GEH-1766A

INSTRUCTIONS *Switchgear*

DIRECTIONAL OVERCURRENT RELAYS

Types
IBC51A IBCG51A
IBC52A IBCG52A
IBCV51A
IBCV52A

GENERAL ELECTRIC

CONTENTS

Cover 8007269

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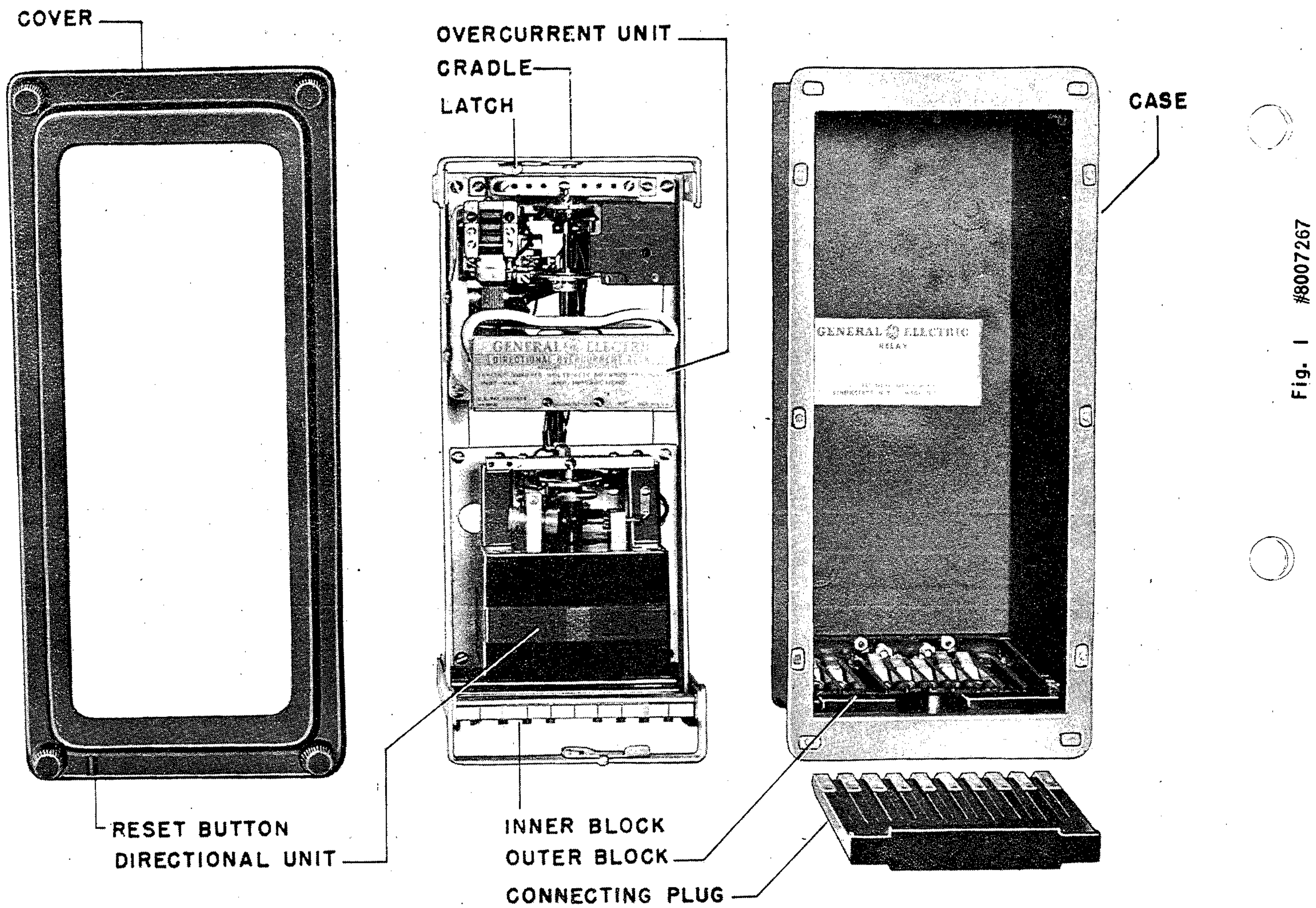

Fig. 1 Type IBC51A Relay - Disassembled (Front View)

DIRECTIONAL OVERCURRENT RELAYS
INVERSE TIME CHARACTERISTICS
TYPES IBC, IBCG AND IBCV

INTRODUCTION

The relays of the IBC type are directional overcurrent relays that are employed primarily for the protection of feeders and transmission lines in applications where single-phase relays, instead of polyphase power-directional relays, are desired or required.

The Types IBC, IBCG and IBCV relays, of the inverse time characteristics, consists of two units, an instantaneous power-directional unit (bottom) of the induction-cup type, and an inverse time overcurrent unit (top) of the induction-disk type. The directional-unit contacts control the operation of the overcurrent unit (directional control).

APPLICATION

PHASE FAULT-IBC

The Type IBC relays are frequently applied for phase-fault protection of a single line. The quadrature and 60-degree connections are used with these relays because the fault currents are usually highly lagging. With these connections, the directional unit will have a substantial maximum torque under the usual fault conditions. The vector relationship of these connections are shown in Table I.

The quadrature or 90-degree connection of current and potential transformers as shown in Fig. 3 is recommended as providing the most reliable potential for the directional units during usual fault conditions. With this connection, the current (at unity-power-factor load) leads the potential 90 degrees at the relay terminals. The internal resistor shorting-link should be opened by disconnecting it from the top screw to give the 45-degree characteristic. (The link is located on the right-hand post at the top of the cup-type unit). The directional unit will then have maximum torque when the fault current lags its unity-power-factor position by about 45 degrees.

When the phase relays are used in conjunction with a ground relay which-requires that the potential transformer primaries be connected in Y, with secondaries in delta, the quadrature connection cannot be employed. For this application the 60-degree connection, as shown in Fig. 4, is recommended. The current at unity-power-factor load then leads the potential 60 degrees at the relay terminals. The internal resistor should be short-circuited by the link to provide maximum torque of the directional unit when the fault current lags its unity-power-factor position by approximately 40 degrees.

PHASE FAULT - IBCV

The Type IBCV relays are used for phase-fault protection when it is necessary to distinguish between fault conditions and overload or power swings. The voltage restraint feature of the relay makes this distinction possible. Fig. 2 shows the effect of voltage restraint placed on the impedance characteristic of the Type IBCV relay, as compared with the Type IBC relay.

When the generation at a given station varies from time to time, it is possible for the maximum load current to exceed the minimum fault current. When this occurs, the Type IBC relay will not distinguish between a heavy load with maximum generation and a fault with minimum generation. This is a typical application for the Type IBCV relay. When a fault occurs with minimum generation, the restraint torque in the directional unit collapses rapidly as the voltage drops, thus permitting the relay to trip at the low value of fault current. On the other hand, the relay is prevented from tripping on heavy load currents with maximum generation as the directional unit will not pick up due to the system voltage being maintained.

Long or overloaded lines, that are operating near the stability limit, are subject to severe power swings. These power swings appear to the relay as traveling faults. Since the voltage is maintained near normal during a power swing, the area on the impedance diagram within which the fault must remain to cause tripping, is somewhat smaller when the Type IBCV relay is used, than it would be if a relay without voltage restraint were used.

Typical connections for the Type IBCV relay with voltage restraint are shown in Fig. 5. If voltage restraint is removed, the relay would be similar to a Type IBC relay with a quadrature connection and a resistor in the circuit. The link on the right-hand bearing support of the directional unit is for the purpose of opening the restraint; it is not used for changing the angle of maximum torque, as in the case of the Type IBC relay.

GROUND FAULT - IBCG

The schemes previously described protect against phase-to-phase and polyphase short circuits. They also protect against ground faults, if the ground current is not limited to a value that isn't great enough to operate the relay. For cases where the ground current is limited (either by resistance in the system ground by the system characteristics) to a value that will not operate the phase relays, a ground relay should be used, as shown in Figs. 6, 7, and 8. The relays used for ground-fault protection usually have a low-range operating coil which is rated either 0.5/2 or 1.5/6 amperes (4/16 rating is also available). These relays may be either potential or current polarized. The Type IBCG relays described in these instructions, may be polarized by either means. Normally no current flows in either the operating or current-polarizing coils of the ground relay, nor is there voltage across the potential polarizing coils.

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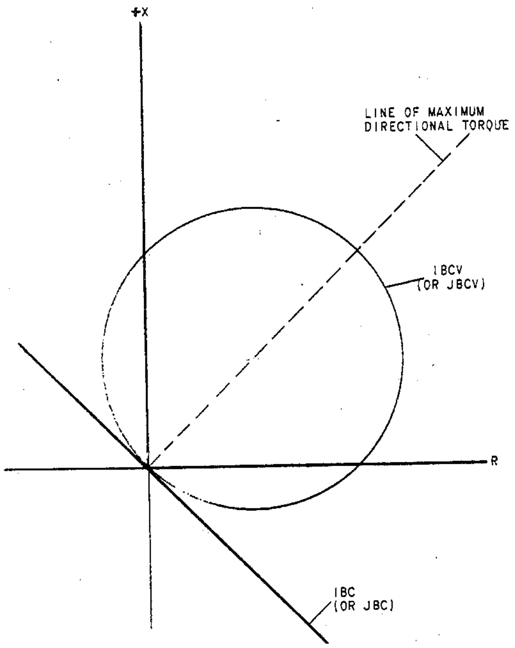

Fig. 2 Impedance Characteristics Of The Type IBC And IBCV Relays

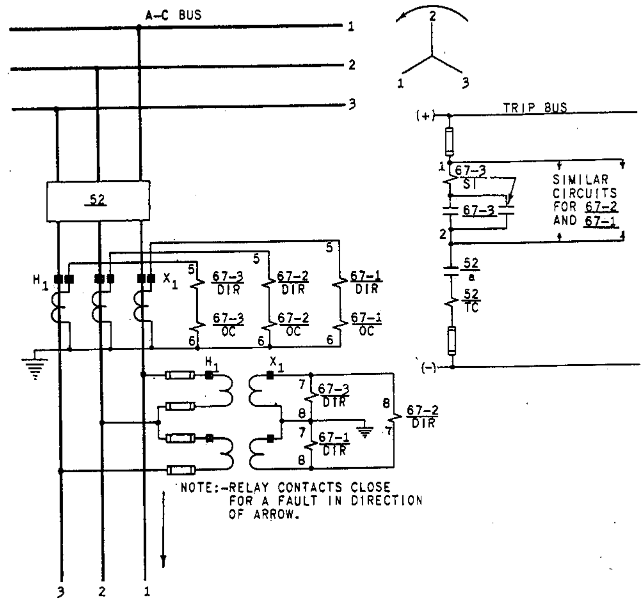

Fig. 3 The 90-Degree Connection Of Three Type IBC51A Relays Used For Directional Overcurrent Protection Of A Single Line

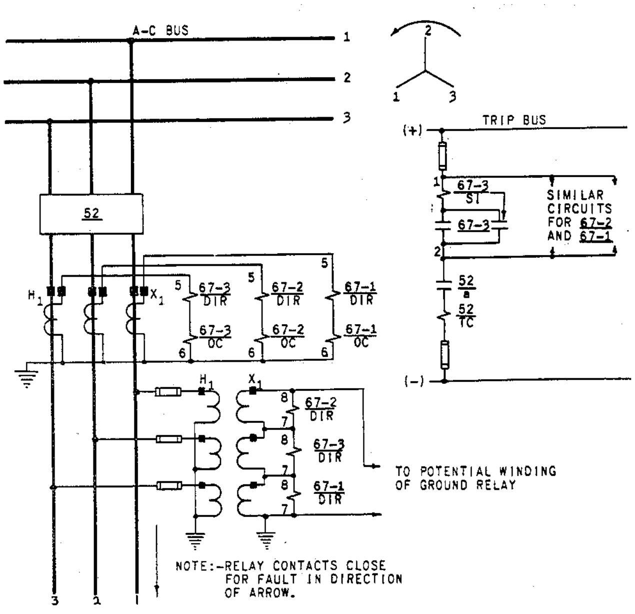

Fig. 4 The 60-Degree Connection Of Three Type IBC51A Relays Used For Directional Overcurrent Protection Of A Single Line

