INSTRUCTIONS

GEH-2026 D
Supersedes GEH-2026 C

NEGATIVE-PHASE-SEQUENCE TIME OVERCURRENT RELAY

TYPE INC77B

GENERAL ELECTRIC

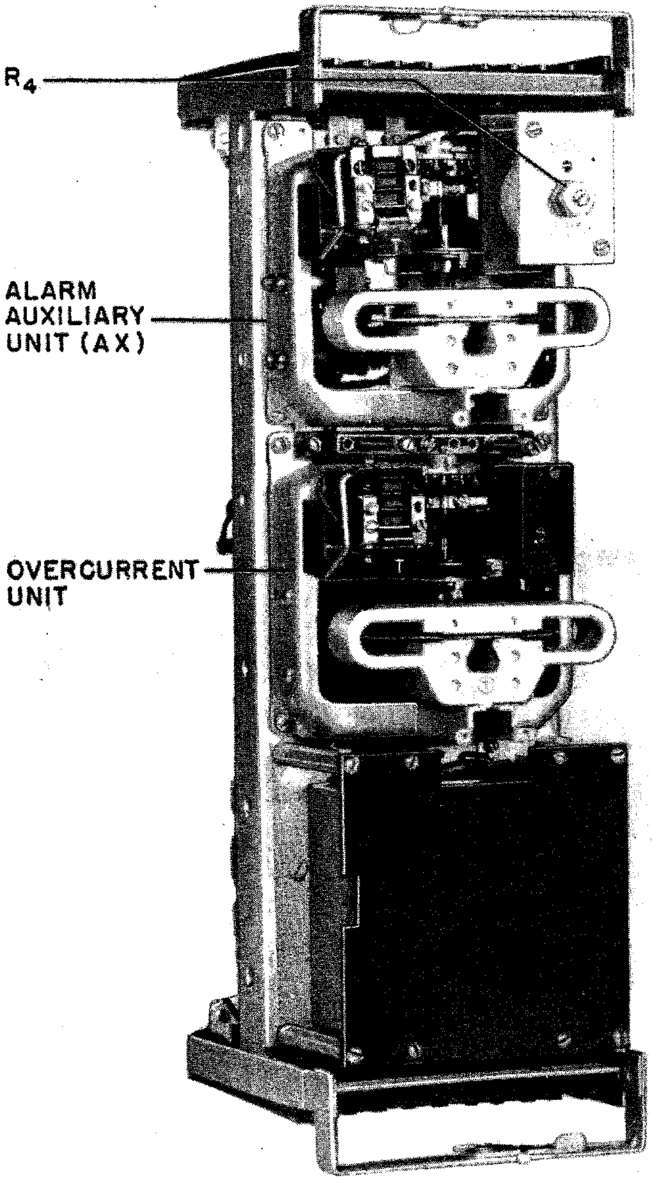

Fig. 1 (8025971) INC77B Relay Showing Components Referred to in Text (Front View)

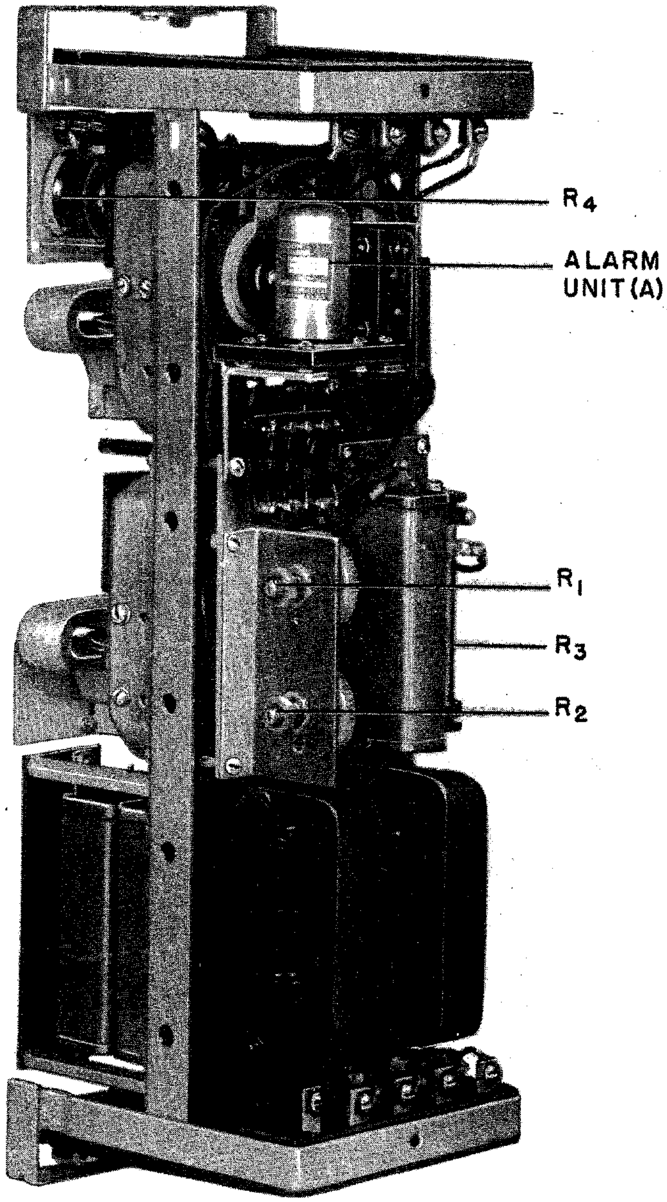

Fig. 2 (8021206) INC77B Relay Showing Components Referred to in Text (Rear View)

NEGATIVE-PHASE-SEQUENCE TIME OVERCURRENT RELAY TYPE INC77B

INTRODUCTION

The INC77B relay is a negative-phase-sequence time overcurrent relay used primarily to protect generators from unbalanced phase currents. The relay consists essentially of an induction-disk overcurrent unit connected with a negative-phase-sequence component of the generator load.

APPLICATION

The elementary diagram of Fig. 6 shows typical connections of the INC77B relay for the protection of a generator against the effects of phase faults or unbalanced loads. The INC77B relay has been designed to provide the best possible coordination between the generator's heating characteristic and the other system protection.

Since the relay is protecting the generator from damage caused by faults on the system rather than from internal faults, it is providing essentially back-up protection. Hence, it is essential that the relay time characteristic be such that it can be coordinated with other relays on the system, but still provide the necessary machine protection. The heating effect on the rotor of a synchronous machine caused by unbalanced currents can best be expressed as a function of the negative-phase-sequence current and of time. This relationship is discussed more thoroughly in the Appendix.

RATINGS

CURRENT COILS

The relay is rated for a balanced three-phase input of five amperes on all taps. It has a one-second rating of two hundred amperes, either three phase or any pair of phases, with any tap setting.

The tap plate is marked for machine full-load ratings (secondary) of 3, 3.7 and 4.5 amperes. These tap markings do not refer to the negative-phase-sequence pick-up current (see OPERATING CHARACTERISTIC).

CONTACTS

The circuit-closing rating of the negative-phase-sequence induction unit and alarm auxiliary unit (AX) contacts is 30 amperes for voltages not exceeding 250 volts. Their current-carrying rating is limited by the tap rating of the seal-in unit.

The contact interrupting ratings for the AX unit are listed in the following Table.

VOLTS	AMPERES	
	AC	DC +
125 250 600	1.5 0.75 0.00	0.3 0.15 0.00

+ Non-Inductive Load

ALARM AUXILIARY

The alarm auxiliary unit circuit is rated for operation on 120 volts AC.

