INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE KAB HIGH IMPEDANCE BUS DIFFERENTIAL RELAY

CAUTION: Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The type KAB relay is an instantaneous relay of the high impedance type used for bus differential protection.

* APPLICATION CONSIDERATIONS

The type KAB relay can be applied for bus protection in most cases where bushing type ct's are in use, and in metal-clad equipment where ct's with toroidally wound cores have their windings completely distributed are employed. Dwg. 265C196 shows the external connection.

The following points should be considered or should be known on any proposed type KAB relay application:

1. All ct's in the bus differential circuit should have the same ratio, and should be operated on their full tap. If tap connection cannot be avoided, the winding section between the taps being used must be fully distributed and the high voltage which may appear at the full tap terminal due to the auto-transformer action should be checked.
2. The leakage impedance of the ct's which are to be used should be low.
3. The use of the auxiliary ct's is not recommended. If this cannot be avoided the additional impedance from the auxiliary ct's and the high voltage which transformed by the auxiliary ct should be checked.
4. The best location for the junction points is equidistant from all ct's.
5. The lead resistance from the junction points to the relay terminals is not critical.
6. A lockout relay contact is recommended to short circuit the varistor following the relay operation in order to prevent the varistor from overheating.
7. To insure a substantial margin of operation the voltage-unit should not be set higher than V_K, where V_K = the knee voltage value of the poorest ct which be connected to the relay. The knee voltage is defined as the intersection of the extension of the two straight line portions of the saturation curve, ordinate and abscissa must be same scale for each decade.
8. The maximum number of circuits which can be connected to the relay or the minimum internal fault current required to operate the relay can be estimated from the following equation

$$I_{min.} = (XI_e + I_R + I_V)\ N$$

where $I_{min.}$ = minimum internal fault current, RMS.

I_e = ct secondary excitation current at a voltage equal to the setting value of V-unit.

I_R = Current in V-unit at setting voltage V_R (i.e. $I_R = V_R / 2600$)

I_V = Current in varistor circuit at a voltage equal to the setting value of V-unit.

N = ct turn's ratio.

X = Number of circuits connected to the bus.

CONSTRUCTION

The relay consists of a high speed overvoltage cylinder unit (V) a high speed overcurrent unit (IT),

SUPERSEDES I.L. 41-337.4

*Denotes change from superseded issue.

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a voltage limiting suppressor (varistor), an adjustable reactor and capacitors for completing a tuned circuit.

Overvoltage Unit V

The voltage unit is a product induction cylinder type unit operating on the interaction between the polarizing circuit flux and the operating circuit flux.

Mechanically, the voltage unit is composed of four basic components: A die-cast aluminum frame, an electromagnet, a moving element assembly, and a molded bridge.

The frame serves as the mounting structure for the magnetic core. The magnetic core which houses the lower pin bearing is secured to the frame by a locking nut. The bearing can be replaced, if necessary, without having to remove the magnetic core from the frame.

The electromagnet has two series-connected polarizing coils mounted diameterically opposite one another; two series-connected operating coils mounted diametrically opposite one another; two magnetic adjusting plugs; upper and lower adjusting plug clips, and two locating pins. The locating pins are used to accurately position the lower pin bearing, which is threaded into the bridge. The electromagnet is secured to the frame by four mounting screws.

The moving element assembly consists of a spiral spring, contact carrying member, and an aluminum cylinder assembled to a molded hub which holds the shaft. The shaft has removable top and bottom jewel bearing. The shaft rides between the bottom pin bearing and the upper pin bearing with the cylinder rotating in an air gap formed by the electromagnet and the magnetic core.

The bridge is secured to the electromagnet and frame by two mounting screws. In addition to holding the upper pin bearing, the bridge is used for mounting the adjustable stationary contact housing. The stationary contact housing is held in position by a spring type clamp. The spring adjuster is located on the underside of the bridge and is attached to the moving contact arm by a spiral spring. The spring adjuster is also held in place by a spring type clamp.

With the contacts closed, the electrical connection is made through the stationary contact housing clamp, to the moving contact, through the spiral spring out to the spring adjuster clamp.

Overcurrent Unit (IT)

The instantaneous unit is a small a-c operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attached to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts completing the trip circuit.

A core screw accessible from the top of the switch provides the adjustable pickup range.

The coil is tapped and the taps brought out to a tap block. By means of the Hi and Lo tap and the adjustable core, a pickup range of 16 to 1 may be obtained.

Varistor

The varistor is an non-linear voltage dependent resistor. It consists of four discs of electrical grade silicon carbide material mounted between cooling fins and connected in series. They are assembled in an integral mechanical assembly and should not be taken apart.

Reactor

The adjustable reactor is an air-gap type having two iron screws which are used at the factory to tune the circuit for maximum current at rated frequency. This feature allows retuning of the circuit in the event other parts of the circuit are replaced.

Indicating Contactor Switch Unit (ICS)

The indicating contactor switch is a small d-c operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup value of the switch.

* OPERATION

The relay is connected as shown in external connection figure 5. In normal operation the voltage at the relay terminals is approximately zero. In the case of an external fault, the ct in the faulted feeder will produce a secondary voltage necessary to force the total secondary fault current through its windings. Neglecting the effect of load current, the unfaulted ct's will produce no secondary voltage. If both the source ct's and the faulted feeder ct's are not saturated, the voltage at the relay remains approximately zero.

However, during severe external faults the feeder ct may saturate. The source ct's would then, have to produce enough voltage to force their currents, through their own windings and through the winding and leads of the faulted ct. In this case a voltage would appear across the junction point equal to the total secondary currents of the source ct's multiplied by the resistance of the faulted ct secondary winding plus its leads to the junction point. The relay is usually set to operate at some voltage higher than the anticipated voltage expected for this condition. This faint voltage will be lower than the calculated voltage since the fault ct will always produce some voltage and also the source ct will tend to saturate. The dc offset component of this voltage does not affect the relay operation by reason of the series tuned circuit as well as the insensitivity of the voltage unit to dc.

In the case of an internal fault, the feeder ct's have in effect open circuited primaries and therefore secondary impedances equal to the magnetizing impedance which is high. The source ct's will produce high voltages to drive the fault current through the feeder ct secondaries. This high voltage will appear at the relay terminals and will be well above the pickup setting.

During severe internal faults the source ct will saturate to limit the RMS value of secondary voltage. However, the peak voltages of the wave form could be quite high and overstress the insulation. A varistor is connected internally to reduce this voltage. Figure 2 shows the electrical characteristics of this device.

The overvoltage unit is a high speed device and will operate in 2 cycles at twice pickup using a sine wave test voltage. Under fault condition, the crest voltage is rather high for the first few cycles, the operating speed of the V-unit would be faster, Figure 6 shows the operating speed of 1.5 cycles from the typical staged faults. However, an overcurrent unit is provided which may be connected in series with the varistor and will operate on current flow during severe internal faults when the varistor conducts current to limit the secondary voltage. The application of overcurrent unit has no effect on the operating speed of the voltage unit.

CHARACTERISTICS

Overvoltage Unit (V)

The range of pickup of the overvoltage unit is adjustable from 75 to 300 volts. The pickup is obtained by means of adjusting the spring windup.

* Speed of operation is 2 cycles at twice pickup. (sine wave test voltage).

Overcurrent Unit (IT)

The range of the overcurrent unit is 3 to 48 amperes. A tap is used to obtain this by use of two settings (Hi and Lo). The Lo setting permits the core screw to be adjusted over a 3 to 12 ampere range. The Hi setting permits a 12 to 48 ampere range of adjustment. The scale plate is calibrated in multiples of minimum pickup. The pickup should be within ± 10% of the setting.

Indicating Contactor Switch (ICS)

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

Trip Circuit Constants

Contactor Switch –
0.2 ampere tap – 6.5 ohms d-c resistance
2.0 ampere tap – 0.15 ohms d-c resistance

* SETTING CALCULATIONS

1. SETTING VOLTAGE UNIT

The setting of the voltage unit can be expressed as follows:

$$V_R = K \ (R_S + R_L) \frac{I_F}{N}$$

where V_R = pick up setting of the V-unit, (RMS, volts.)

R_S = dc resistance of ct secondary winding, including internal leads to bushing terminals.

R_L = resistance of lead from junction points to the most distance ct. (One-way lead for phase fault, two way lead for phase to ground fault).

I_F = Maximum external fault current (RMS amp.) contributed by the bus.

N = ct turn's ratio.

K = Margin factor

The margin factor is a modification number. It varies with the reciprocal of the ct saturation factor, i.e. $\left[\frac{(R_S + R_L) I_F}{N V_K}\right]$

Figure 3 shows the margin factor curve, which is based on the High Power Lab tests on the KAB relay and considers a safety factor of 2. The use of this curve is explained in the sample calculation.

2. SETTING CURRENT UNIT

This unit is not intended for speed improvement. The High Power Lab. test data shows that its operation is always slower than the V-unit. Therefore, the setting calculation for this unit is rather simple. First, calculate the value of $(R_S + R_L)(\frac{I_F}{N})$, then from curves in Fig. 4 find the value for the setting. These curves have considered a safety factor of 2.

3. Example:

Assume a 6 circuit bus, for which the maximum external 3-phase fault current is 60,000 amperes rms, symmetrical, maximum external phase to ground fault current is 45,000 amperes, and the minimum internal fault current is 10,000 amperes. Assume the ct's ratios are 2000:5, class C400, V_K = 375 volts, secondary winding resistance R_S = 0.93 Ω, and one way lead resistance to junction point R_L = 1.07Ω.

A. SETTING OF VOLTAGE UNIT

a) for 3-phase fault condition

$$[(R_S + R_L)\frac{I_F}{N}] / V_K = [(0.93 + 1.07) \times \frac{60000}{400}] / 375$$

$$= 0.9$$

from Fig. 3 K $\geq$ 0.76

$$\therefore V_R = K (R_S + R_L) \frac{I_F}{N}$$

$$V_R \geq 0.76 (0.93 + 1.07) \times \frac{60000}{450} = 234$$

volts,

b) for phase to ground fault condition

$$[(R_S + R_L)\frac{I_F}{N}] / V_K = [(0.93 + 2 \times 1.07) \times \frac{45000}{400}] / 375$$

$$= 0.89$$

from Fig. 3 K $\geq$ 0.77

$$\therefore V_R \geq K (R_S + R_L) \frac{I_F}{N}$$

$$V_R \geq 0.77 (0.93 + 2 \times 1.07) \times \frac{45000}{400} = 265$$

volts.

choose the maximum of (a) and (b), to prevent the relay from false pickup on external faults, its minimum setting should be at least this maximum 265 volts. This adjustment is made by varying the spring tension. See "Routine Maintenance".

c) The minimum fault current required to operate the relay at the setting of 265 volts. Assume that from the ct saturation curve I_e = 0.045 amp. at 265 volts. And from figure 2b I_V = 0.16 amp. at 265 volts. (RMS).

$$I_{min.} = (X I_e + I_R + I_V) N$$

$$= (6 \times 0.045 + \frac{265}{2600} + 0.16)\ 400$$

$$= 0.532 \times 400 = 213 \text{ amp.}$$

B. SETTING OF CURRENT UNIT

Since $(R_S + R_L)\frac{I_F}{N} = (0.93 + 1.07) \times \frac{60000}{400} = 300$ for 3-phase fault.

$(R_S + R_L)\frac{I_F}{N} = (0.93 + 2 \times 1.07) \times \frac{45000}{400} = 330$ for phase to ground fault.

From Fig. 4, using the higher number of 330 the current unit setting is determined to be 42 amperes. (for RS + R_L = 3 Ω). Set the overcurrent unit at 45 amp.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

External Connections are made per external connection drawing 265C196.

Note that the Varistor is brought out to a separate terminal to provide flexibility in using the overcurrent unit. It must be connected in service. In addition, the contacts of an auxiliary 86 device should be wired across the relay terminals to protect the Varistor against prolonged overload.

RATINGS

Device	Continuous
Overvoltage Unit (V)	250 volts ac 300 volts ac (15 seconds)
Varistor	200 volts ac
Overcurrent Unit (IT)	
Lo Range	2.5 Amps 70 Amps (1 second)
Hi Range	10 Amps 280 Amps (1 second)
Indicating Contactor Switch (ICS)	
0.2 Amp tap	0.4 Amps 11.5 Amps (1 second)
2.0 Amp tap	3.2 Amps 88 Amps (1 second)

Trip Circuit

The overvoltage unit contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The overcurrent unit contacts will safely close 30 amperes at 250 volts d-c, and will carry this current long enough to trip a breaker.

BURDEN

The relay burden is approximately 2600 ohms in the tuned circuit. However, this burden is not seen by any of the CTS during normal operation or during an external fault. During an internal fault the source CT sees a burden composed of the 2600 ohms in parallel with the Varistor resistance plus the parallel impedance of the unloaded feeder CTS. The resistance of the Varistor can be calculated from the volt-ampere curve Figure 2.

ADJUSTMENTS & MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under "SETTINGS" should be required.

ACCEPTANCE CHECK

Overvoltage Unit (V)

The overvoltage unit has been set at the factory for 75 volts pickup. If a different pickup is desired, the relay should be energized from a variable voltage source. Terminal 8 and 9 should be energized. The varistor should not be connected when making adjustments for greater than 200 volts ac. The voltage unit can withstand 250 volts ac. continuously and up to 300 volts ac. for 15 seconds.

The pickup is increased by winding the spring CCW (top view) with a screwdriver or tool style number 774B180G01 and inserting it in one of the notches located on the perephery of the spring adjuster.

Contact Gap – The gap between the stationary and moving contacts with the relay in the de-energized position should be approximately .030".

Overcurrent Unit (IT)

The pickup of the overcurrent unit should be within 10% of its setting.

Indicator Contactor Switch (ICS)

Close the main relay contacts and pass sufficient dc current through the trip circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used.

The contact gap should be approximately .047'' between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

ROUTINE MAINTENANCE

All relays should be inspected periodically and the operation should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments have been disturbed. This procedure should not be used unless it is apparent that the relay is not in proper working order. (See ''Acceptance Check'').

Care should be used to avoid contact with the capacitors since high voltages may be present with the circuit energized.

Tuned Circuit

If the capacitors, reactor, or overvoltage unit have been replaced, it may be necessary to retune the circuit. This can be accomplished using a regulated ac voltage with good sine wave. Initially set the adjustable reactor screws about ½ of their total travel. The screws may be adjusted without loosening the spring nuts.

* Apply 75 volts ac to terminals 6 and 8 and adjust either screw for maximum current as measured by a milliammeter. This current should be less than 30 ma. The two screws should be positioned approximately equal for the final adjustment.

After the above adjustment has been made it may be necessary to re-adjust the overvoltage unit spring for the desired operate voltage.

Overvoltage Unit (V)

1. The upper bearing screw should be screwed down until there is approximately .025'' clearance between it and the top of the shaft bearing. The upper pin bearing should then be securely locked in position with the lock nut.
2. The contact gap adjustment for the overcurrent unit is made with the moving contact in the reset position, i.e., against the right side of the bridge. Move in the left-hand stationary contact until it just touches the moving contact. Then back off the stationary contact one turn for a gap of approximately .030''. The clamp holding the stationary contact housing need not be loosened for the adjustment since the clamp utilizes a spring-type action in holding the stationary contact in position.
3. The sensitivity adjustment is made by varying the tension of the spiral spring attached to the moving element assembly. The spring is adjusted by placing a screwdriver or tool style number 774B180G01 into one of the notches located on the periphery of the spring adjuster and rotating it. The spring adjuster is located on the underside of the bridge and is held in place by a spring type clamp that does not have to be loosened prior to making the necessary adjustments.
4. Apply the desired pickup voltage and adjust the spring until the contacts just make. Voltages above 250 volts ac RMS should not be applied for more than 15 seconds at a time.

Overcurrent Unit (IT)

The stationary contacts should be set for 3/32'' contact gap. The bridging contact should make simultaneously with both stationary contacts.

When the unit is energized above pickup current the armature should seal in against the core and the moving contacts should provide about 1/32'' contact wipe.

Indicating Contactor Switch (ICS)

The stationary contacts should be set for 3/64'' contact gap. The bridging contact should make simultaneously with both stationary contacts.

