C. A. SPANGLER

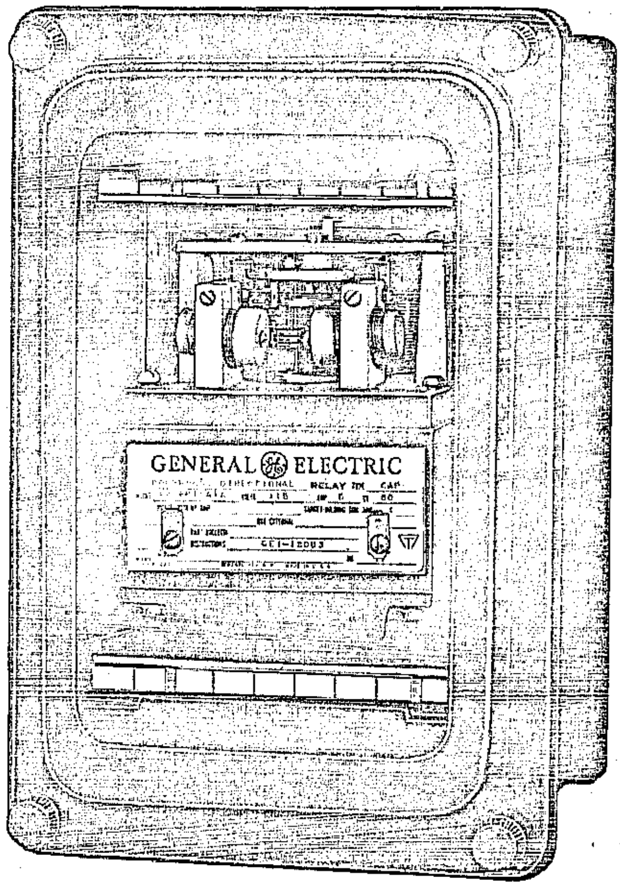
INSTRUCTIONS

GEI-12083F

SUPERSEDES GEI-12083E

Eastern Substation Division

POWER DIRECTIONAL RELAYS



Types

CAP15A

CAP15B

LOW VOLTAGE SWITCHGEAR DEPARTMENT

A

GENERAL ELECTRIC

PHILADELPHIA, PA.

