IN-810-9C

JULY, 1980

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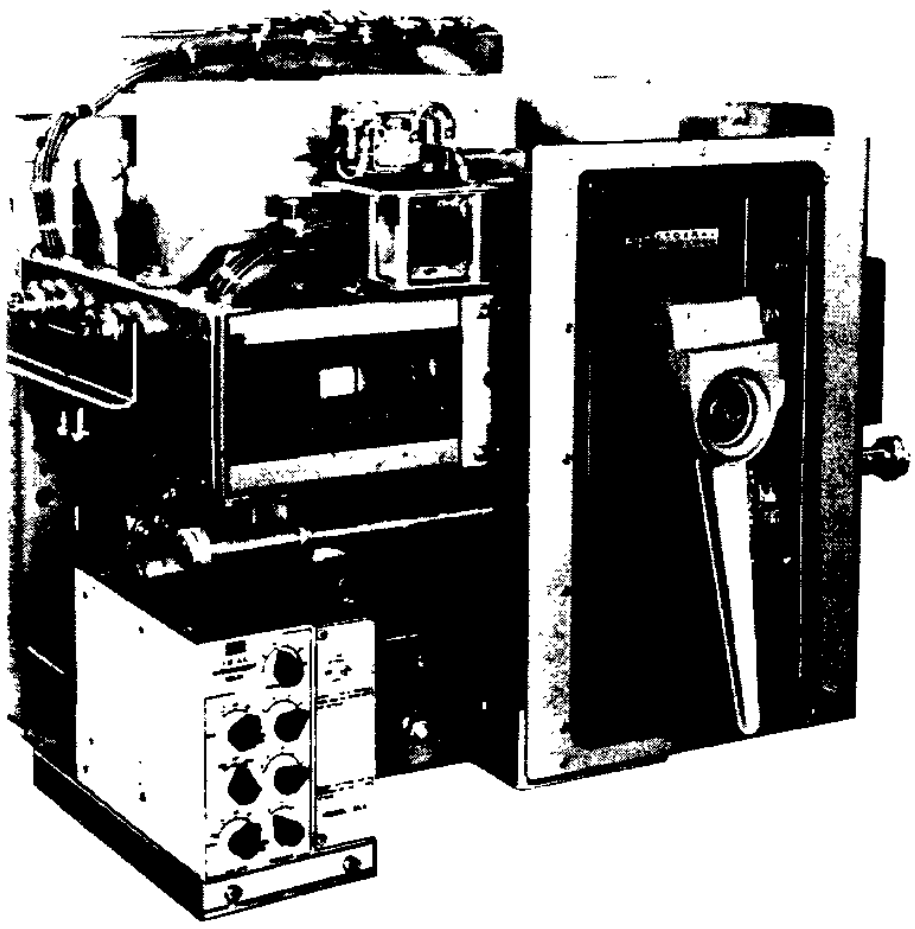
STATIC A.C. OVERCURRENT TRIP DEVICES USED WITH FPS2 POWER CIRCUIT BREAKERS

INSTRUCTION MANUAL



FEDERAL PACIFIC ELECTRIC COMPANY

SWITCHGEAR DEPARTMENT – POWER EQUIPMENT SYSTEMS DIVISION

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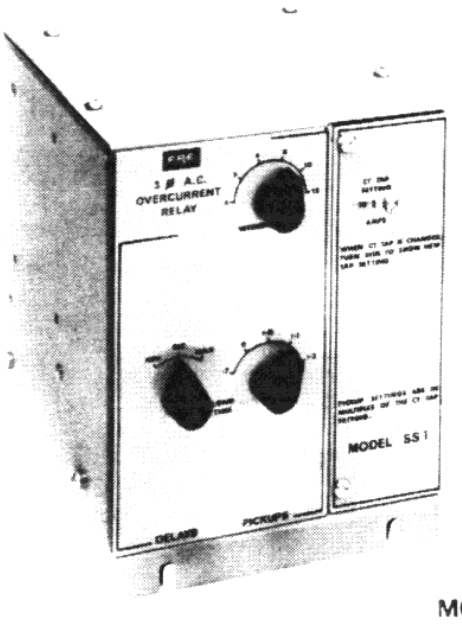

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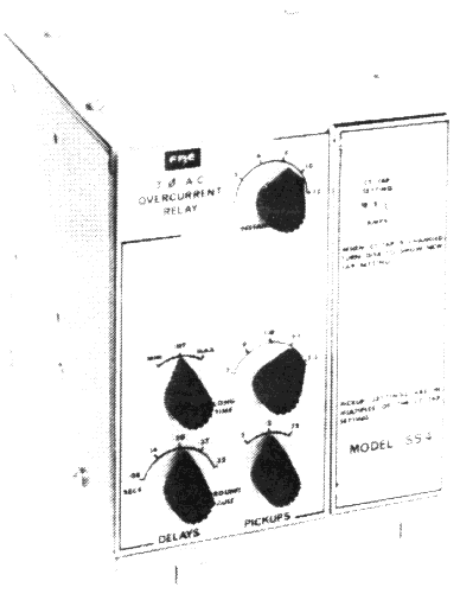

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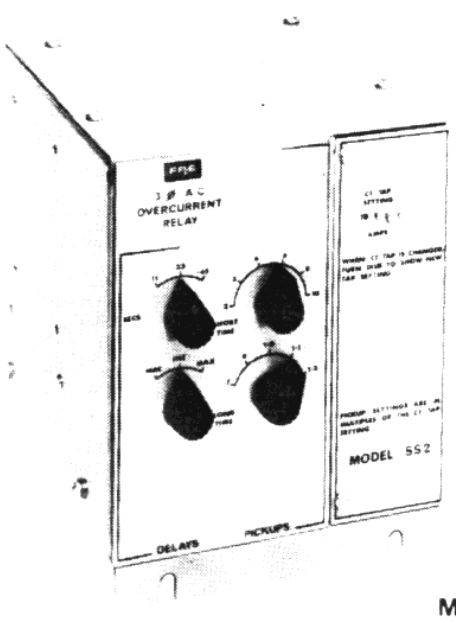

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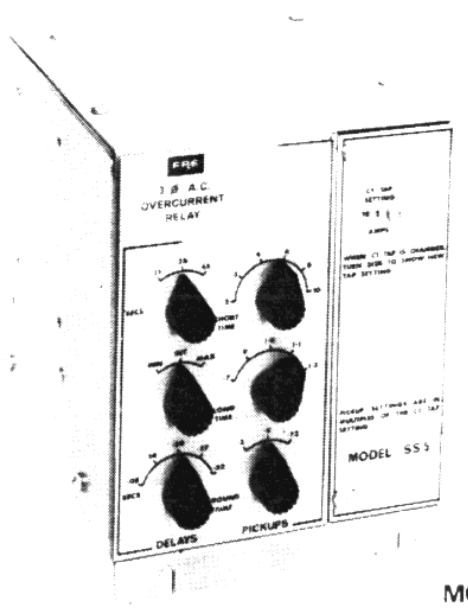

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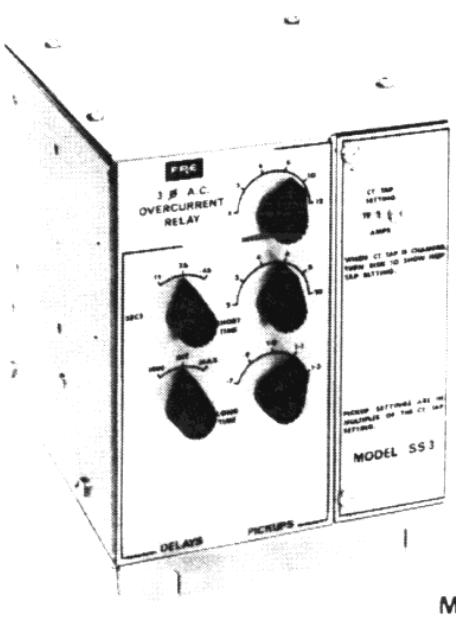
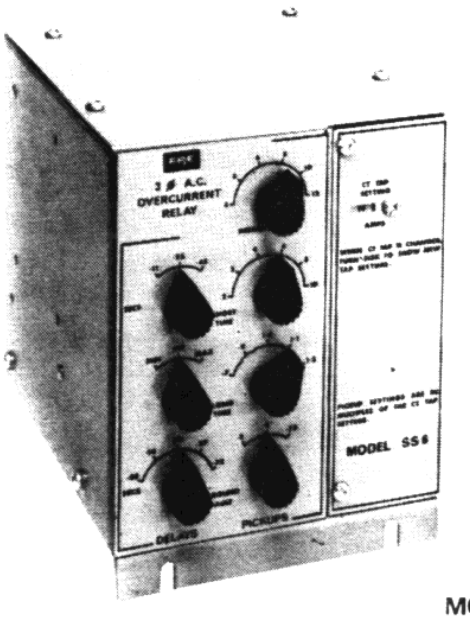


MODEL SS3



MODEL SS6

Fig. 1 — Static Overcurrent Trip Devices

INDEX

ILLUSTRATIONS

I – INTRODUCTION

This instruction manual contains descriptive, operating, testing, and maintenance information for Federal Pacific Electric static overcurrent trip devices with 600-volt class type FPS-2 power circuit breakers.