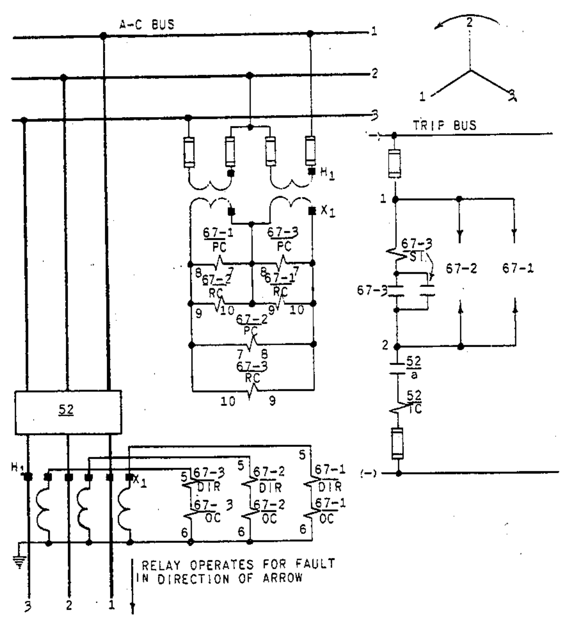

Fig. 5 Typical External Connections For Directional Overcurrent Protection Of A Line Using Three Type IBCV51A Relays

Fig. 2 K-6507920

Fig. 3 K-6154278

Fig. 4 K-6375707

Fig. 5 362A680

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Fig. 6 362A683

Fig. 7 362A681

Fig. 8 K-6154273

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DEVICE FUNCTION NUMBERS FOR USE WITH EXTERNAL DIAGRAMS

- 52 - Power Circuit Breaker
- 67 - Directional Overcurrent Relays, Type IBC or Type IBCV
- 67N - Directional Ground Relay, Type IBCG
- a - Auxiliary Contact, Open when Breaker Opens
- DIR - Directional Unit
- SI - Seal-in Unit with Target
- OC - Overcurrent Unit
- TC - Trip Coil
- PC - Polarizing Coil (Dir. Unit)
- RC - Restraining Coil (Dir. Unit)

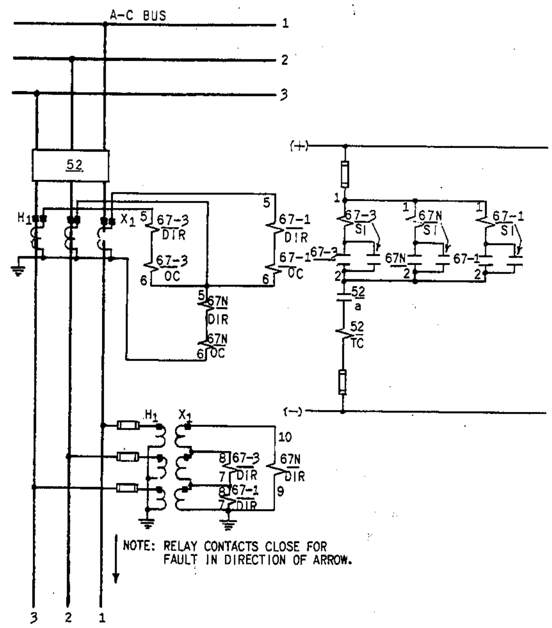


Fig. 6 Connections Of Two Type IBC51A And One Type IBCG51A Relays Used For Directional Phase And Ground Protection Of A Single Line

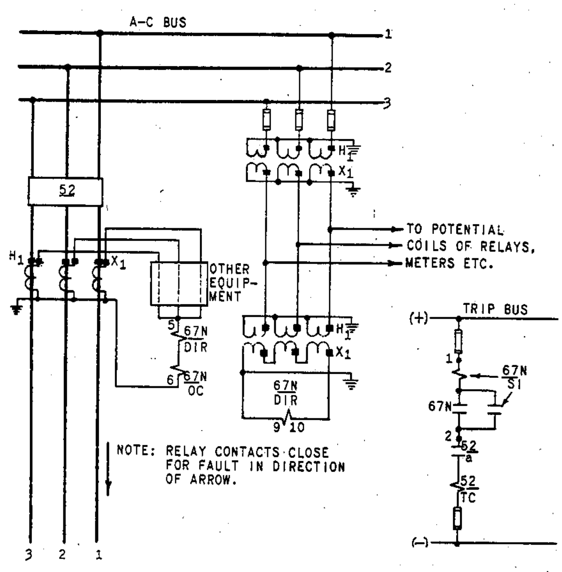


Fig. 7 Connections For Directional Ground Protection Of A Single Line Using One Type IBCG51A Relay With An Auxiliary Wye-Broken-Delta Transformer

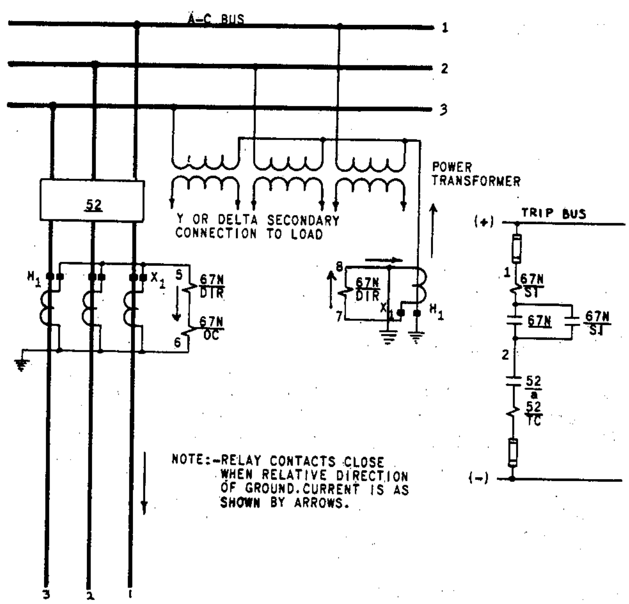
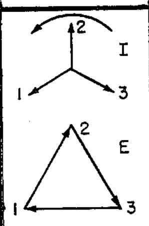
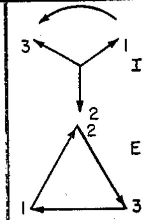
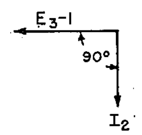
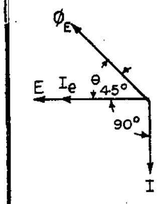
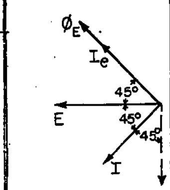
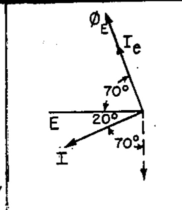
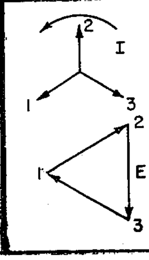
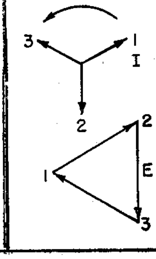
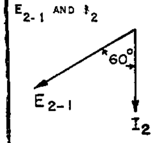
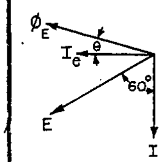
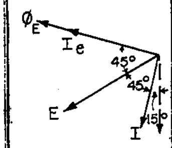
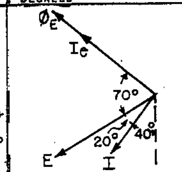


Fig. 8 Connections For Directional Ground-Fault Protection Of A Single Line Using Type IBCG51A Relay With Current Polarization

TABLE I

CONDITIONS FOR MAXIMUM TORQUE IN IBC RELAYS USING 90^0 AND 60^0 CONNECTIONS

Connection (1-2-3 Phase. Sequence)	Phase Relationship at Relay Terminals for Current Flowing in the Non-Trip Direction at Unity Power Factor Load	Phase Relationship at Relay Terminals for Current Flowing in the Tripping Direction at Unity Power Factor Load	Voltage and Current Used in Phase 2 Relay with Phase Relationship of Unity P.F. Load when Current Flows in Trip Direction	Vector Relationship of Eddy-Currents in Induction Cylinder to Flux Set Up by Potential Winding at Unity P.F. Load Shorting Link Off (Freq. -60 Cycles)	Condition for Maximum Torque with Shorting Link Off (Freq. 60 Cycles)	Condition for Maximum Torque with Shorting Link On (Freq. 60 Cycles)
Quadrature (Current Leads Potential 90 Degrees when Flowing in Tripping Direction at Unity P.F. Load)			E_{3-1} and I_2  I Leads E by 90 Degrees		 Max. Torque occurs when I lags unity P.F. position by 45 Degrees.	 Max. Torque occurs when I lags unity P.F. position by 70 Degrees
60 Degree (Current Leads Potential 60 Degrees when Flowing in Tripping Direction at Unity P.F. Load)			E_{2-1} and I_2  I Leads E by 60 Degrees		 Max. Torque occurs when I lags unity P.F. position by 15 Degrees	 Max. Torque occurs when I lags unity P.F. position by 40 Degrees

NOTES: I_e=Eddy-current in induction cup, set up by I; ϕ_E=Flux in potential winding; θ=Angle between I_e and ϕ_E; Torque $=K\phi_E I_e \cos\theta$

Fig. 8 shows the external connections for the Type IBC phase relays and the Type IBCG ground relays when used for directional overcurrent protection with wye-broken delta potential transformers (broken delta signifies a complete delta with one corner open). If the potential transformers are connected wye-wye instead of wye-broken delta, auxiliary wye-broken delta potential transformers should be used for the connection as shown in Fig. 7. Either the Type IBC or Type IBCV phase relays can be used with this scheme.

Fig. 8 shows typical external connections to be used when the Type IBCG ground relay is current polarized from a local source of ground current. On some applications, system conditions may at one time be such that potential polarization of ground relays is desirable and at another be such that current polarization would be preferred. The Type IBCG relay, with its feature of dual polarization, is well suited for such applications. The curve of Fig. 9 compare the performance of the dual-polarized relay with that of the potential and current polarized relays for such an application.

OVERCURRENT UNIT

On systems where the fault current flowing through a given relay is influenced largely by the system generating capacity at the time of the fault, best results are usually obtained with the inverse time relays covered by these instructions. In cases where the fault current magnitude is dependent mainly upon the location of the fault in relation to the relay, and only slightly or not at all upon the system generating setup, best results will in general be obtained by using relays having a very inverse time characteristic.

The reason for this is that relays must be set to be selective with maximum fault current flowing. For currents below this value, the time becomes greater as the current is decreased. If there is a wide range in generating capacity, together with variation in short-circuit current with fault position, the operating time with minimum fault current may be exceedingly long with very-inverse-time relays. For such cases the inverse-time relay is recommended.

OPERATING CHARACTERISTICS

The Type IBC51A potential-polarized phase relay consists of a time overcurrent unit with single circuit-closing contacts. The directional unit is provided with a resistor in series with the potential polarizing coils, which can be cut into or out of the circuit by means of a link to change the angle of maximum torque (see Table II).

The Type IBC52A relay is similar to the Type IBC51A relay except that its time overcurrent unit has two circuit-closing contacts.

The Type IBCV51A relay is a potential-polarized phase relay similar to the Type IBC51A relay except that its directional unit is provided with volt-

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TABLE II

Types IBC, IBCG, And IBCV Relays - Inverse Time Characteristics

Relay	Functions on	Overcurrent Unit Contacts	Directional Unit Polarized	Dir. Unit Phase Angle Obtained by	Approx. angle of max. torque (Current with respect to voltage)
IBC51A	Phase faults (May operate on ground faults)	one circuit closing	Potential	Internal Res. in series with polarizing coils.	Resistor Cut out 50/60 Cyc. - 20 degree lead 25 cyc. - 30 degree lead. Resistor in - 25/50/60 cyc. 45 degrees lead
IBC52A		two circuit closing			
IBCV51A		one circuit closing			60 cycles - 45 deg. lead
IBCV52A		two circuit closing			
IBCG51A	Ground Faults	one circuit closing	Potential and/or Current	Series Cap. for pot. polarized. Floating winding & Cap. for Current Polarized	60 degree lag for Pot. Pol.; currents approx. in phase for current polarized
IBCG52A		two circuit closing			

age restraint. If the restraint circuit is opened by means of the link, the relay is similar to the Type IBC51A relay with maximum torque at 45 degrees lead.