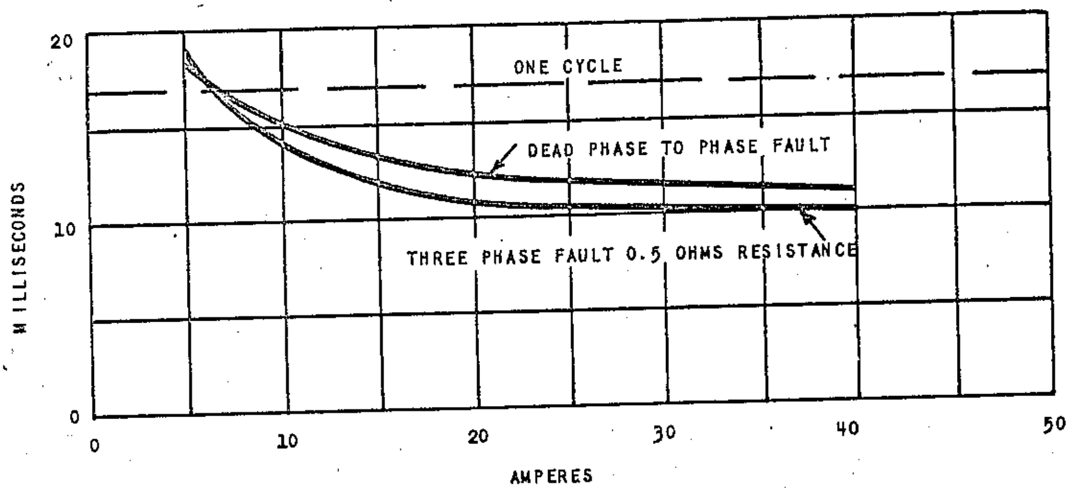


Fig. 1 Average Time Characteristics of the Type CAP15A Relay

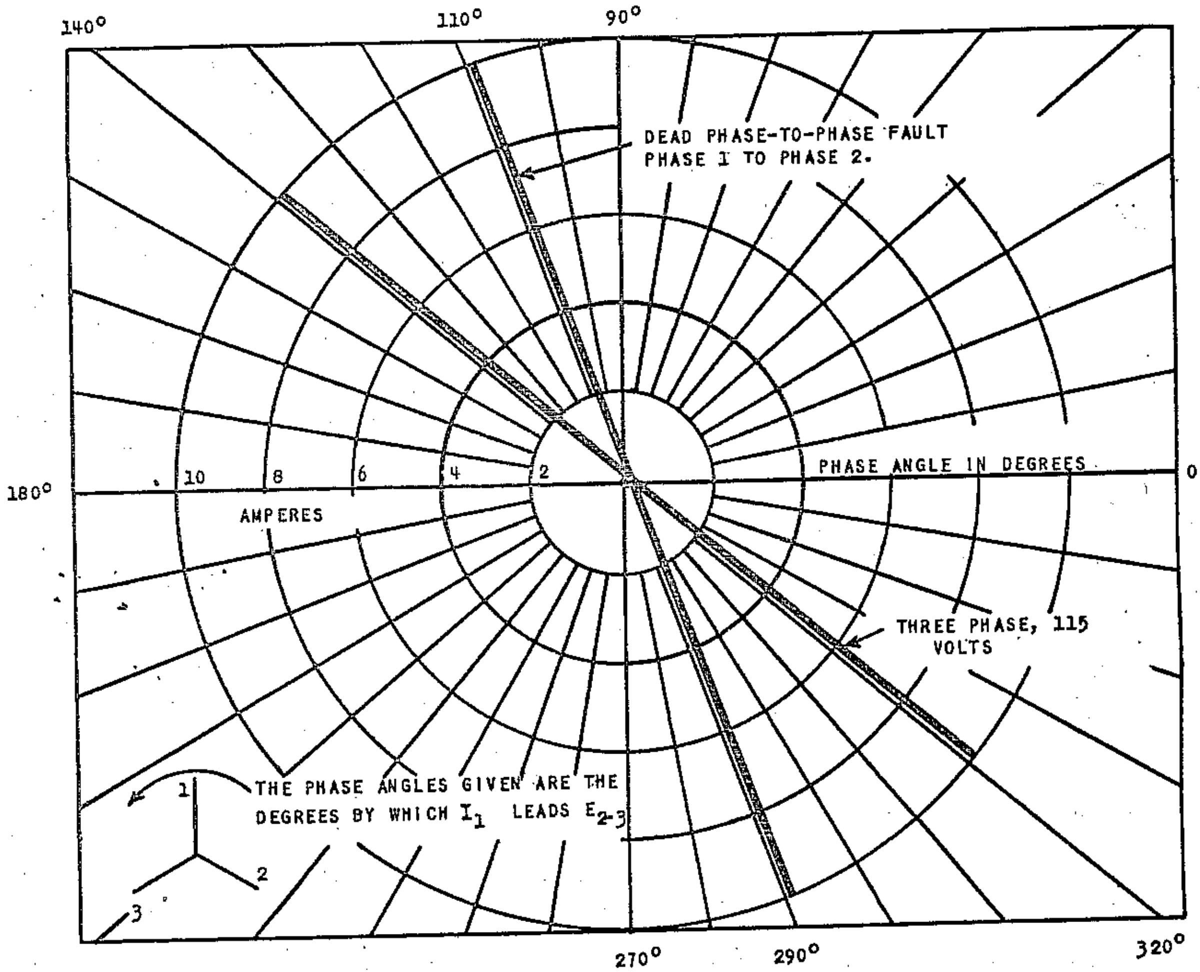


Fig. 2 Phase Angle Characteristics of the Type CAP15A Relay-60 Degree Connection

Fig. 1 (362A611)

Fig. 2 (362A610)

Cover (8008317)

POWER DIRECTIONAL RELAYS
TYPES CAP15A AND CAP15B

INTRODUCTION

The Type CAP15A and Type CAP15B relays consist of one three-phase unit, with one rotor mounted on a shaft. The contact assembly consists of two electrically separate contacts, one normally-open and one normally-closed. The normally closed contacts are held closed, when the relay is not energized, by means of two spiral springs which also complete the control circuit to the moving contacts.

APPLICATION

The Type CAP15A relay is an induction-cylinder power directional relay used with three-phase alternating-current circuits. It is used where there is low voltage and high current conditions.

The recommended a-c external-wiring connections for the Type CAP15A relay are shown in Fig. 9, connection A. With this connection, the relay has maximum torque on a three-phase fault circuit when the line current leads its quadrature voltage by 50 degrees or lags its unity power factor position by 40 degrees. On a phase-to-phase fault circuit, the relay located at the fault has maximum torque when the line current leads its quadrature voltage by 20 degrees (see Fig. 2). This connection is known as the 60 degree connection. The 30 degree and 90 degree connections are shown in Fig. 9, with the corresponding angle of maximum torque on a three-phase basis.

If the relay is used in an application where there is the possibility of a momentary reversal of power immediately following the clearing of a fault, and if the overcurrent relay contacts have closed, it is necessary to provide directional control to prevent false tripping. In the case of time delay overcurrent relays, this may be done by allowing the overcurrent relays to operate only if the fault is in the protected direction. If the overcurrent relay is instantaneous in operation, discriminating control may be obtained by using the right-hand contact to control a Type HGA auxiliary relay as shown in Fig. 3.

If both directional contacts are used and if a momentary reversal of power immediately following the clearing of a fault is not possible, it is still advisable to use some method of directional control. This is evident because when a fault is removed, sufficient energy will be stored in the deflected contact to cause rebound to the other contact. If only one contact is being used, the

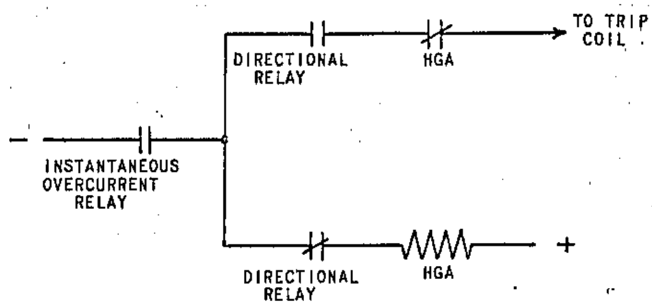


Fig. 3 Circuit Diagram of a Type CAP Relay Operating with a Type HGA Relay

Fig. 3 (362A607)

stored energy in the other contact may be substantially eliminated by reversing the contact barrel and its sleeve in the contact holder thereby using the back end as a solid stop. This is done by loosening the screw that locks the barrier in place, remove the barrel and sleeve, unscrew the sleeve from the barrel, insert the sleeve into the contact support from the inside and screw the barrel into it from the outside with the contact pointing out. When the stop is located where desired, lock in position by tightening the screw. It has been found advisable to remove the corresponding moving conact finger as well.

The Type CAP15B relay is used where sensitive reverse-power protection is required under conditions where there is normal voltage and low current. This relay measures true watts and is practically unaffected by the reactive component. For this application, the 30 degree connections are used, as shown in Fig. 13.

OPERATING CHARACTERISTICS

The phase angle and time characteristics of the 60 cycle relay are shown in Figs. 1 and 2 with the recommended connections.

RATINGS

CONTACT

The current-closing rating of the contact is 30 amperes for voltage not exceeding 250 volts. The

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.

current-carrying ratings are limited by the two different ratings of target and holding coils.

TARGET AND HOLDING COIL

The ratings for the target and holding coil are given in the following table:

*

Function	Amperes, A-C or D-C	
	1 Amp. (0.25 ohm d-c)	0.2 amp. (7 ohm d-c)
Tripping Duty	30	5
Carry Continuously	+1.25	0.5

+ Determined by control spring.

The 0.2 ampere coil is for use with trip coils that operate on currents ranging from 0.2 ampere to one ampere at the minimum control voltage. If this coil is used with trip coils that take one ampere or more, there is a possibility that the 7 ohms resistance will reduce the tripping current to a low value and then the breaker will not trip. This coil can safely carry tripping currents as high as 5 amperes.

The one-ampere coil should be used with trip coils provided the tripping current does not exceed 30 amperes at the maximum voltage. If the tripping current exceeds 30 amperes, an auxiliary relay must be used to control the trip-coil circuit. It must be connected in such a manner that the tripping current does not pass through the contacts or the target and holding coil of the protective relay.

When it is desirable to adopt one type of relay as standard to be used anywhere on a system, relays with the one ampere coil should be chosen. These relays should also be used when it is impossible to obtain trip coil data, but attention is called to the fact that the target may not operate if used with trip coils taking less than one ampere.

BURDENS

CURRENT

The burden imposed by each current coil at 5 amperes is given in the table below. With standard connections, one of the three current transformers supplies two current coils in series so that the burden on that transformer will be twice the amount given below. The other two current transformers will each supply one current coil and will have a burden as given in the following table:

Type CAP15A			
Frequency	Volt Amps.	Watts	P.F.
60 50 25	0.40 0.35 0.60	0.20 0.20 0.55	0.50 0.57 0.92
Type CAP15B			
60 50 25	3.6 3.2 2.6	1.8 1.8 2.4	0.50 0.57 0.92

POTENTIAL

The potential burdens per relay circuit (studs 13-14, 15-16, 17-18 and 19-20) are listed in the following table.