WARRANTY: The sales contract carries all information on warranty coverage. Should the need occur, the Field Service Department of the Power Equipment Systems Division of Federal Pacific Electric Company is equipped to assist you with any maintenance or repair which may be required throughout the anticipated long life of this equipment.

FPE "On-Site Test Facilities" are available to you. This service includes engineering inspection and testing of electrical equipment planned to supplement your regular maintenance program, to improve equipment reliability, and to protect your investment.

For further information regarding service, please contact the Manager of Field Service Department, Power Equipment Systems Division, Federal Pacific Electric Company, Newark, New Jersey.

A – GENERAL DESCRIPTION: Federal Pacific Electric overcurrent trip devices are completely static. There are no moving parts or contacts with the exception of the magnetic latch release. Components used are semi-conductors, capacitors, transformers, etc. The circuits are designed with conservative loading of components for long life and minimum maintenance. Although designed primarily for use with type FPS-2 power circuit breakers, static overcurrent trip devices are not limited to that class of equipment. They perform the same functions – with greater accuracy and versatility – as electro-mechanical series overcurrent trip devices.

Static overcurrent trip devices operate to open the circuit breaker when the circuit current exceeds a preset value for a predetermined time. Depending on the selected settings, tripping may be instantaneous or delayed. Energy to operate the tripping system is obtained solely from current sensors in the circuit being protected. Batteries or other power sources are not needed. The complete static overcurrent trip system consists of three parts:

(1) primary circuit current sensors,
(2) the static overcurrent trip device,
(3) a magnetically held circuit breaker latch release device.

B – CURRENT SENSORS: Toroidal current sensors, similar to standard bushing current transformers, are mounted, one per phase, on the primary studs of the circuit breaker. They provide a signal proportional to primary current and supply power to operate the static trip device including the magnetic latch release. The sensors are selected for a specific circuit breaker requirement and establish the current rating of that breaker. Each sensor provides a choice of ratings, which are listed on the sensor table shown in figure 4. The current sensors have color-coded wire leads connected to a terminal block located on the circuit breaker frame. The required sensor tap is selected by connecting the static-trip device to the proper terminals on this terminal block. The sensors have a nominal 2 amp. secondary rating.

C – STATIC TRIP DEVICE: The static-trip device receives the signal from the current sensors. It monitors the signal, senses overloads and faults and determines the required action in accordance with preselected settings. The static-trip device is the "brains" of the tripping system. The long delay is inversely proportional to the magnitude of the circuit overcurrent. The long time delay I^2t characteristic affords accurate thermal protection of cables, motors, transformers, and other loads. The phase overcurrent short delay and ground fault current trip delay characteristics are independent of the overcurrent magnitude. The trip device will reset instantly during the delay program if the primary current drops below the selected pick-up value. The pick-up tolerance is ±10%.

A metal enclosure, attached to the breaker, houses the trip device and its electronic circuits. On the front of the metal enclosure is a calibration plate with the necessary adjusting knobs. All pick-ups and delay bands are adjustable. Each function is controlled by a rotary selector switch with discrete steps and positive positioning. Although several types of static trip devices are available, all are similar in size and appearance (Fig. 1). The trip device terminal cover contains a current sensor tap setting window. The current rating showing in this window should correspond to the current rating of the sensor tap in use. The current rating showing in this window may be changed by removing the cover, loosening the center screw and rotating the pre-printed indicator disc to the desired rating. All pick-up values are expressed as multiples of the sensor tap current rating.

The wiring terminals for external connections and a special test plug receptacle are located behind the removable terminal cover. Wires from the current sensors and the flux-shift trip device connect to the labeled screw-post terminals. There is a wiring diagram on the inside of the removable front cover of the static trip device.

D – MAGNETIC LATCH RELEASE: When the static-trip device senses a circuit condition that requires the circuit breaker to open, it produces an electrical output that is fed to the magnetic latch release device. The resultant reduction of magnetic holding flux operates the device and causes the circuit breaker to open and isolate the circuit. The magnetic latch release is mechanically reset by the circuit breaker mechanism when the breaker stored energy closing spring is recharged.

E – TYPES OF TRIP DEVICES: Six types of static-trip devices are available. Similar in many respects, they differ only in functions provided. All use identical current sensor inputs and provide the output signal to the magnetic latch release. The following table (Fig. 2) shows the functions performed by the various trip device models.

FUNCTION	MODEL					
	SS1	SS2	SS3	SS4	SS5	SS6
Long Delay	X	X	X	X	X	X
Short Delay		X	X		X	X
Instantaneous	X		X	X		X
Ground Fault				X	X	X

Fig. 2 – Functions of Static Trip Models

F – FUNCTIONS AND THEIR CHARACTERISTICS:

1. **Phase Overcurrent Protection**
   (Long Delay; Inverse Time Characteristic)
   a. The Long Delay Pick-Up is adjustable with settings of 0.7, 0.9, 1.0, 1.1, and 1.3 times the current sensor tap rating.
   b. The Long Delay Band is adjustable with three settings:

      Minimum–6.5 seconds delay at 600% overcurrent.
      Intermediate–19 seconds delay at 600% overcurrent.
      Maximum–35 seconds delay at 600% overcurrent.

The dependent I^2t characteristics of the long delay function and the individual band widths are shown on Fig. 3 "Time Current Characteristics".

2. **Phase Selective Fault Protection**
   (Short Delay; Definite Time Characteristic)
   a. The Short Delay Pick-Up is adjustable with settings of 2, 3, 4, 6, 8, and 10 times the current sensor tap rating.
   b. The Short Delay Band is adjustable with delays of 0.11 sec, 0.25 sec, and 0.45 sec. The delay is independent of the current magnitude.

3. **Phase Fault Protection**
   (Instantaneous; No Intentional Delay)
   The Instantaneous Pick-Up is adjustable with settings of 4, 5, 6, 8, 10, and 12 times the current sensor tap rating.

4. **Ground Fault Protection**
   (Short Delay; Definite Time Characteristic)
   a. Ground fault pick-up is adjustable with setting of 0:2, 0.5, and 0.75 times the phase current sensor tap rating.
   b. Ground fault time delays (which are independent of fault current) are adjustable with settings of 0.08, 0.14, 0.20, 0.27, and 0.32 seconds. The ground current may be sensed by either a residual current connection of the three-phase sensors and the neutral sensor (4 wire system) or by direct connection to a current sensor on the power system ground strap.

II – OPERATION

A – GENERAL DESCRIPTION: There are three current sensors on the circuit breaker – one on each phase of the primary circuit. On 4-wire models, an identical current sensor on the neutral is used. The current sensors supply a signal to the static trip device which is proportional to the current in the primary circuit. This signal passes through residually connected set of auxiliary transformers in the solid state trip device where it is processed to obtain energy storage for tripping, regulated reference voltages, and D.C. signal voltages. The trip device responds only to the phase conducting the highest current.

The D.C. voltage signal is compared to a standard reference voltage and operates a trigger circuit when the phase or ground current exceeds the selected pick-up value. The pick-up trigger starts the selected timing function. After the proper delay, the timing circuit fires a static switch which discharges an energy storage capacitor to operate the circuit breaker magnetic latch release.

If the current magnitude drops to less than 90% of the set pick-up level, the static-trip device resets.