TARGET AND SEAL-IN UNIT

The target and seal-in unit ratings are tabulated in the following table:

	TAP 0.2	TAP 2.0
Carry 30 Amps for (sec)	0.05	2.2
Carry 10 Amps for (sec)	0.45	2.0
Carry continuously (Amp)	0.37	2.3
Minimum Operating (Amp)	0.2	2.0
Minimum Drop-out (Amp)	0.05	0.5
DC resitance (Ohms)	8.3	0.24
60 Hz impedance (Ohms)	50	0.65
50 Hz impedance (Ohms)	42	0.54
DC resistive interrupting rating (Amps)	2.5 Amp @125 VDC	

BURDENS

With a balanced three-phase load of five amperes in the primaries of the auxiliary current transformers the burdens of the three current circuits, with connections as shown in Fig. 6, will be as shown in the following Table on Page 5.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

To the extent required the products described herein meet applicable ANSI, IEEE and NEMA standards; but no such assurance is given with respect to local codes and ordinances because they vary greatly.

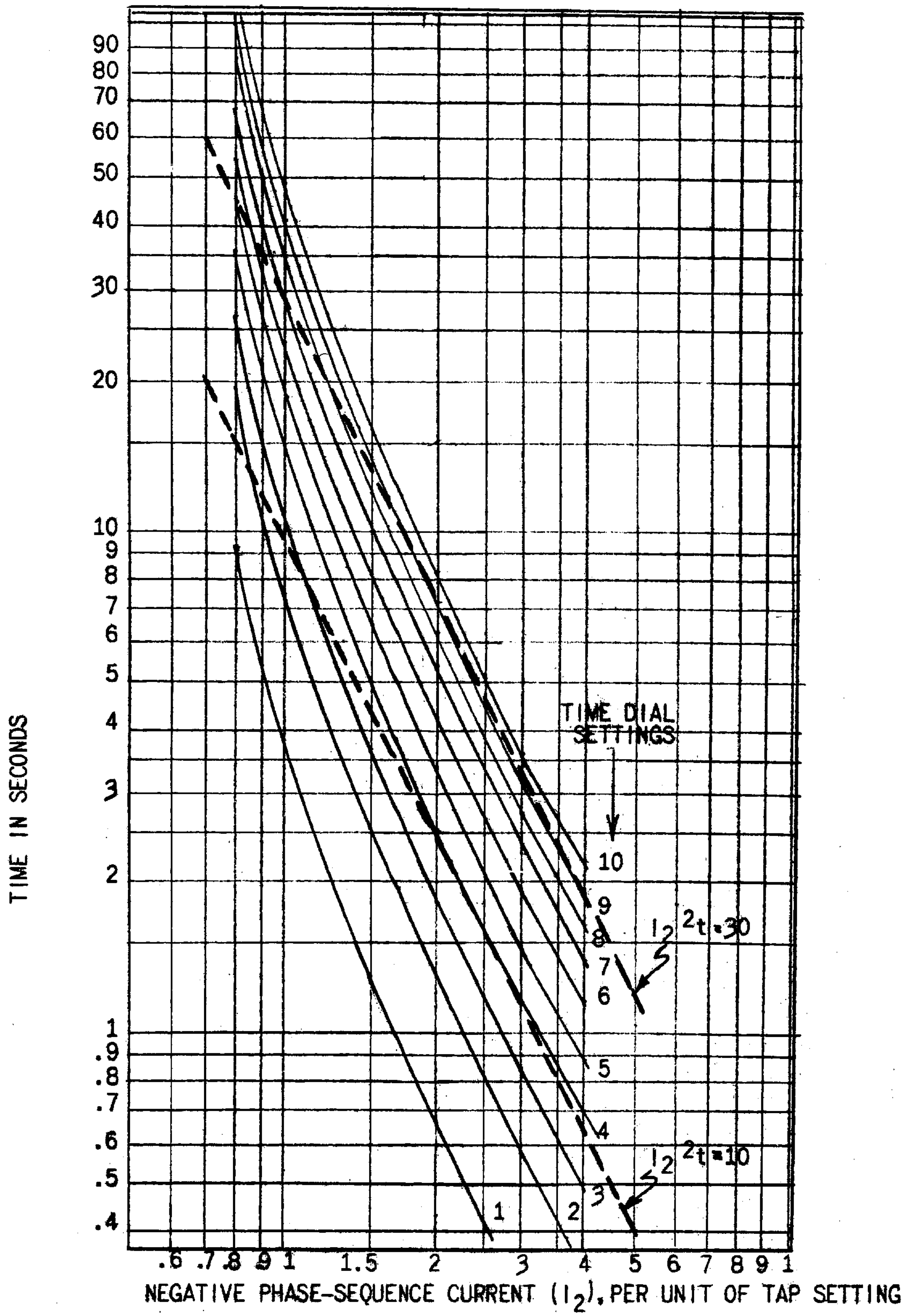

Fig. 3 (377A147-4) Time-Current Curve for the INC77B Relay

		Current Circuit					
		Terminal 3-4		Terminal 5-6		Terminal 7-8	
Freq. Freq.	Tap (Amp)	V-A	P.F.	V-A	P.F.	V-A	P.F.
60	3.0	5.7	0.90	2.0	0.90	7.6	0.95
	3.7	4.0	0.90	1.9	0.90	5.6	0.95
	4.5	3.5	0.90	1.9	0.90	4.7	0.95
50	3.0	6.0	0.90	2.25	0.90	7.25	0.95
	3.7	4.5	0.90	2.5	0.90	5.75	0.95
	4.5	3.75	0.90	2.25	0.90	4.75	0.95

When the relay operates as the result of an unbalanced load or phase-to-phase fault, two of the line current transformers will carry additional burden. For example if phases 1-2 are faulted, the current transformer in line 1 will carry the relay circuit between terminals 3 and 4, and the current transformer in line 2 will carry the circuit between terminals 5 and 6. The following tabulation shows the burden on the line current transformers for the three possible phase-to-phase faults. This burden is shown at the pick-up current of the relay, expressed in line amperes (secondary basis) for the three tap positions:

			Burden on CTs in:					
PHASES FAULTED	Tap	Pickup Line Amps	Line 1		Line 2		Line 3	
			V-A	P.F.	V-A	P.F.	V-A	P.F.
1-2	3.0	3.25	2.0	.97	1.4	.90	---	---
	3.7	4.00	2.9	.89	1.8	.88	---	---
	4.5	4.88	3.7	.90	2.4	.81	---	---
2-3	3.0	3.25	---	---	1.6	.80	2.0	.96
	3.7	4.00	---	---	1.9	.88	3.3	.88
	4.5	4.88	---	---	2.5	.80	3.8	.88
3-1	3.0	3.25	2.8	.97	---	---	2.8	.97
	3.7	4.00	3.4	.98	---	---	3.8	.90
	4.5	4.88	4.6	.90	---	---	4.6	.90

ALARM AUXILIARY UNIT				
Freq.	Terminals	V-A	Watts	P.F.
60	13-14	20.3	7.8	0.38
50	13-14	15.6	6.7	0.43

OPERATING CHARACTERISTICS

INDUCTION UNIT

With normal factory adjustment the minimum negative-phase-sequence current required to close the induction unit contacts is 0.63 per unit (plus or minus 5 percent) on the tap-current base. For example if the tap plugs are set in the 3A positions the unit will close its contacts if the negative-phase sequence current entering the auxiliary CT primaries is 0.63 x 3 = 1.89 amps. The contacts will reset if they have not sealed closed, when the negative-phase-sequence current decreases to less than 90 percent of this minimum closing value. The time required for the disk to reset completely to the No. 10 time dial position, when the relay is de-energized is 80 to 98 seconds.

The curves in Fig. 3 show the time dial setting of Nos. 5, 6, 7, 8, 9 and 10. Note that the No. 7 time dial curve, with a set point of 30 seconds at a current of 1.0 per unit, matches the machine characteristic of $(I_2)^2 t = 30$. There is sufficient adjustment range on the time dial to obtain an operating time as high as 50 seconds at a current of 1.0 per unit. Refer to the APPENDIX for further information on the expression for the machine heating characteristic.

