usual practice is to set all pick-up knobs at the same mark, but this is not necessary and different phases can have different pick-up settings.

The rating of the circuit breaker depends solely on the primary current transformers selected for the application, and is limited only by the circuit breaker frame size. The rating of a circuit breaker may be changed if desired merely by replacing the current transformers and the breaker rating plate. Nothing changes on the static trip device or other breaker components. Figure 4 shows breaker ratings available with various current transformers.

EXAMPLE: The transformers on the breaker represented by the rating plate in Figure 4 are changed to have 600 maximum rated Amps (thus A = 300, B = 375, C = 450, D = 525, E = 600). The pick-up settings are still on "A". The circuit will now carry up to 300 Amps and will trip on anything above 300 Amps in the primary circuit.

Ground Pick-Up Selection

Model AG, DG. The middle knob on the right-hand side of the Model AG, DG is used to select the sensitivity of ground current detection. It is calibrated as a percentage of the minimum available pick-up current shown on the breaker rating plate (Figure 4A). It does not have any relationship to the pick-up current selected for the



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

1-F (continued)

phase settings. Calibrations are marked at 20, 40, 60, 80% but adjustment is continuous. Figure 4A shows available ground current pick-up settings for various primary current transformers.

**EXAMPLE**: 1. A circuit breaker has a rating plate per Figure 4A. The pick-up settings are on "C" to select 300 Amps pick-up. The ground pick-up is set at 40%.

The ground current that will cause tripping is therefore not less than 40% of 200 Amps, or 80 Amps.

**EXAMPLE**: 2. Same conditions except pick-up settings are on "E" to select 400 Amps pick-up.

The ground current pick-up is still 80 Amps, based on the minimum available pick-up of 200 Amps.

Ground current pick-up is treated in the same manner as phase current pick-up when using the current-time curve, and the same curve (Figures 12, 13) is used for defining time delay.

**EXAMPLE**: 3. Breaker rating per Figure 4A. Phase pick-up setting "E" (400 Amps). Ground pick-up setting 40% (80 Amps). An actual ground current of 320 Amps is flowing.

320 Amps ground current is four times (4X) pick-up and will cause a trip operation in four and one-half seconds (on the minimum time band) as shown on the current-time curve (Figure 12). However, this ground current is much less than the phase pick-up setting, and would not be recognized on the phase pick-ups.

"The lower limit of ground fault recognition on the Models AG, AG–1, DG static trip devices is 40 amps ground current. Primary current transformers that provide a minimum continuous setting of less than 200 amps should not be used for ground fault detection. LA–1600 breakers using the DG static trip device will have the limitations of 80 amps minimum ground fault recognition and will require primary current transformers that provide a minimum continuous current setting of 400 amps or more." (See Fig. 4A).

## Instantaneous Trip Selection

Models AI and AG. The knob on the lower left selects a current value above which tripping takes place instantaneously instead of on time delay. The calibration is marked in multiples of pick-up and allows selection between five times (5X) and fifteen times (15X) pick-up. It is thus dependent on the settings selected for phase pick-up (as well as ground pick-up on the Model AG). The current-time curve (Figure 12) shows how the time delay will follow the appropriate time band curve until the instantaneous setting is reached, then will go to the instantaneous value for all currents above that setting.



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

1-F (continued)

EXAMPLE: Breaker rating as per Figure 4. Phase pick-up settings "A" (200 Amps). Long-time band setting is on Maximum. Short-time band setting is on Minimum. Transfer to short-time is set at 10X.

Currents between 200 Amps and 2000 Amps will trip the breaker after a time delay defined by the maximum long-time curve (Figure 13). Currents above 2000 Amps will trip the breaker in the time indicated by the minimum short-time curve.

If the phase pick-up settings were changed to "B" (250 Amps), then the short-time band would be used for currents of 2500 Amps and above.

## 1-G PERFORMANCE OF STATIC TRIP DEVICES IN SERVICE

Ambient conditions and length of service will have negligible effects on the performance of static overcurrent trip devices. The circuits used are very stable and will show excellent repeatibility over long periods of time. Service involving frequent operations will not cause the characteristics to change or drift, since there are no moving mechanical parts to wear or bearings to lubricate.

For the same reason, the static trip devices are tolerant of dusty conditions, and will function properly in many areas that would affect the serviceability of electro-mechanical trip devices.

The temperature at the static trip device does have some effect on the characteristics, due to changes in response of some of the components. However, the changes are small and will not be a factor in most applications. Over the range of -40°C to 55°C (-40°F to 131°F), the variation from performance at room temperature is very small, amounting to less than 5% in pick-up value and timing, and up to 10% on the Model D, DG in transferring from the long-time band to the short-time band.

Operation should not be contemplated beyond this range without control of the temperature, such as by heaters or ventilation.

www . ElectricalPartManuals . com

www . ElectricalPartManuals . com

## SECTION 2 - MAINTENANCE AND TESTING

### 2-A MAINTENANCE

Each static overcurrent trip device is adjusted, calibrated, and tested before shipment and is ready for use after selecting appropriate settings and locking the potentiometer shafts.