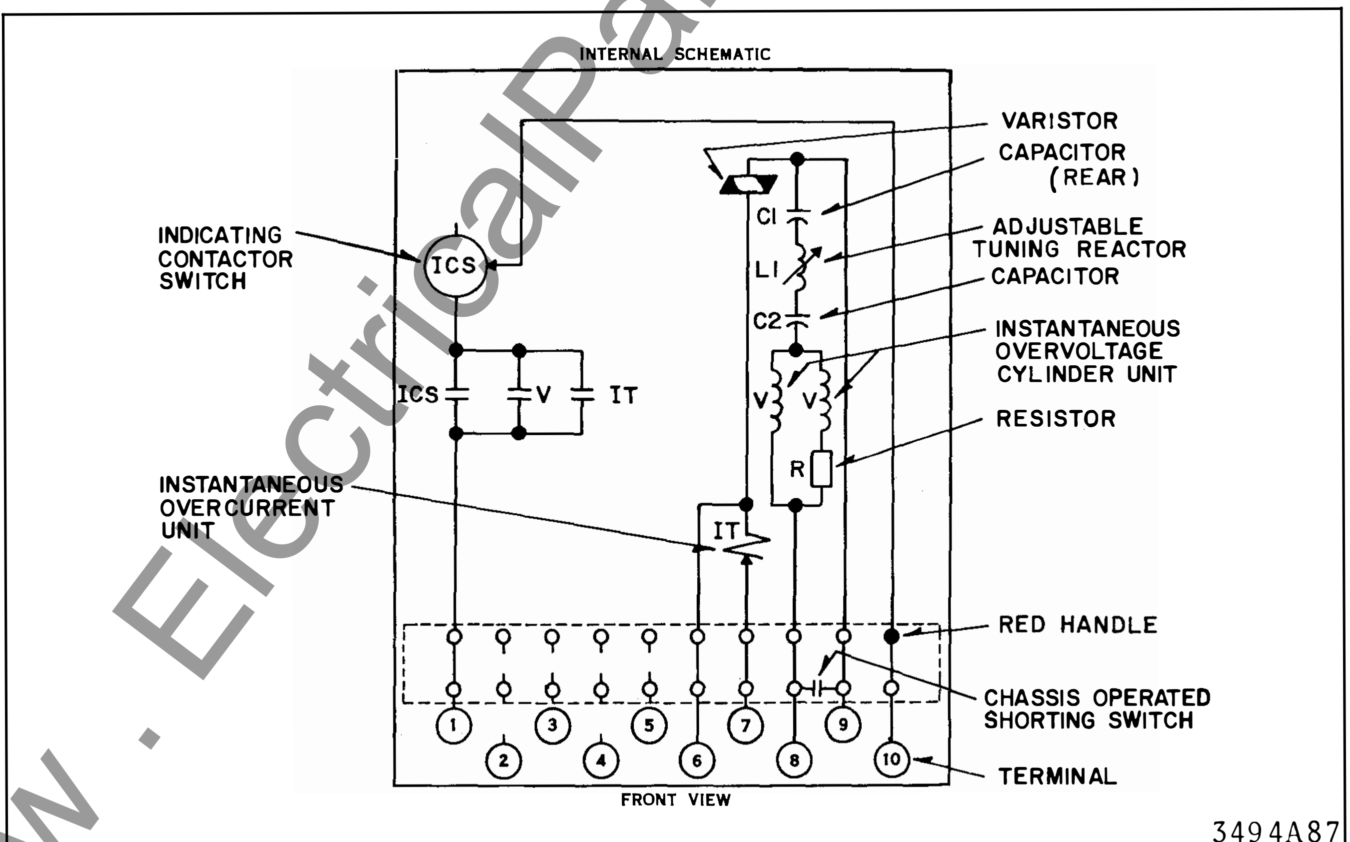
Set the ICS on the 0.2 ampere tap and pass 0.2 ampere dc through the coil. The moving contacts should provide about 1/32'' contact wipe. The target should drop freely.

Varistor

The varistor may be checked for proper electrical characteristics by passing 25 milliamps dc through it. The voltage should measure 175 volts ac ± 10%. A high resistance voltmeter should be used.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.



* *Fig. 1. Internal Schematic of KAB Relay.*

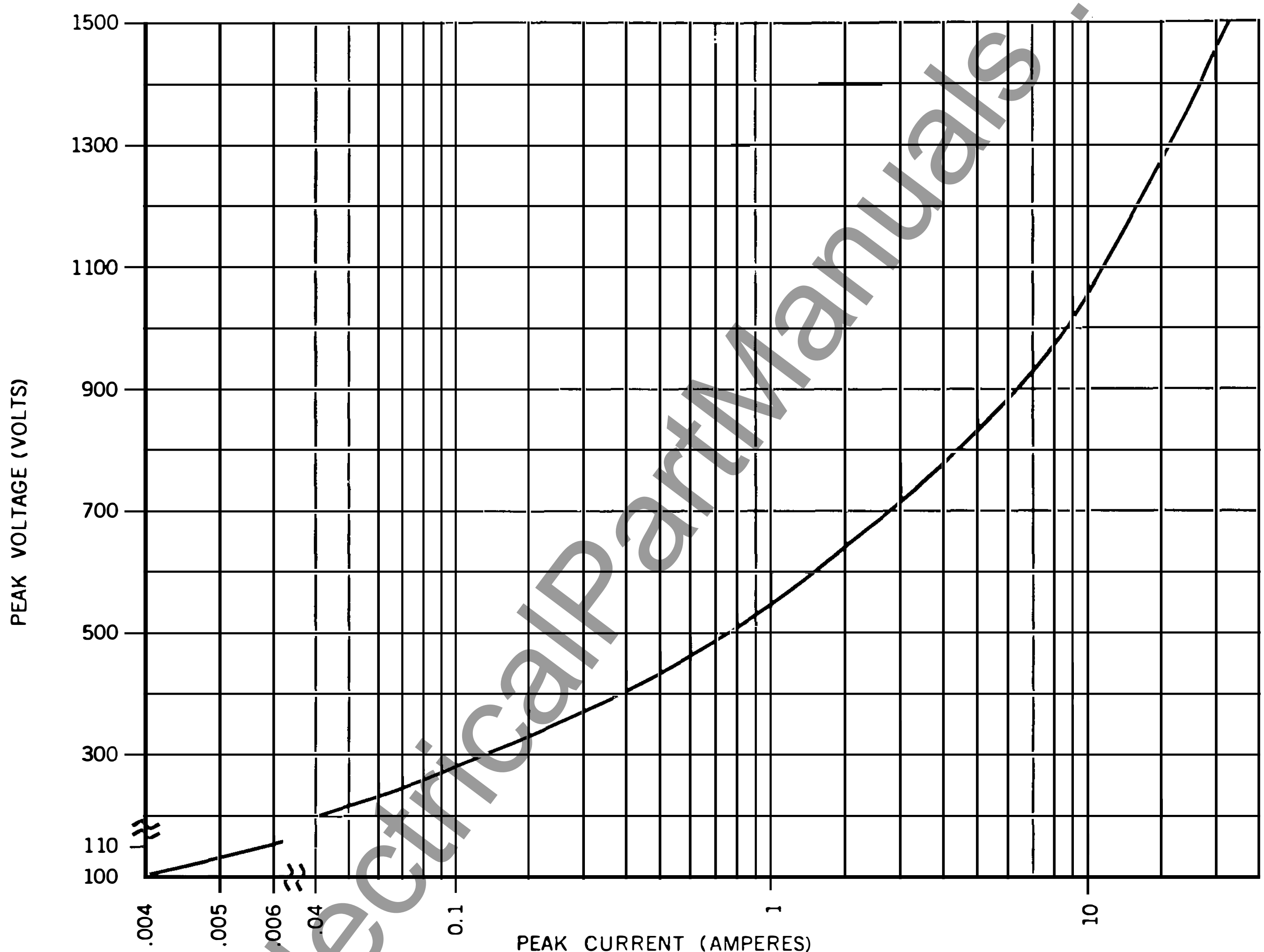


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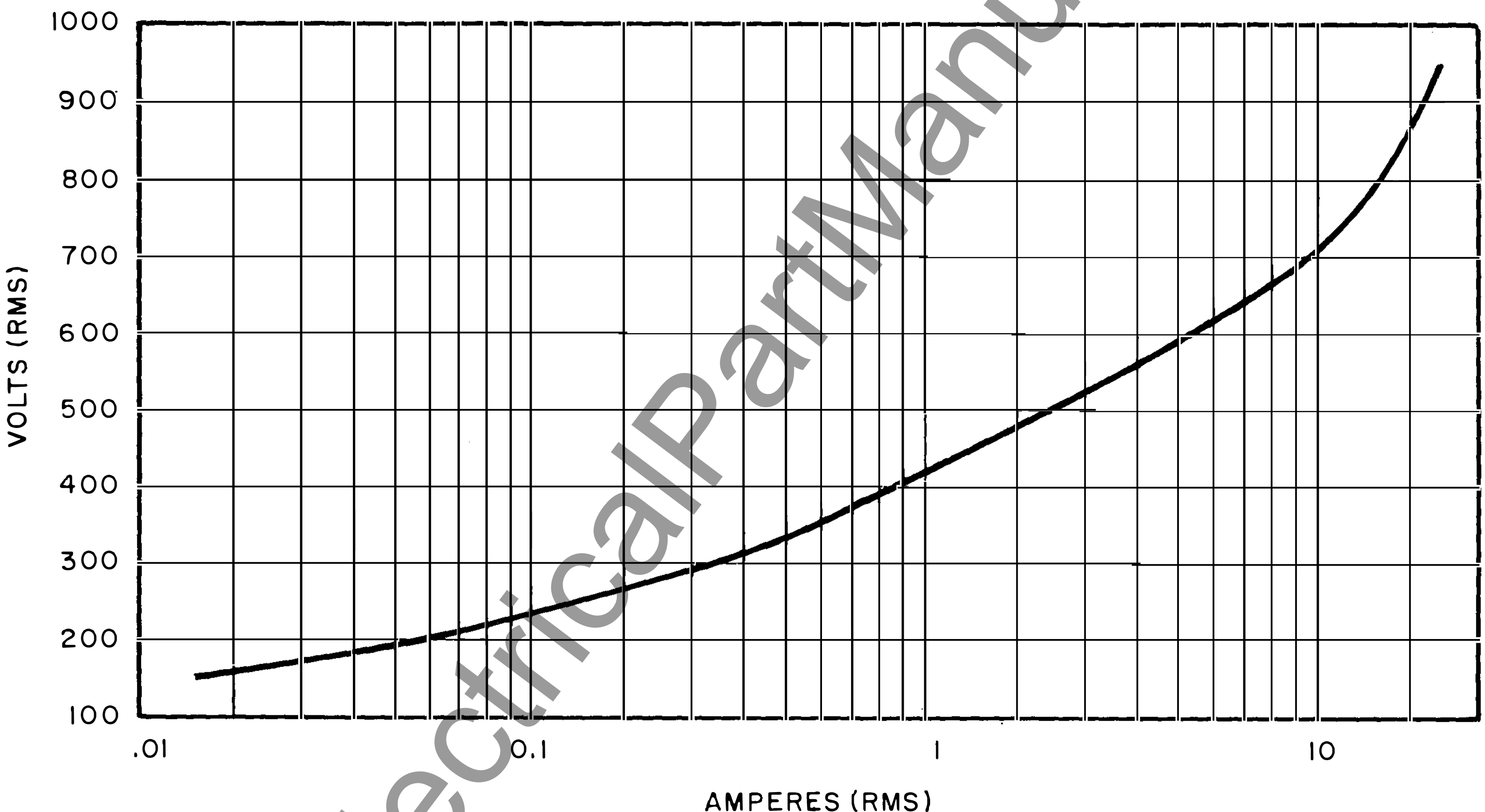
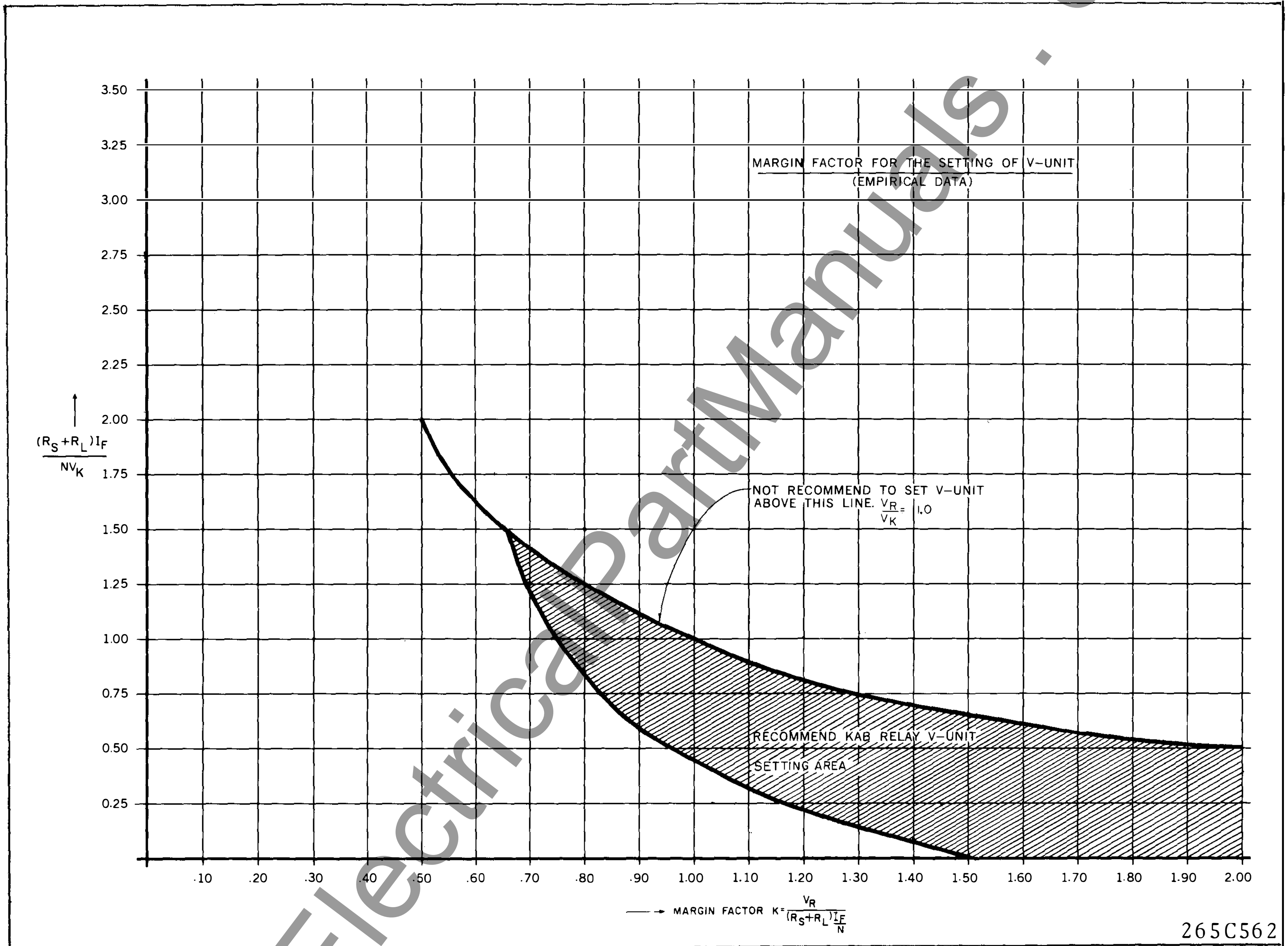
Fig. 2a. Typical Volt-Ampere Characteristic of Varistor in Type KAB Relay (Peak Value).