ALARM CIRCUIT

The alarm unit will operate on negative-phase-sequence current in excess of 0.07 per unit (.07 - .15 per unit range) (tap-current base). It should be noted that this figure of 0.07 per unit is not the continuous rating of the machine in terms of negative-phase-sequence current. The contacts of the alarm unit control a time delay alarm auxiliary unit which will operate at approximately 60 percent of its AC rating specified on the nameplate. The time characteristic of this auxiliary unit may be seen in Fig. 8.

RECEIVING, HANDLING AND STORAGE

These relays, when not included as a part of a control panel will be shipped in cartons designed to protect them against damage. Immediately upon receipt of a relay, examine it for any damage sustained in transit. If injury or damage resulting from rough handling is evident, file a damage claim at once with the transportation company and promptly notify the nearest General Electric Apparatus Sales Office.

Reasonable care should be exercised in unpacking the relay in order that none of the parts are injured or the adjustments disturbed.

If the relays are not to be installed immediately, they should be stored in their original cartons in a place that is free from moisture, dust and metallic chips. Foreign matter collected on the outside of the case may find its way inside when the cover is removed and cause trouble in the operation of the relay.

DESCRIPTION

The INC77B relay consists of an induction-disk time overcurrent unit, an alarm unit, and an alarm-auxiliary unit, (see Figs. 1, 2 and 10) with associated transformers, capacitiors, resistors, and rectifiers.

SEQUENCE NETWORK

The negative-phase-sequence segregating network consists of two auxiliary current transformers (T_1 and T_2), each with a three-winding primary and a tapped secondary. The capacitor-resistor load across the T_1 secondary and the resistor across T_2 secondary are so selected and adjusted that with proper primary connections (see Fig. 6), the overcurrent unit will respond only to the negative-phase-sequence component of generator load. The network is discussed more thoroughly in the APPENDIX.

OVERCURRENT UNIT

The induction-disk time overcurrent unit in this relay is of the wattmetric-type similar to that used in the IAC77B relay. The upper portion of the unit has two windings on the middle leg of the magnetic circuit. A capacitor (C_3) is connected across the inner winding to provide a phase-shifting circuit. The operating circuit is connected in series with an adjustable resistor across the negative-phase-sequence filter.

The disk-shaft carries the moving contact which completes the trip circuit when it touches the stationary contact. The shaft is restrained by a spiral spring and its motion is retarded by a permanent magnet which acts on the disk to produce the desired time characteristic. The variable restraining force which results from the gradient of the spiral spring is compensated for by the spiral shape of the induction disk, which results in an increased driving force as the spring winds up.

SEAL-IN UNIT

A seal-in unit is mounted to the left of the induction-disk overcurrent unit. Its coil is in series and its contacts in parallel with the main contacts of the induction unit so that when the main contacts close the seal-in unit picks up and seals in. When the seal-in unit operates it raises a target into view which latches and remains exposed until released, by pressing the reset button projecting below the lower left corner of the cover.

ALARM UNIT

The alarm unit (A) is fed through a full-wave rectifier which in turn is connected across the lower windings of the induction unit operating circuit. The unit is of the meter type construction and is mounted on a standard 7 prong tube base. The rectifier is protected from surge voltage damage by means of a parallel stack of + Thyrite resistors.

ALARM AUXILIARY

The contacts of the sensitive alarm unit control operation of the alarm auxiliary (AX). This unit is a time-delay voltage unit of the induction disk construction. A potential operating coil on a laminated U-magnet actuates the disk. The sensitive alarm unit contacts complete the circuit of the wound shading coils to provide a flux shift. The contacts of this auxiliary may be used to sound an alarm. This unit has a target seal-in device which is mainly used for target indication. If the seal-in feature is not wanted, the seal-in contacts should be disconnected.

INSTALLATION

LOCATION

The location should be clean and dry, free from dust and excessive vibration, and well lighted to facilitate inspection and testing.

MOUNTING

The relay should be mounted on a vertical surface. The outline and panel drilling diagram is shown in Fig. 11. The outline of the external capacitor used with relays for 50 cycle operation is shown in Fig. 14.

CONNECTIONS

The internal connection diagram for models 12INC77B1A and 12INC77B3A is shown in Fig. 4.

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The internal connection diagram for all other type INC77B relays is shown in Fig. 5.

OPERATION

Before the relay is placed in service it should be given a check to be sure that factory adjustments have not been disturbed. The time dial will be set at zero before the relay leaves the factory. This setting must be changed to obtain the desired time characteristics as described under operating characteristics. If it is desired to check the operating time for a given dial setting refer to the section on ADJUSTMENTS.

If it is desired to check the setting of the sequence networks or the operating point of the overcurrent unit refer to ADJUSTMENTS.

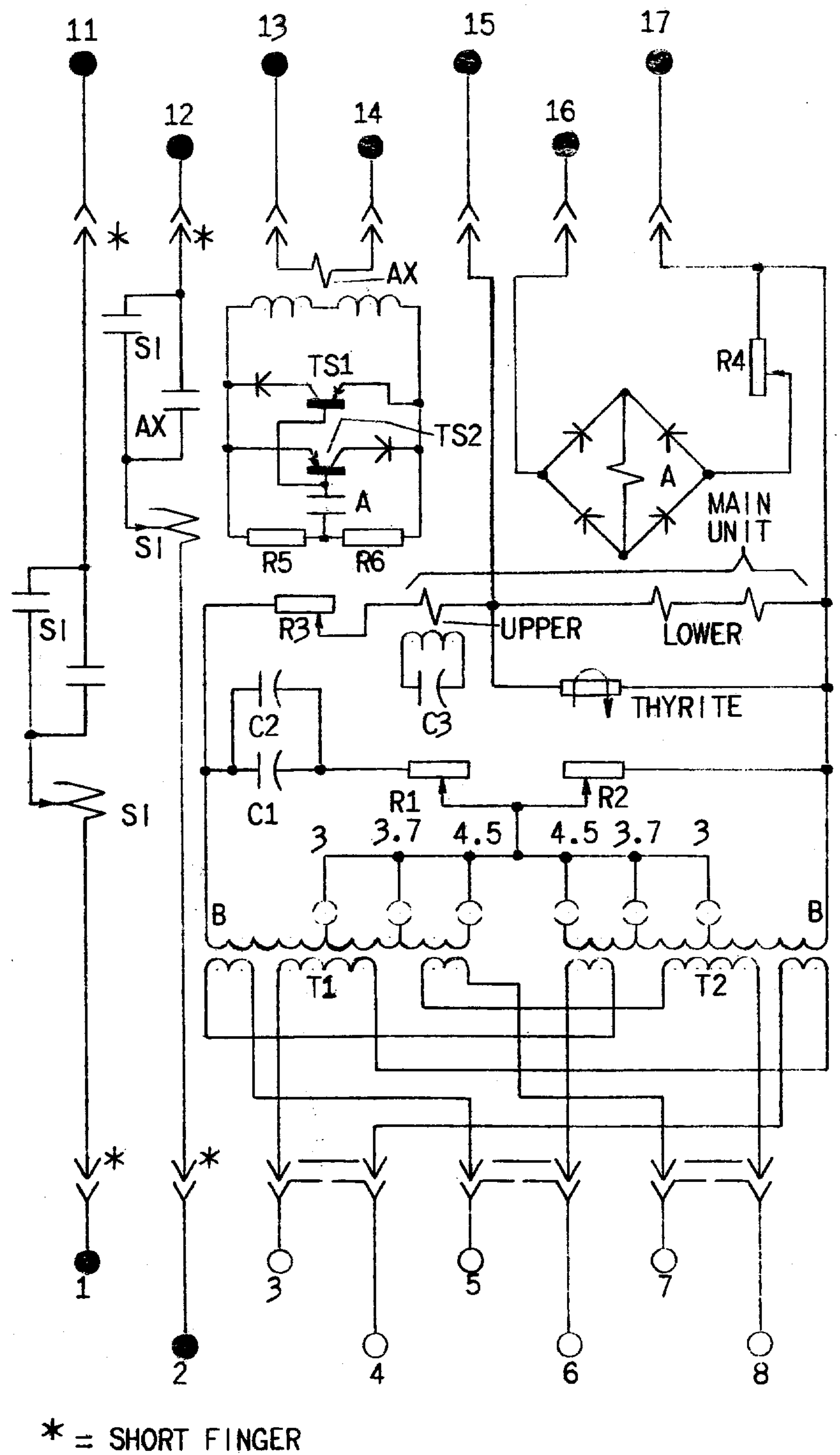

Fig. 4 (418A705-1) Internal Connection Diagram for INC77B Relay Forms 1 and 3 only (Front View)