The Type IBCV52A relay is similar to the Type IBCV51A relay except that its time overcurrent unit has two circuit-closing contacts.

The Type IBCG51A dual-polarized ground relay consists of a time overcurrent unit with single circuit-closing contacts. The directional unit is provided with two sets of polarizing coils which permit it to be polarized from a potential source or from a local ground current source, or from both simultaneously.

The Type IBCG52A relay is similar to the Type IBCG51A relay except that the time overcurrent unit has two circuit-closing contacts.

The distinguishing features of all these relays have been summarized for convenience in Table II.

DIRECTIONAL UNIT

The directional unit of the Type IBC relays will operate on one volt and 4 amperes of proper relative polarity for relays with 4/16 ampere overcurrent units and 115 volt rating, and on one volt and 2 amperes for 1.5/6 ampere relays.

The Type IBCV relay is available with directional-unit pickup of either 9 amperes (2/8 ampere range) or 12 amperes (4/16 ampere range) at rated voltage and maximum torque angle. At restraint voltages of less than rating, the operating current is also less, as shown in Fig. 10.

The Type IBCG directional unit, when potential-polarized, will operate at 3.6 volt-amperes at the maximum torque angle of 60 degrees lag. When current polarized, it will operate at approximately 0.5 ampere with the two coil sets (operating and polarizing) connected in series. The performance of the unit with simultaneous current and potential polarization is typified by Fig. 9.

OVERCURRENT UNIT

The minimum operating current required to close the contacts of this unit, at any time-dial position, will be within five percent of the tap-plug setting. The contacts will reset if they are not sealed closed when the current decreases to less than 90 per cent of the minimum closing value. The time for the disk to reset completely to the No. 10 time-dial position, when the relay is deenergized, is approximately six seconds for inverse-time relays.

The relay will operate repeatedly within one or two percent of the same time. The inverse-time characteristic of the overcurrent unit is shown in Fig. 22.

RATINGS

CURRENT COILS

The short time and continuous ratings of the operating coil circuits are given in Table III.

CONTACTS

The current-closing rating of the induction-unit 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.

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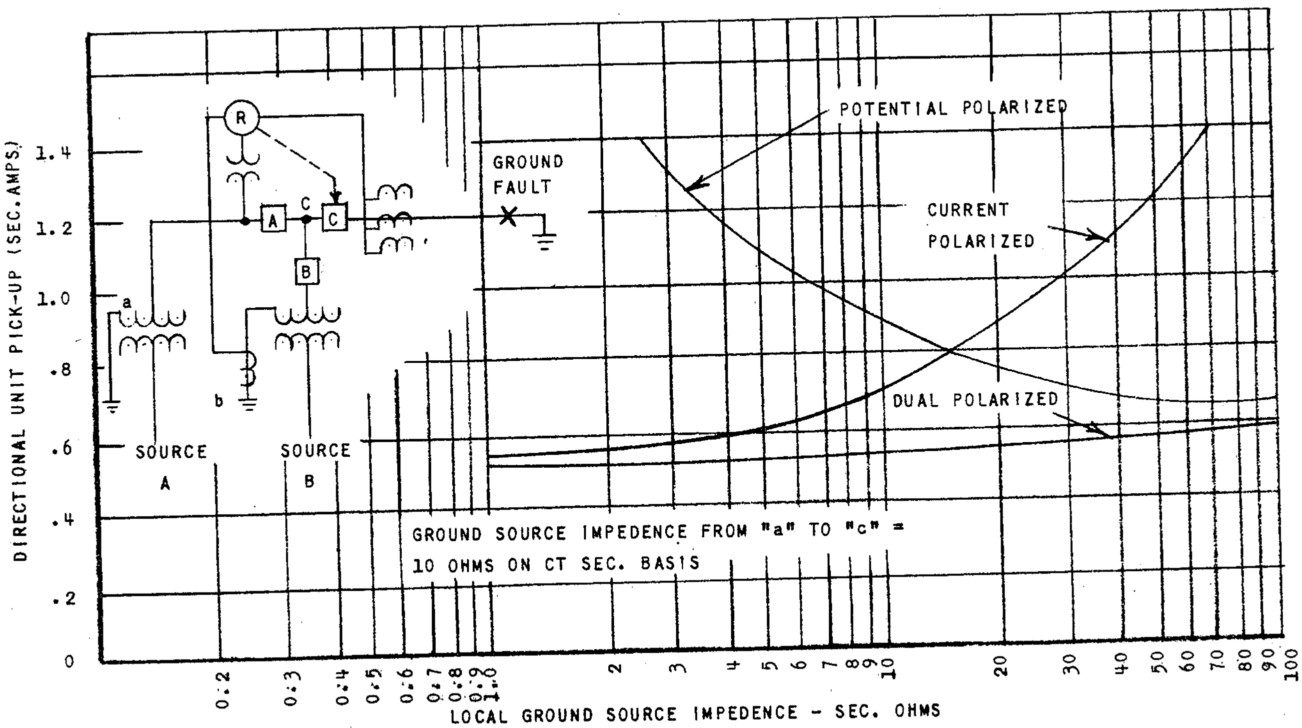

Fig. 9 Type IBCG Directional Unit Pickup For Various Values Of Ground-Fault Impedance With Current, Potential Or Dual Polarization

Fig. 9 362A684

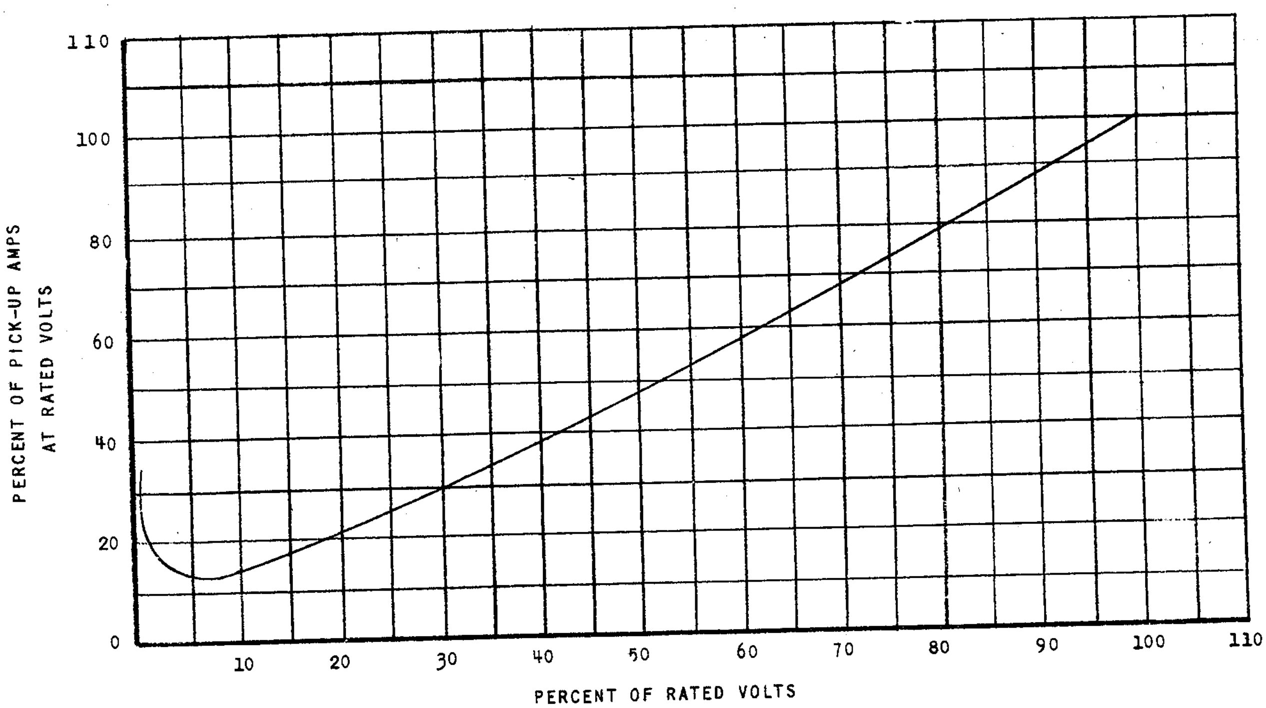

Fig. 10 Typical Directional Unit Pick-up Characteristic Of The Type IBCV51A Relay, With Balanced Voltages And At Maximum Torque Angle

Fig. 10 K-6507958

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TABLE III

Tap Range in Amps.	Tap Ratings in Amps.	1 Sec. Rating (amps)	Continuous** Rating (amps)
4/16	4, 5, 6, 8, 10, 12, 16	220	10
*2/8	2, 2.5, 3, 4, 5, 6, 8	200	5
1.5/6	1.5, 2, 2.5, 3, 4, 5, 6	200	5
0.5/2	0.5, 0.6, 0.8, 1.0, 1.2, 1.5, 2.0	100	1.5

*2/8 ampere range available in IBCV only.
**Continuous rating is the same as tap rating where this exceeds the value shown.

The current and potential polarizing coils of the dual-polarized ground relay are rated as follows:

Potential polarizing coils - 360 volts for 10 seconds at rated frequency.

Current polarizing coils - continuous rating of 5 amps with a one (1) second rating 160 amps.

SEAL-IN UNIT

The rating and impedance of the seal-in unit for the 0.2 and 2 ampere taps are given in Table IV. The tap setting used will depend on the current drawn by the trip coil. The current ratings are either a-c or d-c.

TABLE IV

	2 amp Tap	0.2 amp Tap
Carry-Tripping Duty	30 amps	5 amps
Carry continuously	4 amps	0.8 amps
D-C Resistance	0.13 ohms	7 ohms
Impedance (60 cyc.)	0.53 ohms	52 ohms

The 0.2 ampere tap is for use with trip coils that operate on currents ranging from 0.2 up to 2.0 amperes at the minimum control voltage. If this tap is used with trip coils requiring more than 2 amperes, there is a possibility that the resistance of 7 ohms will reduce the current to so low a value that the breaker will not be tripped.

The 2-ampere tap should be used with trip coils which take 2 amperes or more at minimum control voltage. If the tripping current exceeds 30 amperes, the connections should be arranged so that the induction unit contacts operate an auxiliary relay which in turn energized the trip coil or coils. On such an application, it may be necessary to connect a loading resistor in parallel with the auxiliary relay coil, to allow enough current to be drawn to operate the target-seal-in unit.

BURDENS

Tables V and VI give the burdens of potential and current circuits, respectively, for both phase and ground relays.

TABLE V
BURDENS OF POTENTIAL COILS
(at 120 volts 60 cycles)

Relay	Freq.	Watts	Volt Amperes	P.F.	See Note
IBC51A	60	8.3	21.9	0.38	(D)
IBC52A	60	11.8	16.7	0.71	(E)
IBCG51A IBCG52A	60 60	15.4	19.6	0.78	(F)
IBCV51A	60	20.5	32	0.64	(G)
IBCV52A	60	3.9	5.9	0.66	(H)

(D) Burden with internal resistor shorted (link closed).
(E) Burden with internal resistor in circuit (link open).
(F) Capacitive burden of potential polarizing circuit calculated at 120V.
(G) Polarizing circuit.
(H) Restraint circuit

TABLE VI
BURDENS OF CURRENT COILS

Relay	Tap Range	Burdens at minimum Pickup: Eff. Res. (ohms)	Reactance (ohms)	Impedance (ohms) (A)	P.F.	Volt Amp.(B)	Burdens in ohms Impedance at 3 x Pickup	10 x Pickup	Volt Amperes at 5 amperes (Calculated from Burden at min. Pickup)
IBC5IA	1.5/6	1.12	3.0	3.2	0.35	7.20	1.9	1.1	80
IBC52A	4/16	0.20	0.48	0.52	0.38	8.30	0.31	0.18	13
IBCG51A IBCG52A	0.5/2	8.0	20.0	22.5	0.36	5.6	13.4	7.8	560 (C) (O)
	0.5/2	0.35	0.12	0.37	0.95	.09	0.37	0.37	9.3 (C) (P)
	1.5/6	1.00	2.65	2.90	0.35	6.5	1.7	1.0	73 (C) (O)
	1.5/6	0.35	0.12	0.37	0.95	0.83	0.37	0.37	9.3 (C) (P)
IBCV51A	2/8	0.45	1.0	1.1	0.41	4.4	0.91	0.40	27.5
IBCV52A	4/16	0.15	0.40	0.44	0.34	7.0	0.36	0.16	11.0

NOTE A The impedance values given are those for the minimum tap of each relay. The impedance for other taps, at pickup current (tap rating), varies inversely approximately as the square of the current rating. Example: for the Type IBC51A, relay 4/16 ampere, the impedance of the 4 ampere tap is 0.52 ohms. The impedance of the 6 ampere tap, at 6 ampere is approximately $(4/6)^2 \times 0.52 = 0.23$ ohms.