Relay	Freq.	Volt Amps	Watts	P.F.
CAP15A	60 50 25	5.3 6.2 3.5	1.60 2.15 1.85	0.30 0.35 0.53
CAP15B	60 50 25	4.7 5.8 3.5	2.35 2.89 1.85	0.50 0.50 0.53

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 the 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

INDUCTION UNIT

The principle by which torque is developed is the same as that employed in an induction-disk relay with a watthour-meter unit with the exception of the arrangement of parts being like that of a split-phase induction motor.

CUP AND STATOR

The stator has eight laminated magnetic poles projecting inward and arranged symmetrically around a central magnetic core. The poles are fitted with current and potential coils. In the annular air gap between the coils and central core,

 * Denotes change since superseded issue.

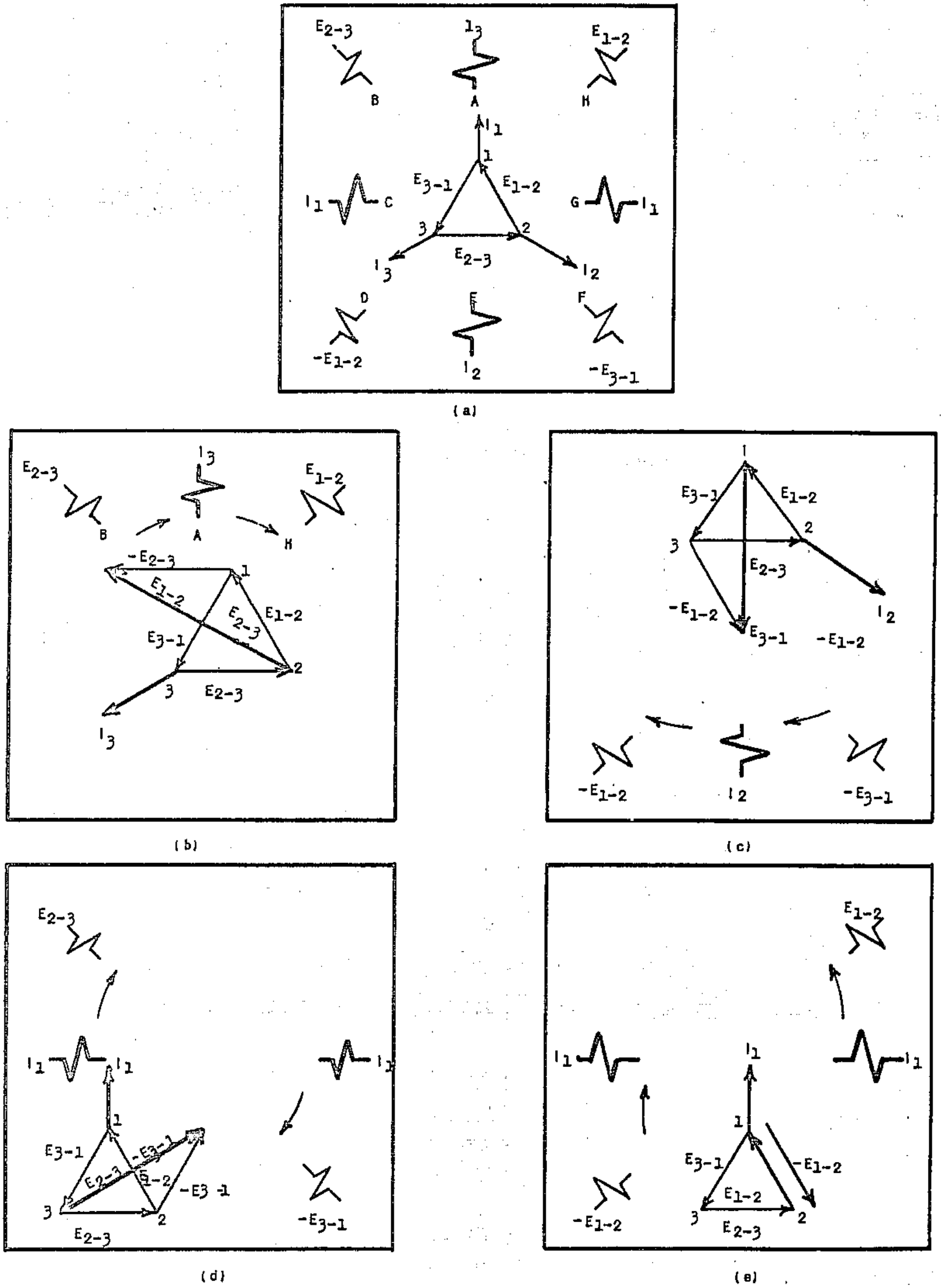


Fig. 7 (K-6177877)

Fig. 7 Schematic Diagrams of the Type CAP15A Relay

No. 12 B & S gage copper wire or its equivalent. The outline and panel drilling diagrams is shown in Fig. 14.

CONNECTIONS

The internal connection diagrams are shown in Figs. 4 and 5. The external connections diagrams are shown in Figs. 9, 11, 12, and 13.

INSTALLATION TESTS

Upon installing the relay, it is necessary to know (1) that the voltages and currents go to the proper relay terminals, and (2) that none of the relay coils is open circuited.

Item (1) may be checked easily by means of a phase-angle meter. Determination of the angle between a current and the three voltages and between a voltage and the other two currents gives all the information necessary for a complete vector diagram. The vector diagram plus a knowledge of the direction of power flow will immediately indicate whether or not the connections are correct.

The above test may be made with a wattmeter but the method is somewhat more involved than the phase-angle meter test.

Item (2) may be checked by noting that torque is available and in the correct direction upon removal of two in the three currents. Each of the three current combinations should be tested in turn. When making these tests, the phase angle of the currents should be considerably different from the angle of zero torque.

CAUTION: Every circuit in the drawout case has an auxiliary brush; this is the short one in the case (not on the cradle) which the connection plug or test plug should engage first. On every current circuit or other circuit with a shorting bar, make sure these auxiliary brushes are bent high enough to engage the connection plug or test plug before the main brushes in the case do, as otherwise the CT secondary circuit may be opened (where one brush touches the shorting bar) before the circuit is completed from the plug to the other main brush.