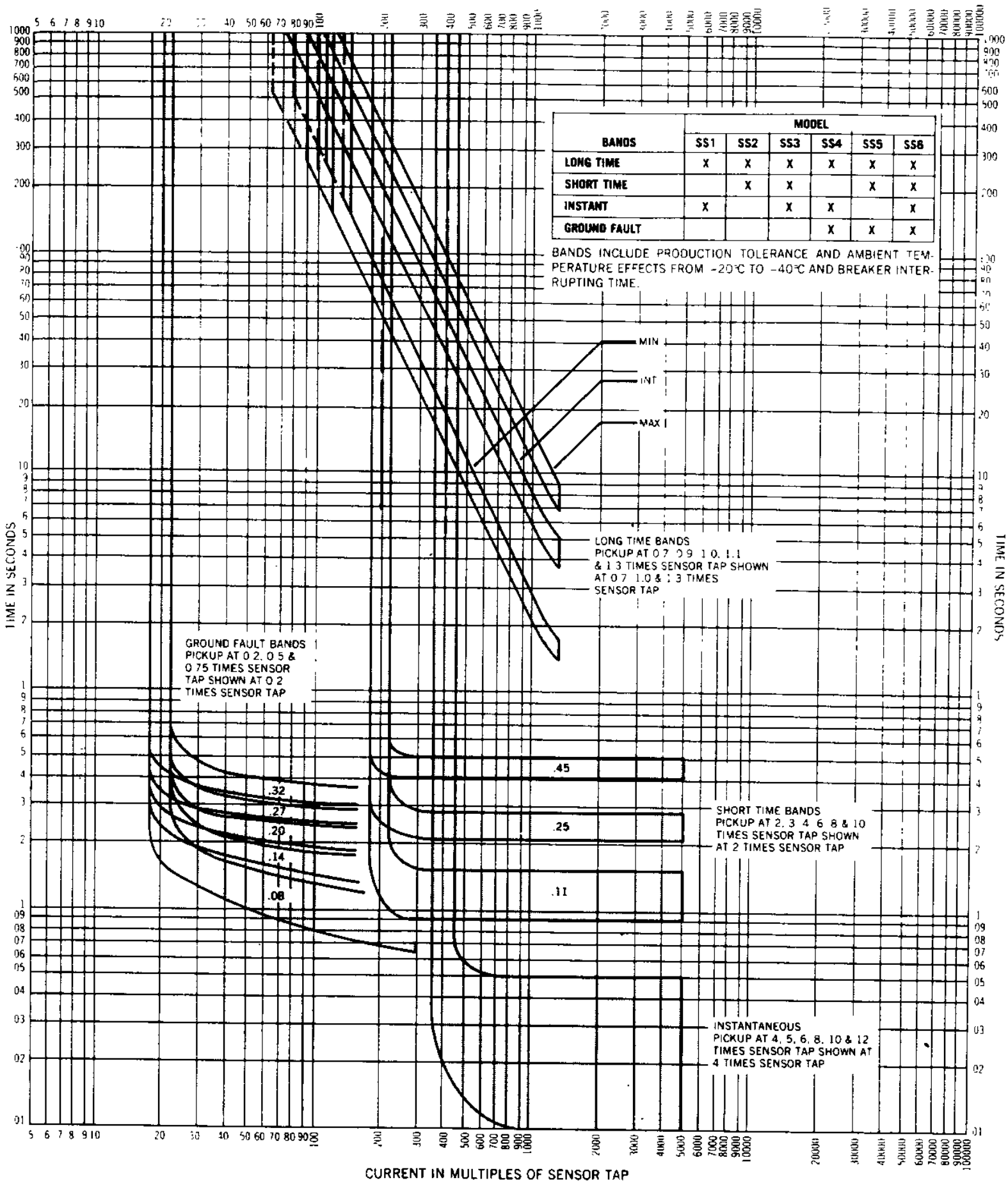
The trip device has independent pick-up trigger elements for phase fault (instantaneous short time and long time) and ground fault functions.

The ground current may be monitored by either a residual connection with or without a neutral sensor or a direct connection using a ground strap sensor. Fig. 5 shows the various sensor and static device connections.

B – SELECTING SETTINGS: The 3ϕ A.C. overcurrent trip device has a number of control knobs that can be set to select specific conditions to cause the breaker to open. Selection of settings is usually made when the breaker is placed in service. Future changes are unnecessary unless load conditions or other primary circuit changes are made.

All selector switches have "D"-type shafts to assure retention of settings. Turning the knobs beyond the marked settings will cause the relay to operate at the maximum setting for that function.

The knobs arranged vertically on the right hand side of the relay are pick-up settings. Knobs on the left are the time-delay settings. Fig. 4 shows the ampere values of pick-up current for the various pick-up settings, functions, and current sensor taps.



CURVE 1100B — 7042

	VARIATION	
RESISTOR	PICK-UP	TIME DELAY
5 Ohm	Nil	Nil
10 Ohm	Nil	+5% to +7%

NOTE: The use of resistors on dedicated motor circuit applications in the residual ground current protection circuit alters the ground current pick-up and time delay values shown on curve 1100B-7042 as follows:

Fig. 3 — Type SS Time-Current Characteristics

Circuit breaker current rating depends solely on the sensors selected for the application. The rating may be changed by selecting new tap settings or replacing the current sensors and changing the tap setting indicator disc on the front plate of the relay. The trip device and other components remain unchanged. All timing functions are independent of each other. Any long-time band can be selected to work with any short-time band. The selection of settings is, therefore, governed only by system design considerations.

C — SELECTIVE COORDINATION EXAMPLE: The circuit breaker directly feeding a phase overload or a ground current fault should always trip first in a selective trip system. A circuit overload on a feeder circuit will trip the feeder circuit breaker while the main circuit breaker remains closed to continue serving the remaining feeders in the system. All circuit breakers have full interrupting capacity. See Fig. 6.

1. THE MAIN CIRCUIT BREAKER:

a. **Current sensor** (1600) and long delay pick-up (0.9, 1440A) are selected to coordinate with transformer continuous current rating of 1200A.

b. **Long Delay Band** (Min.) is selected to coordinate with high voltage fuse melting characteristic. The fuse characteristic is converted to the 480V side of the transformer.

Note: Some overlapping of the main circuit breaker and fuse characteristic curves is often unavoidable. The maximum fuse is determined by the transformer short circuit capacity. The minimum main circuit breaker depends on the continuous current rating of the transformer secondary.

c. **Short Delay Pick-Up** (6 X, 9600 AMP) is safely above the feeder instantaneous pick-up to afford main system short-circuit protection while preventing unnecessary tripping.

d. **The Short Delay Band** (.25 sec, min) is selected to best limit main-bus fault damage while preserving selectivity. Note: Lower limit of short delay curve is above feeder ground delay and phase instantaneous max. time to trip.

e. **The Ground Current Pick-Up** (.2 X, 320A) is selected (lowest setting) for best protection.

f. **The Ground Current Band** (.20 sec.) is selected to coordinate with the feeder ground current band. A 0.05 second spread between main circuit breaker ground current lower limit and feeder circuit breaker ground current upper limit is recommended. This example has 0.08 seconds separation.

2. FEEDER CIRCUIT BREAKER

a. **Current sensor** (500A) and long delay pick-up (1 X 500A) are selected to protect the feeder cables and/or load. Single motor feeder breakers should be set 125% of motor full load current.

b. **The Long Delay Band** (MIN.) is set below the main and as low as practical. Thermal characteristics of sub feeder molded case circuit breakers, fuses, or special loads may further govern the long-delay band selection.

c. **The Instantaneous Pick-Up** (8 X, 4,000A) is set higher than all normal transients. Special consideration is required on motor starting (inst. PU 2X locked rotor current), incandescent illumination, and capacitor switching applications.

d. **The Ground Current Pick-Up** is set (0.2 X, 100A) at the minimum setting. Higher settings may be required to coordinate with down stream ground current protection devices in some applications.

e. **The Ground Current Band** (0.08 sec.) min. delay available is selected to best limit ground fault damage.

D — PERFORMANCE IN SERVICE: Ambient conditions and length of service will have little effect on the performance of the solid state overcurrent trip device. The circuits are stable and will show excellent repeatability over long periods of time. Service involving frequent operations will not cause the characteristics to change or drift since there are no mechanical moving parts to wear or bearings to lubricate.

For the same reason the relay will withstand the severe environmental conditions often encountered in industrial applications. It will function properly in areas that would affect the serviceability of electro-mechanical trip devices.

The solid state trip device will operate within the published characteristics over the temperature range of −40°C to +65°C. Operation outside this temperature range should be referred to Federal Pacific Electric Company, Switchgear Division.

III — MAINTENANCE

A — GENERAL: Each trip device is calibrated and tested before shipment. It is ready for use after the appropriate settings have been selected and current sensor tap setting indicated.

No cleaning readjustment or lubrication is required. The only maintenance that is recommended is periodic verification that the relay and magnet latch release are functioning properly.