Maintenance in the usual sense of clean, readjust, lubricate, etc. is not required on static overcurrent trip devices. The only maintenance that is recommended is periodic verification that the device is functioning. This may be supplemented as desired by checking the calibration, inspection for loose or broken external wiring, restoring lost calibration, etc.

Restoring Lost Calibration

The calibration of the static overcurrent trip device depends on the knobs being properly oriented on their shafts. If the knobs are forced by neglecting to loosen the shaft locks, calibration will be lost, but can readily be restored.

A knob will be in proper calibration if, when turned counter-clockwise as far as it can go, the pointer lines up precisely with the red calibration dot on the dial. Refer to Figure 8B.

If the above check shows the calibration to be in error, remove the knob by loosening its set screw and slipping it off the shaft. Then be sure the shaft lock is loosened (see Figure 8A) and turn the shaft counterclockwise as far as it will go. Keep the shaft in that position and replace the knob so that it is directly over the red calibration dot. Tighten the set screw in the knob.

With the shaft lock loosened, the knob may now be turned to the selected dial position, the shaft locked, and the device returned to service.

### 2-B TESTING

The testing of Allis-Chalmers Static Overcurrent Trip Devices is easily accomplished under field conditions with a minimum of equipment and preparation. Various tests can be made, and in a manner that makes them suitable for use during routine maintenance. Calibration cannot normally be done under field conditions.

The tests that will be described can be done on a complete breaker assembly located in the disconnect position in the cubicle, on the complete breaker on a work table, or on a static trip device completely removed from the breaker. It is not necessary to remove permanent wiring in order to make tests. Testing can be done on a breaker exactly as it is used in normal service.



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

## 2-C DESCRIPTION OF TESTS

A number of tests can be made on static overcurrent trip devices in order to verify the proper operation of the device, or to establish the accuracy of the various functions. The user will normally establish test routines to suit the particular application and his standard operating procedures. The following is a brief description of available tests and their purposes.

a) Function Test
In many cases this is the only test that need be done. Using a minimum of equipment, it determines that the static trip device is operating. It gives the static trip device an input above the pick-up setting and establishes that an output (tripping of the circuit breaker) is produced. It does not check calibration, although it will show that timing is generally in the right area.

b) Power Supply Test

This test verifies that the internal power supply of the static device is functioning normally and is adjusting itself properly to changes in input.

c) Pick-Up Test

This test is used to show that the pick-up current properly corresponds to the pick-up dial setting. It checks the turn-on of the trigger circuit to assure that a timing operation will start when the input signal has reached the proper magnitude.

d) Time Delay Test

In this test the actual time-to-trip is carefully measured to assure that the selected settings will produce time delays as specified on the current-time characteristic curve. It is also useful in establishing time delay for non-standard settings between the calibrated pick-up points if such settings are desired.

e) Transfer Test

This test verifies that the circuits used to transfer from long time delay curve to the instantaneous trip (Models AI and AG) and to the short time delay curve (Models D and DG) are functioning properly.

f) Trip Signal Test

Determines that the static overcurrent trip device produces a proper output for tripping the circuit breaker. It is



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

2-C (continued)

usually used as a simple test to isolate the cause of unknown tripping trouble, since if a proper trip signal is obtained, the trouble is limited to the latching system on the circuit breaker.

2-D TEST EQUIPMENT

Simple, readily available equipment is used in the testing of static overcurrent trip devices. The following items of equipment are required for performing the routine FUNCTION Test described in paragraph 2-C(a).

1. A 115 VAC variable voltage transformer with at least 3 Amps output.

2. An ammeter which will indicate 1 to 3 Amps with reasonable accuracy.

3. An air-core reactor of 35 milli-henries or more with a DC resistance of 20 ohms or less. A standard 125 V DC power circuit breaker solenoid trip coil (such as Allis-Chalmers No. 71-200-745-501) may be used, as may other similar coils. However, a reactor designed for the purpose is available, and is also suitable for the more accurate requirements of time delay testing. It may be ordered as - REACTOR - 71-142-395-501.

The test connections for the above equipment are shown in Figure 5. Paragraph 2-E describes test procedures.

To perform TIME-DELAY tests as described in paragraph 2-C(d), similar equipment is used except that better accuracy is required and a timing device is needed. The required equipment is as follows:

1. A 115 VAC variable voltage transformer with 5 Amps output.

2. An air-core reactor of at least 60 milli-henries and 6 ohms or less DC resistance. (Allis-Chalmers Reactor 71-142-395-501 may be ordered for this purpose.)

3. Ammeters which are accurate in the range of 0.5 to 5 Amps.

4. A DC voltmeter with high resistance - at least 20,000 ohms per volt, such as a good multi-meter.

5. A double-pole, single-throw switch.

6. A cycle counter or similar timing device.



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

2-D (continued)

The test connections for this equipment are shown in Figure 6. Paragraph 2-E describes test procedures.