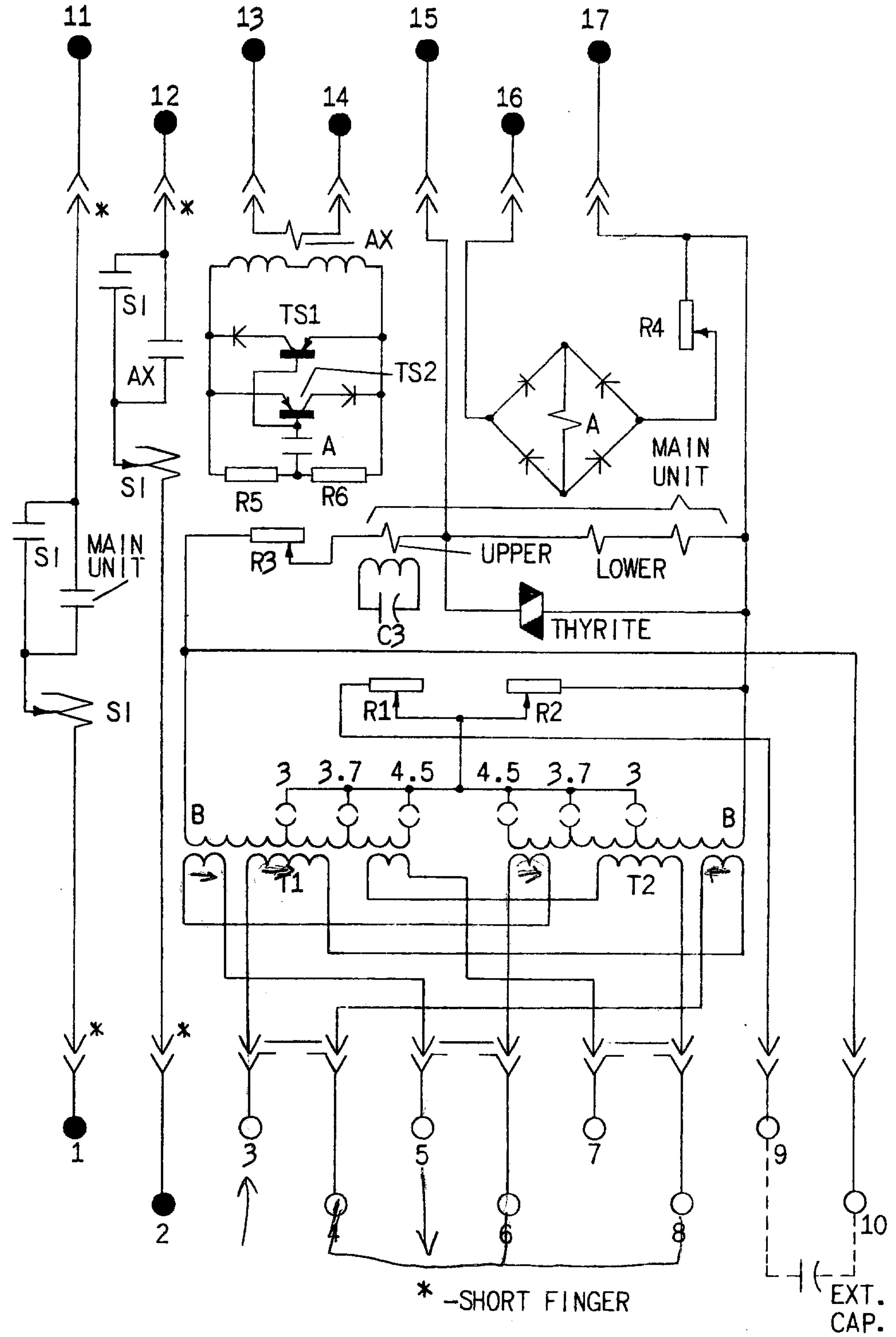

Fig. 5 (418A897-0) Internal Connection Diagram for INC77B Relay Except Forms 1 and 3

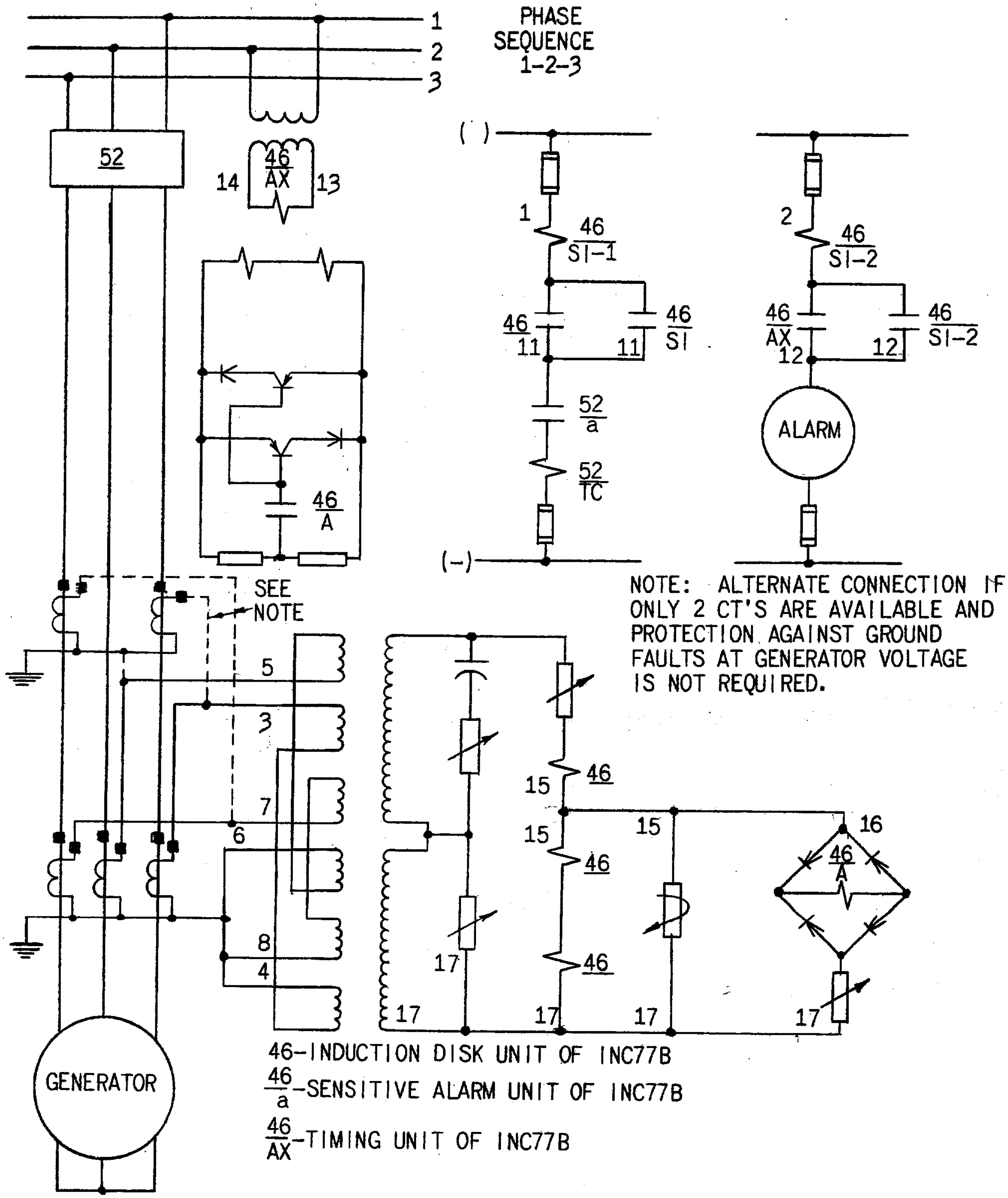

Fig. 6 (418A718-4) Typical External Connection Diagram for INC77B Relays

ADJUSTMENTS

OVERCURRENT UNIT

TARGET AND SEAL-IN UNIT

When trip coil current falls within the range of 0.2 to 2.0 amperes at minimum control voltage, the tap screw of the target and seal-in unit should be set in the 0.2 ampere tap. When the trip coil current ranges from 2 to 30 amperes at minimum control voltage, the tap screw should be placed in the 2.0 ampere tap.