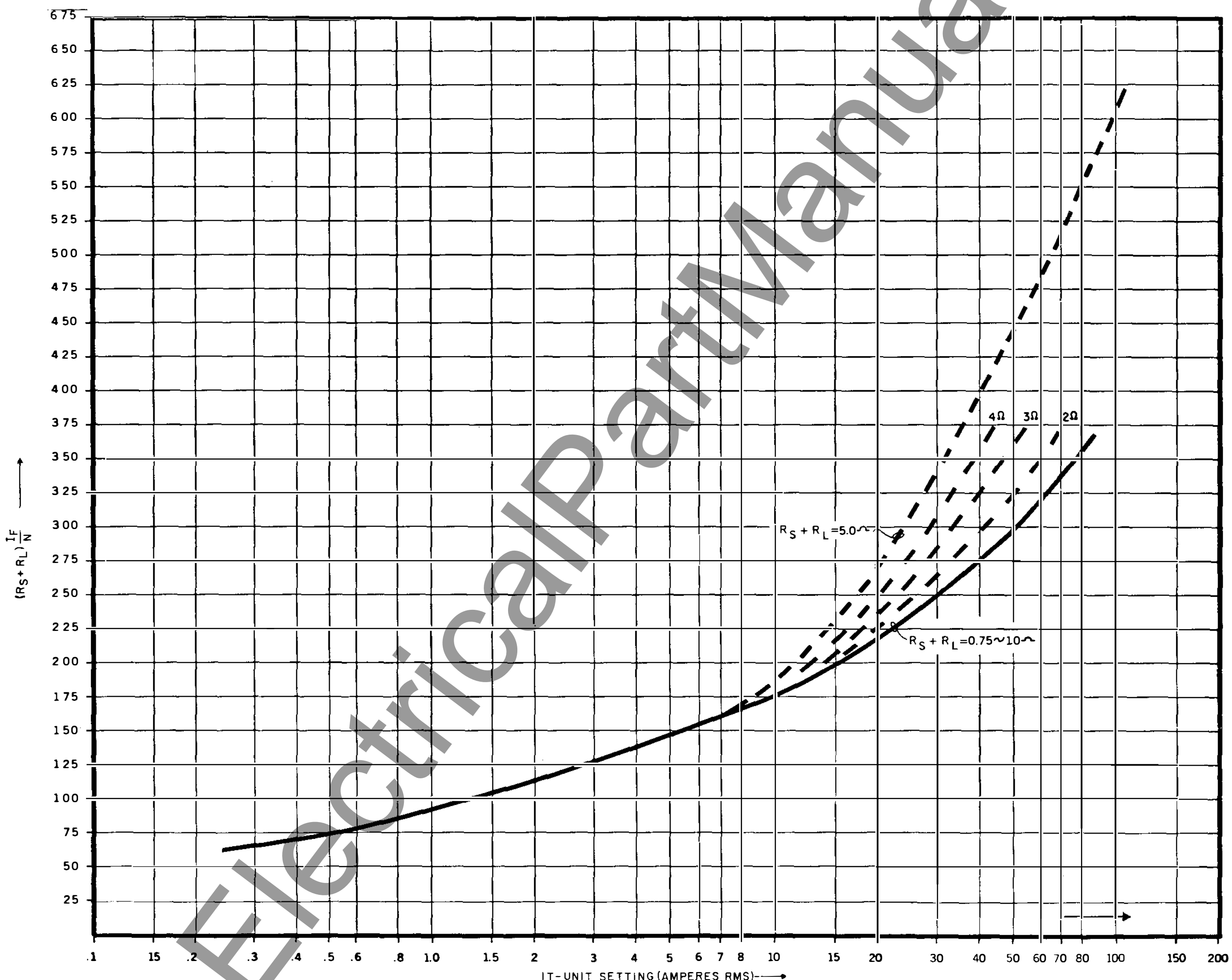


Curve 619414

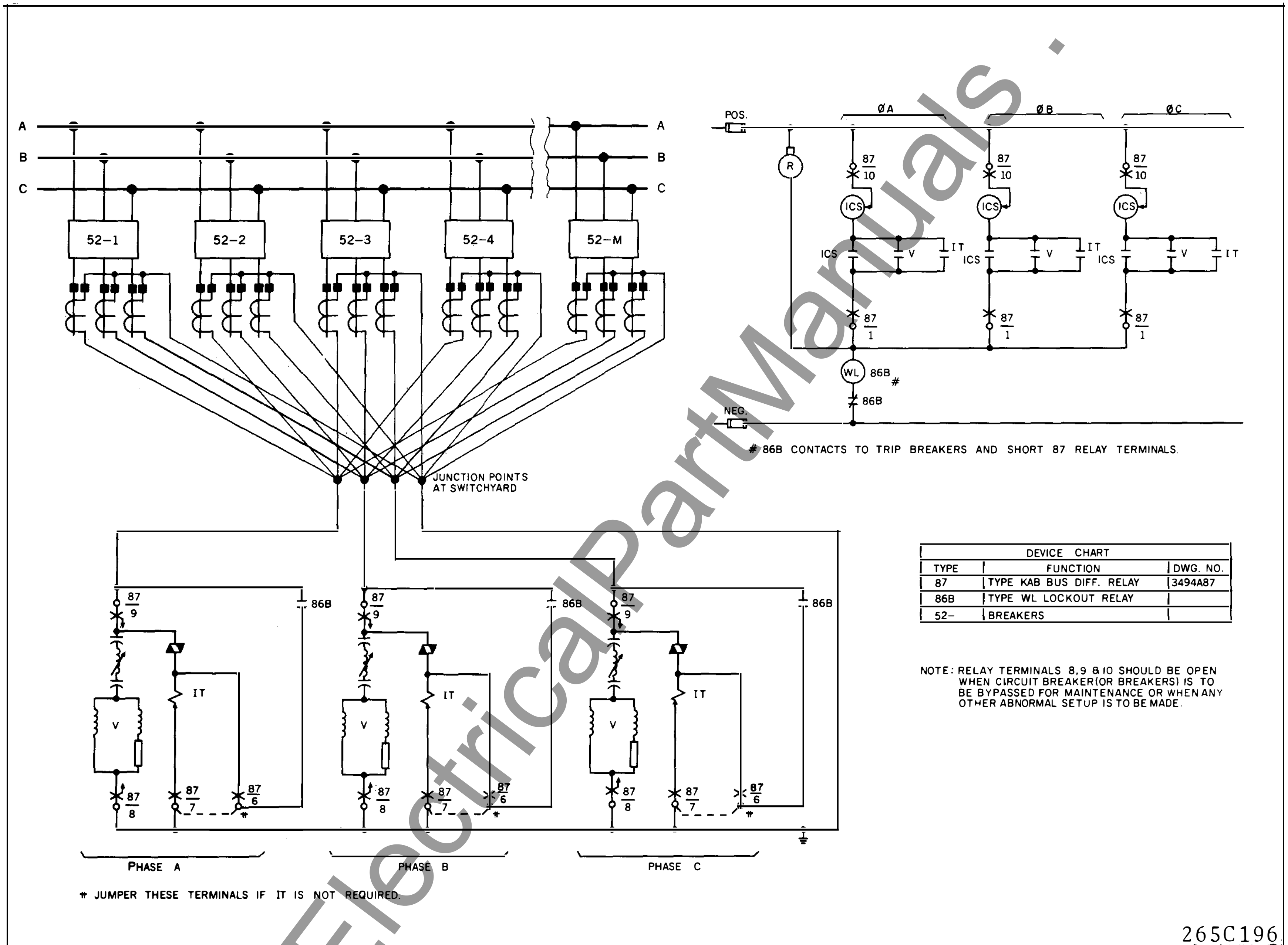
Fig. 2b. Typical Volt-Ampere Characteristic of Varistor in Type KAB Relay (RMS).



*** Fig. 3. Margin Factor for V-Unit Setting.**



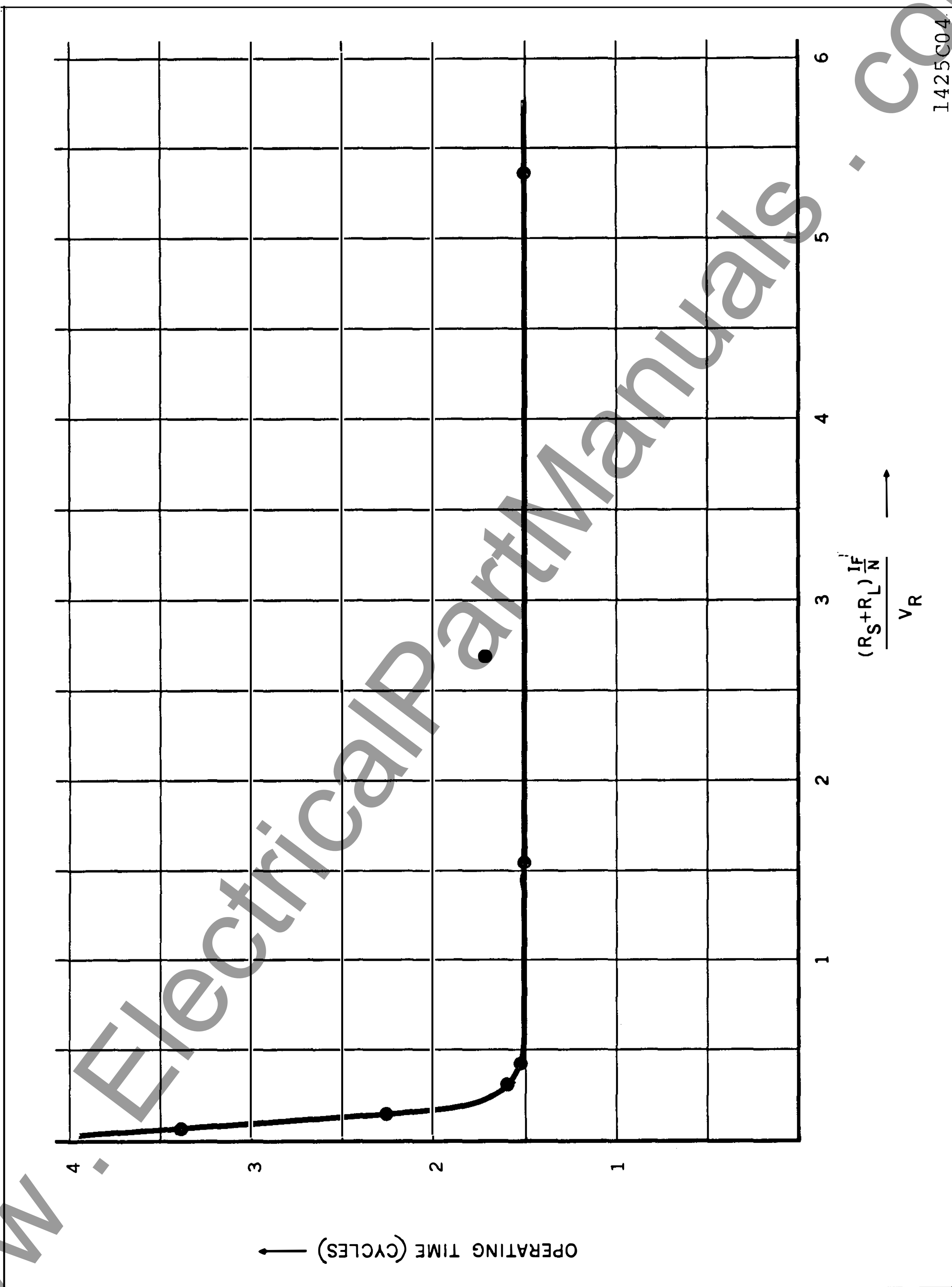
* *Fig. 4. IT Unit Setting.*



DEVICE CHART		
TYPE	FUNCTION	DWG. NO.
87	TYPE KAB BUS DIFF. RELAY	3494A87
86B	TYPE WL LOCKOUT RELAY	
52-	BREAKERS	

NOTE: RELAY TERMINALS 8,9 & 10 SHOULD BE OPEN WHEN CIRCUIT BREAKER(OR BREAKERS) IS TO BE BYPASSED FOR MAINTENANCE OR WHEN ANY OTHER ABNORMAL SETUP IS TO BE MADE.

* ***Fig. 5. External Connections***



* Fig. 6. KAB Relay Typical Operating Time (from Stage Fault Tests).

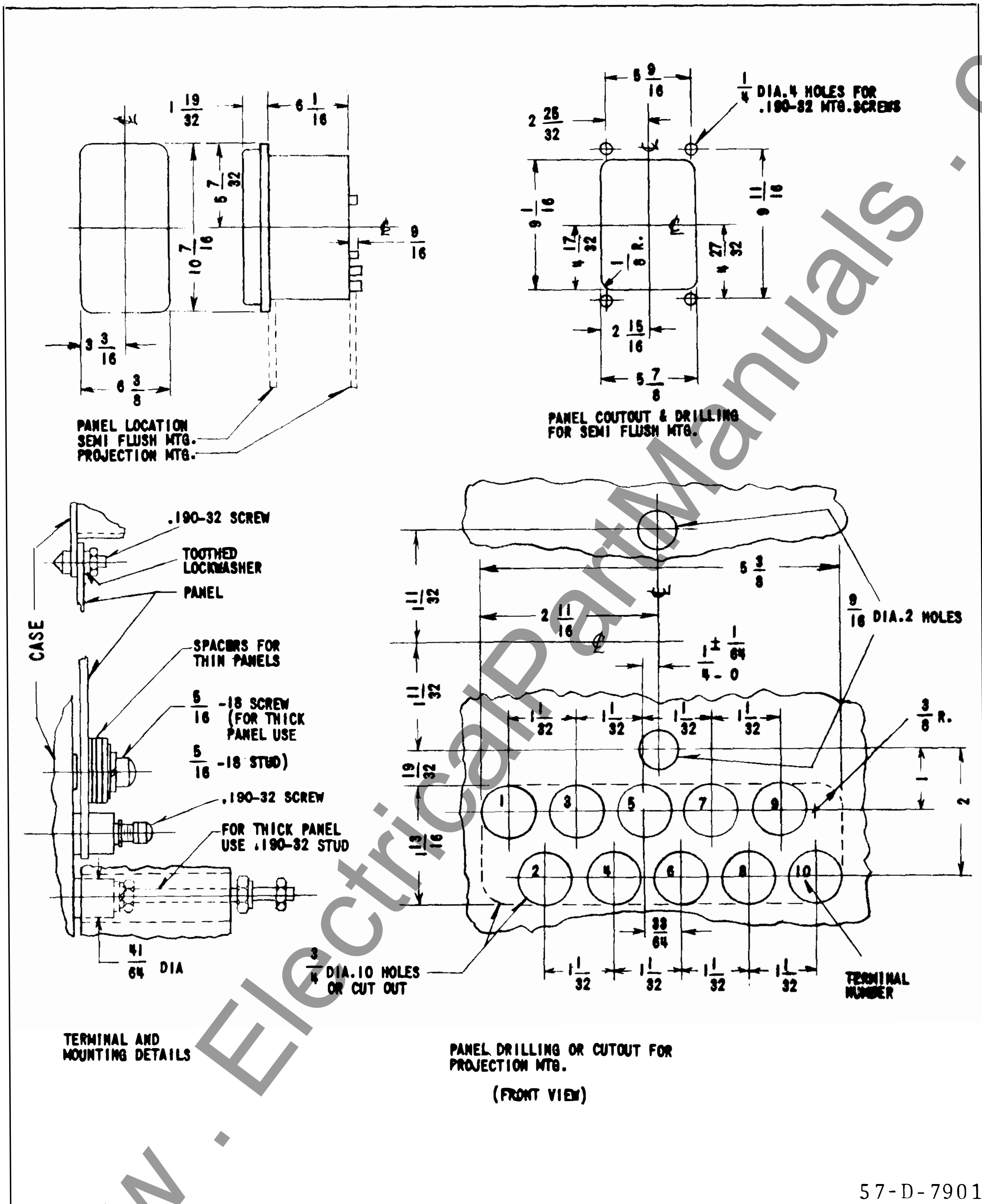


Fig. 7. Outline and Drilling Plan for Type KAB Relay in Type FT-21 Case.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES CA—16 and CA—26 PERCENTAGE DIFFERENTIAL RELAYS FOR BUS AND TRANSFORMER PROTECTION

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

* APPLICATION

The current transformers should not saturate when carrying the maximum external fault current. This requirement is met if the burden impedance does not exceed $\frac{N_p V_{cL} - (I_{ext.} - 100) R_S \cos 60°}{1.33 (I_{ext.})}$ for CA-16 applications and $\frac{V_p V_{cL} - (I_{ext.} - 100) R_S \cos 60°}{I_{ext.}}$ for CA-26 applications,

where N_p = proportion of total ct turns in use.

V_{cL} = current transformer accuracy class C voltage.

$I_{ext.}$ = maximum external fault current in secondary RMS amperes. (let $I_{ext.}$ = 100 if max. external fault current is less than 100 A)

R_S = current transformer secondary winding resistance, ohms.

For example, if the 400:5 tap of 800:5 C400 current transformers are used, N_p = 400/800 = 0.50, if $I_{ext.}$ = 120A, R_S = 1.0 ohm the burden should not exceed:

$$\frac{N_p V_{el} - (I_{ext.} - 100) R_S \cos 60°}{1.33 (I_{ext.})} = \frac{0.50 \times 400 - (120-100) \times 1.0 \times 0.866}{1.33 \times 120} = 1.14 \text{ ohms}$$

CONTENTS

This instruction leaflet applies to the following types of relays:

CA-16 Bus Differential Relay
CA-26 Transformer Differential Relay

The CA-16 relay should not be utilized for transformer differential applications since it is too sensitive for overriding the inrush. Likewise the CA-26 relay should not be used for bus protection with the "four-circuit bus" connections of Fig. 8. The CA-26 relay is suitable for combination bus-transformer applications. See "Connections".

CONSTRUCTION

The type CA-16 relay consists of an indicating contactor switch, autotransformer, three restraint elements, and an operating element. For applications where the CA-16 relay is subjected to shock such as on swinging panels, a sensitive fault detector circuit is provided.

The type CA-26 (in addition to the components of the CA-16 relay) also contains an indicating instantaneous trip unit. The principal component parts of the relay and their location are shown in Figures 1 to 5.

Restraint Elements

Each restraint element consists of an "E" laminated electromagnet with two primary coils and a secondary coil on its center leg. Two identical coils on the outer legs of the laminated structure are connected to the secondary winding in a manner so that the combination of all fluxes produced by the electromagnet results in out-of-phase fluxes in the air gap. The out-of-phase fluxes cause a contact opening torque.

Operating Circuit

The operating circuit consists of an auto-transformer and an operating element. The primary of the auto-transformer, which is the whole winding, is connected to receive the differential or unbalanced current from the various transformers connected to the bus. The secondary winding of the auto-transformer, which is a tapped section of the winding, is connected to the operating element of the relay.

The operating element consists of an "E" type

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*Denotes change from superseded issue.