Allis-Chalmers can also supply a complete, integrated, and easily portable test set comprising essentially the above equipment, as illustrated in Figure 7. Contact the local Allis-Chalmers office for further information.

## 2-E TEST PROCEDURES

This section will describe in detail the steps to be taken to carry out the tests described in paragraphs 2-C. Tests may be conducted on the completed circuit breaker, either in the disconnected cubicle position, or removed from the cubicle. It is not required to remove or disconnect any permanent wiring on the circuit breaker as long as primary and control circuits are not connected to the breaker. It will usually be advantageous to perform normal routing maintenance on the circuit breaker before testing the static trip device.

Although the following descriptions relate to a completed circuit breaker unit, it will be apparent that the tests can also be carried out on a static trip device by itself.

Paragraph 2-D describes the equipment suggested for these tests.

a) Function Test. Proceed as follows:

Connect test circuit as shown in Figure 5.
Loosen shaft locks.
Set pick-up knobs at "A".
Set instantaneous (or transfer) knob at 10X or higher.
Close breaker.
Quickly increase current to 1.5 Amps (3X pick-up) and hold.
Breaker should trip in approximately 10 to 45 seconds, depending on the time band (see current-time curve, Figures 12, 13).
Reduce or shut off current.
Repeat as desired.
Set instantaneous (or transfer) knob at 5X.
Close Breaker.
Quickly increase current to 2.5 Amps.
Breaker should trip instantly at 2.5 Amps or a little less.
Reduce or shut off current.
Repeat as desired.
Restore original settings and tighten shaft locks.

This function test will show that the time delay circuit and the short time circuit are functioning. Repeatability should be good, but the specific value of time delay should not be judged except in the broad sense.



www . ElectricalPartManuals . com

www . ElectricalPartManuals . com

2-E (continued)

Obviously, other parameters can be used for this test - those described will give a reasonably fast test with minimum test power. Higher currents at the "A" setting will give faster trip times. Settings other than "A" require more current to get the desired multiples of pick-up (e.g. 3 Amps at "E" setting is required for 3X pick-up.)

The function test may be repeated using terminals 2-4 and 3-4 (Models Al and D); or terminal 3-2 (Models AG and DG). It is not recommended to test terminals 4-2 on the Models AG, DG, since the ground detection transformer circuit has a very much higher impedance and is beyond the capabilities of the usual low power test facilities.

Since the function circuits are common for all input terminals, little is gained in testing more than one input terminal.

If the breaker does not trip on the function tests, a trip-signal test (paragraph f) may be made to determine whether the trouble is in the static trip device or in the circuit breaker.

As noted in paragraph 2-C(a), the function test is the only test usually desirable for routine service. The other tests described are for specific requirements, or for trouble shooting.

b) <u>Power Supply Test</u>

Connect test circuits as shown in Figure 5 and Figure 6. Connec voltmeter leads to terminals 8 and 4 (terminals 8 and 2 on Model AG, DG)(8 is positive). Adjust variable voltage transformer until ammeter reads about 0.5 Amps. The voltmeter should read approximately 20 to 24 volts. The actual value is not critical and varies with each device. Increase the current briefly to about one Amp and note that the voltage does not change. This indicates that the power supply is normal.

c) <u>Pick-Up Test</u>

Connect test circuit as shown in Figure 6. Connect voltmeter to terminals 5 and 4 (terminals 5 and 2 on the Models AG, DG). (5 is positive). Set pick-up adjustment at "A". Increase the current slowly until the voltmeter suddenly jumps from a very low value to approximately 6 to 8 volts. This is the pick-up point and the ammeter should read 0.5 Amps. The test currents for othe pick-up settings are as follows (test currents for various multip of pick-up are also shown as a convenience):



www . ElectricalPartManuals . com

www . ElectricalPartManuals . com

2-E(c) continued

| PICK-UP SETTING | PICK-UP CURRENT | 3X PICK-UP | 5X PICK-UP | 10X PICK-UP |
|---|---|---|---|---|
| A | 0.5 Amps | 1.5 Amps | 2.5 Amps | 5.0 Amps |
| B | 0.625 | 1.875 | 3.125 | 6.25 |
| C | 0.75 | 2.25 | 3.75 | 7.5 |
| D | 0.875 | 2.625 | 4.375 | 8.75 |
| E | 1.0 | 3.0 | 5.0 | 10.0 |

This test may also be made on the other phases of the static trip device. For Models Al and D, change connections to terminals 2-4 and then 3-4. For Models AG, DG, change the connection to terminals 3-2; do not test on terminals 4-2, as explained in paragraph 2-E(a).

The pick-up test is quite sensitive to the wave shape of the test current, which will not be perfect in most field test equipment. This may cause an apparent low reading which may be in the order of 10%, in addition to the production tolerance of plus or minus 10%. Thus, if the test shows that pick-up is within these limits, the pick-up calibration marks can be relied upon.

d) Time Delay Test

Connect test circuit as shown in Figure 6. Since the same timing circuit is used for all phases, it is not necessary to test more than one phase.