The tap screw for the seal-in unit is the screw holding the right-hand stationary contact of the seal-in unit. To change the seal-in unit tap setting first remove the relay connection plugs. Then take a screw from the left-hand stationary contact and place it in the desired tap. Next, remove the screw from the other tap and place it back in the left-hand contact. This procedure is necessary to prevent the right-hand stationary contact from getting out of adjustment.

CURRENT SETTING

The minimum negative-phase-sequence current at which the overcurrent unit will close its contact is determined by the adjustment of resistor R_3 in series with the operating coils of the unti. The resistor has been adjusted at the factory for a pickup of approximately 0.63 per unit, referring to the tap setting as a base. This pick-up setting of course affects the time curve (Fig. 3) and should not be changed unless tests indicate that it has been disturbed.

Note that the tap markings of 3, 3.7 and 4.5 amperes do not indicate the current load which will cause the overcurrent unit to operate. Tap markings refer to machine full-load in terms of secondary current. For example if the relay were to be applied with a machine whose full load rating was 3.2 amperes secondary, the tap screws would be set in the 3.0 ampere position.

If a closer match to machine full-load rating is desired, it can be obtained as described in a subsequent paragraph.

If tests indicate that the pick-up adjustment has been disturbed it should be restored by adjusting R_3. The control spring adjustment should not be changed since this has been set for proper compensation, providing the same pickup regardless of the time dial setting.

The diagram in Fig. 7 shows the recommended connections for checking the pick-up current of the relay, as well as for making the time checks which are described later. Use a source of 120 volts or more having good wave form and constant frequency. Be sure to connect the external capacitor when testing the 50 cycle INC77B relay. Step-down transformers or phantom loads must not be employed since their use may result in a distorted wave form.

The resistor, R_3, should be set so that the unit will just close its contacts at a negative-sequence current of 0.63 per unit, using the tap setting for a base. For a system as shown in Fig. 7 the negative-sequence current equals line current divided by $\sqrt{3}$. Consequently R_3 should be set to give a pickup of:

$$I_L = 0.63 \times I_T \times \sqrt{3}$$

where: I_L = Ammeter reading

I_T = Tap setting

If it is desired to have a closer match to machine full load rating than is obtainable with the available taps, it can be done in the following manner. Assume that full load current is 3.3 amperes (secondary). Using the connections of Fig. 7 set resistor R_3 so that the induction-disk unit just closes its contacts when:

$$I_L = 0.63 \times 3.3 \sqrt{3}$$

The negative sequence pickup current will now be 0.63 per unit referred to 3.3 amperes as a base. The alarm unit will remain at 0.07 per unit on this new base. The per unit reference on the time curves in Fig. 3 will also now refer to the new base. When pickup is being checked or adjusted it is recommended that the time dial be set at the No. 1/2 position. Pickup will be consistent within five

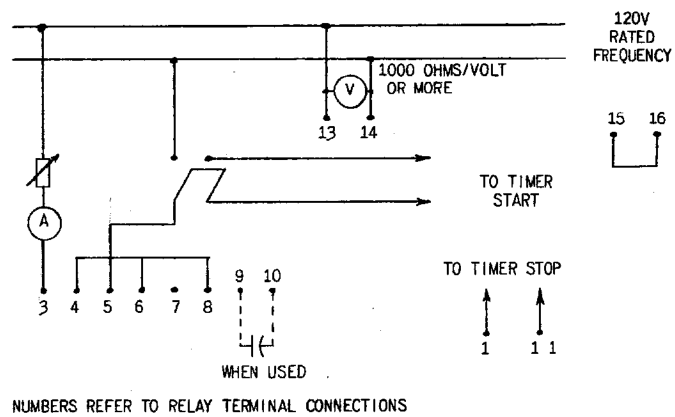

Fig. 7 (104A8599-0) Test Connections for Checking Pick-up and Operating Time of the Overcurrent Unit of the INC77B Relay percent of the set value (in per unit) regardless of the tap setting, time dial setting, or phase combination used in simulating the phase-to-phase fault or load.

TIME SETTING

The operating time of the overcurrent unit for a given magnitude of negative-phase-sequence current is determined by the time dial setting. This operating time is inversely proportional to the magnitude of negative-phase-sequence current as illustrated by the time curves in Fig. 3. Note that the current values on these curves are given as equivalent negative-sequence current in per unit, referring to tap setting as a base.

The time curve is intended to match the machine heating characteristic as closely as possible.

As discussed in the APPENDIX, heating of the machine rotor caused by unbalanced load or a phase fault can be expressed as a function of the negative-sequence current and time. For example the characteristic of a turbo-generator is expressed as:

$$(I_2)^2 t = 30$$

When the time dial is set at No. 7 the operating time of the unit will be slightly faster than the time indicated by the $(I_2)^2$ t = 30 line, for values of negative-phase-sequence current in excess of 1.0 per unit. Fig. 3 also shows curves for other time dial settings up to No. 10.

Operating time of the overcurrent unit can be checked by means of the connections in Fig. 7. Note that the values of equivalent I in per unit are given by the expression:

$$I_2 = \frac{I_L}{I_T \times \sqrt{3}}$$

where: I_2 = Equivalent negative-sequence current in per unit.

I_L = Ammeter reading

I_T = Tap setting

ALARM UNIT

The minimum negative-phase-sequence current at which the alarm unit will close its contacts (the point where the middle unit disk will just move) with the tap plugs in the 3A positions and R_4 turned fully counterclockwise is 0.07 per unit. This is equivalent to an ammeter reading of less than 0.365 amps using the circuit of Fig. 7. R_4 may be turned fully clockwise to give an alarm pickup of 0.15 per unit. This per unit value corresponds to 0.78 amp in Fig. 7 and is the point where the disk of the upper unit just begins to move.

ALARM AUXILIARY

This unit has been set to pickup at 65 volts. The time setting of the unit is determined by the time dial setting. The time is 10 seconds when the time dial is set at #10 T-D-S. (See Fig. 8 for time curve.)