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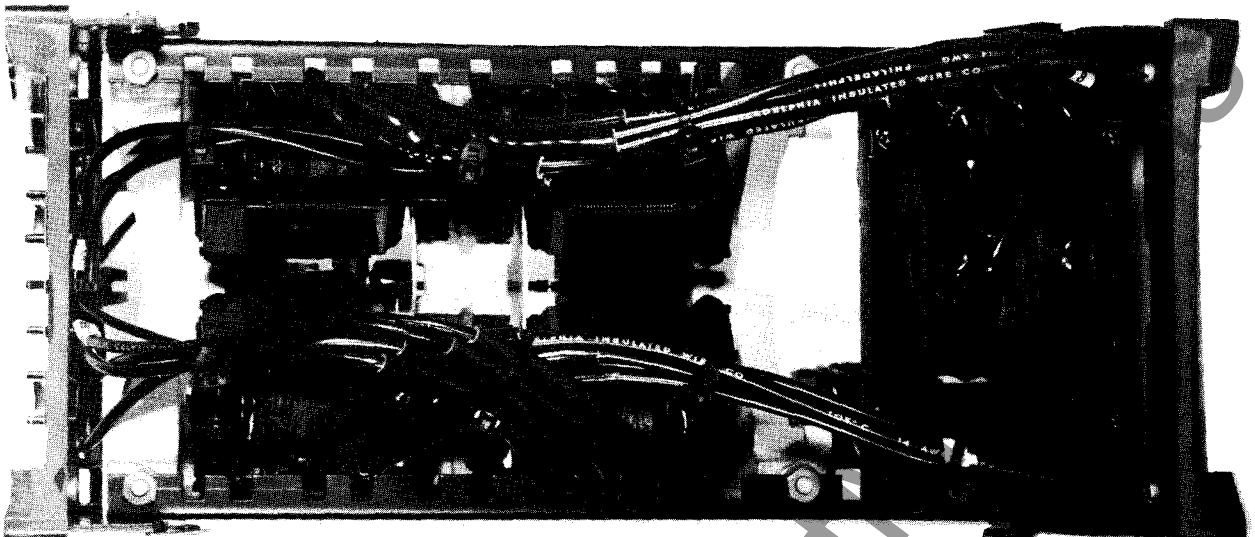


Fig. 2. Types CA-16 Relay (rear view)

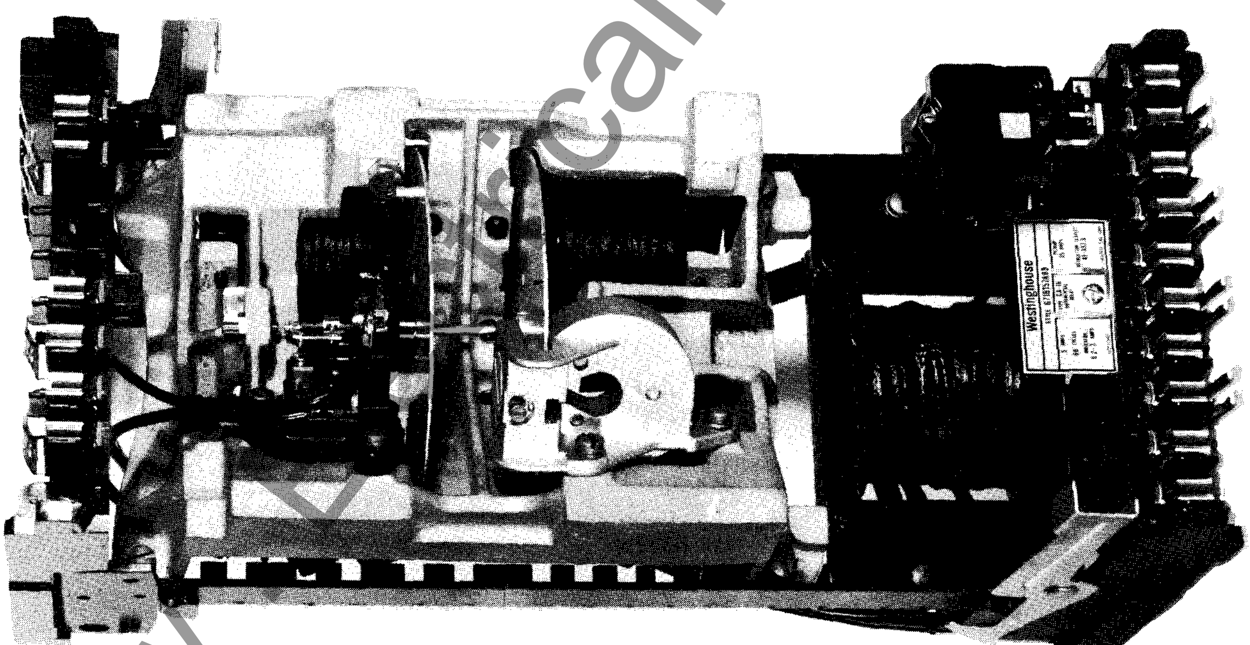


Fig. 1. Types CA-16 Relay (front view)

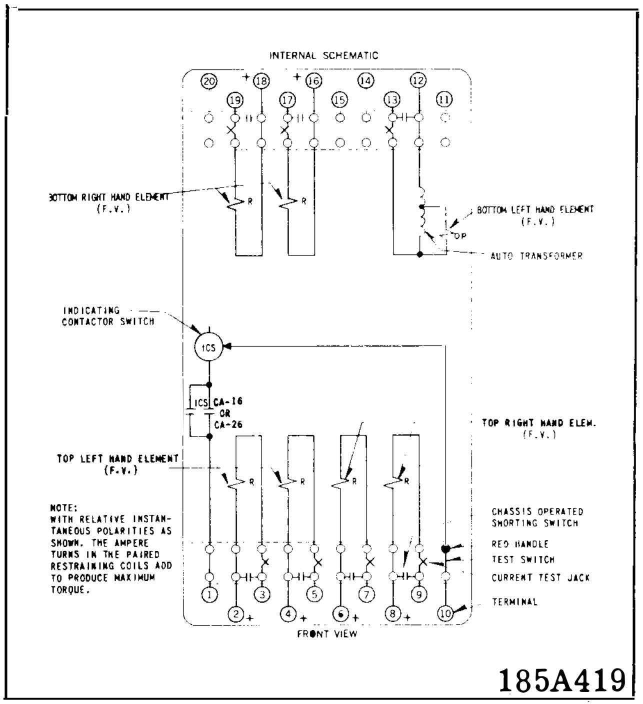


Fig. 3 Internal Schematic of the Type CA-16 Bus Relay or CA-26 Transformer Relay.

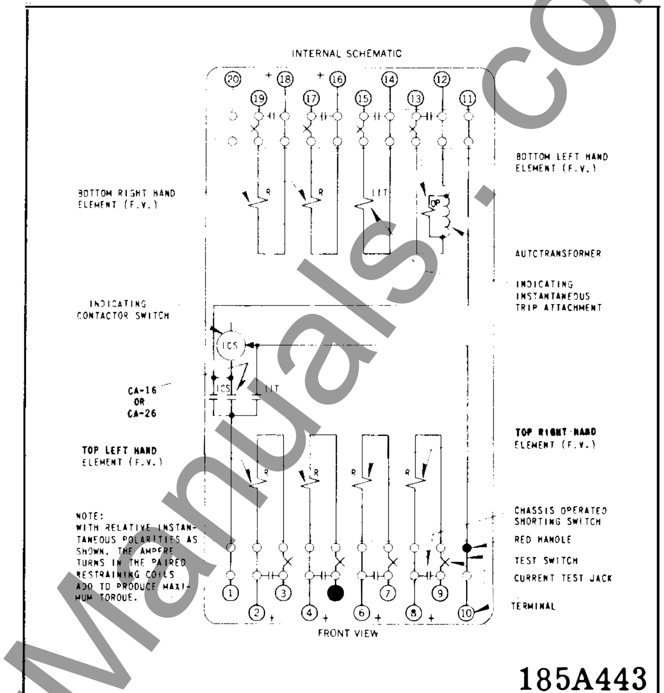


Fig. 4 Internal Schematic of the Type CA-16 Bus Relay or CA-26 Transformer Relay.

laminated electromagnet with an auto-transformer winding on its center leg. Two identical coils on the outer legs of the laminated structure are connected to the secondary (tapped section) of the auto-transformer winding in a manner so that the combination of all fluxes produced by the electromagnet results in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes cause a contact closing torque.

Sensitive Fault Detector Circuit (where used)

The sensitive fault detector circuit consists of an auto-transformer and a contactor switch. The contactor switch is connected across the secondary (tapped section) of the auto-transformer winding.

The contactor switch is a small solenoid type element. A cylindrical plunger rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core, which in turn screws into the unit frame. A silver disc is fastened to the moving plunger through a helical spring. When the coil is energized, the plunger moves upward carrying the silver disc which bridges three conical-shaped stationary contacts. In this position, the helical spring is compressed and the plunger is free to move while the contact remains stationary. Thus, a-c vibrations of, the plunger are prevented from causing contact bouncing. A Micarta disc is fastened to the bottom of the guide rod by two small nuts. Its position determines the pick up current of the element.

The auto-transformer is designed to saturate at high values of current to limit the amount of current to the contactor switch.

Indicating Contactor Switch Unit (ICS)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pick-up value of the switch.

Indicating Instantaneous Trip Unit (IIT)

* Fault Detector (FD) – when used

The instantaneous trip unit is a small a-c operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the

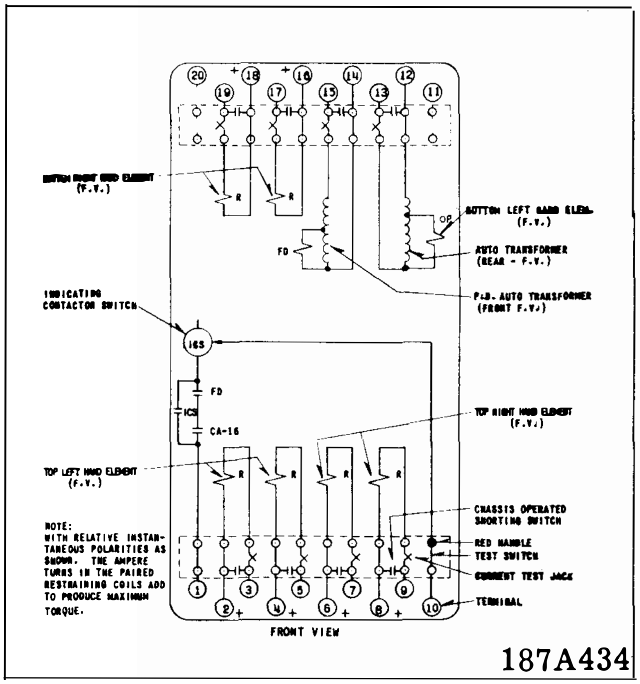


Fig. 5. Internal Schematic of the Type CA-16 Bus Relay with a Sensitive Fault Detector

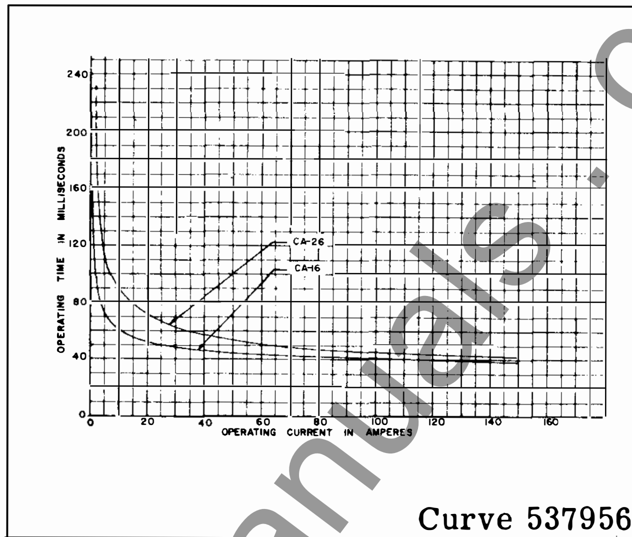


Fig. 6. Typical Time Curves of the CA-16 and CA-26 differential Relays

switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip * circuit. Also during this operation, (for the IIT only) two fingers on the armature deflect a spring located on the front of the switch which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

A core screw accessible from the top of the switch provides the adjustable pick-up range.

OPERATION

The types CA-16 and CA-26 relays are induction disc relays with four electromagnets mounted on two discs that are fastened on a common shaft. One of the electromagnets is the operating element while the other three are restraint elements. The restraint elements are energized from the secondaries of current transformers connected to the bus, and the operating circuit is energized in accordance with the current flowing in the differential connection of the current transformers.

A current of 5 amperes in at terminal 18 and out of terminal 19 will produce a definite amount of restraining torque (see Fig. 3.) Similarly, a current of 5 amperes flowing in at terminal 16 and out of terminal 17 will produce an equal amount of torque. If both of these currents flow at the same time with the polarity as indicated above, their effect will be additive and they will produce the same torque as though 10 amperes were flowing in terminal 16 and out of terminal 17. Conversely, if equal currents flow in these two coils, but in opposite directions, their ampere turns will cancel and no torque will be produced. The same relationship applies for the paired coils of the other two restraining units of the relay. The restraint * effect will always be additive if currents flow in the coils which belong to different restraint elements.

CHARACTERISTERICS

CA-16 Bus Relay

This relay has variable percentage characteristics which means that the operating coil current required to close the relay contacts, expressed in per cent of the total restraint current, varies with the magnitude of the restraint current. The relay sensitivity is high, corresponding to a low percentage ratio, at light currents, and its sensitivity is low, corresponding to high percentage unbalance, at high currents. The relay is made sensitive at low currents in order to detect light internal faults on the bus being protected. At the same time, however, its reduced sensitivity at the higher currents allows the various current transformers involved to depart from their true ratio to a large extent without causing false tripping of the relay for external faults.

The variable percentage characteristics are particularly advantageous when severe saturation of current transformers is caused by the d-c component of asymmetrical short circuits. In the case of buses located close to generating stations where the d-c components decay slowly, the breakdown in ratio of the current transformers will be much greater than

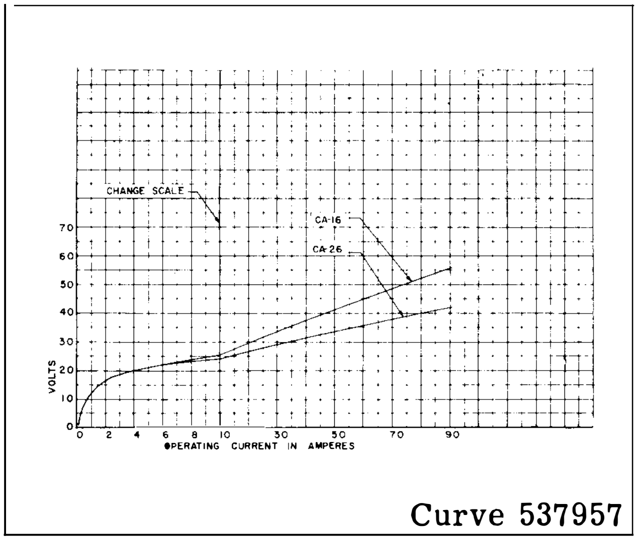


Fig. 7. Typical Burden Characteristic of the Operating Circuit of the CA-16 and CA-26 Differential Relays

would ever be expected from a consideration of the usual ratio curves of the current transformers involved.

The time of operation of the relays is shown in Figure 6.

CA-26 Transformer Relay

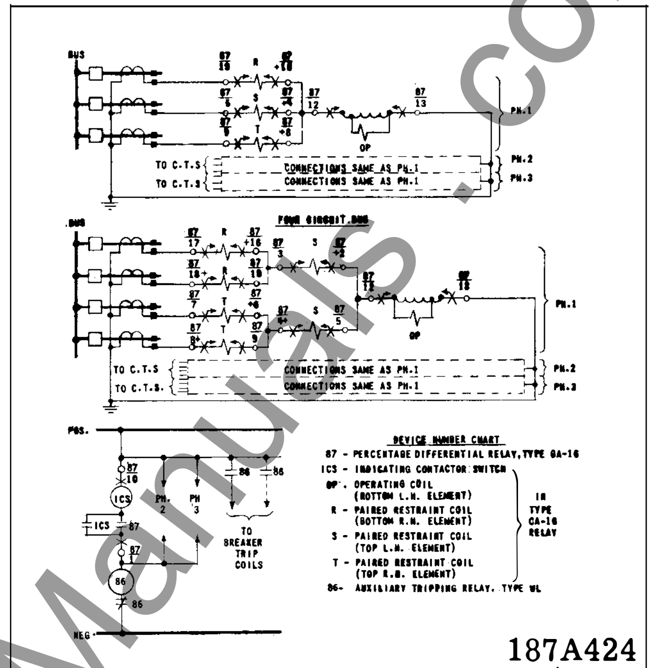
The type CA-26 transformer differential relay includes an indicating instantaneous trip unit (see Fig. 4), which operates on internal faults. The instantaneous unit should have a setting equal to the maximum rms symmetrical external fault current. Such a setting will prevent operation of the instantaneous unit when a current transformer is severely saturated by the d-c component of an asymmetrical external fault current.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating instantaneous trip contacts will safely close 30 amperes at 250 volts d-c, and will carry this current long enough to trip breaker.

The indicating contactor switch has two taps that provide a pick-up setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.