NOTE B Some companies list relay burdens only as the volt-ampere input to operate at minimum pickup. This column is included so a direct comparison can be made. It should not be used in calculating volt-ampere burdens in a CT secondary circuit, since the burden at 5 amperes is used for this purpose.

NOTE C These relays are ordinarily used in the residual circuit of current transformers for ground-fault protection. The burden is, therefore, only imposed for the duration of a ground fault and need be considered only for this brief period.

NOTE O Burden of operating coils of directional and overcurrent units.

NOTE P Burden of current-polarizing coil of directional unit.

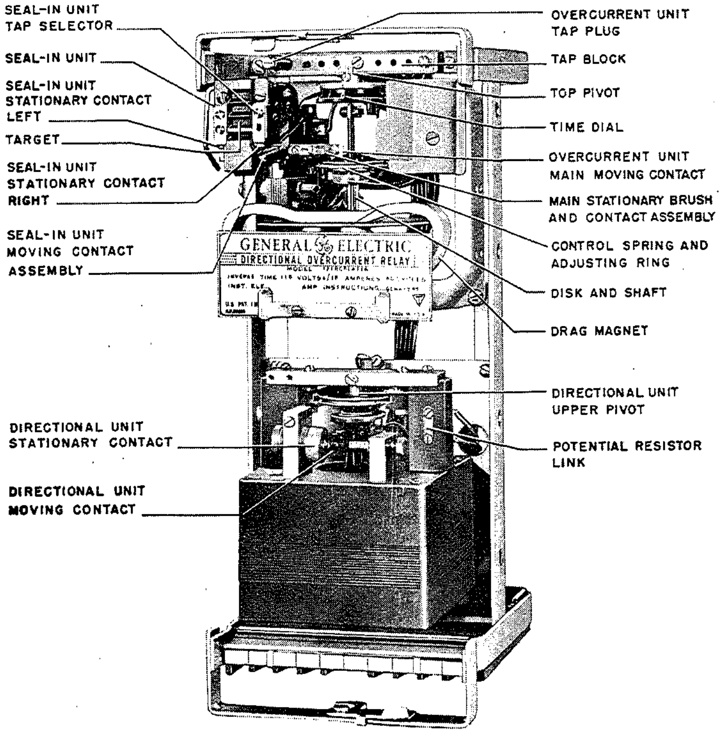

Fig. 11 Type IBC51A Relay - Unit In Cradle (Front View)

Fig. 11 #8007270

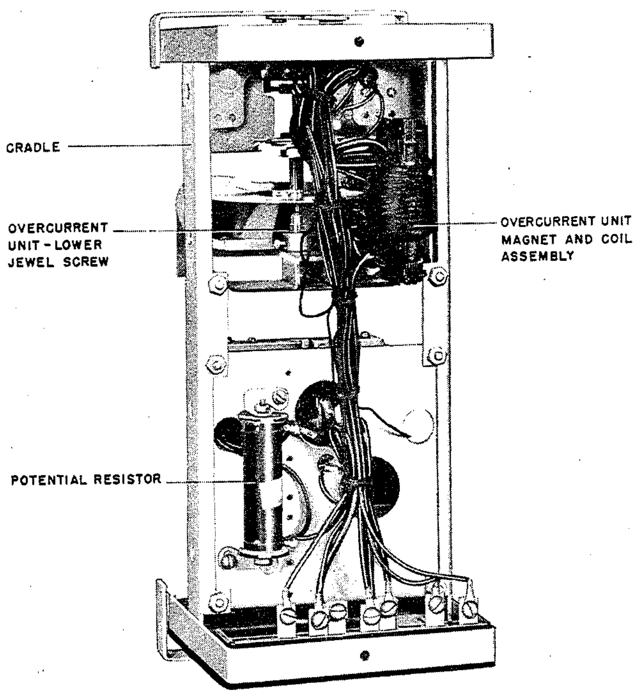

Fig. 12 Type IBC51A Relay - Unit In Cradle (Rear View)

Fig. 12 #8007268

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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 relays covered by these instructions are identified by model numbers. These models are similar in description with the exception of the number of contacts on the overcurrent unit, the angle of maximum torque of the directional unit, and in the method of polarizing the directional unit.

OVERCURRENT UNIT

The inverse time overcurrent unit in these relays is similar to the standard Type IAC51 relay, except that it has wound shading coils in place of the punched shading rings. The disk is actuated by a current operating coil which is assembled on a laminated U-shaped magnet. The disk shaft carries the moving contact which completes the alarm or trip circuit when it touches the stationary contact or contacts. The shaft is restrained by a spiral spring to give the proper contact-closing current, and its motion is retarded by permanent magnets acting on the disk to produce the desired time characteristic. The variable retarding force resulting from the gradient of the spiral spring is produced by the spiral shape of the induction disk, which results in increased driving force as the spring winds up.

The wound shading coils on the U-shaped magnet acts to produce a split-phase field, which in turn develops torque on the operating disk. In the case of 60 cycle relays, the two leads from the shading coils are connected directly across the directional unit contacts. For other frequencies, the shading coil leads are connected to an internally mounted step-up transformer, the secondary of which is connected to the directional contacts. In either case, when the directional unit contacts are closed, the overcurrent unit is operative, and when they are open it resets and will not close its contacts even though the current exceeds 20 times pick up value. The overcurrent unit, therefore, will only operate when power flows in the desired direction for tripping. This method of obtaining directional descrimination is known as "Directional Control".

There is a seal-in element mounted on the front to the left of the shaft. This element has its coil in series and its contacts in parallel with the main contacts such that when the main contacts close, the seal-in element picks up and seals in. When the seal-in element picks up, it raises a target into view which latches up and remains exposed until released by pressing a button beneath the lower-left corner of the cover.

DIRECTIONAL UNIT

The directional unit is of the induction-cylinder construction with a laminated stator having eight poles projecting inward and arranged symmetrically around a stationary central core. The cup-like aluminum induction rotor is free to operate in the annular air gap between the poles and the core. The poles are fitted with current operating coils and with potential or current polarizing coils.

The principle by which torque is developed is the same as that of an induction-disk relay with a wattmetric element, although in arrangement of parts the unit is more like a split-phase induction motor. The induction-cylinder construction provides a higher torque and lower rotor inertia than the induction disk construction, resulting in a faster and more sensitive relay.

CONTACTS

The contacts of the directional unit, Fig. 13,

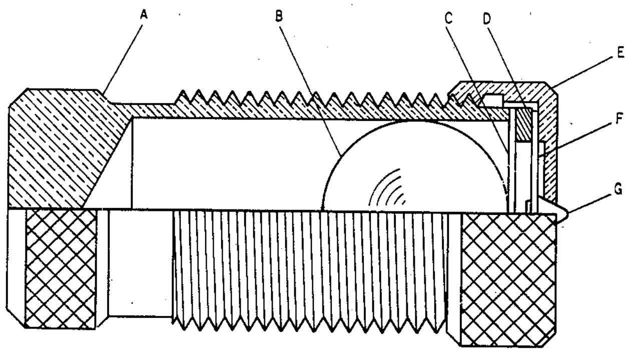

Fig. 13 Contact Assembly Of The Directional Unit

Fig. 13 K-6077069

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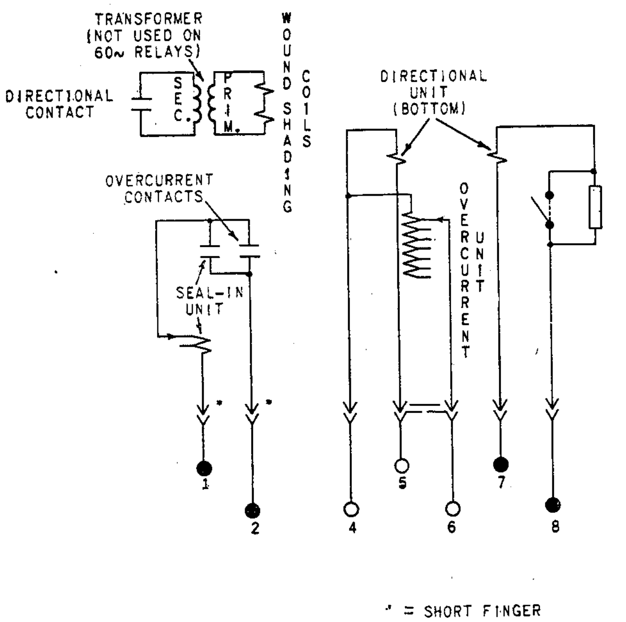

Fig. 14 Internal Connections For The Type IBC51A Relay (Front View)

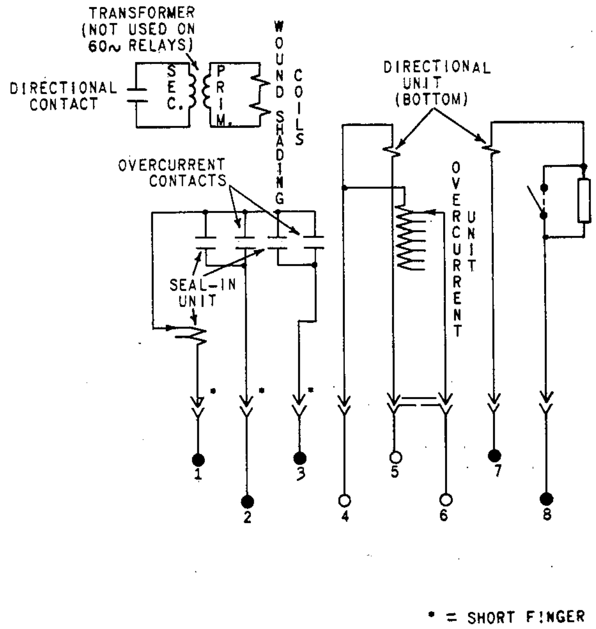

Fig. 15 Internal Connections For The Type IBC52A Relay (Front View)

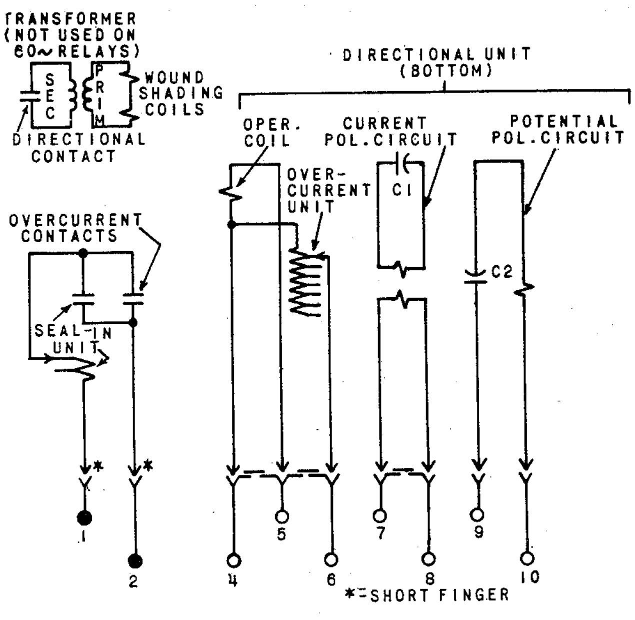

Fig. 16 Internal Connections For The Type IBCG51A Relay (Front View)