OPERATION

In analyzing various connections to the Type CAP15A relay, it is convenient to consider the magnet as a group of eight wattmeter type units acting upon a single rotor, a combination of each coil and an adjacent coil being assumed to be one element.

Of course, extraneous torques are developed by combinations of coils which are not adjacent. However, the torque of an adjacent pair of poles is largely relative to that of any other pair. For instance, the torque produced by the interaction between coils B and H (Part "a", Fig. 7) is approximately 15 per cent of that produced by coil combinations A-H, while the torque produced by combination C-H is about 2 percent, a negligible amount. The torques of alternate poles (e.g. A-C or B-H) being appreciable, the connections are arranged so that their torques balance out substantially to zero, a factory adjustment being provided for more accurate balance of the current torques. (See CURRENT BIAS ADJUSTMENT). Referring to the currents in Part "a", Fig. 7, it can be seen that the torque produced by the interaction between coils A and G is balanced by the equal and opposite torque of combination E-G is balanced by that of combination C-E.

Part "a" of Fig. 7 shows schematically the currents and voltages applied to the eight coils with connections as in Fig. 9, connection A. For clarity one current coil and its adjacent potential coils are isolated in Part "b", Fig. 7. It is observed that I_3 acts with E_{1-2} and E_{2-3} - the resulting torque being equivalent to the reaction of I_3 with the vector difference of E_{1-2} and E_{2-3} (difference because the potential coils are on opposite sides of the current coil). The vector relations are also shown in Part "b". Part "c" and "d" show corresponding coil and vector relations for the other two currents, I_2 and I_1. It is noted (Part "e" of Fig. 7) that the two remaining coil combinations produce equal and opposite torques.

Considering a potential coil and its adjacent current coil, this combination would have maximum torque when the current leads the voltage by 20 degrees. With the connections of Part "a" of Fig. 7, it is seen that I_3 will lead E_{1-2}-E_{2-3}, by 20 degrees when I_3 lags its phase-to-neutral voltage by 40 degrees. Thus, with these connections, maximum torque (blanced three-phase conditions) is obtained when a current lags its phase-to-neutral voltage by 40 degrees.

MAINTENANCE

ADJUSTMENTS

CUP AND STATOR

These relays are properly adjusted at the factory to obtain the desired characteristic and it is advisable not to disturb these adjustments. If for any reason it becomes necessary to remove the contact plate and rotor, the following procedure must be followed:

1. Remove the cradle from the case.

2. Remove the two screws holding the top inner block to the cradle and tilt the block up and back so that it is possible to work on the top of the relay.

3. Disconnect the four leads which go to the contact plate at the terminals in the upper and lower inner blocks and draw the loose ends out through the holes in the mounting plate.

4. Remove the two screws which secure the top bearing plate.

5. The contact plate is secured to the stator by means of three screws. The screws are located on the right-hand and left-hand sides in the front and at the middle at the rear. Remove the three screws.

6. The shaft rotor and top bearing plate will now lift out of the stator as the contact plate is raised.

7. The rotor may be removed from the shaft by loosening the two set screws which fit into V-holes in the shaft.

The two stator castings are permanently fastened together with the laminations clamped between them, and the faces of the poles and the cylindrical surfaces on these castings are then machined true about the same axis. To preserve this alignment, the large rivets in the corners should never be removed.

Use care in handling the rotor while it is out of the relay, and see that the air gap and rotor are kept clean.

In reassembly, the rotor will go into the air gap easily without forcing, if the parts are held in proper alignment.

The lower-jewel bearing should be screwed all the way in until its head engages the end of the threaded core. 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 may be tested for fractures by exploring its surface with a fine needle. If replaced with a new jewel a new pivot should be screwed into the end of the shaft at the same time.

CONTACT GAP

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 time curves of Fig. 1 were taken with a contact gap of 0.018 inch. This gap may be obtained in the following manner: With the right-hand contact tube or barrel secured in place, turn the left-hand barrel in the opposite direction approximately 210° or 0.6 revolution. Tighten the screw which secures the barrel.

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

HOLDING COILS

The location of each holding coil may be adjusted by loosening the mounting screw and sliding the coil either to the left or the right in a groove provided for that purpose. The holding coils are located in the factory so that there is a gap of about .055 inch between the pole pieces and the armature .055 inch is equivalent to 1-3/4 turns of the contact barrel.

CONTROL AND LEAD-IN SPRING

The control and lead-in springs are adjusted in the factory to close the right-hand contact when the relay is de-energized. The closing spring torque is equivalent to about 45 degrees motion of the spring adjusting ring located just under the top bearing plate. The tension of the control spring may be changed by loosening the hexoganal screw located at the rear of the adjusting-ring to the desired position.

CLUTCH

The clutch adjusting screw should be tightened as much as possible so that the clutch does not slip.

BIAS ADJUSTMENTS

The following adjustments must be made using a three-phase test source of current or voltage:

On the Type CAP15A relay the two variable resistors, Fig. 4, are used to balance the extraneous current torques. This adjustment is made in the factory and should not have to be changed. However, it may be checked by making current connections according to Fig. 8 and short-circuiting all potential terminals. With about 30 amperes flowing in each of the current circuits, the current bias is adjusted substantially to zero by means of one or the other of the adjustable resistors on the left-hand side of the relay.

No current bias adjustment is made on the Type CAP15B relay. A voltage bias adjustment is made, however, by applying rated potential and frequency to the potential circuit, with potential connections as in Fig. 9, connections C and with the current circuits open. Zero torque is then obtained by loosening the nut at the bottom of the stator which locks the core in position and turning the core a small amount by means of a screwdriver in the slot at the bottom of the core. Small notches in the core face, parallel to the axis of the core, redistribute stray fluxes so as to give zero net torque.

PERIODIC TESTING

An operation test and inspection of the relay at least every six months is recommended. The test (2) under INSTALLATION TESTS is a sufficient check of operation.

LABORATORY TESTS

POLARITY TESTS

Complete polarity tests are made in the factory and these may be checked by connecting terminals A and C together, connecting terminals B and D through a resistor (20 ohms), and apply rated voltage to terminals C and D. With these connections, the left-hand contact (front view) should close in each of the following eight checks:

Current Coil		Potential Coil	
A	B	C	D
3	4	19	20
3	4	14	13
5	6	17	18
5	6	20	19
7	8	15	16
7	8	18	17
9	10	13	14
9	10	16	15

PHASE ANGLE TESTS

Tests to check the polyphase phase-angle characteristics of the Type CAP15A relay may be made using connections according to the testing diagram, * Fig. 8. This diagram will also give the testing connections for the Type CAP15B by substituiting the relay potential connections of Type CAP15A for those of Type CAP15B relay. Without the phase shifter, one point on the characteristic may be determined; with the phase shifter, the complete characteristic may be determined. The three-phase phase angle characteristic may be derived also from a single phase characteristic which may be taken using connections according to the testing diagram A of Fig. 10. On a single-phase basis, maximum torque is obtained at approximately 20 degrees lead on the 60 cycle relays and 30 degrees lead on the 25 cycle relays.