* *Fig. 8. External Schematic of the Type CA-16 Relays for Three and Four Circuit Bus Protection*

Trip Circuit Constants

Indicating Contactor Switch (ICS)

0.2 ampere tap	6.5 ohms d-c resistance
2.0 ampere tap	0.15 ohms d-c resistance

ENERGY REQUIREMENTS

Burden of each restraint coil at 5 amperes

VOLT AMPERES	POWER FACTOR
.75	.7
Continuous Rating	14 amperes
1 second rating	460 amperes

Burden of operating circuit

VOLT AMPERES

Variable (See Fig. 7)

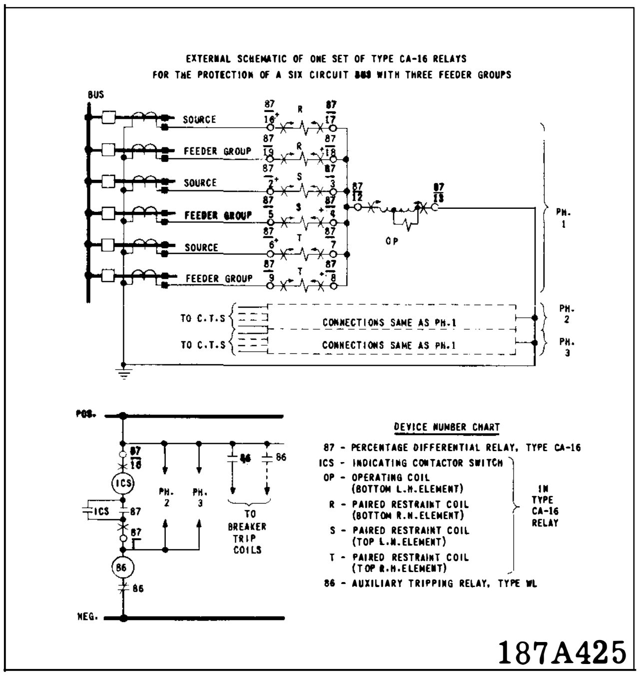
Continuous rating 8 amperes

1 second rating 280 amperes

CONNECTIONS

CA-16

To determine the a-c connections, identify each



* *Fig. 9. External Schematic of the Type CA-16 Relays for Protection of a Six Circuit Bus with Three Feeder Groups*

primary circuit as either a "source" or "feeder". As defined here, a feeder contributes only a small portion of the total fault-current contribution for a bus fault. Otherwise, the circuit is a source. Next lump a number of feeders into a "feeder group" by paralleling feeder CT's, taking the precaution that each feeder group has less than 14 amperes load current (restraint coil continuous rating). Also each feeder group should not contribute more than 10% of the total phase or ground-fault current for a bus fault if figure 9 is to be used.

Connect per Fig. 8 with three or four bus "circuit." The term "circuit" refers to a source or to a feeder group. For example, assume a bus consisting of 2 sources and 6 feeders. Further, assume that the feeders are lumped into 2 feeder groups. The bus now reduces to four circuits.

If the bus reduces to more than four circuits, parallel source-circuit CT's or source-and feeder-cir - CT's until only four circuits remain. Then connect these four sets of CT's to the relays per Fig. 8. The exception to this rule occurs when the application consists of three feeder groups. Then, Fig. 9 applies.

With 3 feeder groups and more than 3 sources, parallel source CT's until the application reduces to 6 circuits; then, connect to the relays per Fig. 9.

Fig. 10 shows the CA-26 relay connections for a 3 circuit bus. Where additional circuits are present use the Fig. 9 connections; where there are more than three sources the source CT's should be parallelled to reduce the effective number of source connections to three. The "four-circuit bus" connections of Fig. 8 are not recommended to be used for bus protection with the CA-26 since it may have too much restraint when energizing the bus on fault. Otherwise the connection considerations are as described above for the CA-16.

SETTING CALCULATIONS

No calculations are required to set the CA-16 and CA-26 relays.

SETTING THE RELAY

No settings are required on either the CA-16 or the CA-26 main units.

Indicating Contactor Switch (ICS)

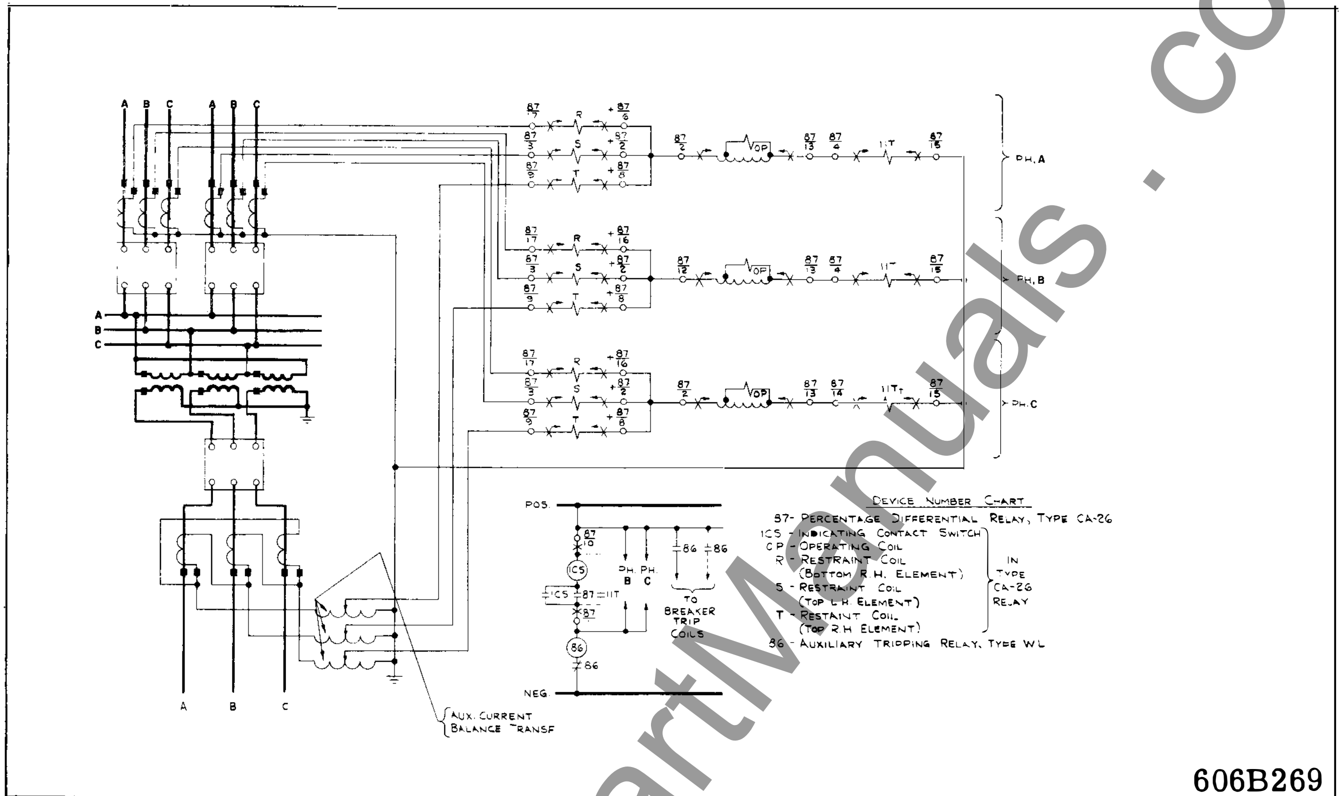
No setting is required on the ICS unit except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a 125 or 250 volt d-c WL relay switch or equivalent, use the 0.2 ampere tap; for 48 volt d-c applications set relay in 2 tap and use WL relay coil S#304-C209G01 or equivalent.

Indicating Instantaneous Trip (IIT)

Since the minimum and maximum markings on the scale only indicate the working range of the core screw must be adjusted to the value of pick-up desired. The application of IIT unit is intended to get faster operating speed for heavy internal faults. For bus protection, it is recommended the IIT unit be set higher than 50% of the maximum external fault current contributed from the bus and with all circuits in service. For transformer protection, apply IIT-unit where internal fault current can exceed twice the maximum total current flowing through the differential zone for an symmetrical external fault, set IIT unit at 50% external fault current or higher than transformer inrush current depending on which is greater.

INSTALLATION

The relays should be mounted on a switchboard panel or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of



* *Fig. 10. External Schematic of the Type CA-26 Relay for Transformer Protection and Bus Protection*

the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments other than those covered under "SETTINGS" should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order.

A. Minimum Trip Current

Apply current to terminals 12 and 13 of the relay. The relay should operate as follows:

1. CA-16	0.15 amperes ± 5%
2. CA-26	1.25 amperes ± 5%

B. Percentage Differential Characteristic

Apply 16 amperes to terminals 9 and 19 of the CA-16 relay or 14 amperes to terminals 9 and 19 of the CA-26 relay. The contacts should close when the following operating current is applied to the relay with connections of Fig. 11.

CA-16	17.0 ± 7% amperes
CA-26	38.0 ± 7% amperes

Check each individual restraint winding by applying 50 amperes to each winding. Apply sufficient operating current to the operating circuit until the contacts just close. The operating current should be:

CA-16	3.9 to 5.1 Amperes
CA-26	15.8 to 18.2 Amperes

C. Time Curve

Apply 20 amperes to terminals 12 and 13 of the relays. The contacts should close in the following times:

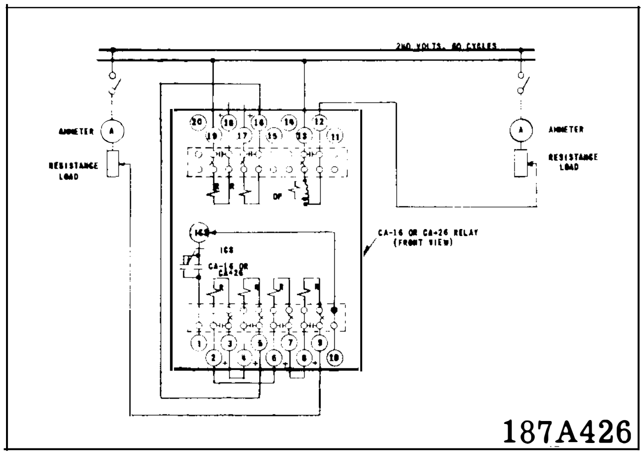


Fig. 11. Diagram of Test Connections for the CA-16 and CA-26 Relays

CA-16	52 ± 5% Milliseconds
CA-26	72 ± 5% Milliseconds

D.- Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contact of the ICS. This value of current should not be greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

The contact gap should be approximately .047 inch between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

* E. Indicating Instantaneous Unit (IIT)-Where supplied) or Fault Detector (FD)

The core screw which is adjustable from the top of the trip unit determines the pick-up value. The trip unit has a nominal ratio of adjustment of 1 to 4 and an accuracy within the limits of 10%.

The making of the contacts and target indication should occur at approximately the same instant. Position the stationary contact for a minimum of 1/32 inch wipe. The bridging moving contact should touch both stationary contacts simultaneously. Apply sufficient current to operate the IIT. Fault detector unit has no target. *

F. Sensitive Fault Detector (where supplied)

Apply current to terminals 14 and 15 of the relay. The fault detector should operate between the limits of 0.142 to 0.158 amperes.

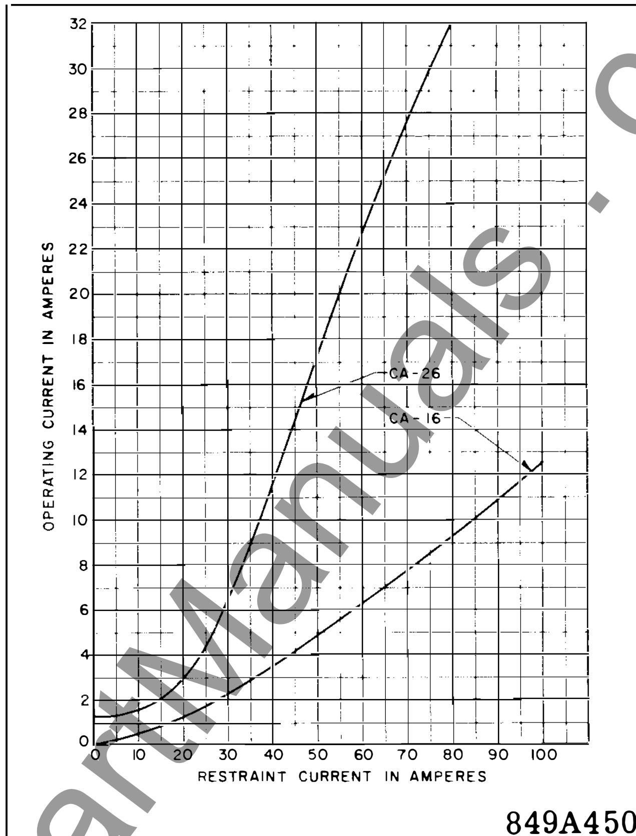


Fig. 12. Percentage Slope Curve of the CA-16 and CA-26 Relays with One Restraint Winding

Routine Maintenance

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order. (See "Acceptance Check").

1. Contacts

Adjust the adjustable stop screw on the upper disc of the relay so that a contact separation of 0.050 inch is obtained between the moving contact and the stationary contact. Lock the screw with the nut provided for the purpose.

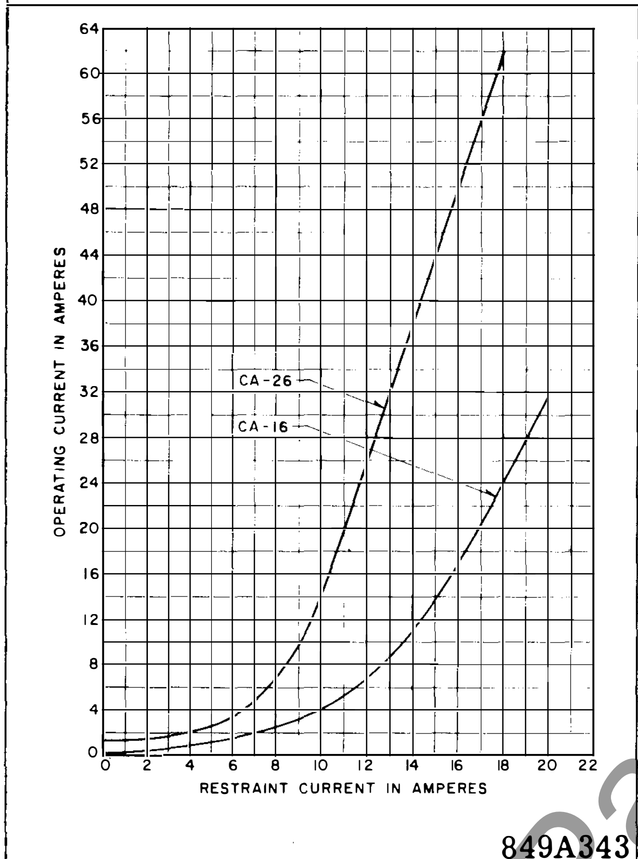


Fig. 13. Percentage Slope Curve of the CA-16 and CA-26 Relays with Six Restraint Windings in Series

2. Minimum Trip

The relay should be level for this test. Minimum trip current can best be determined with the permanent magnet removed.

Adjust the spring tension until the relay just closes its contacts with the following current applied to terminals 12 and 13 of the relay.

CA-16	0.15 amperes
CA-26	1.25 amperes

3. Percentage Slope Characteristic

* Connect the relay per the test circuit of Fig. 11. Pass 20 amperes for the CA-16 and 14 amperes for the CA-26 relay into terminals 9 and 19 of the relay. Adjust the plug (when used) in the operating electromagnet until the contacts just close with the following currents into the operating circuit of the relays.

CA-16	29.4 to 34 amperes
CA-26	36 to 40 amperes

4. Time Curve

Place the permanent magnet on the relay and apply 20 amperes to terminals 12 and 13 of the relay. Adjust the keeper of the permanent magnet until the contacts just close in the following times:

CA-16	52 ± 5% milliseconds
CA-26	72 ± 5% milliseconds

These times should be the average of 5 readings

5. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

6. Indicating Instantaneous Trip Unit (IIT)

The core screw must be adjusted to the value of pick-up current desired. It is recommended that the IIT be set to pick-up at a value of current that is equal to the maximum rms symmetrical external fault current to the relay.