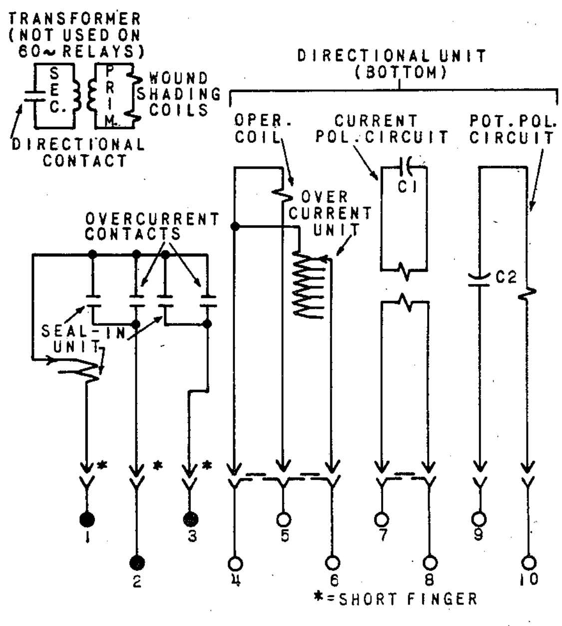

Fig. 17 Internal Connections For The Type IBCG52A Relay (Front View)

Fig. 14 K-6209667
Fig. 15 K-6209668
Fig. 16 362A565
Fig. 17 362A566

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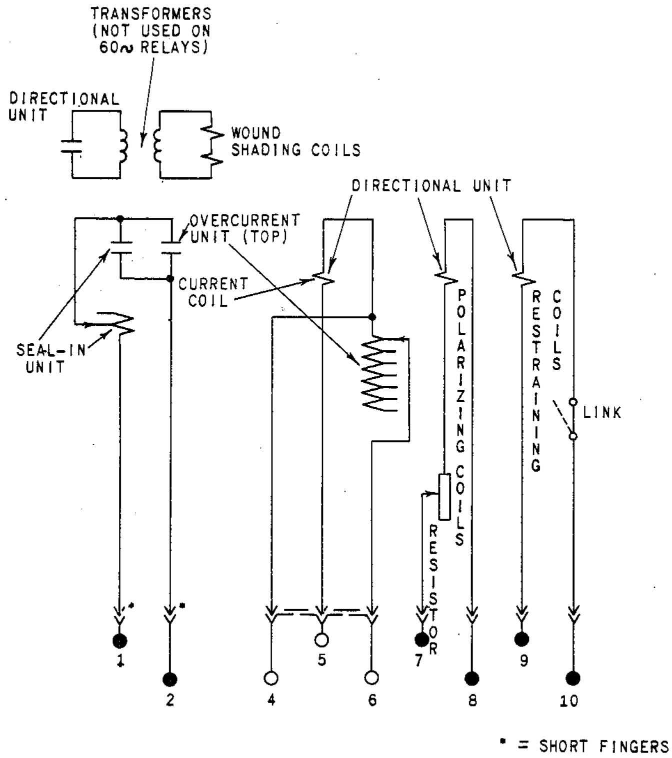

Fig. 18 Internal Connections For The Type IBCV51A Relay (Front View)

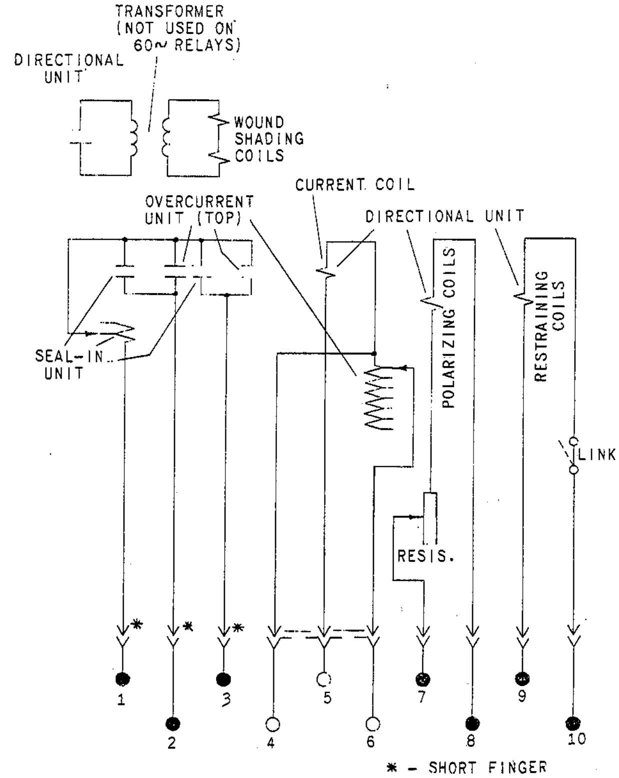

Fig. 19 Internal Connections For The Type IBCV52A Relay (Front View)

are specially constructed to suppress bouncing. The stationary contact (G) is mounted on a flat spiral spring (F) backed up by a thin diaphragm (C). These are both mounted in a slightly inclined tube (A). A stainless steel ball (B) is placed in the tube before the diaphragm is assembled. When the moving contact hits the stationary contact, the energy of the former is imparted to the latter and thence to the ball, which is free to roll up the inclined tube. Thus the moving contact comes to rest with substantially no rebound or vibration. To change the stationary contact mounting spring, remove the contact barrel and sleeve as a complete unit after loosening the screw at the front of the contact block. Unscrew the cap (E). The contact and its flat spiral mounting spring may then be removed.

CASE

The case is suitable for either surface or semiflush panel mounting and an assortment of hardware is provided for either mounting. The cover attaches to the case and also carries the reset mechanism when one is required. Each cover screw has provision for a sealing wire.

The case has studs or screw connections at both ends or at the bottom only for the external connections. The electrical connections between the relay units and the case studs are made through spring backed contact fingers mounted in stationary molded inner and outer blocks between which nests a removable connecting plug which completes the circuits. The outer blocks, attached to the case, have the studs for the external connections, and the inner blocks have the terminals for the internal connections.

The relay mechanism is mounted in a steel framework called the cradle and is a complete unit with all leads being terminated at the inner block. This cradle is held firmly in the case with a latch at the top and the bottom and by a guide pin at the back of the case. The cases and cradles are so constructed that the relay cannot be inserted in the case upside down. The connecting plug, besides making the electrical connections between the respective blocks of the cradle and case, also locks the latch in place. The cover, which is fastened to the case by thumbscrews, holds the connecting plug in place.

To draw out the relay unit the cover is first removed, and the plug drawn out. Shorting bars are provided in the case to short the current transformer circuits. The latches are then released, and the relay unit can be easily drawn out. To replace the relay unit, the reverse order is followed.

A separate testing plug can be inserted in place of the connecting plug to test the relay in place on the panel either from its own source of current and voltage, or from other sources. Or, the relay unit can be drawn out and replaced by another which has been tested in the laboratory.

Fig. 19 376A901 Fig. 18 K-6400779

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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. 25.

CONNECTIONS

The internal connection diagrams for the various relays are shown in Figs. 14 to 19. Typical wiring diagrams are shown in Figs. 3 to 8.

One of the mounting studs or screws should be permanently grounded by a conductor not less than No. 12 B&S gage copper wire or its equivalent.

INSPECTION

At the time of installation, the relay should be inspected for tarnished contacts, loose screws, or other imperfections. If any trouble is found, it should be corrected in the manner described under MAINTENANCE.

OPERATION

Before the relay is put into service, it should be given a partial check to determine that factory adjustments have not been disturbed. The time dial will be set at zero before the relay leaves the factory. It is necessary to change this setting in order to open the overcurrent contacts.

ADJUSTMENT

OVERCURRENT UNIT

TARGET AND SEAL-IN UNIT

When used with trips coils operating on currents ranging from 0.2 to 2.0 amperes at minimum control voltage, the target and seal-in tap plug 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 plug should be placed in the 2.0 ampere tap.

The seal-in unit tap plug is the screw holding the right-hand stationary contact of the seal-in unit. To change the tap setting, first remove the connecting plug. 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. If tap plugs are left in both taps, the pickup will be less than 2.0 amperes on d-c but the seal-in unit will take longer to close its contacts. On a-c the unit will not pick up with screws in both taps.

CURRENT SETTING

The current at which the contacts operate may be changed by changing the position of the tap plug in the tap block at the top of the relay. Screw the tap plug firmly into the tap marked for the desired current (below which the unit is not to operate).

When changing the current setting of the unit remove the connecting plug to short circuit the current transformer secondary circuit. Next, screw the tap plug into the tap marked for the desired current and then replace the connecting plug.

The pickup of the unit for any current tap is adjusted by means of a spring adjusting ring. The ring may be turned by inserting a tool in the notches around the edge. By turning the ring, the operating current of the unit may be brought into agreement with the tap setting employed, if for some reason this adjustment has been disturbed. This adjustment also permits any desired setting intermediate between the various tap settings to be obtained. The unit is adjusted at the factory to close its contacts from any time-dial position at a minimum current within five per cent of the tap plug setting. The unit resets at 90 per cent of the minimum closing value.

TIME SETTING

The setting of the time dial determines the length of time the unit requires to close its contacts when the current reaches a predetermined value. The contacts are just closed when the dial is set on zero. When the dial is set on 10, the disk must travel the maximum amount to close the contacts and therefore this setting gives the maximum time setting.

The primary adjustment for the time of operation of the unit is made by means of the time dial. However, further adjustment is obtained by moving the permanent magnet along its supporting shelf; moving the magnet in toward the back of the unit decreases the time, while moving it out increases the time.

If selective action of two or more relays is required, determine the maximum possible short-circuit current of the line and then choose a time value for each relay that differs sufficiently to insure the proper sequence in the operation of the several circuit breakers. Allowance must be made for the time involved in opening each breaker after the relay contacts close. For this reason, unless

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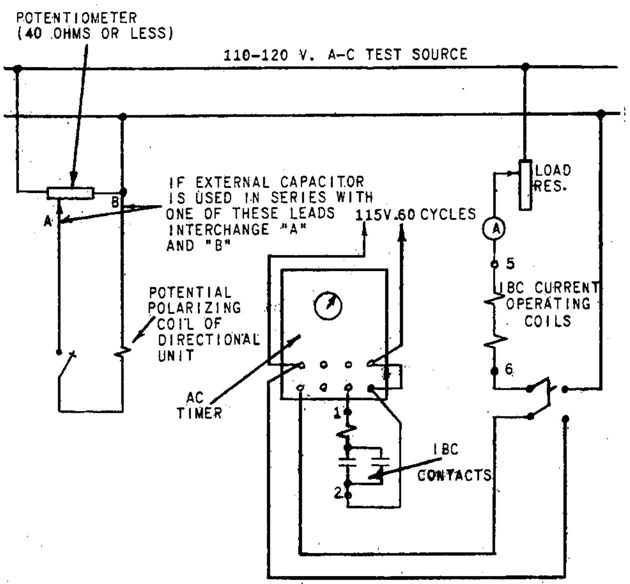

Fig. 20 Test Connections For Checking Pick-up And Operating Time Of The Time-Overcurrent Unit

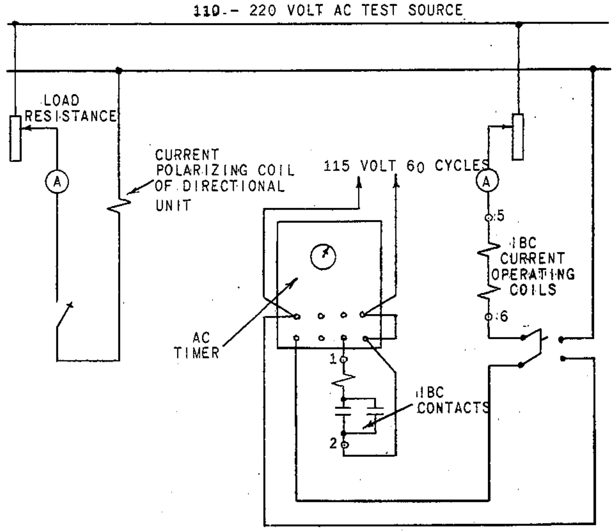

Fig. 21 Test Connections For Checking Pick-up And Operating Time Of The Time-Overcurrent Unit

the circuit time of operation is known with accuracy, there should be a difference of about 0.5 second (at the maximum current) between relays whose operation is to be selective.