OPERATING TIME TESTS

Although diagram Fig. 8 may be used to obtain operating times, it is much simpler to use the single-phase diagram B of Fig. 10. With the latter connection the relay torque is approximately 40 percent greater than with the three-phase connections. Thus, when plotting the three-phase operating time from single-phase data, the single-phase currents should be multiplied by 1.4.

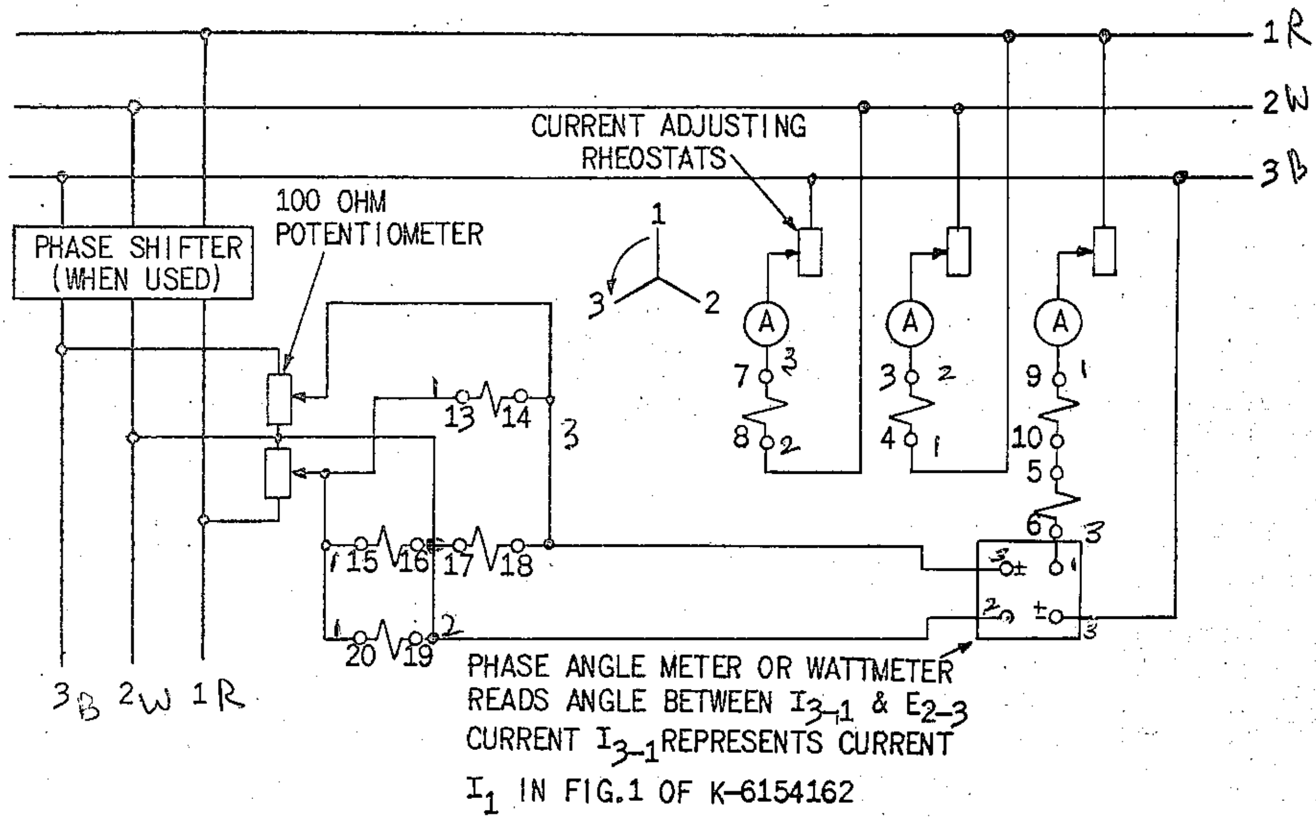
CONTACT CLEANING

If the contacts become dirty or pitted slightly they should be cleaned by burnishing with the burnisher supplied in the relay tool kit. Under no circumstances should emery or crocus cloth be used on fine-silver relay contacts. Finish by wiping the contacts with a clean cloth and avoid touching them with the fingers. Contacts cleaned in this manner will remain in good condition for many months under ordinary conditions of service.

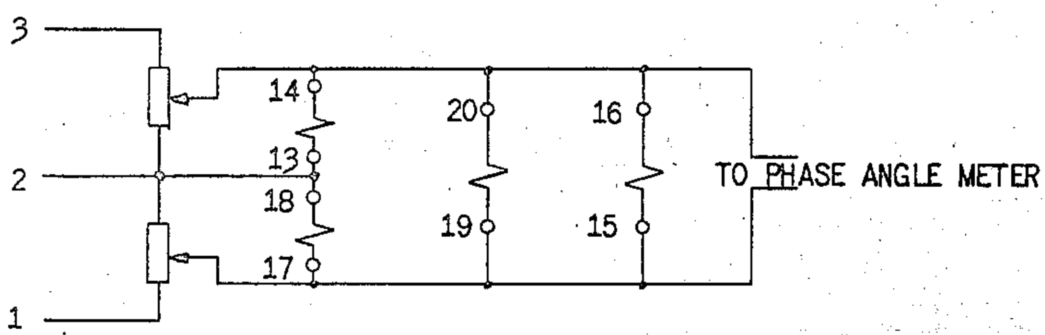
RENEWAL PARTS

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-3445.

* Denotes change since superseded issue.



(A) CAP15A TEST CONNECTIONS



(B) CAP15B POTENTIAL CONNECTIONS
CURRENT CONNECTIONS SAME AS (A) ABOVE

Fig. 8 (K-6154165)

* Fig. 8 Laboratory Testing Diagram for the Type CAP15A and CAP15B Relays

* Denotes change since superseded issue.