Current Sensor			Long Time Pick-Up Amperes					Short Time Pick-Up Amperes						Instantaneous Pick-Up Amperes						Ground Fault Pick-Up Amperes		
Assembly No.	Tap Selection *	Lead Color Code (Red Common)	.7X	.9X	1.0X	1.1X	1.3X	2X	3X	4X	6X	8X	10X	4X	5X	6X	8X	10X	12X	.2X	.5X	.75X
3000 AMPERE FRAME																						
1151A6646	3000	White	2100	2700	3000	3300	3900	6000	9000	12000	18000	24000	30000	12000	15000	18000	24000	30000	36000	600	1500	2250
	2500	Black	1750	2250	2500	2750	3250	5000	7500	10000	15000	20000	25000	10000	12500	15000	20000	25000	30000	500	1250	1875
	2000	Green	1400	1800	2000	2200	2600	4000	6000	8000	12000	16000	20000	8000	10000	12000	16000	20000	24000	400	1000	1500
1600 AMPERE FRAME																						
1151C6645	1600	White	1120	1440	1600	1760	2080	3200	4800	6400	9600	12800	16000	6400	8000	9600	12800	16000	19200	320	800	1200
	1200	Black	840	1080	1200	1320	1560	2400	3600	4800	7200	9600	12000	4800	6000	7200	9600	12000	14400	240	600	900
	1000	Green	700	900	1000	1100	1300	2000	3000	4000	6000	8000	10000	4000	5000	6000	8000	10000	12000	200	500	750
1152C6645	800	White	560	720	800	880	1040	1600	2400	3200	4800	6400	8000	3200	4000	4800	6400	8000	9600	160	400	600
	600	Black	420	540	600	660	780	1200	1800	2400	3600	4800	6000	2400	3000	3600	4800	6000	7200	120	300	450
	500	Green	350	450	500	550	650	1000	1500	2000	3000	4000	5000	2000	2500	3000	4000	5000	6000	100	250	375
1153C6645	400	White	280	360	400	440	520	800	1200	1600	2400	3200	4000	1600	2000	2400	3200	4000	4800	80	200	300
	350	Black	245	315	350	385	455	700	1050	1400	2100	2800	3500	1400	1750	2100	2800	3500	4200	70	175	262.5
	300	Green	210	270	300	330	390	600	900	1200	1800	2400	3000	1200	1500	1800	2400	3000	3600	60	150	225
1154C6645	250	White	175	225	250	275	325	500	750	1000	1500	2000	2500	1000	1250	1500	2000	2500	3000	50	125	187.5
	225	Black	157.5	202.5	225	247.5	292.5	450	675	900	1350	1800	2250	900	1125	1350	1800	2250	2700	45	112.5	168.75
	200	Green	140	180	200	220	260	400	600	800	1200	1600	2000	800	1000	1200	1600	2000	2400	40	100	150
1155C6645	175	White	122.5	157.5	175	192.5	227.5	350	525	700	1050	1400	1750	700	875	1050	1400	1750	2100	35	87.5	131.25
	150	Black	105	135	150	165	195	300	450	600	900	1200	1500	600	750	900	1200	1500	1800	30	75	112.5
	125	Green	87.5	112.5	125	137.5	162.5	250	375	500	750	1000	1250	500	625	750	1000	1250	1500	25	62.5	93.75
1156C6645	100	White	70	90	100	110	130	200	300	400	600	800	1000	400	500	600	800	1000	1200	20	50	75
600 AMPERE FRAME																						
1151C6644	600	White	420	540	600	660	780	1200	1800	2400	3600	4800	6000	2400	3000	3600	4800	6000	7200	120	300	450
	500	Black	350	450	500	550	650	1000	1500	2000	3000	4000	5000	2000	2500	3000	4000	5000	6000	100	250	375
	400	Green	280	360	400	440	520	800	1200	1600	2400	3200	4000	1600	2000	2400	3200	4000	4800	80	200	300
1152C6644	350	White	245	315	350	385	455	700	1050	1400	2100	2800	3500	1400	1750	2100	2800	3500	4200	70	175	262.5
	300	Black	210	270	300	330	390	600	900	1200	1800	2400	3000	1200	1500	1800	2400	3000	3600	60	150	225
	250	Green	175	225	250	275	325	500	750	1000	1500	2000	2500	1000	1250	1500	2000	2500	3000	50	125	187.5
1153C6644	225	White	157.5	202.5	225	247.5	292.5	450	675	900	1350	1800	2250	900	1125	1350	1800	2250	2700	45	112.5	168.75
	200	Black	140	180	200	220	260	400	600	800	1200	1600	2000	800	1000	1200	1600	2000	2400	40	100	150
	175	Green	122.5	157.5	175	192.5	227.5	350	525	700	1050	1400	1750	700	875	1050	1400	1750	2100	35	87.5	131.25
1154C6644	150	White	105	135	150	165	195	300	450	600	900	1200	1500	600	750	900	1200	1500	1800	30	75	112.5
	125	Black	87.5	112.5	125	137.5	162.5	250	375	500	750	1000	1250	500	625	750	1000	1250	1500	25	62.5	93.75
	100	Green	70	90	100	110	130	200	300	400	600	800	1000	400	500	600	800	1000	1200	20	50	75
1155C6644	90	White	63	81	90	99	117	180	270	360	540	720	900	360	450	540	720	900	1080	18	45	67.5
	70	Black	49	63	70	77	91	140	210	280	420	560	700	280	350	420	560	700	840	14	35	52.5
	50	Green	35	45	50	55	65	100	150	200	300	400	500	200	250	300	400	500	600	10	25	37.5
1156C6644	40	White	28	36	40	44	52	80	120	160	240	320	400	160	200	240	320	400	480	8	20	30

* Set current sensor tap rating on trip device indicator

NOTES

1) The power system neutral must be grounded on the power source side of the neutral sensor in residual ground current sensing protection schemes.
2) The current sensor in the neutral bus must be identical to the sensors in each of the phase lines.
3) The current sensors must be carefully connected for proper polarity. Polarity marks on all current sensors face toward the power source.

Fig. 4 — Current Sensor Rating Table

The relay should be checked for pick-up, timing, and tripping functions. The magnetic latch release mechanical adjustments (see Fig. 7) should be checked. The sealed dust cover may be removed to clean the magnetic pole faces to correct relatching problems. Use duct seal or similar sticky compound to remove dirt and magnetic particles. The pole faces and keeper must be perfectly clean and dry to function properly. Reinstall the dust cover ensuring it is properly seated on the elastic sealing ring.

All control wiring should be inspected to ensure connections are tight and wires are not damaged or broken.

Warning: The solid-state trip device is factory sealed after calibration and should not be opened. The guarantee is void if the trip device is tampered with or improperly tested. **DO NOT "HYPOT" TEST SOLID STATE TRIP DEVICE TERMINALS.**

B – TROUBLE SHOOTING:

a. **Failure to Trip:** Failure of the circuit breaker to trip in response to overload, short circuit, or ground current may be caused by any of the following reasons. Corrective action is indicated with the reason for failure to trip.

1) **CT's improperly connected,** check that all terminals are tight, wiring is correct and leads are not broken. Current transformers which have carried load current with the secondary open must be replaced. Connections to trip unit are located under removable terminal cover. Remove two screws on front of trip device to open for inspection.

2) **Flux transfer magnetic latch release open circuited,** check that the wiring to the trip device is not broken and polarity marks are observed. Coil resistance should be approximately 25 ohms. The dust cover may be removed to permit mechanically releasing the magnetic keeper to test the spring and the loading force on the keeper. Fig. 7 shows mechanical adjustments.

3) **Relay set too high,** check that pick-up settings on the relay are correct and the correct current sensor tap is being used. Refer to time current curves (Fig. 3) and table of pick-up currents (Fig. 4).

b. **Failure to Close and Latch the Breaker:** Failure to close and latch mechanically may result from any one of the following causes. Corrective action is indicated with the reasons for failure.

1) **Failure to close and latch mechanically,** check to insure that the magnetic trip release is properly reset by the circuit breaker when the mechanism is charged, open, and relatched. Refer to Fig. 7 for correct adjustment and test standard. Remove the dust cover and thoroughly clean the magnetic keeper and pole faces. Check to ensure that the keeper is positively magnetically retained. The keeper may be forced off the pole faces to permit cleaning. Refer to appropriate circuit breaker instruction manual.

2) **Failure to close and latch because of premature overcurrent tripping.** Check the following causes:

a) Ensure that an overload or short circuit condition does not exist on the load circuit.

b) Ensure that there is no abnormal grounding or ground current. Ground current pick-up may be set as low as 20% of phase current.

c) Check current sensor taps to ensure current sensors are properly selected for the required load. **Important:** check current sensor wiring and mounting for polarity. A reverse connected current sensor will generate residual connection currents which cause ground circuit tripping.

d) Check pick-up setting to ensure setting is at least 120% of the nominal load current. Long- and short-time delay bands should be set to override certain predictable overloads, such as motor starting, spot welder and induction oven feeds, etc.