EXAMPLE OF SETTING

The time and current settings of the overcurrent unit can be made easily and quickly. Each time value shown in Fig. 22 indicates the time required for the contacts to close with a particular time-dial setting when the current is a prescribed number of times the current-tap setting. In order to secure any of the particular time-current settings shown in Fig. 22, insert the removable plug in the proper tap receptacle and adjust the time dial to the proper position. The following example illustrates the procedure in making a relay setting.

Assume a Type IBC relay is used in a circuit where the circuit breaker should trip on a sustained current of approximately 450 amperes; also, the breaker should trip in 1.9 seconds on a short-circuit current of 3750 amperes. Assume further that current transformers of 60/1 ratio are used.

The current-tap setting is found by dividing minimum primary tripping current by the current transformer ratio. In this case, 450 divided by 60 equals 7.5 amperes. Since there is no 7.5 ampere tap, the 8-ampere tap is used. To find the proper time-dial setting to give 1.9 seconds time delay at 3750 amperes, divide 3750 by the transformer ratio. This gives 62.5 amperes secondary current which is 7.8 times the 8-ampere setting. By referring to the time-current curves (Fig. 22), it will be seen that 7.8 times the minimum operating current gives 1.9 seconds time delay when the relay is set slightly above the No. 6 time-dial setting.

The above results should be checked by means of an accurate timing device. Slight readjustment of the dial can be made until the desired time is obtained.

Test connections are shown in Figs. 20 and 21.

Aid in making the proper selection of relay settings may be obtained on application to the nearest Sales Office of the General Electric Company.

DIRECTIONAL UNIT

POTENTIAL RESISTOR LINK

On the directional unit of the phase relays, a link is located on the right-hand molded post which supports the bearing plate. On Type IBCV relays, this link is in series with the voltage restraint circuit and can be opened if the voltage restraint feature is not desired. On Type IBC relays, this link is in parallel with an internal resistor which is used for torque angle adjustment. Table II shows the maximum torque angle which result with the link in or out. When the link is open it should be left attached by the lower screw so that it will not be lost.

POLARITY CHECK

The polarity of the directional-unit connections in phase-to-phase fault applications, may be verified by observing the direction of contact armature torque when the line is carrying load at unity power factor, or slightly lagging power factor. Note that in most directional overcurrent relay applications, the desired directions are: contact-closing for power flow away from the bus, and contact opening for power flow toward the bus. In case of doubt refer to Fig. 23 for a more accurate method of checking the polarity of the connections.

K-6154287 Fig. 20

K-6154288 Fig. 21

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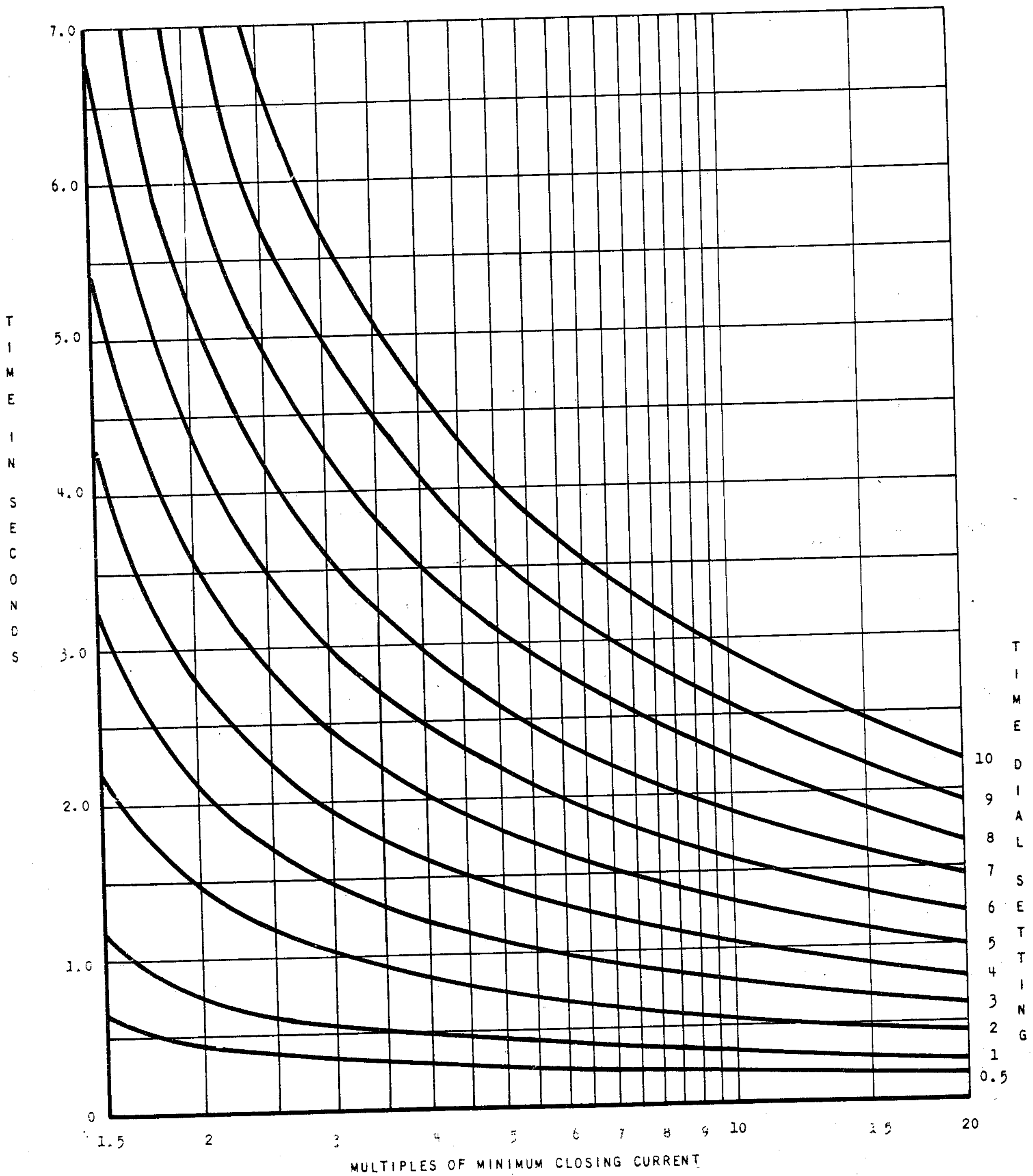

Fig. 22 Time Current Curves For The Inverse Time Overcurrent Unit

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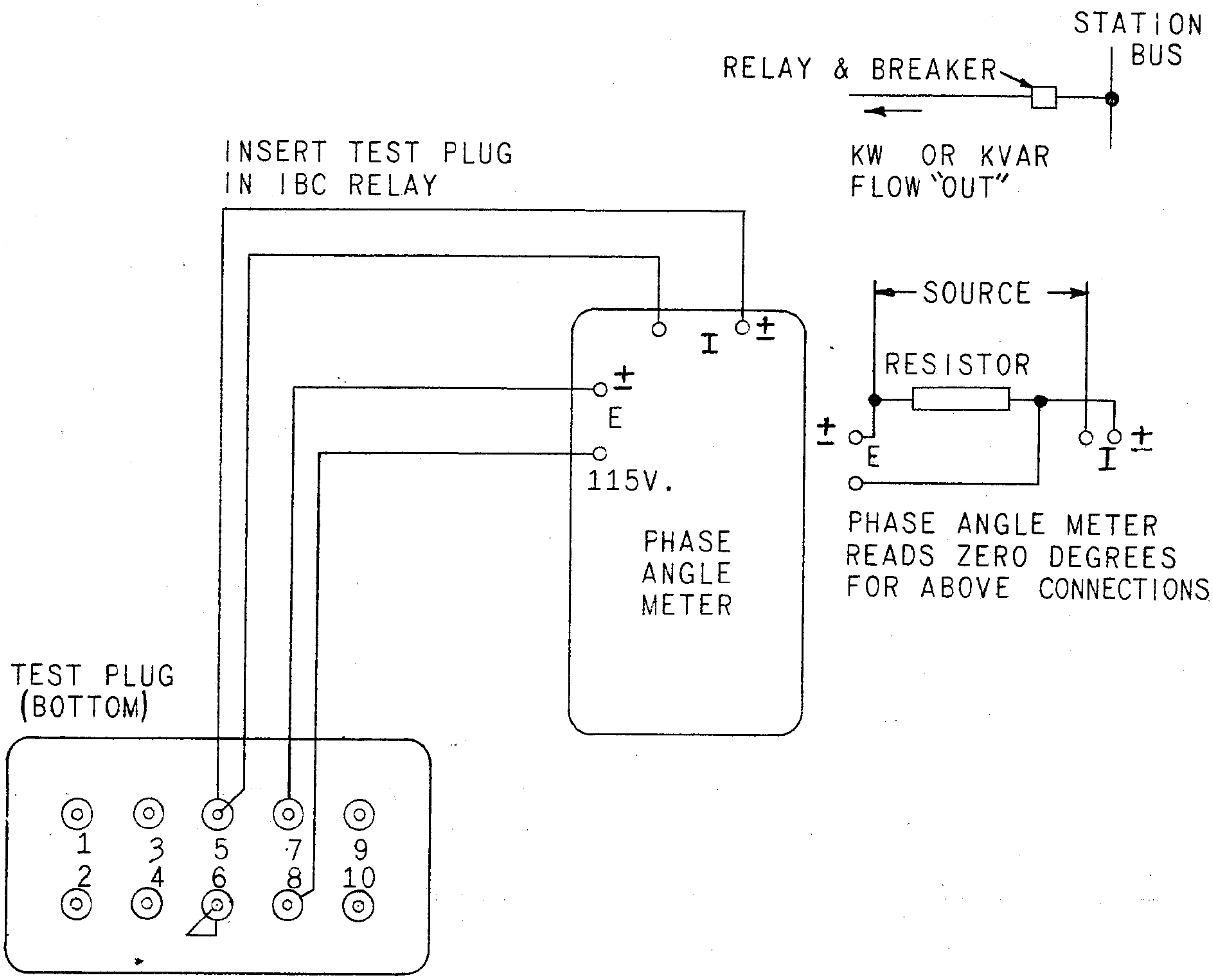
Fig. 23 (377A195)



POWER FACTOR ANGLE (DEG. LEAD)	0-45	45-90	90-135	135-180	180-225	225-270	270-315	315-360
KW & KVAR DIRECTIONS WITH RESPECT TO THE BUS	KW OUT> KVAR IN	KVAR> IN KW OUT	KVAR> IN KW IN	KW IN> KVAR IN	KW IN> KVAR OUT	KVAR> OUT KW IN	KVAR> OUT KW OUT	KW OUT> KVAR OUT
METER READING WITH PROPER EXT.CONNS.	330-15	15-60	60-105	105-150	150-195	195-240	240-285	285-330

THE ABOVE RANGES OF PHASE ANGLE METER READINGS ARE THE ANGLES BY WHICH THE CURRENT LEADS THE VOLTAGE WITH THE DESCRIBED CONDITIONS OF POWER (KW) AND REACTIVE POWER (KVAR) FLOW WITH THE STATION BUS CONSIDERED AS THE REFERENCE IN ALL CASES.

CAUTION: MAKE CORRECTIONS FOR METER ERRORS ON LOW CURRENTS, INHERENT IN SOME PHASE-ANGLE METERS.

23 Test Connections For External Wiring Of Type IBC Relay

In the case of the Type IBCV relay, the voltage restraint circuit should be opened by means of the link while the relative polarity of operating and polarizing circuits is being checked. The polarity of the restraint circuit is automatically checked when it is reconnected. With normal load and rated voltage, the restraint circuit should always cause the directional contacts to open regardless of direction of power flow.

The ground relay connections are shown in Figs. 6 to 8. The following tests should be made on the ground element to insure that the currents, or current and voltage, go to the proper relay terminals.

The polarity of the ground directional unit, when it is potential polarized, may be checked by using load currents. The idea is to obtain current from one transformer and voltage from the same phase. The voltage is obtained by removing phase one from the primary of the broken-delta transformer and shorting the phase one primary winding to ground. Current is obtained by shorting the current transformers in phases two and three and opening their circuits to the relay. This permits the current transformer in phase one to supply the current.