7. Sensitive Fault Detector

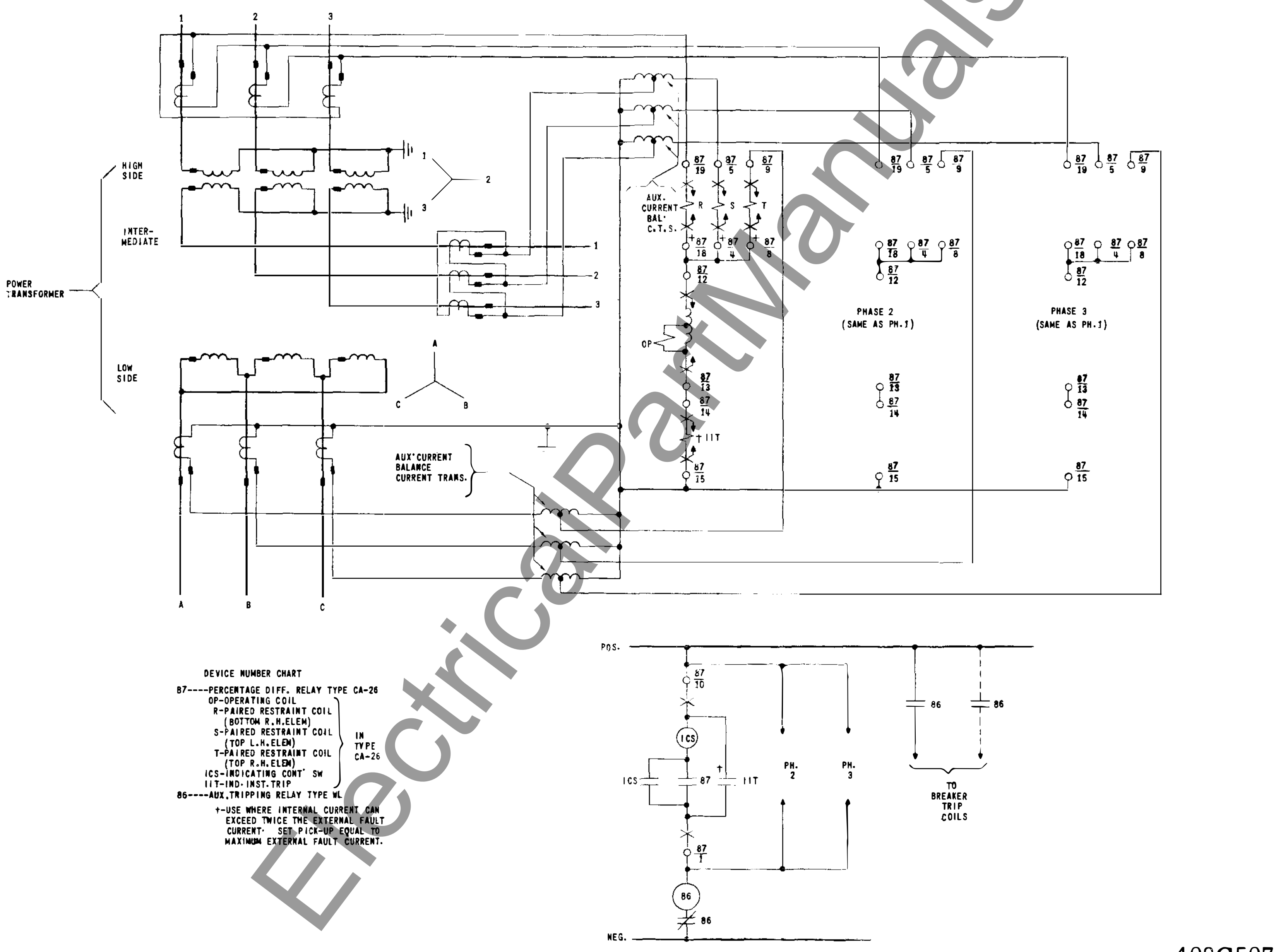
Loosen the lock nut at the top of the element and run the core screw down until it is flush with the top of the lock nut. Back off the Micarta disc by loosening the two lock nuts. Apply 0.15 amperes to terminals 14 and 15. Operate the moving element by hand and allow the current to hold the moving contact disc against the stationary contacts. Now, screw up the core screw slowly. This causes the plunger to move up, compressing the spring until a point of maximum deflection is reached. Further upward motion will cause the plunger to drop part way out of the coil, thus diminishing the spring pressure on the contacts. By thus adjusting the core screw up or down the maximum spring deflection for this value of current may be found. Then lock the core screw in place. Next, adjust the de-energized position of the plunger by raising the Micarta disc until the plunger just picks up electrically at the 0.15 ampere value.

Electrical Checkpoints

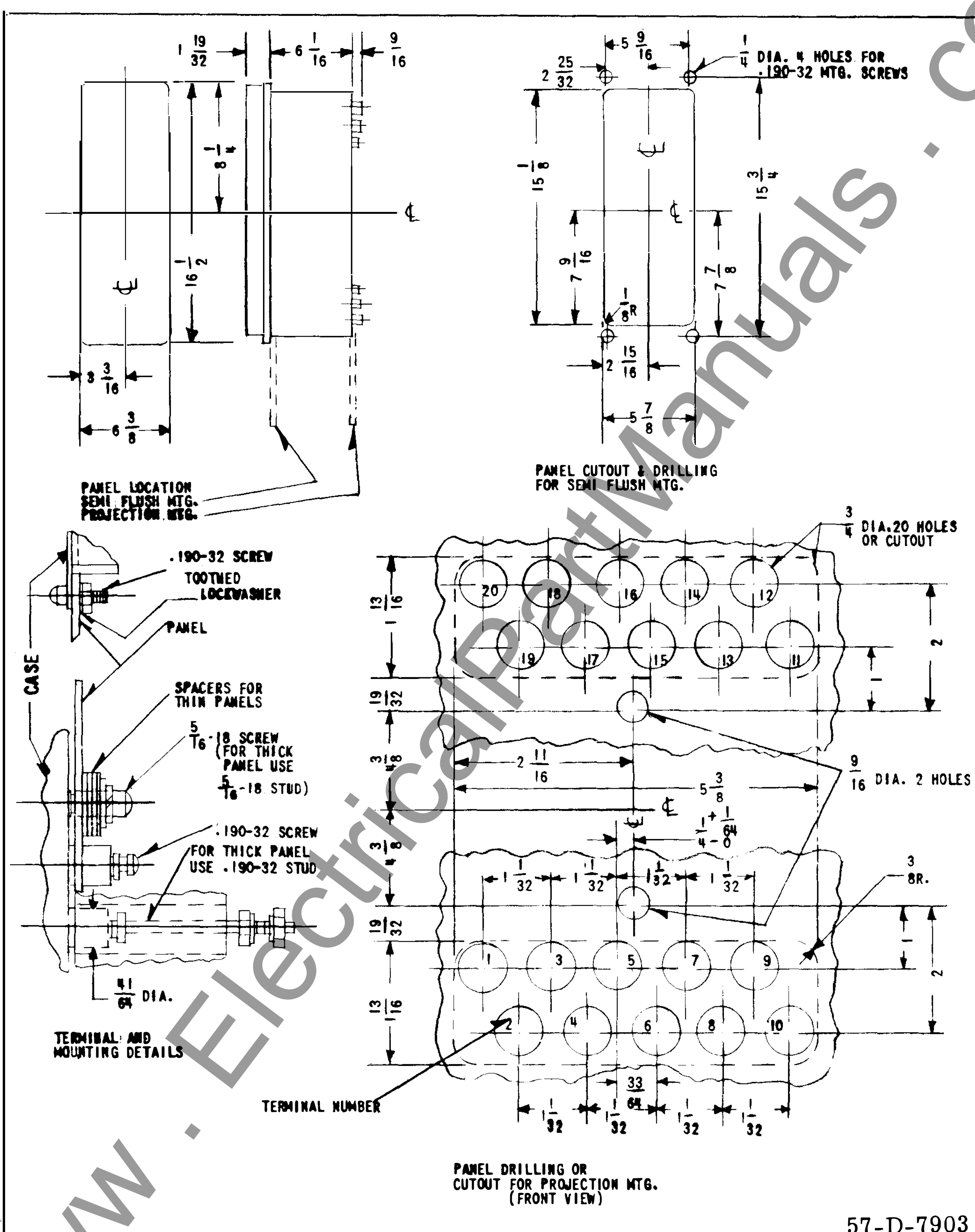
Figures 12 and 13 will aid in trouble shooting either the CA-16 or the CA-26 relays. These curves show the operating current to trip the relay for different restraint current for one restraint element as well as for six restraint elements connected in series.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.



* Fig. 14. External Schematic of the Type CA-26 Relay for Wye-Wye-Delta Transformer Protection.



* *Fig. 15. Outline and Drilling for the CA-16 and CA-26 Relays in FT-32 Case.*

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES CA—16 and CA—26 PERCENTAGE DIFFERENTIAL RELAYS FOR BUS AND TRANSFORMER PROTECTION

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The current transformers should not saturate when carrying the maximum external symmetrical fault current (i.e., exciting current should not exceed one secondary ampere, rms). This requirement is met if the burden voltage does not exceed $N_P V_{CL}/133$, where:

N_P = proportion of total CT turns in use

V_{CL} = current transformer 10L accuracy-class voltage

The burden voltage is described as:

Case 1: Fault current maximum of 100A rms in CT secondary – drop across 2-way lead burden and relays (CA-16 and CA-26 restraint-coil burden is negligible).

Case 2: Fault current greater than 100A rms in CT secondary – drop across 2-way lead burden and relays plus:

$$(I_{EXT} - 100)\ R_{CT}$$

where I_{EXT} = max. external symmetrical fault current in secondary rms amperes.

R_{CT} = CT resistance, ohms

For example, if the 400/5 tap of 600/5 10L200 wye-connected CT's are used N_P = 400/600 = 0.67; if I_{EXT} = 100A, the burden (excluding CT resistance) should not exceed:

$$N_P V_{CL}/133 = (0.67 \times 200)/133 = 1.0 \text{ ohms.}$$

CONTENTS

This instruction leaflet applies to the following types of relays:

CA-16 Bus Differential Relay
CA-26 Transformer Differential Relay

* The CA-16 relay should not be utilized for transformer differential applications since it is too sensitive for overriding the inrush. Likewise the CA-26 relay should not be used for bus protection with the "four-circuit bus" connections of Fig. 8. The CA-26 relay is suitable for combination bus-transformer applications. See "Connections".

CONSTRUCTION

The type CA-16 relay consists of an indicating contactor switch, autotransformer, three restraint elements, and an operating element. For applications where the CA-16 relay is subjected to shock such as on swinging panels, a sensitive fault detector circuit is provided.

The type CA-26 (in addition to the components of the CA-16 relay) also contains an indicating instantaneous trip unit. The principal component parts of the relay and their location are shown in Figures 1 to 5.

Restraint Elements

Each restraint element consists of an "E" laminated electromagnet with two primary coils and a secondary coil on its center leg. Two identical coils on the outer legs of the laminated structure are connected to the secondary winding in a manner so that the combination of all fluxes produced by the electromagnet results in out-of-phase fluxes in the air gap. The out-of-phase fluxes cause a contact opening torque.

Operating Circuit

The operating circuit consists of an auto-transformer and an operating element. The primary of the auto-transformer, which is the whole winding, is connected to receive the differential or unbalanced current from the various transformers connected to the bus. The secondary winding of the auto-transformer, which is a tapped section of the winding, is connected to the operating element of the relay.

The operating element consists of an "E" type

SUPERSEDES I.L. 41-337.3C
*Denotes change from superseded issue.

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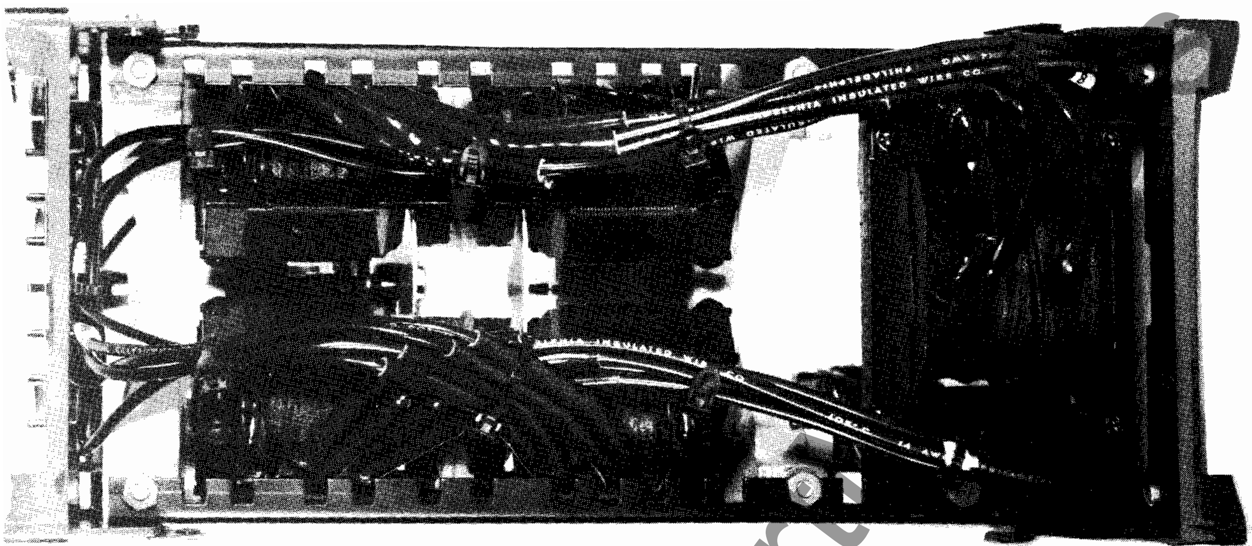

Fig. 2. Types CA-16 Relay (rear view)

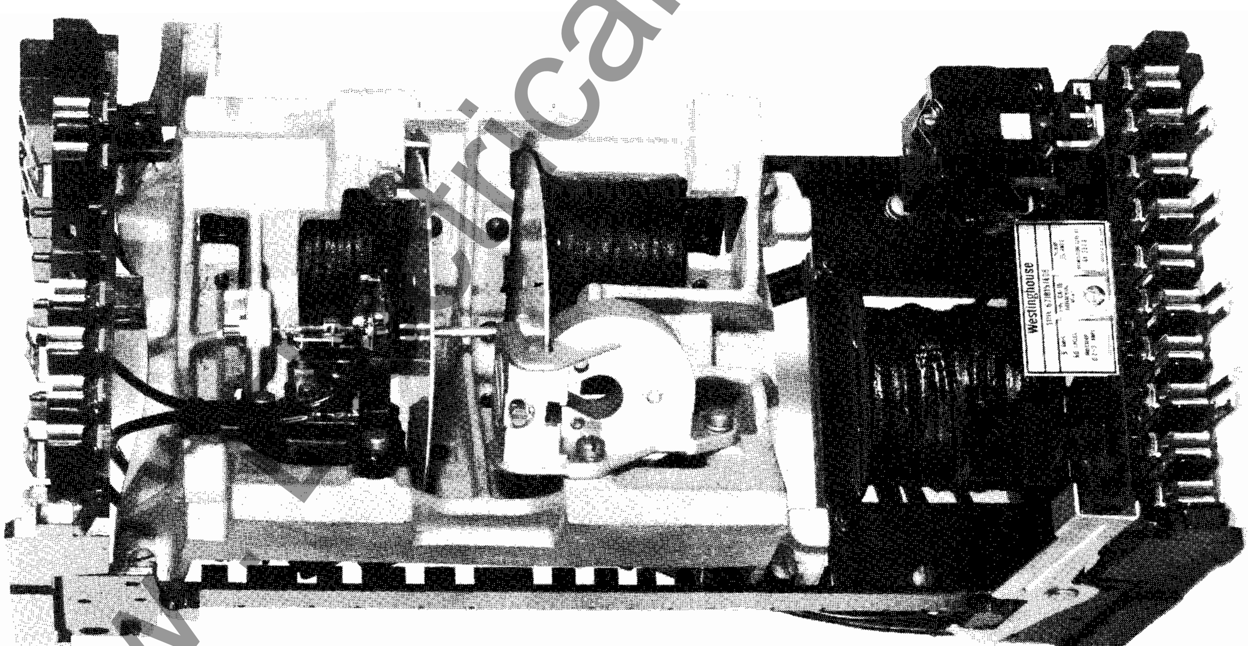

Fig. 1. Types CA-16 Relay (front view)

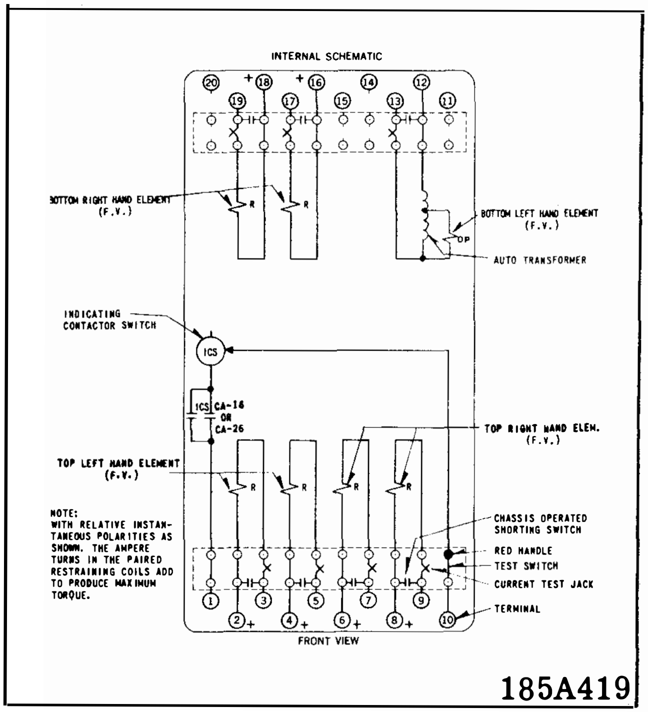

Fig. 3. Internal Schematic of the Type CA-16 Bus Relay

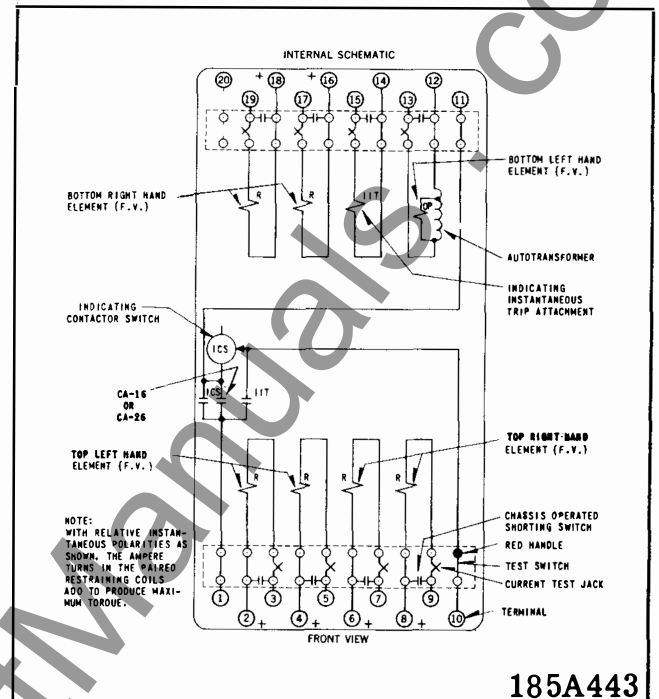

Fig. 4. Internal Schematic of the Type CA-26 Transformer Relay

laminated electromagnet with an auto-transformer winding on its center leg. Two identical coils on the outer legs of the laminated structure are connected to the secondary (tapped section) of the auto-transformer winding in a manner so that the combination of all fluxes produced by the electromagnet results in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes cause a contact closing torque.