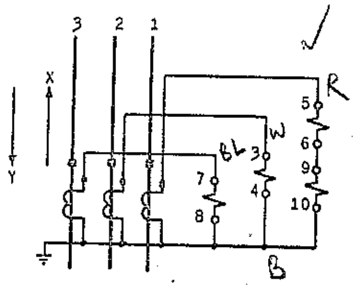


FIG.1

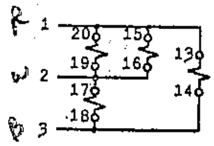


FIG.2

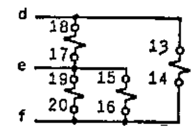


FIG.3

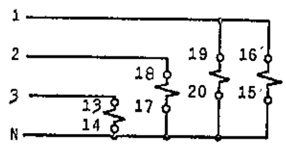
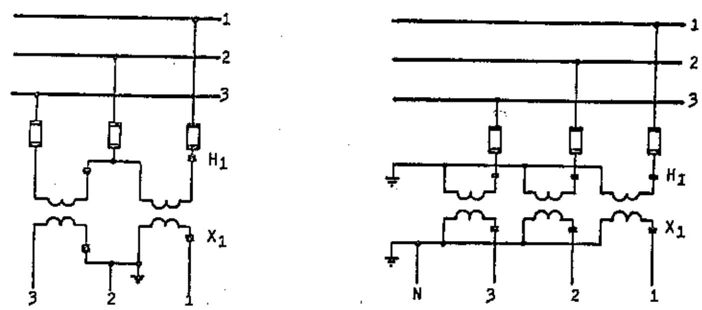


FIG.4



POTENTIAL TRANSFORMERS CONNECTED IN OPEN DELTA

POTENTIAL TRANSFORMERS CONNECTED IN Y-Y

FIG.5

Fig.9 (264B406) Sheet 1

Fig.9 (264B406) Sheet 2

CON-NEC-TION NO.	CONNECTION	CONNECTIONS TO C.T.'S	POTENTIAL TRANSFORMER SEE FIG.5	POTENTIAL CONNECTIONS		MAX. TORQUE OCCURS (BALANCED 3Ø CONDITIONS) WHEN A CURRENT LAGS ITS PHASE-TO-NEUTRAL VOLTAGE BY DEG.		DIRECTION OF POWER FLOW TO CLOSE TRIP CONTACTS (TERMINALS (1-11) L.H. CONTACTS FRONT VIEW
				INTERCONNECTION OF RELAY TERMINALS	CONNECTIONS TO POTENTIAL TRANSFORMERS	50 & 60 CYC.	25 CYC.	
A	60 DEG.	FIG.1	2 IN OPEN DELTA OR 3 IN Y-Y (SEE NOTE 1)	FIG.2		40 DEG.	30 DEG.	ARROW Y FIG.1
B	90 DEG. (QUADRATURE)	FIG.1	2 IN OPEN DELTA OR 3 IN Y-Y (SEE NOTE 1)	FIG.3	PHASE 1-d) PHASE 2-f) FIG.3 PHASE 3-e)	70 DEG.	60 DEG.	ARROW Y FIG.1
C	30 DEG. (ADJACENT)	FIG.1	2 IN OPEN DELTA OR 3 IN Y-Y (SEE NOTE 1)	FIG.3	PHASE 1-e) PHASE 2-d) FIG.3 PHASE 3-f)	10 DEG.	0 DEG.	ARROW X FIG.1
D	90 DEG. (QUADRATURE)	FIG.1	Y-Y (SEE NOTE 2)	FIG.4		70 DEG.	60 DEG.	ARROW X FIG.1
E	NOTE 3 90 DEG. (QUADRATURE)	FIG.1	2 IN OPEN DELTA (SEE NOTE 1)	FIG.2		70 DEG.	60 DEG.	ARROW Y FIG.1

NOTE 1: POTENTIAL COILS CONNECTED TO DELTA VOLTAGES.
NOTE 2: POTENTIAL COILS CONNECTED TO WYE VOLTAGES.
NOTE 3: CURRENT FROM WYE SIDE OF POWER TRANSFORMER. POTENTIAL FROM DELTA SIDE. WYE SIDE LEADING DELTA SIDE BY 30°
FOR CONNECTION OF TYPE CAP15B RELAY SEE K-6154163.