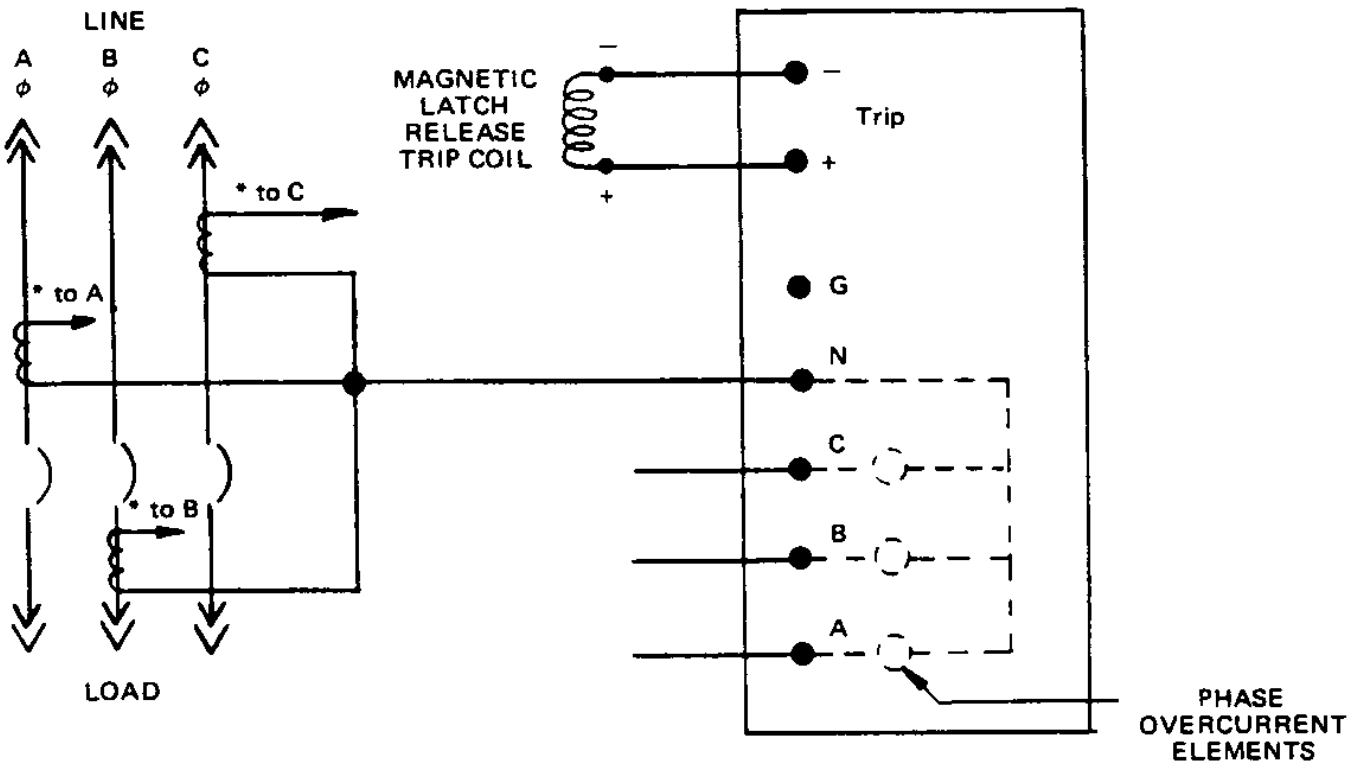
e) Non-sinusoidal current (distorted wave) may cause premature tripping as the solid state circuit is basically a peak metering device. Higher than normal pick-up settings may be required in some applications.

IV – TESTING

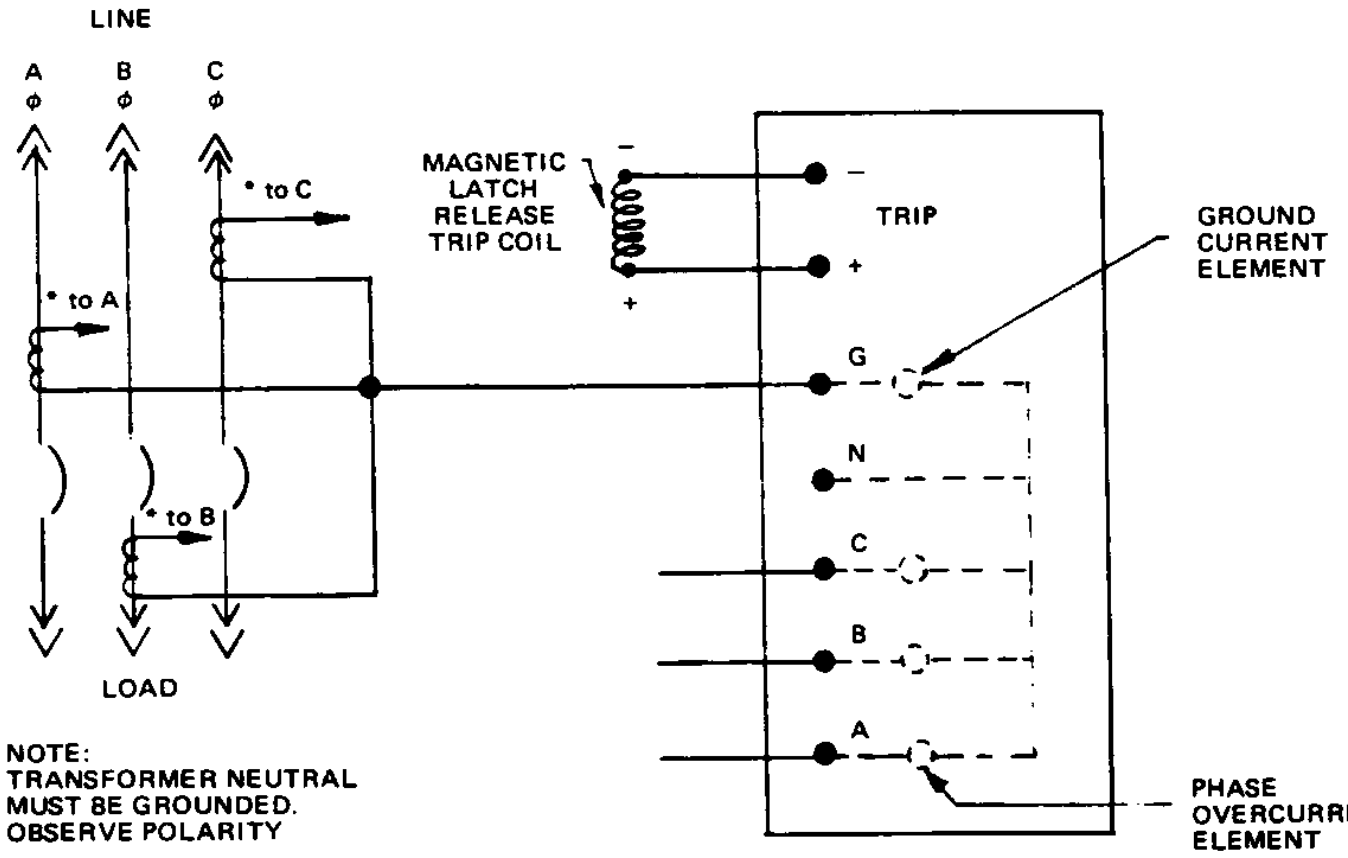
A – GENERAL: Testing of the FPE Static Overcurrent Trip Device is easily accomplished under field conditions with minimum of equipment and preparation. The tests can be done on a complete breaker assembly located in the disconnect position in the cubicle, on the complete breaker on a work table, or on 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.

1) The FPE type DDT-SS Portable Test Unit is recommended for all calibration, maintenance, and qualification testing. The test unit permits checking all trip device functions over the entire range of currents and operating times. It indicates the long delay pick-up trigger has fired and the timing circuit is functioning. This permits checking the long delay pick-up without

SYSTEM: 3ϕ, 3 WIRE UNGROUNDED
3ϕ 4 WIRE WITHOUT GROUND FAULT PROTECTION
PROTECTION: 3ϕ OVERCURRENT TRIP
RELAY MODELS: SS1; SS2; SS3.