Set pick-up on minimum ("A" setting). The pick-up current is then 0.5 Amps. Settings other than "A" may be used, but will not permit the range of test that is possible with the minimum pick-up setting. Refer to the table in paragraph 2-E(c) for actual test currents at various pick-up settings and various multiples of pick-up current.

Set instantaneous (or transfer) at 15X so that the long-time bands may be tested. Any multiple of the pick-up current may be tested within the limits of the test equipment (about 5 Amps on the equipment described).

Close the circuit breaker.
Close the double-pole switch and set the desired test current.
Open the switch and reset the cycle counter.
Close the switch and, holding the current steady, wait for the circuit breaker to open.
Open the switch and read time delay on the cycle counter.
Repeat as desired.
Repeat as desired with other combinations of test current and/or pick-up setting.



www . ElectricalPartManuals.com

www . ElectricalPartManuals . com

Repeated tests at the same settings should agree very closely and show good agreement with the time band used during the tests. Usually the time delay will fall within the width of the time band, however, minor deviations may sometimes occur and are acceptable for reasons discussed in paragraph 2-G and paragraph 2-H.

On the MODELS D, DG static trip device it is possible to test for time delay on the short-time bands also. Connect test circuit as shown in Figure 6. Set the pick-up at "A", set the transfer knob at 5X, and adjust the test current to 5 Amps. Close the circuit breaker, then close the switch. The circuit breaker should trip very quickly, the actual time delay being as shown on the time-current curve (Figure 13) for the time-band tested. Although only a small part of the curve can be tested with the equipment described, the test is a valid one since it does show the short-time circuits to be functioning and in calibration over the entire range.

On the MODELS AG, DG static trip device it is not practical to test for time delay or pick-up on the ground pick-up circuit because of the high saturated reactance in that circuit, and because tests on the phase circuit (terminals 1 and 2, or 3 and 2) also prove the timing and pick-up of the ground pick-up circuit. Such tests can be made, however, if facilities are available. Equipment required would be a 230 V AC supply, a 230 V variable transformer, and an air core reactor of about one Henry inductance. Pick-up currents for the ground pick-up circuit (terminals 4 and 2) are 0.1 Amp for the 20% setting, 0.2 for 40%, 0.3 for 60% and 0.4 for 80%. Procedure is the same as outlined above.

e) <u>Transfer Test</u>

Connect test circuit as shown in Figure 6. For MODELS AI or AG set pick-up at "A" setting and instantaneous at 5X. Increase current rapidly until the circuit breaker trips, which should be at 2.5 Amps. Other combinations of current and settings may also be tried.

For MODEL D connect test circuit as shown in Figure 6. Connect voltmeter leads to terminals 4 and 6. Set pick-up at "A" setting and transfer at 5X. Increase the current until the voltmeter suddenly goes to a reading of 6 to 8 volts at 2.5 Amps. test current. This indicated that transfer to the short-time band has occurred.



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

2-E (continued)

For MODEL DG connect test circuit as shown in Figure 6. Connect voltmeter leads to terminals 2 and 6. Set pick-up at "A" setting and transfer at 5X. Increase the current until the voltmeter suddenly goes to a reading of 6 to 8 volts at 2.5 Amps test current. This indicates that transfer to the short-time band has occurred.

Other settings may also be tested. For example, with "A" pick-up setting and 10X transfer setting, the test current at which transfer to the short-time band takes place will be 5 Amps. A tolerance of 10% on transfer is permissible.

f) Trip Signal Test

This test may be made in conjunction with any other test that produces a circuit breaker tripping signal, and is particularly useful when static trip devices are being tested without the circuit breaker or the circuit breaker tripping device.

Connect a 100 ohm, one Watt Resistor across terminals 7 and 8 of the static trip device when the circuit breaker tripping device (see Figure 1) is not connected to the static trip to simulate a load during this test.

Connect the voltmeter to terminals 7 and 8 (8 is positive). When the test being conducted produces a trip signal, the voltmeter will suddenly jump to a reading of approximately 8 to 10 volts. This voltage will disappear when the test current is shut off.

It is apparent that the time delay before obtaining a trip signal can easily be predicted from the known static trip device settings, known test current, and the appropriate current-time curve.

## 2-F HIGH CURRENT TESTING

It is obviously possible to test the static overcurrent trip system by passing high current through the circuit breaker primary circuit. However, the equipment required for such testing is normally of a special nature and not readily available, whereas the equipment and procedures described in this instruction are universally applicable.

The usual high current test equipment operates at very low voltage, and for this reason it may not drive a sinusoidal current through the static trip device, and the test results will show an apparent error. Current wave shape should be checked and allowances made for distortion if the use of such equipment is contemplated.