Fig. 9 External Connections for the Type CAP15A Relay

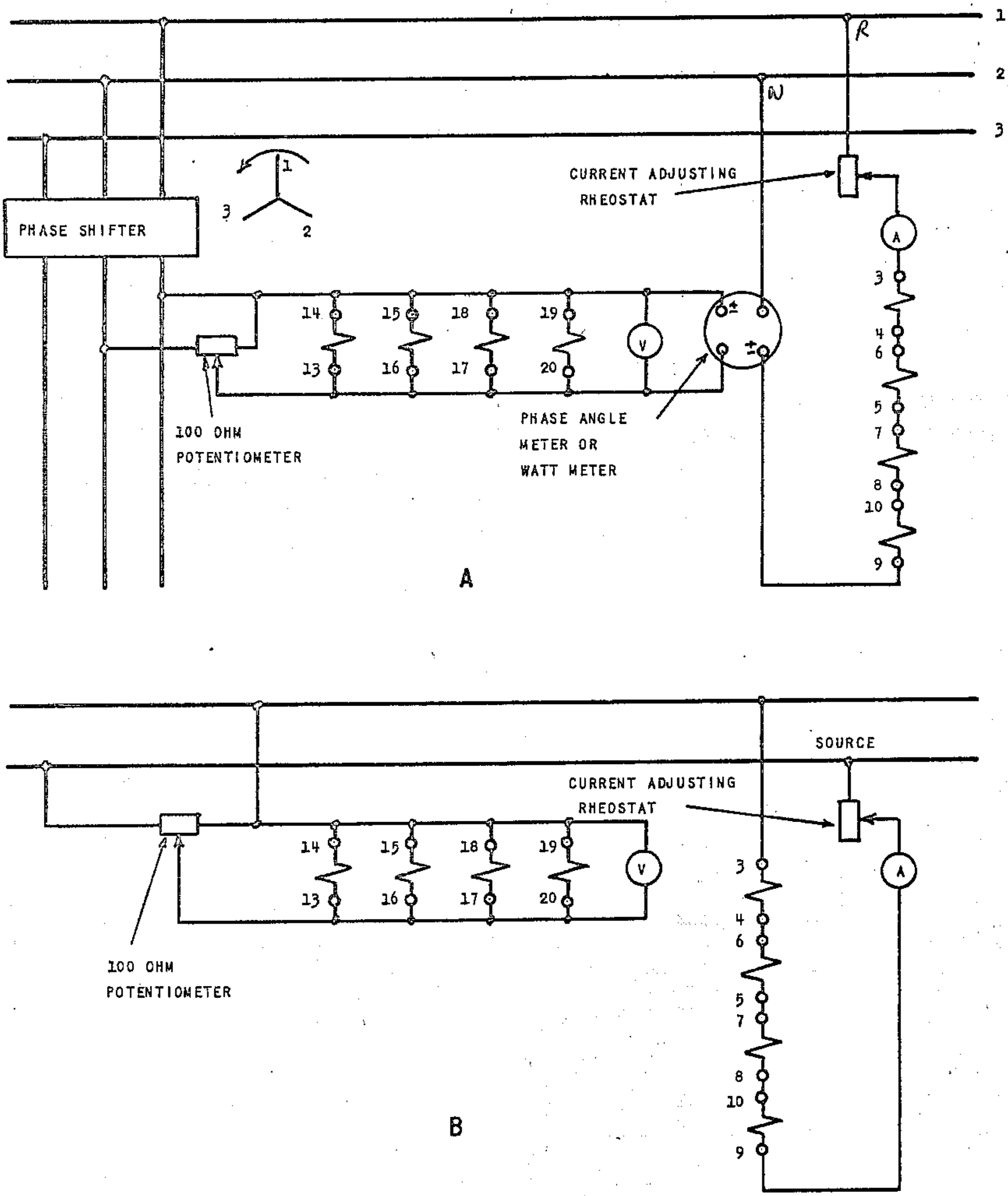


Fig. 10 (K-6154164)

Fig. 10 External Connection Testing Diagrams for the Type CAP15A and Type CAP15B Relays

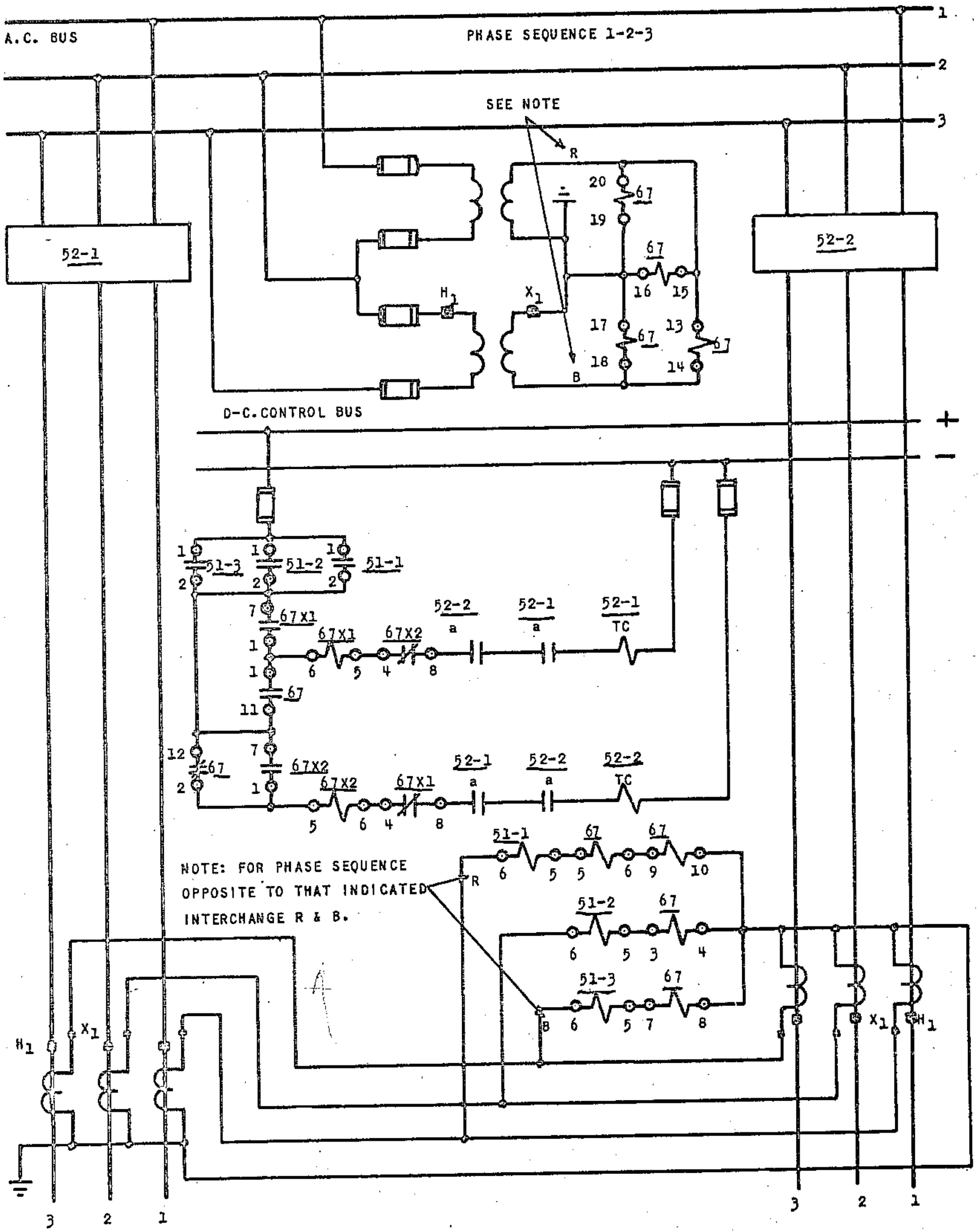


Fig. 12 (K-6154166)

Fig. 12 External Connections of the Type CAP15A Relay for Balance-Power Protection of Two Parallel Incoming Lines. Non Automatic for single-Line Operation