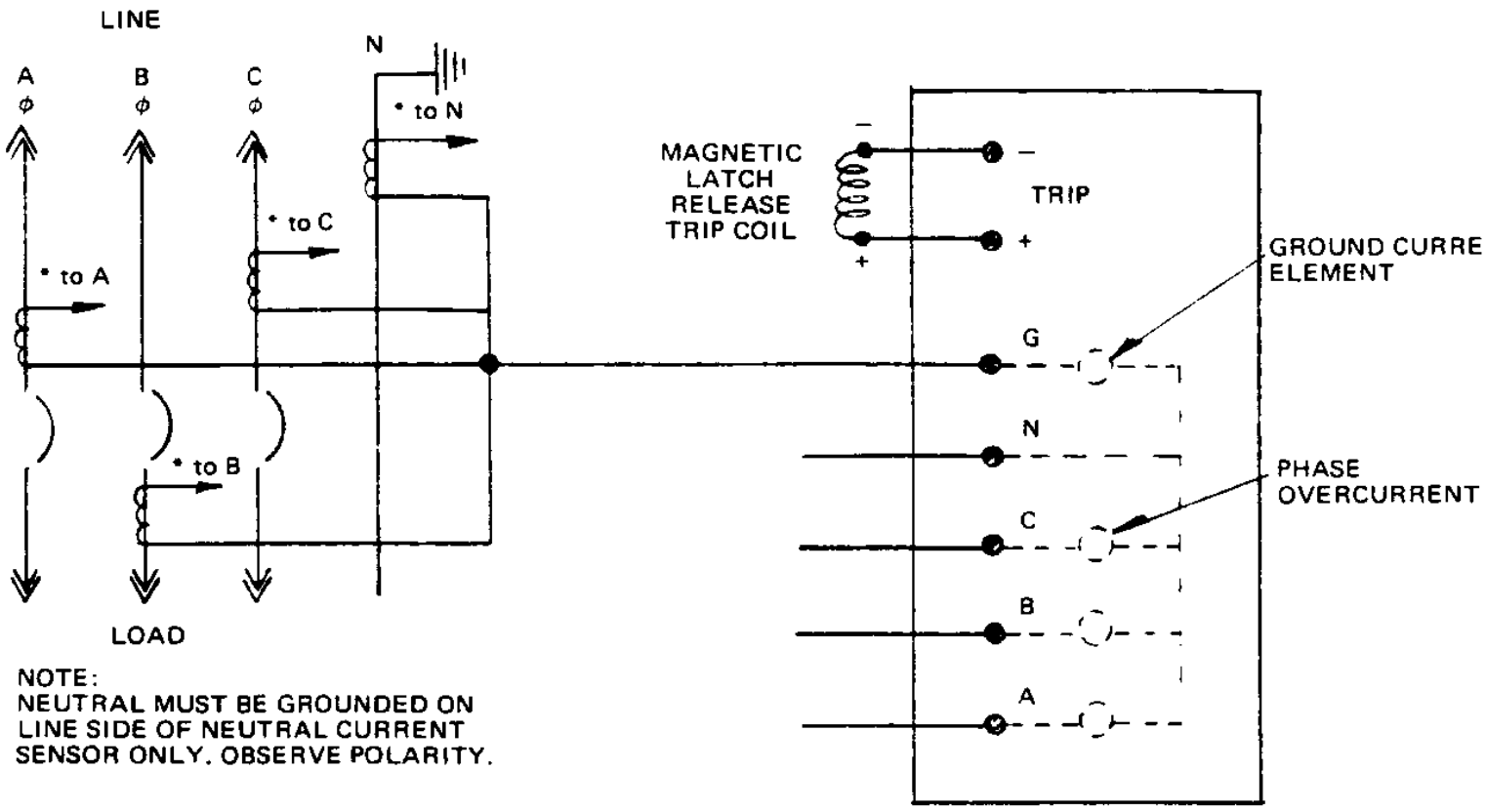
SYSTEM: 3ϕ, 3 WIRE
PROTECTION: 3ϕ OVERCURRENT AND RESIDUAL GROUND CURRENT TRIP.
RELAY MODELS: SS4; SS5; SS6.



NOTE:
TRANSFORMER NEUTRAL
MUST BE GROUNDED.
OBSERVE POLARITY

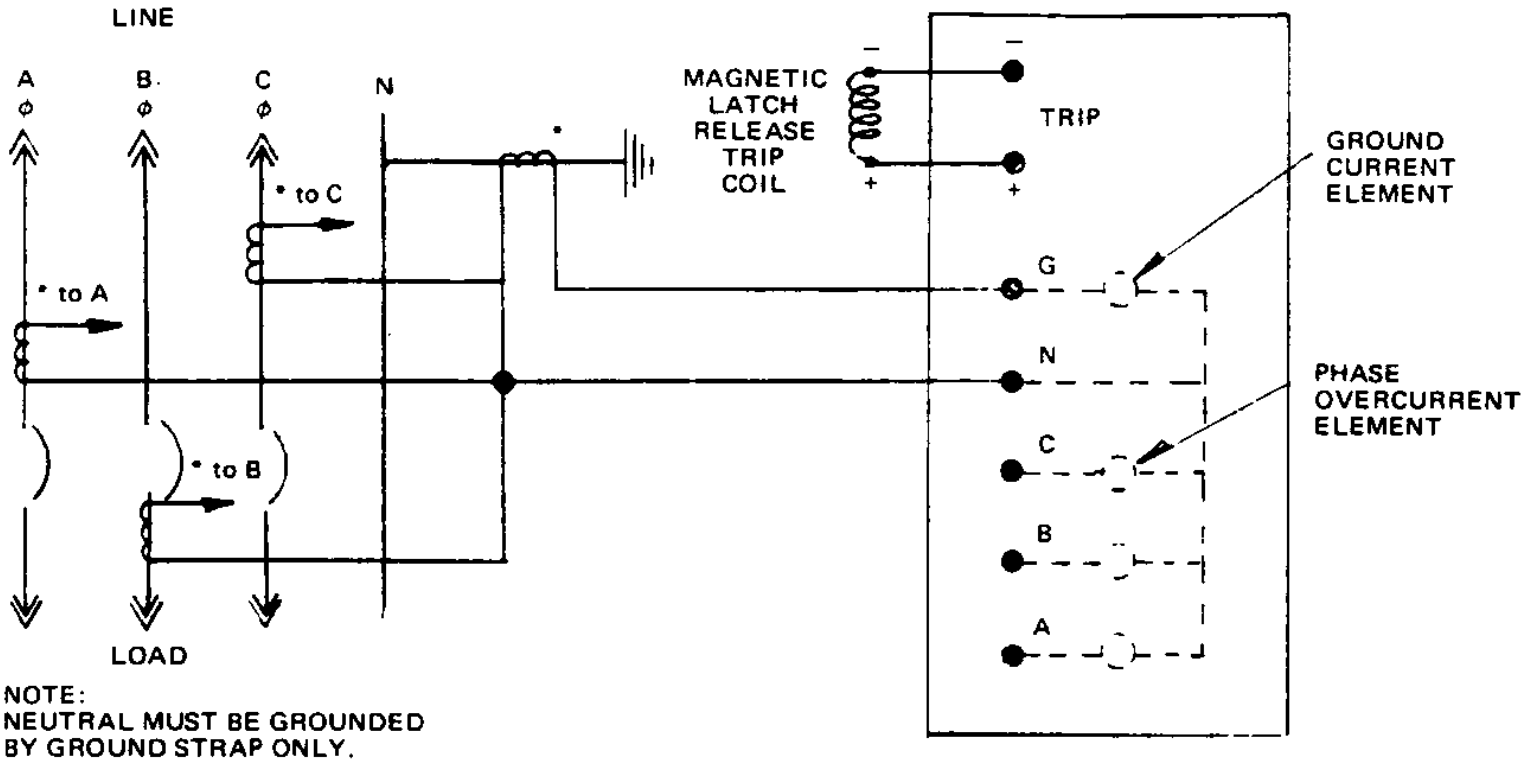
Fig. 5 — Current Connections to SS Relay

SYSTEM: 3ϕ, 4 WIRE
PROTECTION: 3ϕ OVERCURRENT AND RESIDUAL GROUND CURRENT TRIP
RELAY MODELS: SS4; SS5; SS6.