The basic concepts outlined in this instruction are valid for testing with other kinds of equipment and will require only minor detail changes to adapt to different test circuits.



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

## 2-G ACCURACY OF TESTS

A bushing type current transformer on a power circuit is essentiall a constant current device, and will drive a sine wave of current through a saturable reactance and resistance load, such as the stat trip device. Therefore, a pure sine wave of current is used during manufacturing tests and calibrations.

For field testing however, it is convenient to use a variable volta transformer as a source of test current. This is essentially a constant voltage device, and will not drive a sine wave of current through the static trip device load. The resulting distortion of t current wave shape causes the test ammeter to read incorrectly and causes an apparent decrease in the expected time delay, since the time-current curves are based on pure sine wave currents.

Another way to look at it is that a bushing type current transforme will faithfully follow the current wave shape in the primary circui (as long as the transformer does not saturate). Since the primary current is usually a sine wave, the same wave shape will be produce in the load. The circuit will provide whatever voltage is necessar to drive the current, and the resulting voltage at the load may be very different from a sine wave.

A variable voltage transformer on the other hand, when connected to the same load will produce a sinusoidal voltage wave shape and the current will not be sinusoidal. Since the current and voltage are in phase, the voltage will be zero when the current is passing through zero, and there will be no voltage to drive the current just at the time when the rate of change should be very high in order to maintain a sinusoidal current.

By inserting an air core reactor of sufficient size, the phase angle between current and voltage can be altered so that the voltage at current zero is high enough to support the rate of change of current required for a sinusoidal current wave shape. The reactors suggeste in this instruction are adequate for the purpose described, although they do not produce a total correction of the current wave shape. They represent a compromise between degree of correction and magnitude of test currents available from a 115 V source that is satisfactory for all practical purposes.

## 2-H GENERAL COMMENTS ON TEST RESULTS

Good test results, particularly on those tests involving the measurement of time delay, require careful attention and proper use of facilities. The ammeters used to measure test current should be accurate and recently calibrated; and should be read carefully. Any error in current measurement will cause an apparent error in timing of double magnitude. Fluctuations in the test supply voltage will change the test current, and this too can cause an apparent error in timing. Currents should be monitored during test, and the test repeated if the set current varies.



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

2-H (continued)

Knob settings on the static trip device can cause apparent errors if the pointers are not aligned with the calibration marks. Large errors may be found if the knob has been moved relative to its shaft however, correction is easily accomplished as described in paragraph 2-A.

Although the test equipment and procedures described here do not permit testing at high multiples (above approximately 10X) of pick-up current, that is not a detriment to satisfactory confidence in the use of the test results. The tests allow all circuits of the static trip device to be checked, and if they are functioning properly and in calibration at low multiples, it is practically impossible for the high end to be in error. Of course, a broader range of test values can be obtained if more test power is available, but this is not necessary or recommended.

Production procedures involve adjustment, calibration, and test throughout the full range of adjustment on equipment much more elaborate and precise than that suggested for field use. Subsequently prior to shipment, additional proof testing is done by other persons using equipment fundamentally similar to that suggested for field tests. Throughout the manufacturing cycle, the equipment and procedures are rigidly specified and closely controlled to assure continuing accuracy. Consequently if a field test discloses an apparent minor deviation from the expected test result, it is advisable to rely on the calibrations as marked on the static trip device, and not to assume that the calibrations are in error.

Obviously, large deviations and improper functions should not occur. If such is the case, it is recommended that the local office of Allis-Chalmers be contacted for advice. The nature of electronic devices of this type, using special quality components and closely controlled selection and adjustment techniques, precludes the ability to attempt reliable repair of static trip devices in the field.

www . ElectricalPartManuals . com

www . ElectricalPartManuals . com

## SECTION 3 - TECHNICAL DESCRIPTION OF OPERATION OF STATIC OVERCURRENT TRIP DEVICES

This section is presented for the benefit of those that may desire a mo complete and detailed understanding of the circuit functions used in Allis-Chalmers Static Overcurrent Trip Devices. The following paragrap are not necessary to the proper use and servicing of static trip devic - SECTIONS 1 and 2 are complete in that respect.

Operation of the various models of the static trip device can be expla in detail from elementary diagrams. The diagrams to be used are somewh simplified in that some of the auxiliary circuits (such as circuitry fo biasing voltage, factory adjustment for component tolerances, temperatu compensation, reduction of voltage spikes due to transformer saturatio etc.) have been omitted to make the descriptions of functions as simple and clear as possible.

### 3-A OPERATION OF DUAL MODEL A1

Refer to elementary diagram for this device, Figure 9. Each bush current transformer mounted on breaker is connected in series wit a power-supply and auxiliary transformer. The power-supply trans formers are designed to saturate at relatively low voltage to lim the amount of energy in their output at high overcurrents. This energy would otherwise be difficult to control in the small space available. The output of these transformers goes to a full wave rectifier as shown and is then filtered by capacitor C1 and resis R1 to limit ripple. The output voltage is regulated by Zener Dio Z1 to provide a power supply for transistor circuits.