Sensitive Fault Detector Circuit (where used)

The sensitive fault detector circuit consists of an auto-transformer and a contactor switch. The contactor switch is connected across the secondary (tapped section) of the auto-transformer winding.

The contactor switch is a small solenoid type element. A cylindrical plunger rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core, which in turn screws into the unit frame. A silver disc is fastened to the moving plunger through a helical spring. When the coil is energized, the plunger moves upward carrying the silver disc which bridges three conical-shaped stationary contacts. In this position, the helical spring is compressed and the plunger is free to move while the contact remains stationary. Thus, a-c vibrations of the plunger are prevented from causing contact bouncing. A Micarta disc is fastened to the bottom of the guide rod by two small nuts. Its position determines the pick up current of the element.

The auto-transformer is designed to saturate at high values of current to limit the amount of current to the contactor switch.

Indicating Contactor Switch Unit (ICS)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pick-up value of the switch.

Indicating Instantaneous Trip Unit (IIT)

The instantaneous trip unit is a small a-c operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the

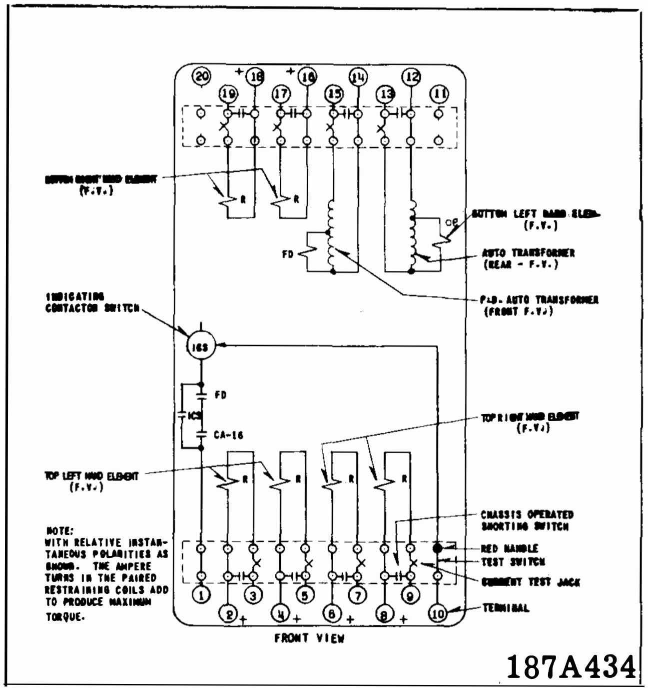

Fig. 5. Internal Schematic of the Type CA-16 Bus Relay with a Sensitive Fault Detector

switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation, two fingers on the armature deflect a spring located on the front of the switch which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

A core screw accessible from the top of the switch provides the adjustable pick-up range.

OPERATION

The types CA-16 and CA-26 relays are induction disc relays with four electromagnets mounted on two discs that are fastened on a common shaft. One of the electromagnets is the operating element while the other three are restraint elements. The restraint elements are energized from the secondaries of current transformers connected to the bus, and the operating circuit is energized in accordance with the current flowing in the differential connection of the current transformers.

A current of 5 amperes in at terminal 18 and out of terminal 19 will produce a definite amount of restraining torque (see Fig. 3.) Similarly, a current of 5 amperes flowing in at terminal 16 and out of terminal 17 will produce an equal amount of torque. If both of these currents flow at the same time with the

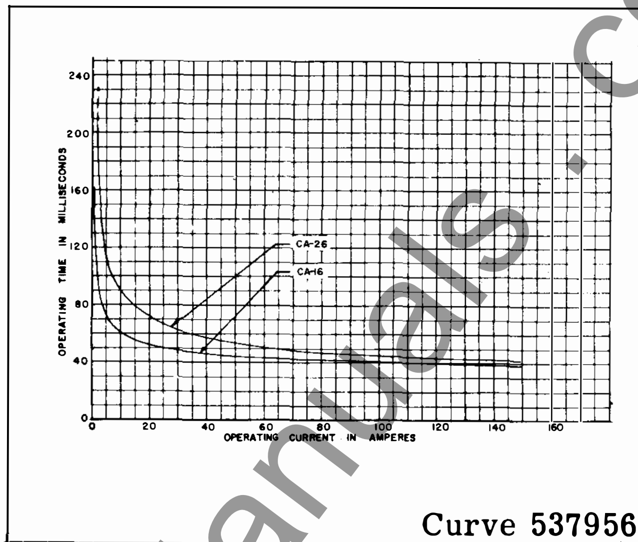

Fig. 6. Typical Time Curves of the CA-16 and CA-26 differential Relays

polarity as indicated above, their effect will be additive and they will produce the same torque as though 10 amperes were flowing in terminal 16 and out of terminal 17. Conversely, if equal currents flow in these two coils, but in opposite directions, their ampere turns will cancel and no torque will be produced. The same relationship applies for the paired coils of the other two restraining units of the relay.

CHARACTERISTERICS

CA-16 Bus Relay

This relay has variable percentage characteristics which means that the operating coil current required to close the relay contacts, expressed in per cent of the total restraint current, varies with the magnitude of the restraint current. The relay sensitivity is high, corresponding to a low percentage ratio, at light currents, and its sensitivity is low, corresponding to high percentage unbalance, at high currents. The relay is made sensitive at low currents in order to detect light internal faults on the bus being protected. At the same time, however, its reduced sensitivity at the higher currents allows the various current transformers involved to depart from their true ratio to a large extent without causing false tripping of the relay for external faults.

The variable percentage characteristics are particularly advantageous when severe saturation of current transformers is caused by the d-c component of asymmetrical short circuits. In the case of buses located close to generating stations where the d-c components decay slowly, the breakdown in ratio of the current transformers will be much greater than

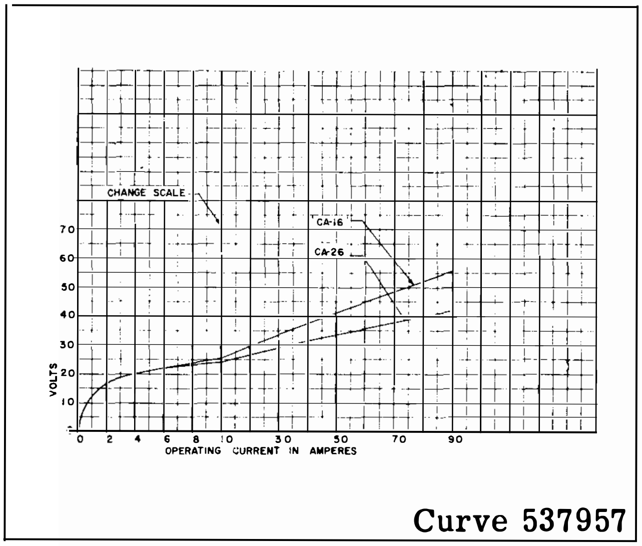

Fig. 7. Typical Burden Characteristic of the Operating Circuit of the CA-16 and CA-26 Differential Relays

would ever be expected from a consideration of the usual ratio curves of the current transformers involved.

The time of operation of the relays is shown in Figure 6.

CA-26 Transformer Relay

The type CA-26 transformer differential relay includes an indicating instantaneous trip unit (see Fig. 4), which operates on internal faults. The instantaneous unit should have a setting equal to the maximum rms symmetrical external fault current. Such a setting will prevent operation of the instantaneous unit when a current transformer is severely saturated by the d-c component of an asymmetrical external fault current.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating instantaneous trip contacts will safely close 30 amperes at 250 volts d-c, and will carry this current long enough to trip breaker.

The indicating contactor switch has two taps that provide a pick-up setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

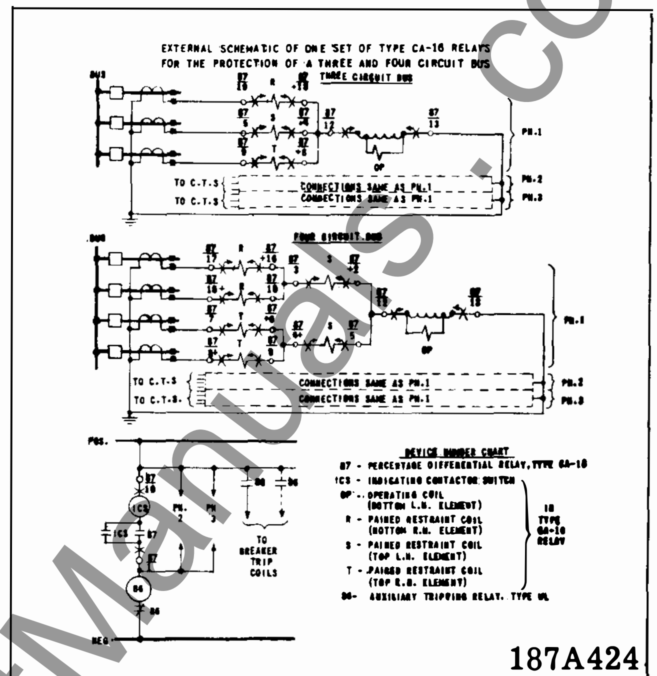

Fig. 8. External Schematic of the Type CA-16 Relays for Three and Four Circuit Bus Protection

Trip Circuit Constants

Indicating Contactor Switch (ICS)

0.2 ampere tap	6.5 ohms d-c resistance
2.0 ampere tap	0.15 ohms d-c resistance

ENERGY REQUIREMENTS

Burden of each restraint coil at 5 amperes

VOLT AMPERES	POWER FACTOR
.75	.7
Continuous Rating	14 amperes
1 second rating	460 amperes

Burden of operating circuit

VOLT AMPERES

Variable (See Fig. 7)

Continuous rating 8 amperes

1 second rating 280 amperes

CONNECTIONS

CA-16

To determine the a-c connections, identify each

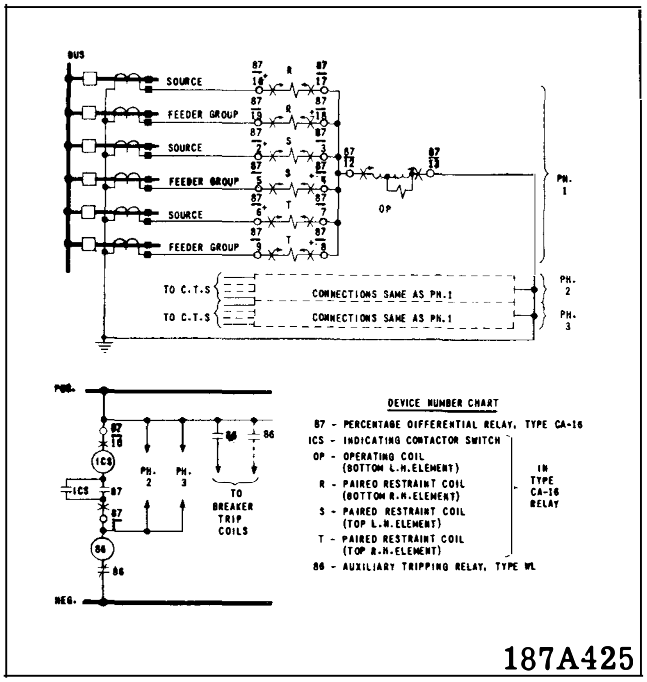

Fig. 9. External Schematic of the Type CA-16 Relays for Protection of a Six Circuit Bus with Three Feeder Groups

* primary circuit as either a "source" or "feeder". As defined here, a feeder contributes only a small portion of the total fault-current contribution for a bus fault. Otherwise, the circuit is a source. Next lump a number of feeders into a "feeder group" by paralleling feeder CT's, taking the precaution that each feeder group has less than 14 amperes load current (restraint coil continuous rating). Also each feeder group should not contribute more than 10% of the total phase or ground-fault current for a bus fault if figure 9 is to be used.

Connect per Fig. 8 with three or four bus "circuit." The term "circuit" refers to a source or to a feeder group. For example, assume a bus consisting of 2 sources and 6 feeders. Further, assume that the feeders are lumped into 2 feeder groups. The bus now reduces to four circuits.

If the bus reduces to more than four circuits, parallel source-circuit CT's or source-and feeder-cir - CT's until only four circuits remain. Then connect these four sets of CT's to the relays per Fig. 8. The exception to this rule occurs when the application consists of three feeder groups. Then, Fig. 9 applies.

With 3 feeder groups and more than 3 sources, parallel source CT's until the application reduces to 6 circuits; then, connect to the relays per Fig. 9.

* Fig. 10 shows the CA-26 relay connections for a 3 circuit bus. Where additional circuits are present use the Fig. 9 connections; where there are more than three sources the source CT's should be paralleled to reduce the effective number of source connections to three. The "four-circuit bus" connections of Fig. 8 are not recommended to be used for bus protection with the CA-26 since it may have too much restraint when energizing the bus on fault. Otherwise the connection considerations are as described above for the CA-16.

SETTING CALCULATIONS

No calculations are required to set the CA-16 and CA-26 relays.

SETTING THE RELAY

No settings are required on either the CA-16 or the CA-26 main units.

Indicating Contactor Switch (ICS)

No setting is required on the ICS unit except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a 125 or 250 volt d-c WL relay switch or equivalent, use the 0.2 ampere tap; for 48 volt d-c applications set relay in 2 tap and use WL relay coil S#304-C209G01 or equivalent.

Indicating Instantaneous Trip (IIT)

Since the minimum and maximum markings on the scale only indicate the working range of the core screw must be adjusted to the value of pick-up desired. It is recommended that the IIT be set to pick up at a value of current that is equal to the maximum rms symmetrical external fault current to the relay.

INSTALLATION

The relays should be mounted on a switchboard panel or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the

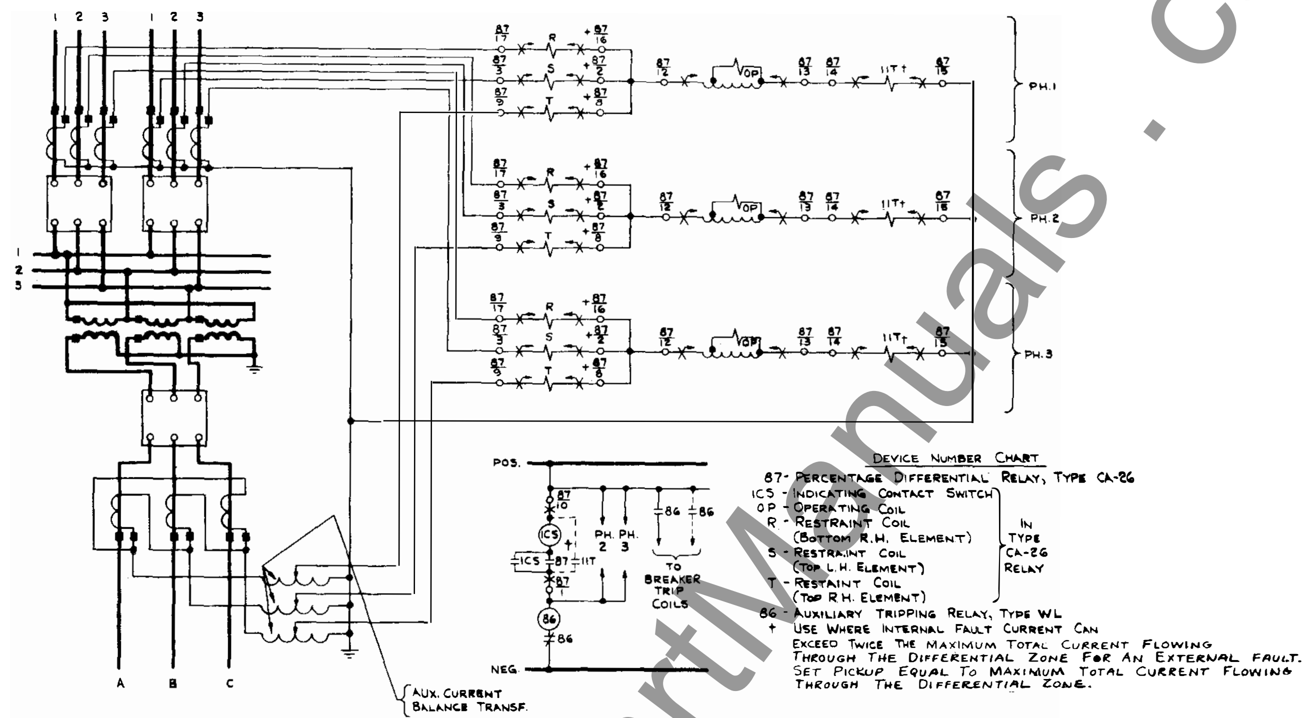

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Fig. 10. External Schematic of the Type CA-26 Relay for Transformer Protection and Bus Protection

stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments other than those covered under "SETTINGS" should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order.