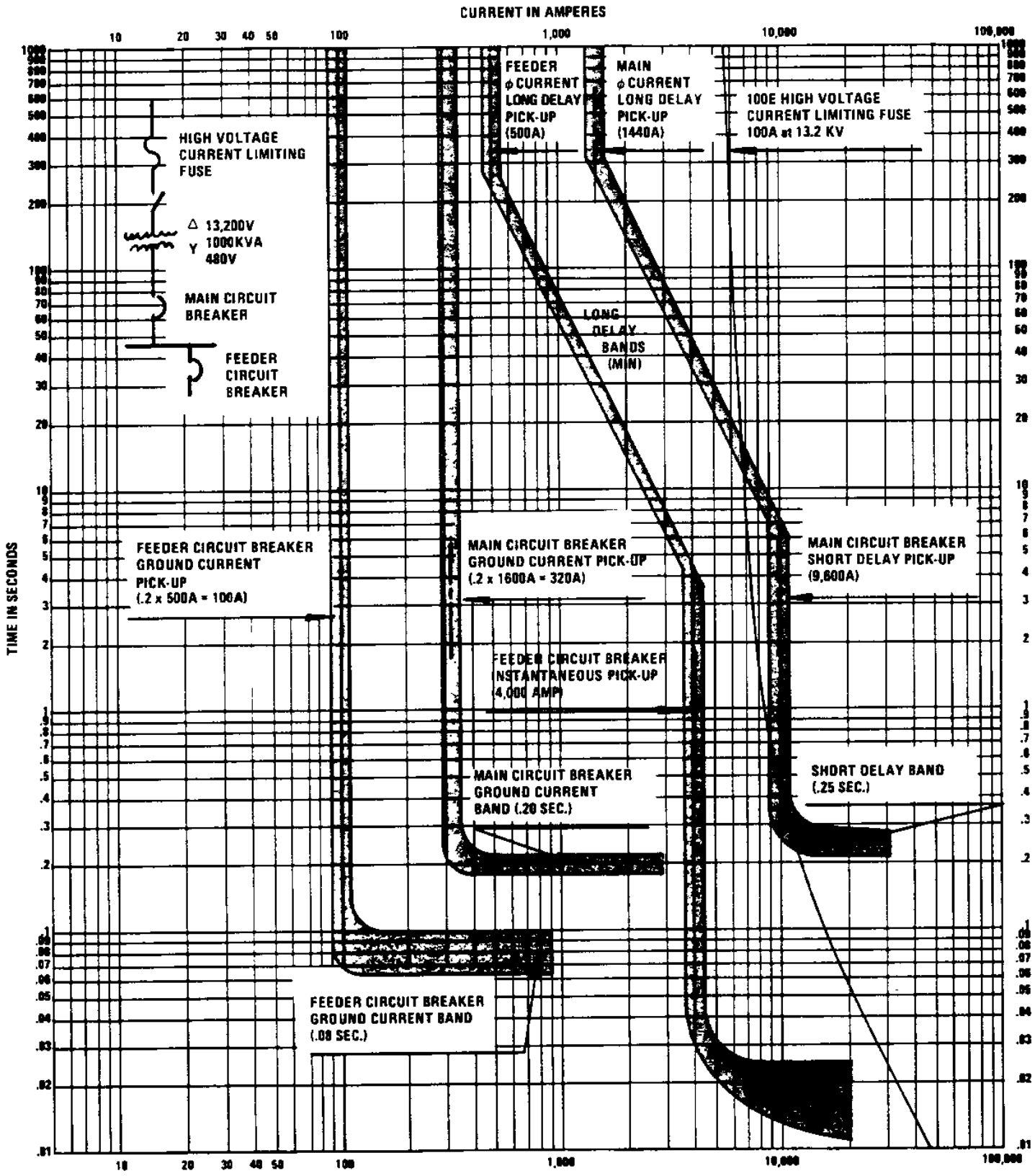
NOTE:
NEUTRAL MUST BE GROUNDED ON LINE SIDE OF NEUTRAL CURRENT SENSOR ONLY. OBSERVE POLARITY.

SYSTEM: 3ϕ, 4 WIRE
PROTECTION: 3ϕ OVERCURRENT AND DIRECT GROUND CURRENT TRIP
RELAY MODELS: SS4; SS5; SS6.



NOTE:
NEUTRAL MUST BE GROUNDED BY GROUND STRAP ONLY.