The auxiliary transformer might also be referred to as impedance matching transformer as they reduce the secondary current from b. to a still lower order of magnitude at higher voltage to serve as the signal current for the device. Most of the current flows thr Pot. P1 (for Phase A) and establishes a voltage proportional to t primary current in the breaker. The magnitude of this voltage determines whether or not the breaker will trip and time delay be tripping. Obviously the relation between this AC voltage and the primary current can be varied by adjusting Pot. P1. This adjustm then varies the minimum primary current at which breaker will tri and is the external pick-up adjustment.

A small portion of signal current from the auxiliary transformer rectified and flows through trim pot. P4 to establish a voltage w actuates the trigger circuit. Setting this voltage at P4 is an internal factory adjustment to allow for component tolerances. T trigger circuit consists of transistors T1 and T2 plus associated circuitry. It is commonly called a Schmitt Trigger Circuit. Normally, when primary current and resulting signal are below pic setting, base current of T1 flows through Zener Z2, Diode D6, and



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

resistor R3 and T1 is on. T2 is biased off by voltage across R4 due to collector current from T1. When voltage at P4 is high enough, base current is blocked at D6. T1 goes off and T2 conducts. Collector current through R5 then establishes a blocking voltage at diode D7 and timing capacitor C3 can then charge. If, at any time, signal voltage goes even slightly below set point, T1 promptly conducts and T2 goes off. Timing capacitor C3 can then discharge through R5 and device is reset.

A very small portion of rectified signal current flows through diode D4 and resistor R2 to establish a DC voltage across capacitor C2. This acts essentially as a peak filter and D.C. voltage is very nearly equal to peak AC voltage. Consequently it makes little difference in the operation of the device whether overcurrent is three-phase or single-phase. The device responds only to the current in the highest phase.

The DC signal voltage across C2 causes a very small current to flow through a non-linear resistance network to capacitor C3. This non-linear resistance is the time shaping circuit and the value of components selected determines the slope and shape of the current-time characteristic curve. If the signal voltage is above the set point so that the trigger has operated, capacitor C3 will gradually charge. When voltage at C3 reaches the peak point emitter voltage of T3, the latter will fire to discharge C3 through resistor R10. Resulting voltage pulse across R10 triggers gate of SCR which then conducts to energize trip coil and open breaker. With breaker open, there is no longer any energy from b.c.t. for the power supply and blocking voltage at D7 disappears. Any remaining charge on timing capacitor C3 then flows through D7 and R5 and the device is reset.

In this arrangement the non-linear resistance network determines the slope and shape of the current-time characteristic curve. The simplest way to increase or decrease time delay without changing slope or shape of curve is to vary the value of C3. This is the method for obtaining the three time bands shown on the characteristic curves and is a factory adjustment for this model.

Instantaneous trip adjustment is by means of Pot. P5 and is an external field adjustment. Whenever the voltage at slider of Pot. P5 is high enough, Zener Diode Z5 conducts to establish a voltage across resistor R9 which exceeds the peak point emitter voltage of T3. T3 then fires to discharge capacitor C6 to create a pulse across R10 which triggers the SCR to energize the trip coil.

3-B OPERATION OF DUAL MODEL AG

Refer to elementary diagram for this device - Figure 10. Note that this diagram is the same as for Model A1 except for arrangement of



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

3-B (continued)

power-supply and auxiliary transformers in device. In this model a power-supply and auxiliary transformer are connected in series with the common or neutral of the b.c.t. and will therefore detect phase to ground faults if the system is grounded. They will not respond to load currents or high three-phase inrush currents since none, or very little, current flows in the neutral under such conditions provided the load is reasonably well balanced between phases.

These transformers in the neutral are different from those in phase circuits and are designed to provide a power supply and signal sufficient to operate the device at current magnitudes 20% of those required to operate from transformers in the phase circuits.

In all other respects this Model AG is the same as Model A1 and description of operation follows paragraph 3-A.

## 3-C OPERATION OF SELECTIVE MODEL D

Refer to elementary diagram for this device - Figure 11. Each bushing current transformer mounted in breaker is connected in series with a power-supply and auxiliary transformer. The power-supply transformers are designed to saturate at relatively low voltage to limit the amount of energy in their output at high overcurrents. This energy would otherwise be difficult to control in the small space available. The output of these transformers is connected to a full wave rectifier as shown and then filtered by resistors R1, R2 and Capacitor C1 to limit ripple. The output voltage is regulated by Zener Diode Z2 to provide a power supply for transistor circuits. Zener Z1 limits the magnitude of the voltage spikes at high overcurrents and reduces duty on Z2.

The auxiliary transformer might also be referred to as impedance matching transformers as they reduce the secondary current from b.c.t. to a still lower magnitude at higher voltage to serve as the signal current for the device. Most of this current flows through Pot. P1 (for phase A) and establishes a voltage proportional to the primary current in the breaker. The magnitude of this voltage determines whether or not the breaker will trip and the time delay before tripping. Obviously the relation between this AC voltage and the primary current can be varied by adjusting Pot. P1. This adjustment then varies the minimum primary current at which breaker will trip and is the external pick-up adjustment.