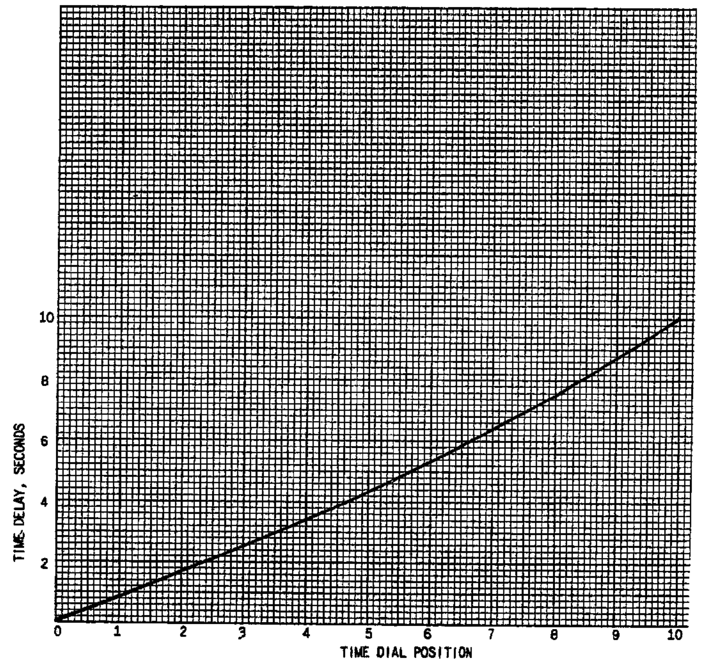

Fig. 8 (418A732-0) Time Characteristic for Alarm Auxiliary Unit

NETWORK

The components of the negative-phase-sequence segregating network are so selected and adjusted that with a balanced three-phase input (phase sequence 1-2-3) to the primaries of the auxiliary current transformers (T_1 and T_2) there will be zero voltage across the output terminals of the network. The network has been properly adjusted at the factory and should normally require no further adjustment.

The network can be checked by means of the connections shown in Fig. 9. Be sure to connect the external capacitor when testing 50 cycle INC77B relays. Set the tap screws in the 3A positions. Adjust the load resistors so that meters A_1, A_2, and A3 read four amperes. The voltmeter across terminals 15 and 17 should read less than 0.25 volts. It is of course impossible to obtain a zero reading in practice since a slight unbalance of load or presence of even a small percentage of harmonics will disturb the network.

The three-phase source used for this test should be 120 volts or more and must have a good wave form. Indicated phase-sequence must be observed. Prior to the test the three ammeters should be connected in series and checked at four amperes to insure identical calibration. Note that a delta connection is suggested for this test to facilitate adjustment of balanced load.

* Denotes change since superseded issue.

If the network adjustment has been disturbed it can usually be restored by slight adjustment of rheostats R1 and R2, located in the lower portion of the case. The locknuts on the rheostat shafts must be loosened before adjustments can be made. The suggested procedure is first to set R1, until the voltage is at a minimum, then adjust R2 until the voltage is a minimum, again adjust R1, and repeat this cross adjustment until adjustment of either rheostat causes an increase in voltage. If the minimum voltage obtainable is in excess of 0.25 volts there is either excessive harmonics in the source or the load currents are not balanced closely enough. If a minimum cannot be obtained within the range of the rheostats, the phase-sequence is incorrect or the polarity of one of the auxiliary current transformer primaries is wrong.

After adjustments are complete be sure to retighten the locknuts.

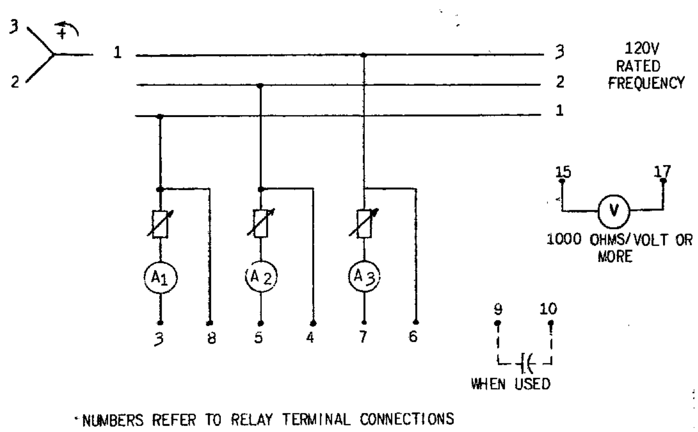

Fig. 9 (104A8919-0) Test Connections for Checking of the Negative-Phase-Sequence Segregating Network of the INC77B Relay

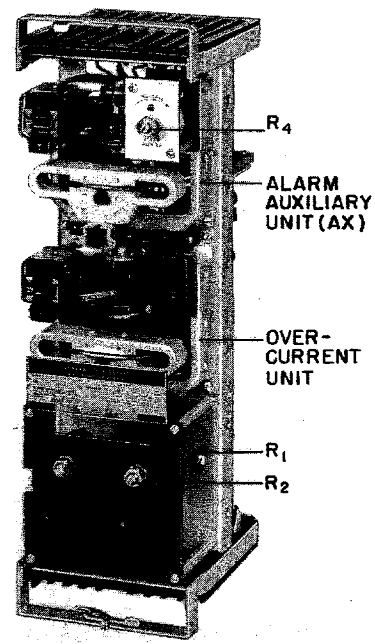

Fig. 10 (8023140) INC77B Relay for 50 Cycle Operation (Front View)

MAINTENANCE

OVERCURRENT UNIT

DISK AND BEARINGS

The lower jewel bearing may be tested for cracks by exploring its surface with the point of a fine needle. The jewel bearing screw should be turned up until the disk is centered in the air gaps of the drag magnet and wattmeteric unit, and then locked in position by means of a set screw. The upper bearing pin should be adjusted so that the shaft has about 1/64-inch of end play.

CONTACTS

The contacts should have about 1/32-inch wipe. That is the stationary contact tip should be deflected 1/32-inch when the disk has completed its travel. Wipe is adjusted by turning the screws in the contact brush, adjusting the position of the brush relative to the brush stop.

When the time dial is moved to the position where the contacts just make, the dial scale should indicate zero. If it does not and the brushes are correctly adjusted, shift the dial by changing the position of the arm attached to the shaft just below the dial. Loosen the screw clamping the arm to the shaft and turn the arm relative to the shaft until the contacts just make for the zero time-dial setting.

CONTACT CLEANING

For cleaning fine silver contacts, a flexible burnishing tool should be used. This consists of a flexible strip of metal with an etched roughened surface, resembling in effect a superfine file. The polishing action is so delicate that no scratches are left, yet corroded material will be removed rapidly and thoroughly. The flexibility of the tool insures the cleaning of the actual points of contact.