Fig. 5A — Current Connections to SS Relay



SELECTIVE CO-ORDINATION EXAMPLE
FIGURE #6

Fig. 6 -- Selective Coordination Example

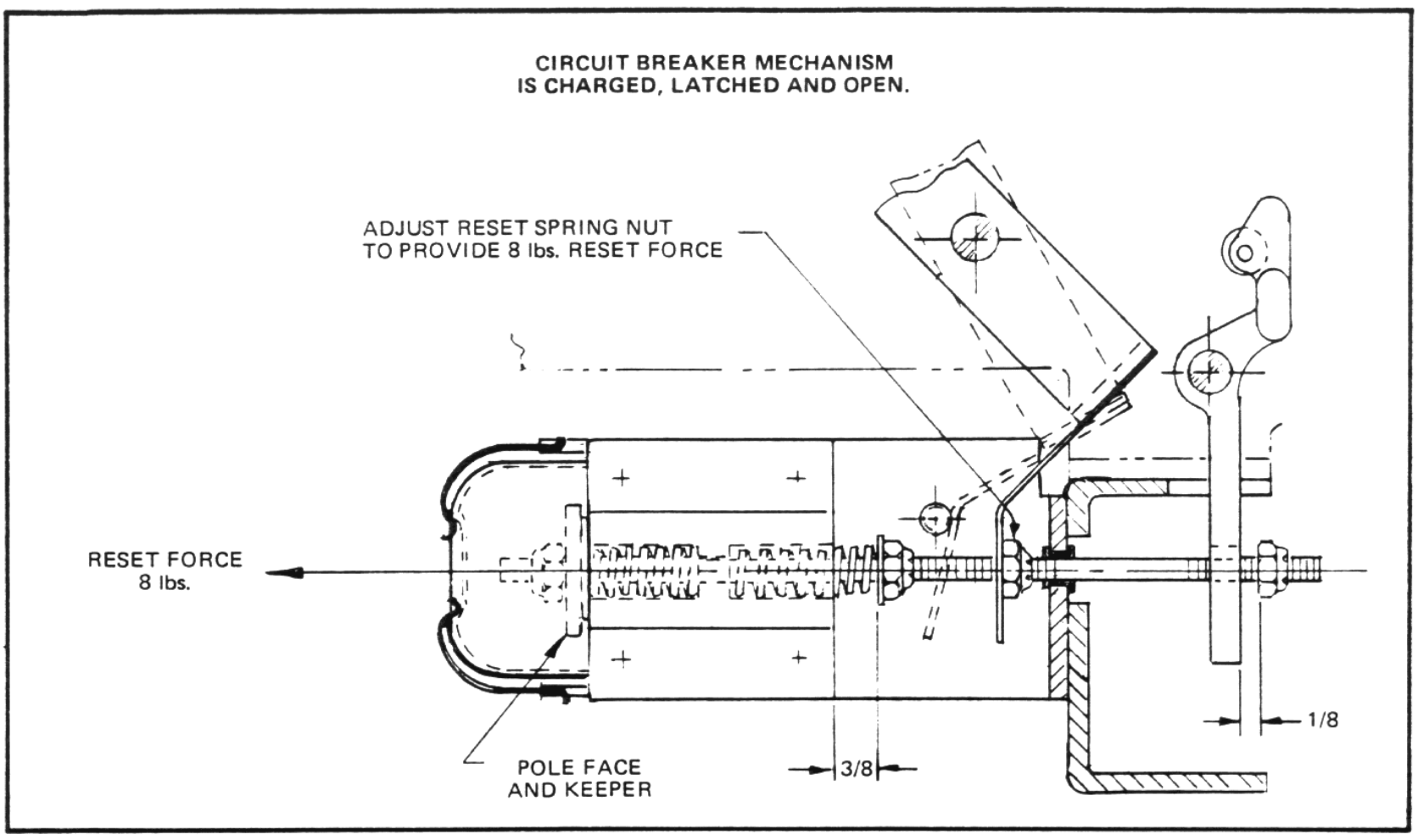


Fig. 7 — Magnetic Latch Release Assembly

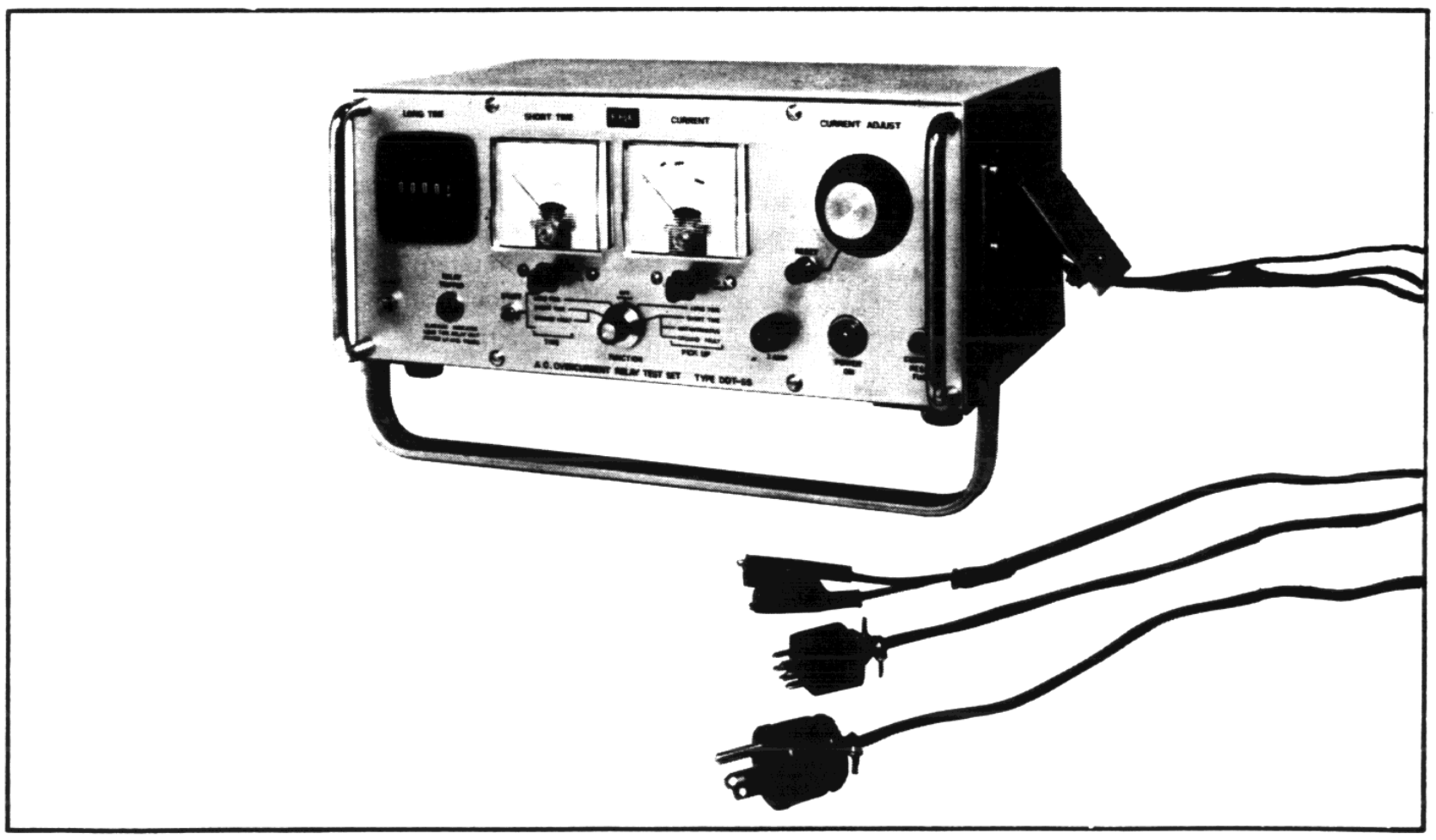


Fig. 8 — Type DDT-SS Portable Test Set

waiting for eventual tripping approximately 20 min. later. Since the clocks, meters, selectors, and indicating lights are all self-contained, a minimum of wiring to the trip unit is required. See Fig. 8.

2) "MULTI-AMP" type high-current equipment can be used for primary current testing. Care must be used to isolate the phase-current protection from the ground-current protection in the current sensor secondary wiring. Single-phase test current applied to a circuit breaker with the residual ground-current connection will cause ground-current tripping.

B – TEST PROCEDURE: Testing with FPE type DDT-SS Test Set.

Notes:

1) It is not necessary to disconnect the current sensors when calibrating with the type DDT-SS Test Unit.

2) The sensor nominal secondary current is 2 amps. The test-set ammeter reads in multiples of this nominal current, i.e. 1.0 on meter equals 2 amp rms secondary injection current.

3) Refer to time-current curve Fig. 3 for ground and overcurrent characteristics.

a) **PRELIMINARY SETTINGS:**

1) Plug the test set 6-pin Jones Plug into the relay test socket.

2) For tests on Inst., Short Time, and Long Time elements, connect the test set current leads to "N" and any "Phase" terminal. For ground fault element connect to "Phase" and "G" terminals. (See Note A) There is no polarity requirement on the current lead connections.

3) Set all switches on the relay under test to highest values.

4) Turn the "Current Adjust" knob on the test set fully counter-clockwise.

5) Turn test set "Function" switch to "Off".

6) Plug-in the test unit line cord into 120V AC supply.

b) **LONG TIME DELAY PICK-UP:**

1) Set the relay Long Time Pick-up to "1.0" and Delay on "Int". (Intermediate band).

2) Set the "Function" switch on test set to "Pick-up – Long time", "Current" meter switch to "MED".

3) Turn the "Current Adjust" knob slowly clockwise until the green light on the test set starts flashing. The meter should read in the green zone marked 1.0 on the "MED" scale. Other pick-up settings .7, .9, 1.1, and 1.3 X may be tested. The tolerance is ± 10%, i.e. .7 X should pick-up (Green light starts flashing) between .63 X and .77 X on test-set current meter.

c) **LONG TIME DELAY BAND:**

1) Set "Current" meter switch to "High".

2) Turn the "Current Adjust" knob to obtain a current reading of "6X" on current meter.

3) Turn the "Function" switch to "Time – Long Time".

4) Make sure the "Long Time" timer on the test set is reset, (i.e. press the "Reset" button on the timer face). Push the "Start" button.

5) Green light should flash, indicating Long Time pick-up and then after a time delay, the circuit breaker should trip. When testing with the circuit breaker open, the green light will become "steady" and the timer will stop. The relay trip time should read between 16 and 21 secs.

d) **SHORT TIME PICK-UP:**

1) Set the relay Short Time Pick-Up switch on 4 and Delay on 0.25 secs.

2) Rotate the "Current Adjust" knob fully counter-clockwise and push the "Reset" button.

3) Turn "Function" switch to "Pick-up" – short time".

4) Set "Current" meter switch on "High".

5) Rotate the "Current Adjust" knob slowly until relay trips. The current meter should read in the green zone marked 4.0 on the "Current" meter "High" scale. The pick-up tolerance is ±10%. Other pick-up values may be tested also.

e) **SHORT TIME DELAY:**

1) Rotate the relay Short Time pick-up switch to 10.

2) Set the "Current" meter switch on "High" and push the "Reset" button.

3) Adjust the current to 6X on the "Current" meter scale using the "Current Adjust" control.

4) Turn the "Function" switch to "Time – Short Time".

5) Set the Short Time Pick-up setting on the relay to 2.

6) Push the "Start" button. The "Short Time" clock should indicate the time delay between 0.22 and 0.28 secs.

f) **INSTANTANEOUS PICK-UP:**

1) Set the Short Time pick-up on the relay to 10 and set the Instantaneous pick-up on 4.

2) Turn the "Current Adjust" knob fully counter-clockwise and push the "Reset" button.

3) Turn "Function" switch to "Pick-up Instantaneous".

4) Set the "Current" meter switch on "High".

5) Turn the "Current Adjust" knob slowly clockwise, until the relay trips. The current meter should indicate in the green zone marked 4.0 on the meter "High" scale. Other values of instantaneous pick-up may be tested also. Tolerance is ±10%.

g) **GROUND FAULT PICK-UP:**

1) Connect current input to "G" and any "Phase" terminals on the relay. Set the "Ground Fault" pick-up on 0.75 and delay on 0.20 secs.

2) Rotate the "Current Adjust" knob fully counter-clockwise and push the "Reset" button.

3) Set the "Function" switch on "Pick-up" – ground fault.

4) Set the "Current" meter switch on "Low".

5) Rotate the "Current Adjust" knob slowly until relay trips. The current meter should indicate in green marked 0.75 on the "Low" scale on the meter. Other pick-up points may be tested also. The tolerance is +10%.

h) **GROUND FAULT TIME DELAY:**

1) Rotate the "Current Adjust" knob on the test set fully counter-clockwise and push the "Reset" button.

2) Put the "Current" meter switch on "MED".

3) Connect input current leads to "N" and any phase terminal on the relay. Do <u>not</u> have current input lead connected to "G" to set the current for time delay check (See Note A).

4) Turn the "Current Adjust" knob to set the current at 2.0 on the meter "MED" scale. Turn "Function" switch to off leaving the "Current Adjust" knob set for 2.0X.

5) Re-connect the current leads to "G" and any phase terminal on the relay. (See Note A).

6) Turn the "Function" switch to "Time – Ground Fault", push the "Reset" button and then push the "Start".

7) The short time meter should indicate the trip time between 0.18 to 0.24 secs.

C. HIGH CURRENT TESTING:

a) It is possible to test the overcurrent relay trip system by passing high current through the circuit breaker primary circuit. The usual high current test equipment operates at very low voltage, and for this reason it may not produce a sinusoidal current through the static trip device. This will show an apparent error. The current wave shape should be checked and allowance made for distortions, if present, when this type of equipment is used.

b) Trip devices equipped with and connected for residual ground current sensing must be re-connected to by-pass the ground current sensing element when testing the phase overcurrent trip functions. (See Note A) Move the common current sensor connection (red sensor lead) from the "G" terminal to the "N" terminal on the relay connection terminal board.

c) Ground-current functions may be tested with single phase current through one of the phase sensors when the common connection (red sensor lead) is connected to the "G" terminal and the other sensor lead is connected to a phase terminal (A,B, or C). (See Note A.)

d) **Warning:** High current test equipment connection studs must be the same thickness as enclosure terminals and must be properly aligned with circuit breaker studs to avoid thermal and mechanical damage to main isolating cluster assemblies.

NOTE "A"

Testing the ground fault pick-up and time delay requires that the red lead be moved from "G" to "N" and then returned to "G" when testing is completed. When a series resistor is mounted on the outside of the static trip case and connected to the residual ground fault trip circuit, the resistor must be by-passed during the testing. To by-pass the resistor, move the red lead from the resistor and attach it directly to "N", returning it from "N" to the resistor after tests.

RESISTOR APPLICATION DATA

SENSOR RATING	RESISTANCE	RESISTOR RATING
200A-225A-250A	5 Ohms	25 Watts
300A-350A-400A	10 Ohms	25 Watts