A small portion of signal current from auxiliary transformer is rectified and flows through trim pot. P4 to establish a voltage which actuates the trigger circuit. Setting this voltage at P4 is an internal factory adjustment to allow for component tolerances. The trigger circuit consists of transistors T1 and T2 plus associated circuitry. Normally, when primary current and resulting



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

3-C (continued)

signal are below pick-up setting, base current of T1 flows through Zener Z3, Diode D6, and Resistor R4, and T1 is on. T2 is then biased off by voltage across R5 due to collector current from T1. When voltage at P4 is high enough, base current is blocked at D6. T1 goes off and T2 conducts. Collector current from T2 through R6 then establishes a blocking voltage at Diode D7 and timing capacitor C3 can then charge.

If, at any time, signal voltage drops even slightly below set point value, T1 promptly conducts and T2 goes off. Timing capacitor C3 can then discharge through R6 and device is reset.

A small portion of rectified signal current flows through diode D4 and resistor R3 to establish a DC voltage across capacitor C2. This acts essentially as a peak filter as the DC voltage is very nearly equal to peak AC voltage. Consequently it makes little difference in the operation of the device whether overcurrent is three-phase or single-phase. The device responds only to the current in the highest phase.

The DC signal voltage at C2 causes a very small current to flow through a non-linear resistance network to capacitor C3 (for Minimum Time Band). This non-linear resistance is the time-shaping circuit and the value of components selected determines the slope and shape of the current-time characteristic curve. If the signal voltage is above the set point so that trigger has operated, C3 will gradually charge. When voltage at C3 reaches the peak point emitter voltage of T5, the latter will fire to discharge C3 through resistor R18. Resulting voltage pulse across R18 triggers gate of SCR which then conducts to energize trip coil and open breaker. With breaker open, there is no longer any energy from b.c.t. for power supply and blocking voltage at D7 disappears. Any remaining charge on timing capacitor C3 then flows through D7 and R6 and device is immediately completely reset.

As mentioned above, the non-linear resistance network determines the slope and shape of the current-time characteristic curve. The simplest way to increase or decrease time delay without changing slope or shape of curve is to vary the value of timing capacitor. This is the method for obtaining the three time bands shown on characteristic curves. By means of switches as shown the number of capacitors in the circuit may be one, two or four. Corresponding to MINIMUM, INTERMEDIATE AND MAXIMUM TIME BANDS. For Model D this is an external field adjustment. Switch contacts are controlled by knob marked LONG TIME BAND SETTING on calibration plate.

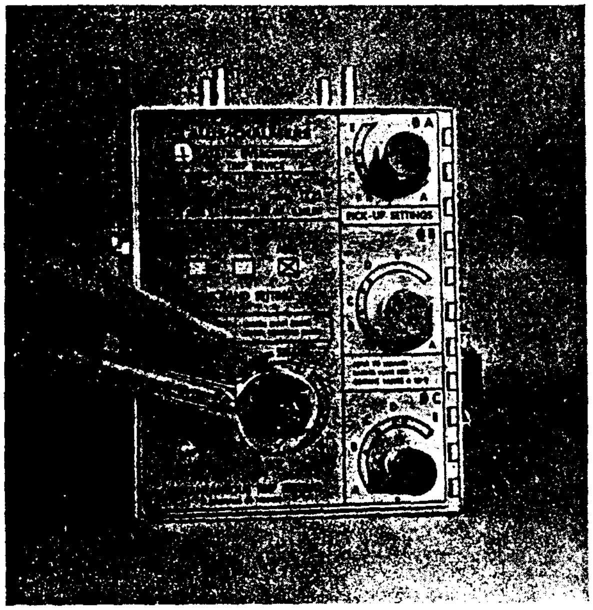
TRANSFER TO SHORT TIME is controlled by setting of Pot. P5 which is an external field adjustment. When signal voltage, and consequently the voltage at slider of P5, is high enough, transfer trigger operates to activate the short time delay circuit. The transfer trigger is comprised of transistors T3 and T4 plus associated circuitry. It functions in much the same manner as trigger for long time delay



www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

ALLIS-CHALMERS



205424

205423

SHAFT LOCKS

205422

AUTION: LOOSEN SHAFT LOCKS
EFORE ROTATING KNOBS

CALIBRATION
REFERENCE
POINTS

FIG. 8

SHAFT LOCKS AND CALIBRATION MARKS FOR
STATIC OVERCURRENT TRIP DEVICES

www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

3-C (continued)

previously described. That is, normally when primary current and consequently DC signal voltage is below value set at P5 base current for transistors T3 flows through diode D9 and resistor R11. T3 conducts and its collector current creates a voltage across R12 which biases T4 off. When signal voltage is high enough, base current is blocked at Diode D9. T3 then goes off and T4 conducts. Collector current from T4 then flows through R13 to create a blocking voltage at D11. Timing capacitor C9 in short-time delay circuit can then charge. This same voltage causes current to flow through Diode D13 and Resistor R5 to create a voltage which biases transistor T2 off so that long-time delay circuit ceases to operate.