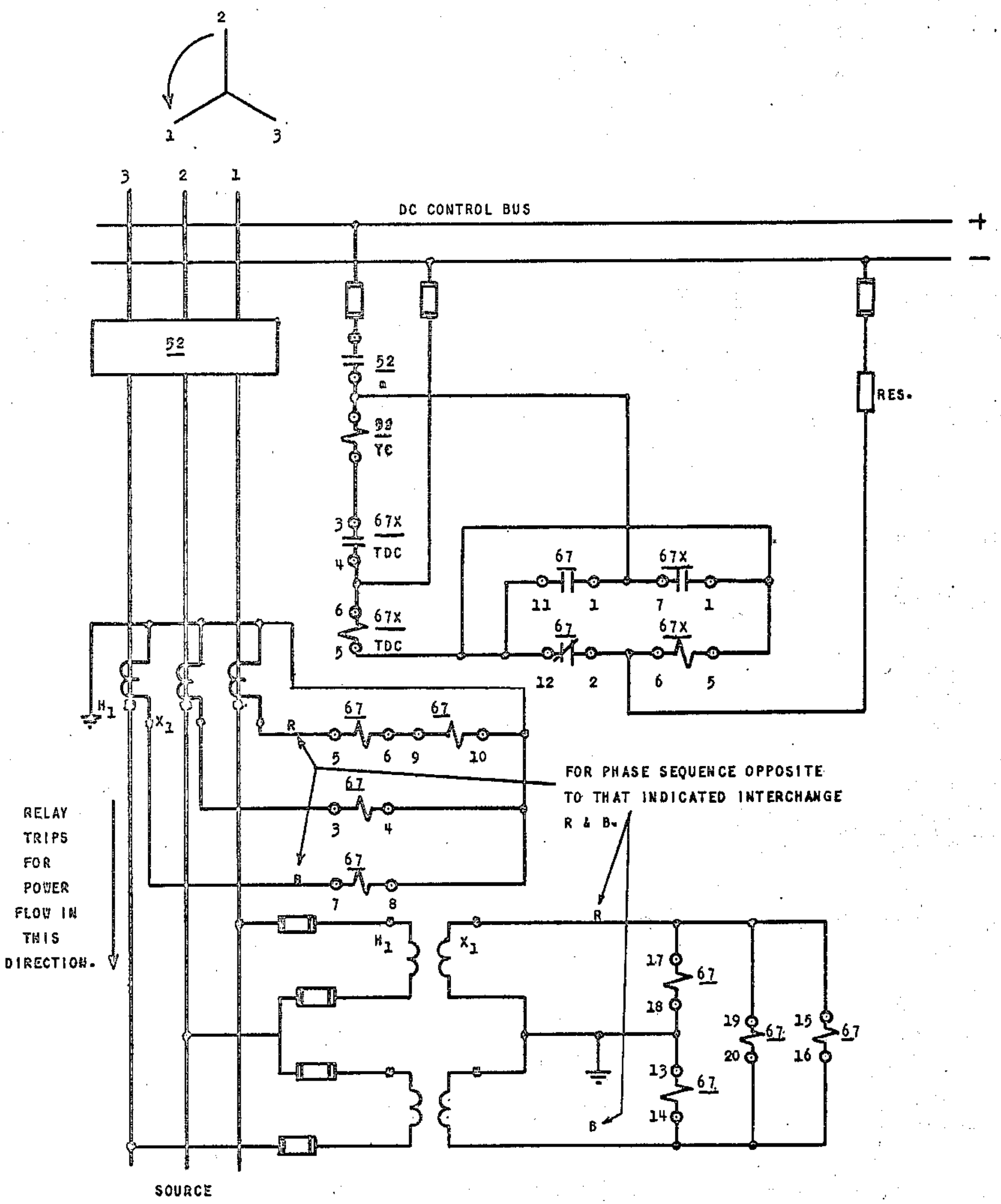


Fig. 13 (K-6154163)

Fig. 13 External Connections for the Type CAP15B Relay When Used to Protect an Alternator

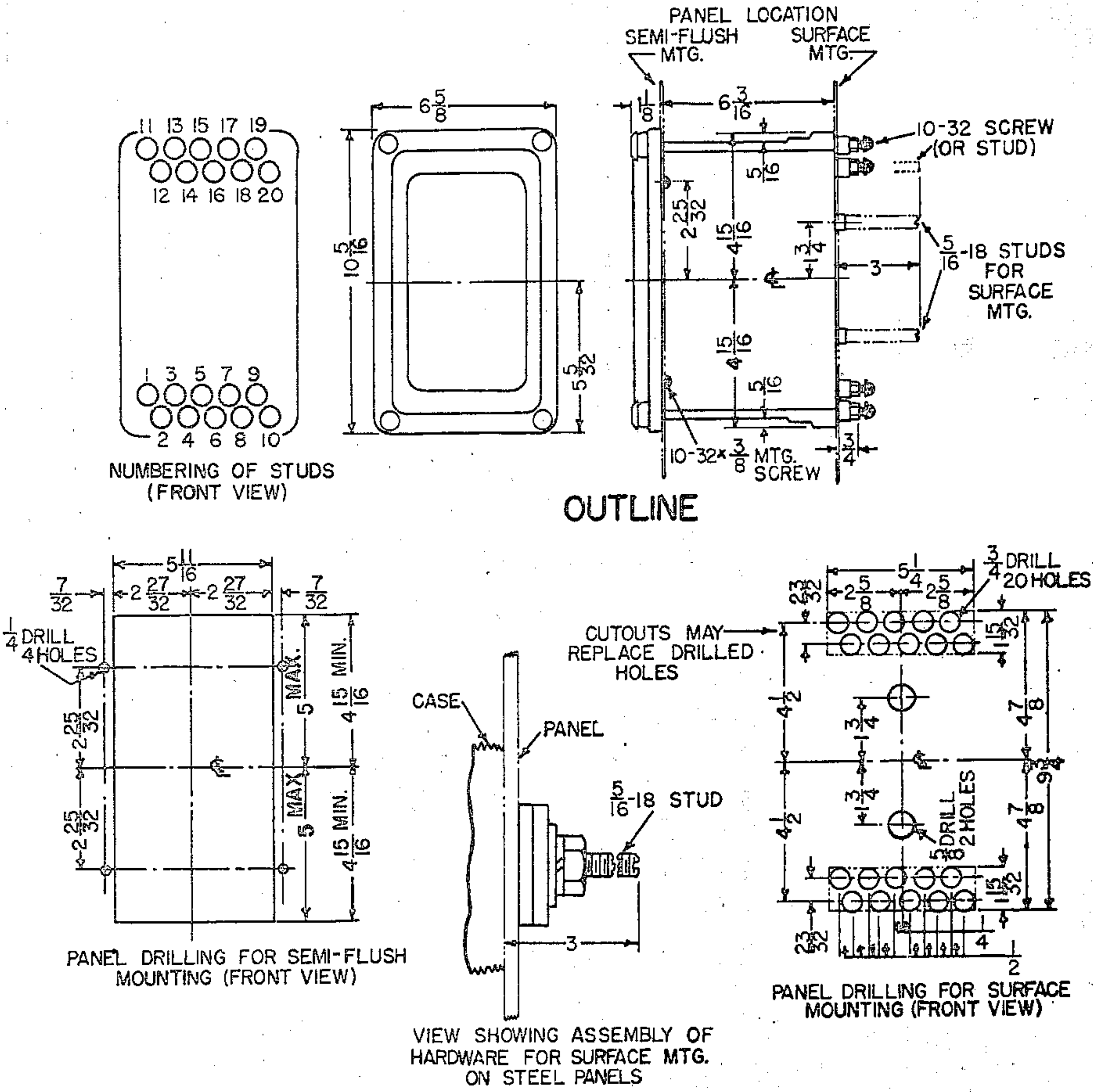


Fig. 14 (K-6209272)

Fig. 14 Outline and Panel Drilling Dimensions for Type CAP15A and Type CAP15B Relays.