Connect a phase-angle meter to read the angle between the current and voltage supplied to the relay. The relay has maximum torque at 45 degree lag. With power flowing in the proper direction for operation, the relay should operate for phase angles within plus or minus 60 degrees of the maximum torque angle.

If the unit is polarized from a current transformer in the power-transformer neutral, such a check is not easily made. It is sometimes practical to introduce a single-phase current in one phase of the primary circuits in such a way that current flows through both the transformer neutral current transformer and one of the line current transformers. If this cannot be done, a careful wiring check must suffice.

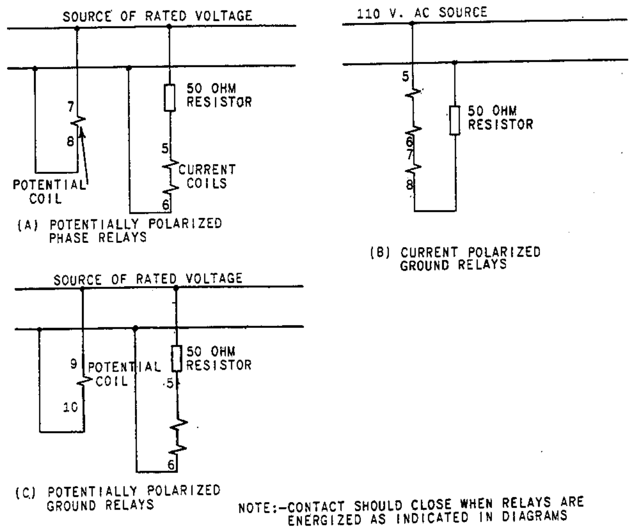


Fig. 24 Polarity Test Connections For Type IBC Relays

The polarity of the directional units in phase or ground relays can be checked by means of the circuits shown in Fig. 24. The connections shown should close the contacts at rated voltage and frequency.

MAINTENANCE

These relays are adjusted at the factory and it is advisable not to disturb the adjustments. If for any reason, they have been disturbed, the following points should be observed in restoring them:

OVERCURRENT UNIT

DISK AND BEARINGS

The lower jewel bearing may be tested for cracks by exploring its surfaces with the point of a fine needle. The overcurrent unit jewel bearing should be turned up until the disk is centered in the air gaps, after which it should be locked in position by the set screw provided for the purpose.

The upper bearing pin should be adjusted so that the disk shaft has about 1/64 inch end play.

CONTACTS

The contacts should have about 1/32 inch wipe. That is, the stationary contact tip(s) should be deflected about 1/32 inch when the disk completes its travel. Wipe is adjusted by turning the screws in the contact brush(es) thereby adjusting the position of the brush(es) relative to the brush stop. The tips should lie in the same vertical plane on two-circuit closing relays.

When the time dial is moved to the position where it holds the contacts just closed, it should indicate zero on the time-dial scale. 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 time dial. Loosen the screw clamping the arm to the shaft and turn the arm relative to the shaft until the contacts just make for zero time-dial setting.

DIRECTIONAL UNIT

CONTACTS

The contact gap may be adjusted by loosening slightly the same screw at the front of the contact block. The screw should be loose enough only to allow the contact barrel to rotate in its sleeve.

The stop screw fastened with a locknut should hold the moving contact arm in a neutral position; i.e., with it pointing directly forward. Then bring the stationary contact up until it just touches the moving contact by rotating the contact barrel. Next, back it away 2/3 turn to obtain approximately 0.020 inch contact gap. Last, tighten the screw which secures the barrel.

The moving contact may be removed by loosening the screw which secures it to the contact arm and sliding it from under the screw head.

CUP AND STATOR

Should it be necessary to remove the cup-type rotor from the directional unit, the following procedure should be followed:

All leads to the unit should first be disconconnected and tagged for identification in reconnecting. The unit can then be removed from the cradle with its mounting plate still attached.

The upper of the three flat-head screws holding the unit to the plate should now be removed. On some models it may be necessary to remove a resistor or capacitor to expose this screw. The four corner screws clamping the unit together should next be removed, and the entire top structure lifted off. This gives access to the cup assembly and exposes the stator assembly, which should be protected to keep it free from dust and metalic particles until the unit is reassembled.

To remove the shaft and rotor from the contact head assembly, the spring clip at the top of the shaft must be pulled out and the clutch adjusting screw taken out of the side of the molded contact arm. The shaft and cup can now be pulled out of the molding. The rotor must be handled very carefully while it is out of the unit.

BEARINGS

The lower jewel bearing should be screwed all the way in until its head engages the end of the threaded core support. The upper bearing should be adjusted to allow about 1/64 inch end play to the shaft.

To check the clearance between the iron core and the inside of the rotor cup, press down on the contact arm near the shaft and thus depress the spring-mounted jewel until the cup strikes the iron. The shaft should move about 1/16 inch.

The lower jewel bearing may be tested for fracture by exploring its surface with the point of a fine needle.

TORQUE ADJUSTMENT

The directional unit in these relays is provided with a notched core which is used to minimize the torque produced on the rotor by current alone in the operating coils with the polarizing circuits, current or potential, de-energized. This adjustment is made at the factory and may be checked as follows:

First, short out the potential polarizing coil circuits of phase relays and the voltage restraint circuit when it is present. Leave both the potential and current polarizing coils open-circuited on ground relays. Adjust the control spring so that the moving contact structure is balanced between the stationary contact and the stop. This can be done by loosening the hexagonal-head locking screw which clamps the spring adjusting ring in position, and turning the ring to the left until the balance point is reached.

Energize the operating circuit with the current specified below for type and rating, and check that the contact arm does not move. The core should be turned in small steps until a point is reached where there is no "bias" torque from current alone. The core can be turned by loosening the large hexagonal nut on the bottom of the unit and by turning the core by means of the slotted bearing screw. This screw should be held securely in position when the nut is retightened.

Type	Current Rating	Test Amps
IBC	1.5/6 4/16	30 60
IBCV	2/8 4/16	30 30
IBCG	0.5/2 1.5/6	30 30

Note that in the above test, the link on the molded support of Type IBC and Type IBCV relays must be closed. Also keep in mind that currents of these magnitudes will cause the coils to overheat if left on too long. Therefore, leave the test current on only for short intervals and allow sufficient time between tests for the coils to cool.

After the torque adjustment has been made, the spiral spring should be set to have barely enough tension to swing the moving contact arm against the stop screw when the unit is deenergized. Sufficient tension will be obtained if the adjusting ring is rotated about 1/2 inch from the neutral position in the counterclockwise direction, as measured on the periphery of the ring.

CLUTCH ADJUSTMENT

The connections shown in Fig. 24 for the polarity check can also be used in making the clutch adjustment. The 50 ohm fixed resistor should be replaced with an adjustable resistor capable of providing the current range listed in Table VII for the relay type and rating in question. A screw projecting from the side of the movable contact arm controls the clutch pressure, and consequently the current value which will cause the clutch to slip. With rated frequency and at rated volts for potential polarized relays, the clutch should be set to slip at the current values listed in Table VII. In all cases, the current is in phase with the voltage.

TABLE VII

Relay Type	Polarization	Pick-up Range (Amps)	Position of Link	Amps for clutch to slip
IBC	Potential	4/16 1.5/6 0.5/2	closed closed closed	22 11 11
IBCG	*current or potential	4/16 1.5/6 0.5/2	- - -	12 7 7
IBCV	potential	2/8 4/16	closed	6** 8.5**

* Make clutch adjustment with unit polarized by one of the two methods only.

** See Text.

On Type IBCV relays, the clutch slip is limited to approximately 20 degrees by means of a stop pin in the shaft. It should first be set to slip in the counterclockwise direction at the current values listed in the table with the polarizing circuit energized but with the restraint circuit open. Then check that the clutch will slip to the limit in the clockwise direction with the restraint circuit energized at rated volts and the current circuit open.

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. Sometimes an ordinary file cannot reach the actual points of contact because of some obstruction from some other part of the 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 in the preceding section 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, specifying the quantity required and describing the parts by catalogue numbers as shown in Renewal Parts Bulletin No. GEF-3805.

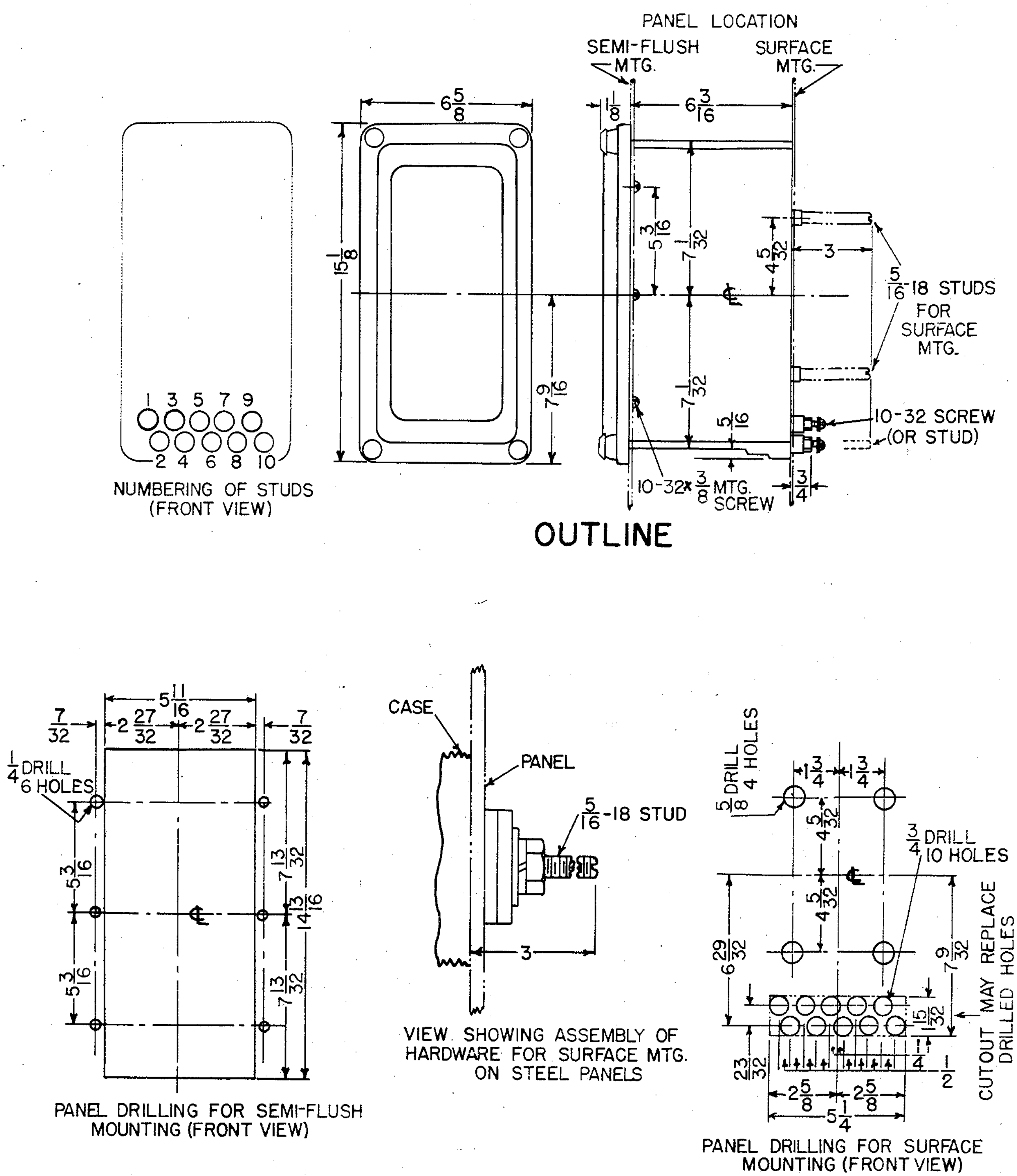


Fig. 25 Outline And Panel Drilling Dimensions For Relay Types IBC51A, IBC52A, IBCG51A, IBCG52A, IBCV51A, And IBCV52A