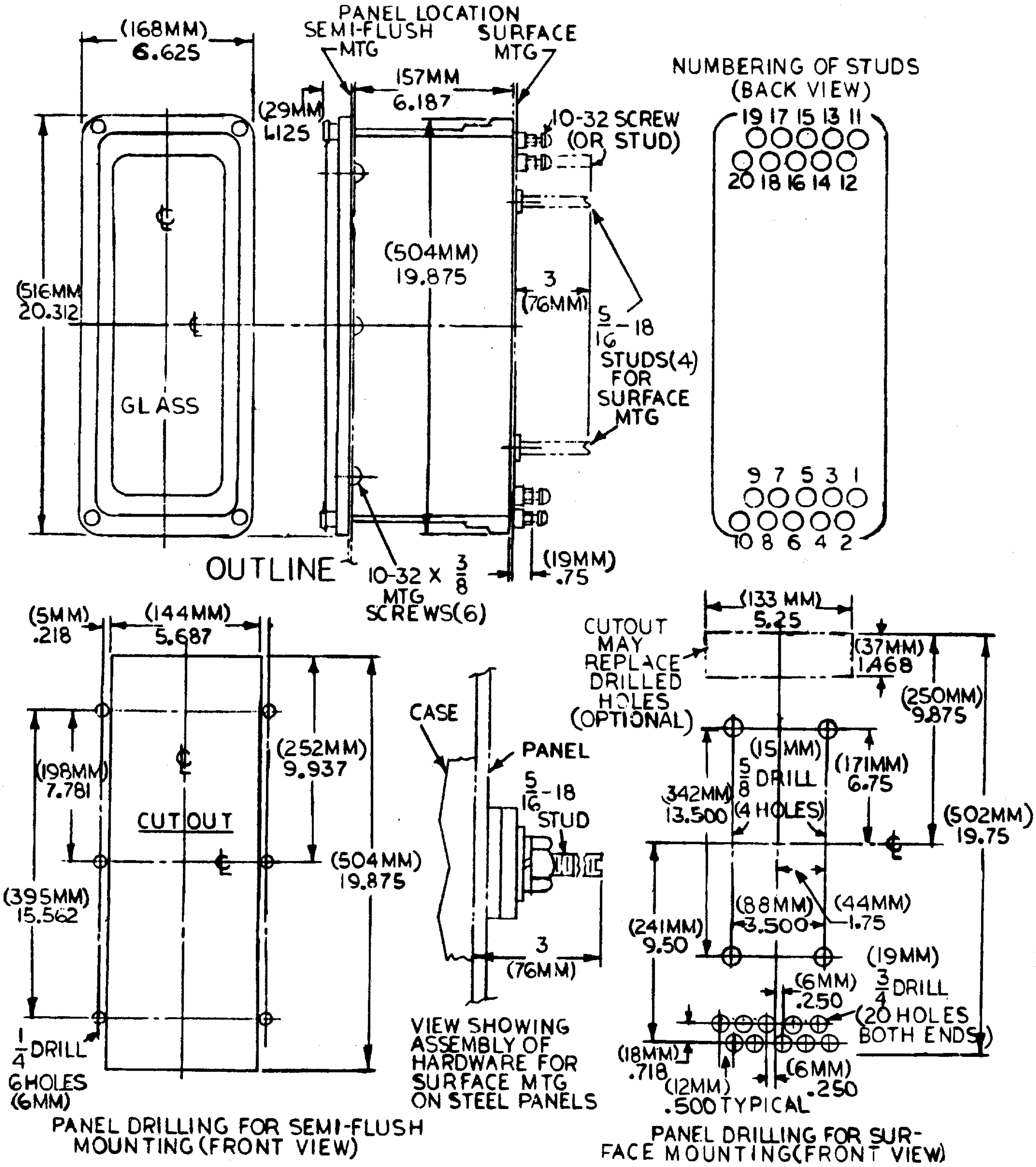

Fig. 11 (K-6209276-3) Outline and Panel Drilling Dimensions for the INC77B Relay

Fine silver contacts should not be cleaned with knives, files, or abrasive paper or cloth. Knives or files may leave scratches which increase arcing and deterioration of the contacts. Abrasive paper or cloth may leave minute particles of insulating abrasive material in the contacts and thus prevent closing.

The burnishing tool described above can be obtained from the factory.

RENEWAL PARTS

It is recommended that sufficient quantities of renewal parts be carried in stock to enable the prompt replacement of any that are worn, broken, or damaged.

When ordering renewal parts, address the nearest Sales Office of the General Electric Company, specify quantity required, name of part wanted, and give complete nameplate data, including serial number. If possible, give the General Electric Company requisition number on which the relay was furnished. The Parts Bulletin is GEF-3944.

APPENDIX

When a generator is subjected to an unbalanced fault or load the stator current includes a negative-phase-sequence component (I_2). This negative-phase-sequence current sets up a counter-rotating flux field in the machine which causes double frequency currents to flow in the rotor iron and slot wedges, resulting in local heating. It has been shown that this heating will not be excessive if the following condition is satisfied.

$$(I_2)^2 \, t < K$$

where $(I_2)^2t$ is the integrated product of negative-phase-sequence current (I_2) and the duration of the fault (t), and K is a constant for the machine in question.

The constant (K) has been determined for various types of machines, when I_2 is expressed in per unit stator current and t is in seconds, as tabulated below:

Type of Machine	K +
Turbine generators (Normal Design)	30
Conductor-cooled turbine generators	10
Hydraulic turbine driven generators	40
Engine driven generators	40
Synchronous condensers	30
Frequency changer sets	30

+ These are typical values of the constant K; for recommended values for a specific machine, refer to the machine manufacturer.

Since the capability of machines to withstand unbalanced faults can be expressed as a function of $(I_2)^2t$, the ideal relay for the protection of generators against unbalanced faults is one which responds only to the negative-phase-sequence component of fault current from the generator, and has a time characteristic matching the $(I_2)^2t$ characteristic of the machine.

The INC77B relay described in the text closely approaches the ideal condition. The induction-disk unit, connected across the negative-phase-sequence segregating network, responds only to the I_2 component of generator current. The time curves (see Fig. 3) closely approximate the $(I_2)^2t$ machine characteristics.

THE CIRCUIT

It can be readily shown by a vector analysis that the circuit arrangement of Fig. 6 results in a relay sensitive only to the negative-phase-sequence component of generator current.

Consider the simplified diagram in Fig. 13. The primaries of the auxiliary current transformers T_1 and T_2 each consist of three windings, one of which has twice the turns of the other two. The network impedances have the following relationships:

$$R_1 = 0.5R_2$$

$$X_C = -j0.866R_2$$

$$Z = 0.5R_2 - j0.866R_2$$

$$Z = R_2 \angle -60^\circ$$

If the auxiliary current transformer turns ratio is K' the secondary currents I_X and I_Y can be expressed as follows:

$$I_X = \frac{1}{K'}(2I_a - I_b - I_c) \quad (1)$$

$$I_Y = \frac{1}{K'}(2I_c - I_b - I_a) \quad (2)$$

For the balanced three-phase condition where $I_a + I_b + I_c = 0$, it can be shown by vectors (see Fig. 12a) that:

$$I_X \propto 3I_a$$

$$I_Y \propto 3I_c$$

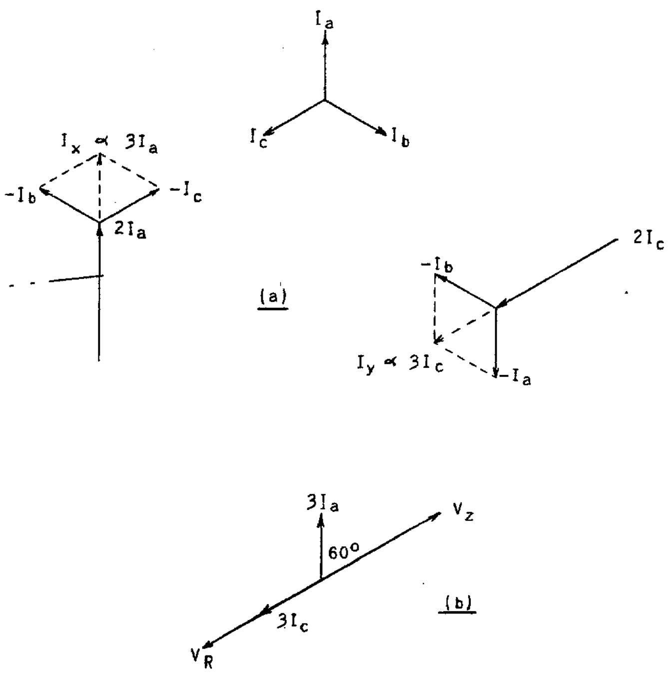

Fig. 12 (377A136-0) Vector Analysis of INC77B Network with Balanced Load

Assume for the moment that the circuit through the induction-disk unit coil is open. The current I_X flowing through the capacitive branch Z results in a voltage drop which lags the current by 60°, and the current I_Y flowing in the resistive branch R_2 results in a voltage drop in phase with the current. As shown in Fig.12b these voltages will be 180° apart and since Z and R_2 are equal in magnitude and $I_a = I_c$, the resultant voltage across the network will be zero. Consequently if the relay unit is connected across the network no current will flow in its coils for balanced three-phase condition.

Any unbalance in the line currents will upset this vector relationship and cause current to flow in the relay operating coils. This current will be proportional to the negative-phase-sequence component of line current for the following reasons:

Any zero-phase-sequence current resulting from the unbalance will be eliminated by the auxiliary current transformers. The positive-phase-sequence component will not flow in he relay coils since it has already been shown that with a balanced three-phase load there will be no voltage across the network.