Note that capacitor C9 is charged from power-supply voltage which is regulated constant voltage. Time to charge is therefore constant and independent of the magnitude of primary current so long as it is above the minimum value to operate trigger circuit as determined by setting of Pot. P5.

The time to charge C9 can obviously be varied by setting of Pot. P6 which is the external adjustment marked "SHORT TIME BAND SETTING" on calibration plate.

When voltage at C9 reaches peak point emitter voltage of T5, the latter fires to discharge C9 through resistor R18 and create a voltage pulse which triggers gate of SCR to energize trip coil. After breaker opens, power supply and blocking voltage disappear and any remaining charge on C9 drains off through D11 and R13. Device is then completely reset.

3-D <u>OPERATION OF SELECTIVE MODEL DG</u>

Refer to elementary diagram for this device - Figure 11A. Note that this diagram is the same as for Model D except for arrangement of power supply and auxiliary transformers in device. In this model a power supply and auxiliary transformer are connected in series with the common or neutral of the b.c.t. and will therefore detect phase to ground faults if the system is grounded. They will not respond to load currents or high three-phase inrush currents since none, or very little, current flows in the neutral under such conditions provided the load is reasonably well balanced between phases.

These transformers in the neutral are different from those in phase circuits and are designed to provide a power supply and signal sufficient to operate device at current magnitudes 20% of those required to operate from transformers in the phase circuits.

In all other respects this Model DG is the same as Model D and description of operation follows paragraph 3-C.

www.ElectricalPartManuals.com

www . ElectricalPartManuals . com

ALLIS-CHALMERS

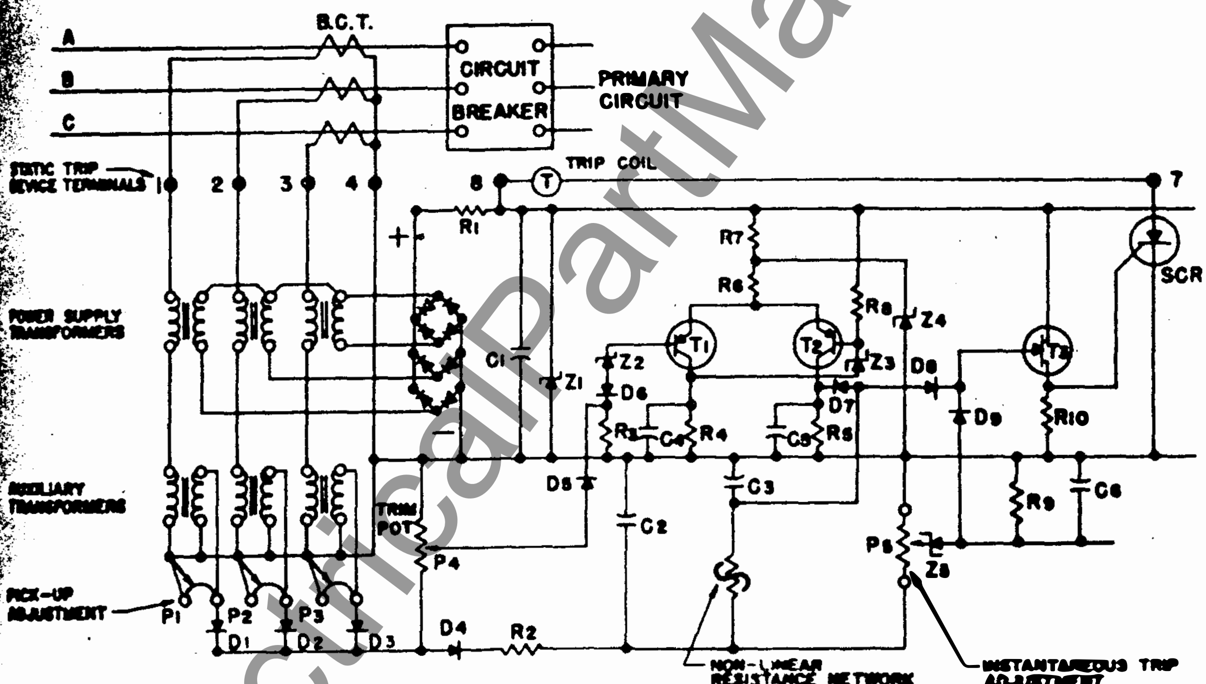



FIG. 9

TYPICAL

ELEMENTARY DIAGRAM-DUAL MODEL A-1,A-2

AUGUST 6, 1964 71-210-474-401

www.ElectricalPartManuals.com

www . ElectricalPartManuals . com