Fig. 25 K-6209273

AGD

WHEN YOU NEED SERVICE

IF YOU NEED TO REPAIR, recondition, or rebuild any electric apparatus, a G-E service shop near you is available day and night, seven days a week, for work in the shops or on your premises. Latest factory methods and genuine G-E renewal parts are used to maintain the original performance of your G-E equipment. For full information about these services, contact the nearest service shop or sales office listed below:

APPARATUS SERVICE SHOPS

Allentown, Pa.......672–676 E. Highland St.
Appleton, Wisc.....Midway Industrial Area, County Trunk, "P"
Atlanta—Chamblee, Ga.....4639 Peachtree Indus. Blvd.
Baltimore 30, Md...........920 E. Fort Ave.
Boston—Medford 55, Mass. Mystic Valley Pkwy.
Buffalo 11, N. Y.............318 Urban St.
Charleston 28, W. Va..306 MacCorkle Ave., S.E.
Charlotte, N. C............2328 Thrift Road
Chicago 32, Ill............4360 W. 47th St.
Cincinnati 2, Ohio.........444 W. Third St.
Cleveland 4, Ohio.....4966 Woodland Ave.
Columbus 23, Ohio..........2128 Eakin Rd.
Corpus Christi, Texas.........115 Busse St.
Dallas 19, Texas.........3202 Manor Way
Davenport—Bettendorf, Ia.....1039 State St.
Decatur, Ill...............2225 E. Logan St.
Denver 5, Colo............3353 Larimer St.
Detroit 2, Mich............5950 Third Ave.
Houston 20, Texas..5534 Harvey Wilson Drive
Indianapolis 22, Ind.....1740 W. Vermont St.
Johnstown, Pa...............841 Oak St.
Kansas City, Mo.........3525 Gardner Ave.
Los Angeles 1, Calif......6900 Stanford Ave.
Louisville, Ky............2014 New Main St.
Midland, Tex..........3404 Bankhead Hwy.
Milwaukee 3, Wisc......940 W. St. Paul Ave.
Minneapolis 12, Minn......2025 49th Ave., N.
New Orleans, La.......2815 N. Robertson St.
New York—N. Bergen, N. J...6001 Tonnelle Ave.
Oakland, Calif.............1525 Peralta St.
Philadelphia 24, Pa........1040 E. Erie Ave.
Pittsburgh 6, Pa............6519 Penn Ave.
Portland 10, Oregon...2727 N.W. 29th Ave.
Richmond 24, Va..........1403 Ingram Ave.
Roanoke, Va............115 Albermarle St.
Sacramento, Calif............99 N. 17th St.
St. Louis 10, Mo............1115 East Road
Salt Lake City 4, Utah.301 S. Seventh West St.
San Francisco 3, Calif......1098 Harrison St.
Seattle 4, Wash..........3422 First Ave., S.
Southington, Conn..........53 Railroad Ave.
Spokane 3, Wash........S. 155 Sherman St.
Tampa 1, Fla. P.O. Box 1245, Naval Indus. Res. Shipyard
Toledo 4, Ohio...........1 So. St. Clair St.
Wheeling, W. Va.........2050 National Rd.
York, Pa................54 N. Harrison St.
Youngstown 5, Ohio....272 E. Indianola Ave.

APPARATUS SALES OFFICES

Abilene, Texas..............442 Cedar St.
Akron 8, Ohio.............335 S. Main St.
Albany 7, N. Y................90 State St.
Albuquerque, N. Mex.....323 Third St., S.W.
Alexandria, La.............720 Murray St.
Allentown, Pa............1132 Hamilton St.
Amarillo, Texas..............Amarillo Bldg.
Appleton, Wisc........531 W. College Ave.
Atlanta 3, Ga......1860 Peachtree Rd., N.W.
Augusta, Ga.................Masonic Bldg.
Augusta, Me.................152 State St.
Baltimore 1, Md.............111 Park Ave.
Bangor, Maine..............77 Central St.
Baton Rouge 6, La........3170 Florida Blvd.
Battle Creek, Mich......25 W. Michigan Ave.
Beaumont, Texas.........1385 Calder Ave.
Billings, Mont.....Rm. 816, 303 No. Broadway
Binghamton, N. Y..........19 Chenango St.
Birmingham 3, Ala.....1804 Seventh Ave., N.
Bismarck, N. Dak............418 Rosser Ave.
Bluefield, W. Va............704 Bland St. Appalachian Bldg.
Boise, Idaho...............1524 Idaho St.
Boston 1, Mass.............140 Federal St.
Buffalo 3, N. Y.........535 Washington St.
Butte, Mont..P.O. Box 836, 103 N. Wyoming St.
Canton 2, Ohio......700 Tuscarawas St., W.
Cedar Rapids, Iowa.....210 Second St., S.E.
Charleston 28, W.Va..306 MacCorkle Ave., S.E.
Charlotte 1, N. C...........112 S. Tryon St.
Chattanooga 2, Tenn......832 Georgia Ave.
Chicago 80, Ill..P.O.Box 5970A, 840 S. Canal St.
Cincinnati 2, Ohio.........215 W. Third St.
Cleveland 4, Ohio.....4966 Woodland Ave.
Columbia 1, S.C., P.O. Box 1434, 1420 Lady St.
Columbus 15, Ohio..........40 S. Third St.
Corpus Christi, Texas.......205 N. Chaparral
Dallas 2, Texas..........1801 N. Lamar St.
Davenport—Bettendorf, Ia.....1039 State St.
Dayton 2, Ohio......11 W. Monument Bldg.
Dayton 9, Ohio. Avia. & Def., 2600 Far Hills Ave.
Denver 2, Colo.........650 Seventeenth St.
Des Moines 9, Iowa.......505 W. Fifth Ave.
Detroit 2, Mich...........700 Antoinette St.
Duluth 2, Minn...........14 W. Superior St.
Elmira, N. Y......Main and Woodlawn Aves.
El Paso, Texas............215 No. Stanton
Erie, Pa....................1001 State St.
Eugene, Ore.. . Cascade Bldg., 1170 Pearl St.
Evansville 19, Ind........123 N.W. Fourth St.
Fairmont, W. Va..........310 Jacobs Bldg., P.O. Box 1626
Fergus Falls, Minn. 108 N. Court Ave. P.O. Box 197
Flint 3, Mich.............653 S. Saginaw St.
Fort Wayne 6, Ind......3606 So. Calhoun St.
Fort Worth 2, Tex.......408 W. Seventh St.
Fort Worth, Tex.....Avia. & Def., 6200 Camp Bowie Blvd.
Fresno 1, Calif..........407 Patterson Bldg. Tulare and Fulton St
Grand Rapids 2, Mich.....425 Cherry St., SE
Greensboro, N. C............301 S. Elm St.
Greenville, S. C......108 W. Washington St.
Gulfport, Miss.............207 Jo-Fran Bldg.
Hagerstown, Md.......Professional Arts Bldg.
Hartford 5, Conn...........764 Asylum Ave.
Houston 1, Texas..........1312 Live Oak St.
Indianapolis 4, Ind..........110 N. Illinois St.
Jackson, Mich.........120 W. Michigan Ave.
Jackson 1, Miss..........203 W. Capitol St.
Jacksonville 2, Fla..........700 E. Union St.
Jamestown, N. Y...P.O. Box 548, 2 Second St.
Johnstown, Pa...............841 Oak St.
Joplin, Mo..P.O. Box 948, 220½ W. Fourth St.
Kalamazoo 3, Mich........112 Parkway Ave.
Kansas City 6, Mo.....106 W. Fourteenth St.
Knoxville 16, Tenn........1301 Hannah Ave.
Lake Charles, La...........422 Seventh St.
Lansing 8, Mich..306 Michigan National Tower
Lexington, Ky.......First National Bank Bldg.
Lincoln 8, Nebr..Sharpe Bldg., 206 S. 13th St.
Little Rock, Ark.........103 W. Capitol Ave.
Los Angeles 54, Calif......212 N. Vignes St.
Louisville 2, Ky............455 S. Fourth St.
Lubbock, Texas...........3302 Avenue "A"
Macon, Ga..................682 Cherry St.
Madison 3, Wisc...........16 N. Carroll St.
Manchester, N. H..............875 Elm St.
Medford, Ore., P.O. Box 1349, 107 E. Main St.
Memphis 3, Tenn..............8 N. Third St.
Miami 32, Fla..........25 S.E. Second Ave.
Midwest City, Okla.........Avia. & Def., 207 Post Off. Bldg.
Milwaukee 3, Wisc.....940 W. St. Paul Ave.
Minneapolis 3, Minn...........12 S. Sixth St.
Mobile 13, Ala............54 St. Joseph St.
Nashville 3, Tenn..........234 Third Ave., N.
Newark 2, N. J..............744 Broad St.
New Haven 6, Conn..........129 Church St.
New Orleans 12, La.........837 Gravier St.
New York 22, N. Y.......570 Lexington Ave.
New York.........Avia. & Def., Fed. Bldg., N. Y. International Airport, Jamaica 30, N. Y.
Niagara Falls, N. Y..........253 Second St.
Norfolk 10, Va............229 W. Bute St.
Oakland 12, Calif.........409 Thirteenth St.
Oklahoma City 2, Okla....119 N. Robinson St.
Omaha 2, Nebr.......409 S. Seventeenth St.
Pasco, Wash.............824 W. Lewis St.
Peoria 2, Ill............309 Jefferson Bldg.
Philadelphia 2, Pa...........1405 Locust St.
Phoenix, Ariz..P.O. Box 4037, 303 Luhrs Tower
Pittsburgh 22, Pa..The Oliver Bldg., Mellon Sq.
Portland 7, Ore.........920 S.W. Sixth Ave.
Providence 3, R. I.......Industrial Trust Bldg.
Raleigh, N. C....Room 401, 16 W. Martin St.
Reading, Pa.................31 N. Sixth St.
Richmond 17, Va..........700 E. Franklin St.
Riverside, Calif..............3570 Ninth St.
Roanoke 16, Va.........920 S. Jefferson St.
Rochester 4, N. Y................89 E. Ave.
Rockford, Ill.................110 S. First St.
Rutland, Vt................38½ Center St.
Sacramento 14, Calif........626 Forum Bldg.
Saginaw, Mich....Second National Bank Bldg.
St. Louis 1, Mo................818 Olive St.
Salt Lake City 9, Utah.......200 S. Main St.
San Antonio 5, Texas.....434 So. Main Ave.
San Diego 1, Calif........1240 Seventh Ave.
San Francisco 6, Calif....235 Montgomery St.
San Jose 10, Calif...........460 Park Ave.
Savannah, Ga................4 E. Bryan St.
Seattle 4, Wash............710 Second Ave.
Seattle 8, Wash..Avia. & Def., 220 Dawson St.
Shreveport, La..............206 Beck Bldg.
Sioux City 13, Iowa.572 Orpheum Electric Bldg.
South Bend 1, Ind.....112 W. Jefferson Blvd.
Spokane 4, Wash............S. 162 Post St.
Springfield, Ill.............607 E. Adams St.
Springfield 3, Mass...........1387 Main St.
Stockton, Calif.........11 So. San Joaquin St.
Syracuse 6, N. Y............3532 James St.
Tacoma 1, Wash.....1202 Washington Bldg.
Tampa 6, Fla............1206 North A St.
Toledo 4, Ohio...........420 Madison Ave.
Trenton 8, N. J...........214 E. Hanover St.
Tucson, Ariz...P.O. Box 710, 650 N. Sixth Ave.
Tulsa 3, Okla............320 S. Boston Ave.
Utica 2, N. Y..............258 Genesee St.
Washington 5, D. C......777–14th St., N.W.
Waterloo, Iowa.............206 W. 4th St.
Wenatchee, Wash...328 N. Wenatchee Ave.
Wheeling, W. Va.........40 Fourteenth St.
Wichita 2, Kan..............200 E. First St.
Williamston, N. C...........115 E. Main St.
Worcester 5, Mass...........288 Grove St.
York, Pa................56 N. Harrison St.
Youngstown 5, Ohio.....272 E. Indianola Ave.

Hawaii: American Factors, Ltd., P. O. Box 3230, Honolulu 1 **Canada: Canadian General Electric Company, Ltd., Toronto**

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