This conclusion can be proved more vigorously by symmetrical component theory, but such treatment is beyond the scope of this text.

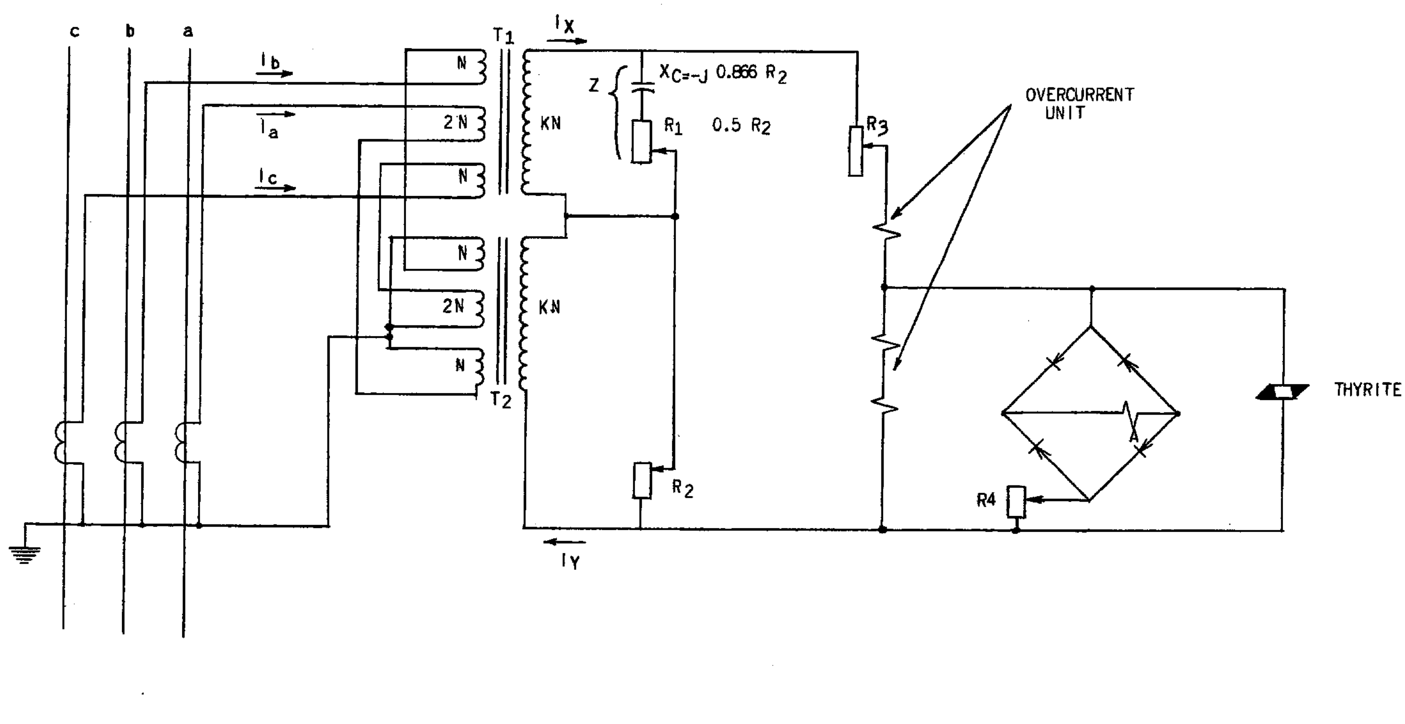

Fig. 13 (264B424-1) Simplified Elementary Diagram of Type INC77B Relay Showing Circuit Constants

TIME CHARACTERISTICS

The time curves in Fig. 3 are plotted in terms of time in seconds vs. equivalent negative-phase-sequence current in per unit using the relay tap setting as the base. In other words if the tap screws are in the 3A positions, one per unit equals three amperes.

This method of showing the magnitude of the negative-phase-sequence current is logical since the I_2 term in the expression $(I_2)^2t = K$ is expressed in terms of per unit stator current, and the tap positions on the relay are marked in terms of machine full-load current.

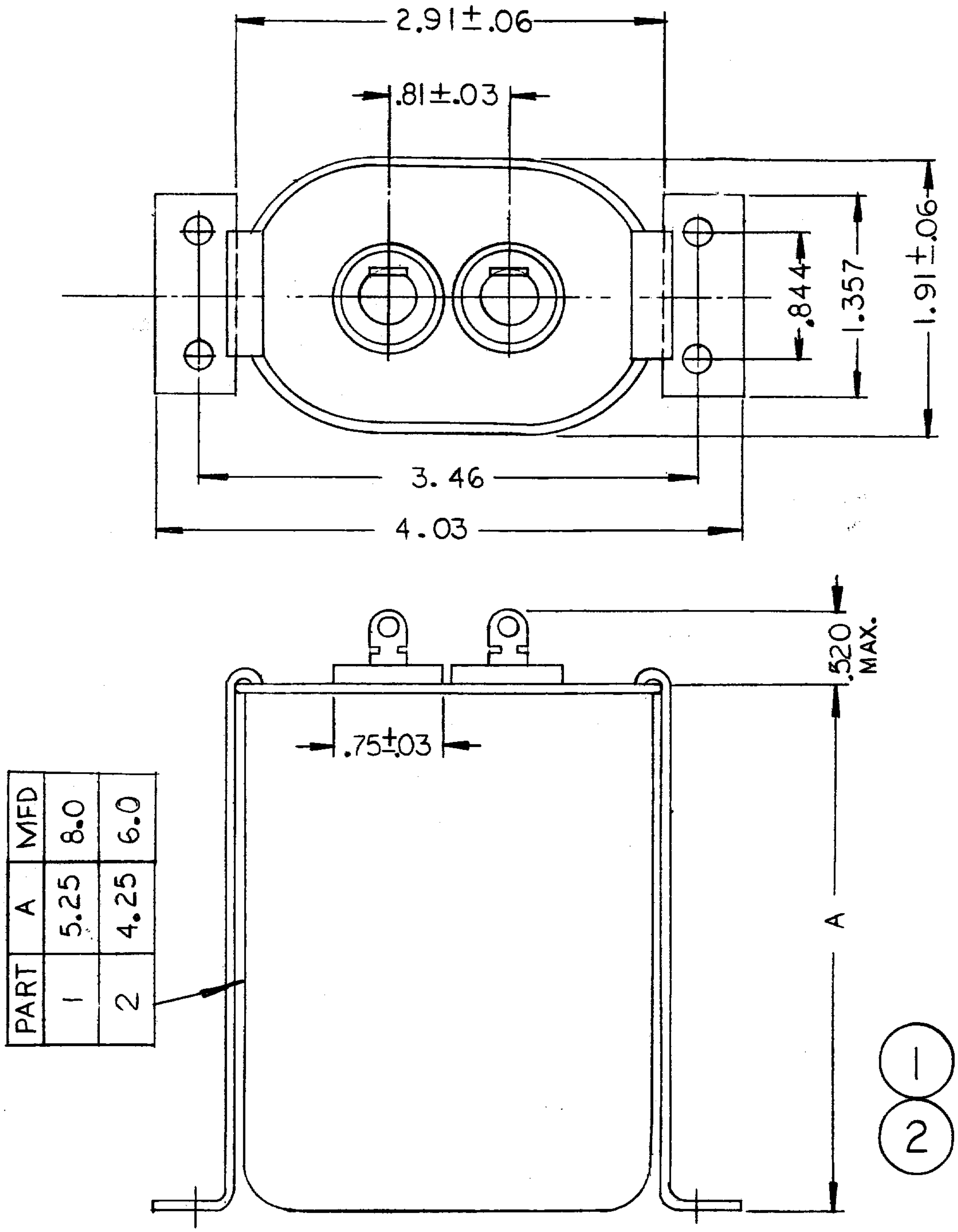

Fig. 14 (0273A9587-0) Outline of External Capacitor Used with INC77B Relays