A. Minimum Trip Current

Apply current to terminals 12 and 13 of the relay. The relay should operate as follows:

1. CA-16 0.15 amperes ± 5%
2. CA-26 1.25 amperes ± 5%

B. Percentage Differential Characteristic

* Apply 16 amperes to terminals 9 and 19 of the CA-16 relay or 14 amperes to terminals 9 and 19 of the CA-26 relay. The contacts should close when the following operating current is applied to the relay with connections of Fig. 11.

CA-16	17.0 ± 7% amperes
CA-26	38.0 ± 7% amperes

Check each individual restraint winding by applying 50 amperes to each winding. Apply sufficient operating current to the operating circuit until the contacts just close. The operating current should be:

CA-16	3.9 to 5.1 Amperes
CA-26	15.8 to 18.2 Amperes

C. Time Curve

Apply 20 amperes to terminals 12 and 13 of the relays. The contacts should close in the following times:

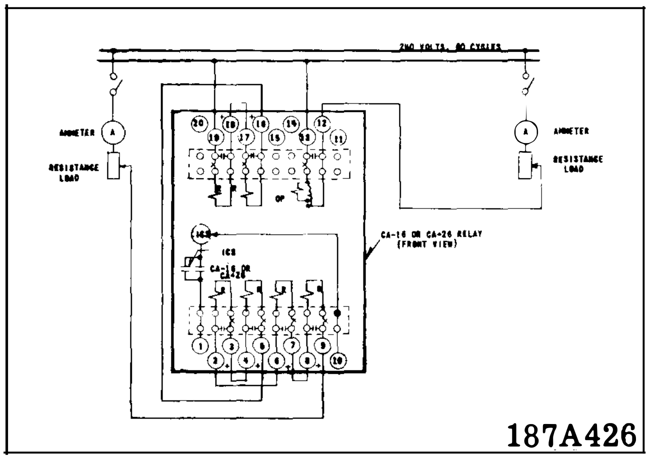

Fig. 11. Diagram of Test Connections for the CA-16 and CA-26 Relays

CA-16	52 ± 5% Milliseconds
CA-26	72 ± 5% Milliseconds

D. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contact of the ICS. This value of current should not be greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

The contact gap should be approximately .047 inch between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

E. Indicating Instantaneous Unit (IIT)-Where supplied)

The core screw which is adjustable from the top of the trip unit determines the pick-up value. The trip unit has a nominal ratio of adjustment of 1 to 4 and an accuracy within the limits of 10%.

The making of the contacts and target indication should occur at approximately the same instant. Position the stationary contact for a minimum of 1/32 inch wipe. The bridging moving contact should touch both stationary contacts simultaneously. Apply sufficient current to operate the IIT.

F. Sensitive Fault Detector (where supplied)

Apply current to terminals 14 and 15 of the relay. The fault detector should operate between the limits of 0.142 to 0.158 amperes.

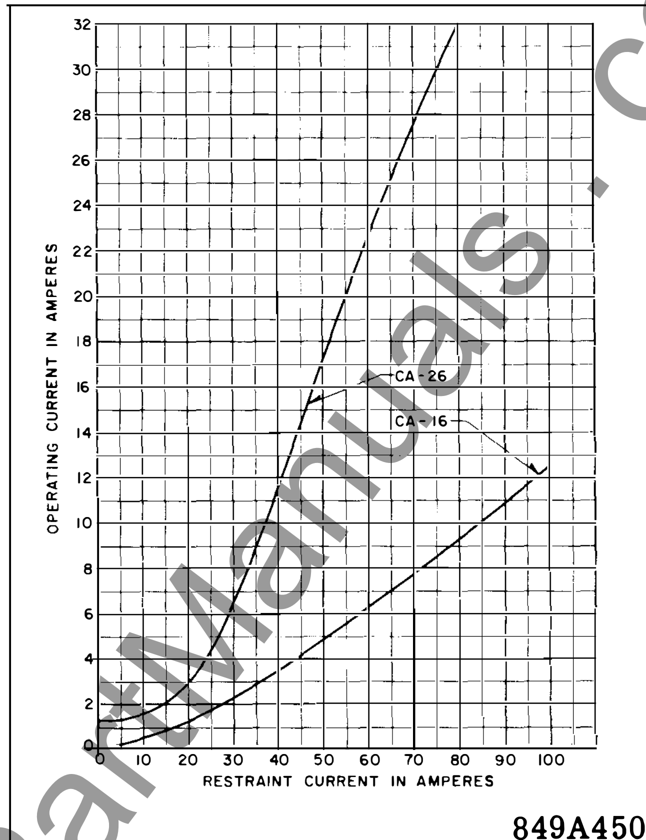

Fig. 12. Percentage Slope Curve of the CA-16 and CA-26 Relays with One Restraint Winding

Routine Maintenance

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order. (See "Acceptance Check").

1. Contacts

Adjust the adjustable stop screw on the upper disc of the relay so that a contact separation of 0.050 inch is obtained between the moving contact and the stationary contact. Lock the screw with the nut provided for the purpose.

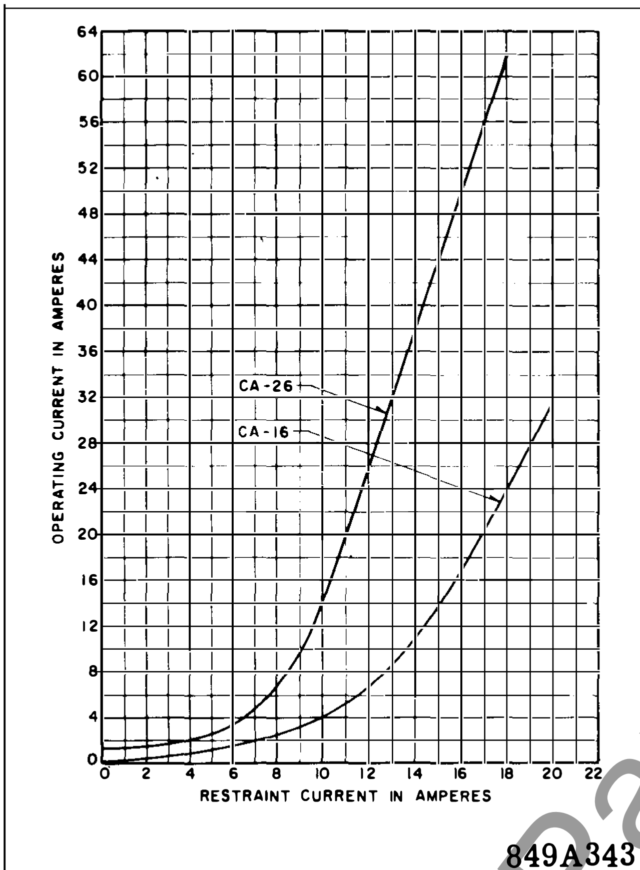

Fig. 13. Percentage Slope Curve of the CA-16 and CA-26 Relays with Six Restraint Windings in Series

2. Minimum Trip

The relay should be level for this test. Minimum trip current can best be determined with the permanent magnet removed.

Adjust the spring tension until the relay just closes its contacts with the following current applied to terminals 12 and 13 of the relay.

CA-16	0.15 amperes
CA-26	1.25 amperes

3. Percentage Slope Characteristic

Connect the relay per the test circuit of Fig. 11. Pass 20 amperes for the CA-16 and 14 amperes for the CA-26 relay into terminals 9 and 19 of the relay. Adjust the plug in the operating electromagnet until the contacts just close with the following currents into the operating circuit of the relays.

CA-16	29.4 to 34 amperes
CA-26	36 to 40 amperes

4. Time Curve

Place the permanent magnet on the relay and apply 20 amperes to terminals 12 and 13 of the relay. Adjust the keeper of the permanent magnet until the contacts just close in the following times:

CA-16	52 ± 5% milliseconds
CA-26	72 ± 5% milliseconds

These times should be the average of 5 readings

5. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

6. Indicating Instantaneous Trip Unit (IIT)

The core screw must be adjusted to the value of pick-up current desired. It is recommended that the IIT be set to pick-up at a value of current that is equal to the maximum rms symmetrical external fault current to the relay.

7. Sensitive Fault Detector

Loosen the lock nut at the top of the element and run the core screw down until it is flush with the top of the lock nut. Back off the Micarta disc by loosening the two lock nuts. Apply 0.15 amperes to terminals 14 and 15. Operate the moving element by hand and allow the current to hold the moving contact disc against the stationary contacts. Now, screw up the core screw slowly. This causes the plunger to move up, compressing the spring until a point of maximum deflection is reached. Further upward motion will cause the plunger to drop part way out of the coil, thus diminishing the spring pressure on the contacts. By thus adjusting the core screw up or down the maximum spring deflection for this value of current may be found. Then lock the core screw in place. Next, adjust the de-energized position of the plunger by raising the Micarta disc until the plunger just picks up electrically at the 0.15 ampere value.

Electrical Checkpoints

Figures 12 and 13 will aid in trouble shooting either the CA-16 or the CA-26 relays. These curves show the operating current to trip the relay for different restraint current for one restraint element as well as for six restraint elements connected in series.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

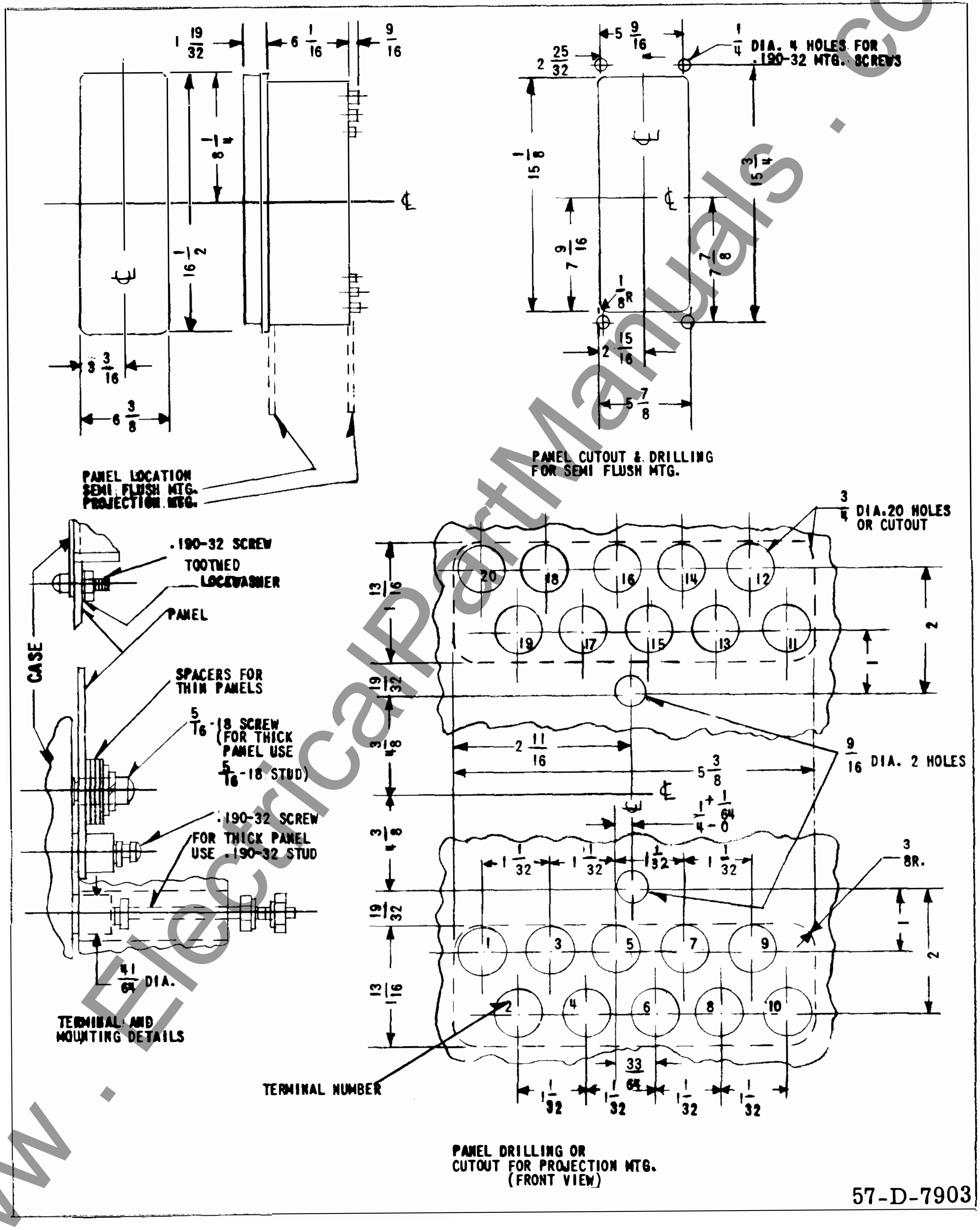

Fig. 14. Outline and Drilling for the CA-16 and CA-26 Relays in FT-32 Case.

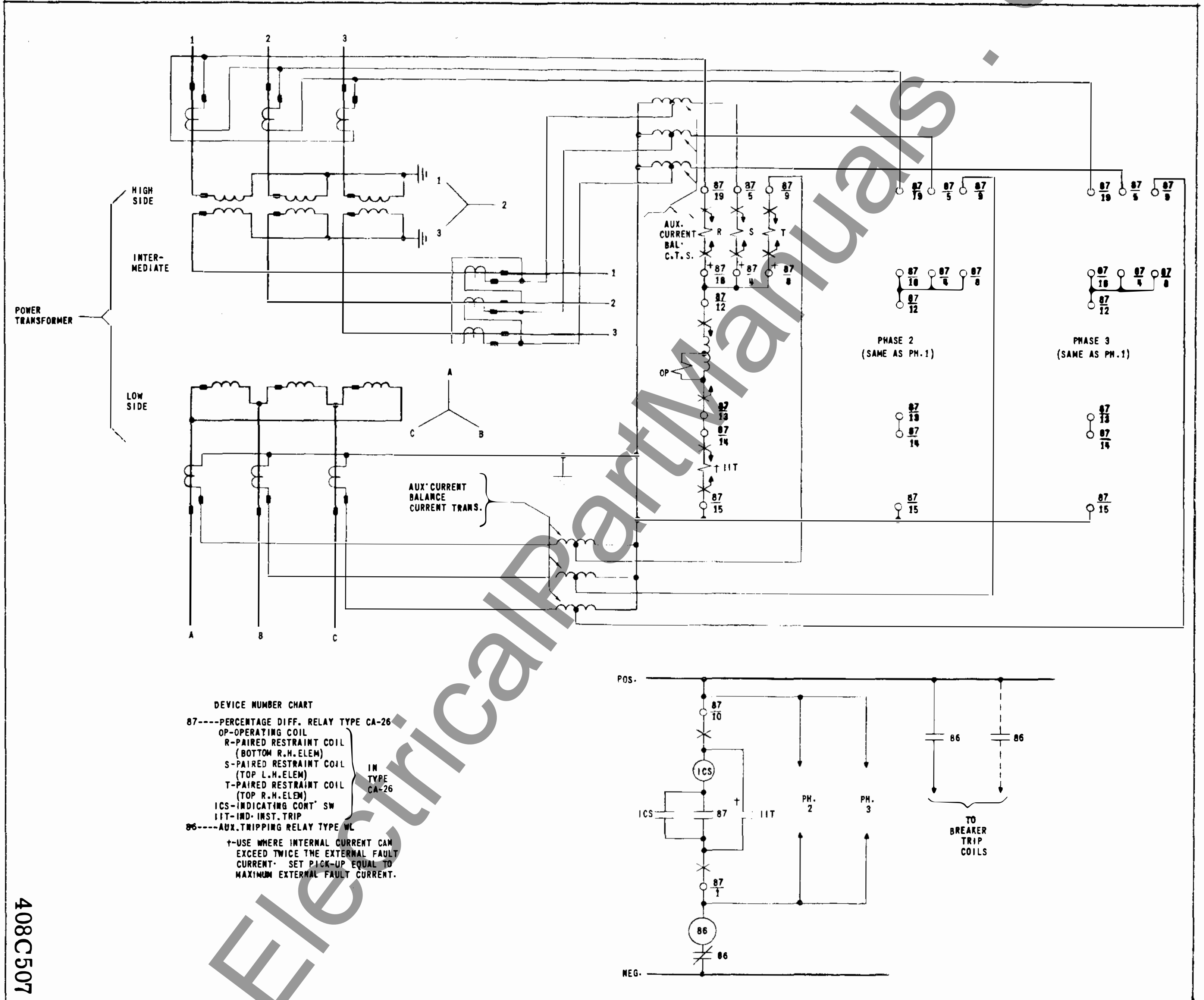

Fig. 15. External Schematic of the Type CA-26 Relay for Wye-Wye-Delta Transformer Protection

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES CA–16 and CA–26 PERCENTAGE DIFFERENTIAL RELAYS FOR BUS AND TRANSFORMER PROTECTION

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The types CA-16 and CA-26 relays are used for the differential protection of multi-circuit buses and transformers respectively. The two relays differ in their sensitivity and percentage differential characteristics. The following paragraphs describe the application requirements.

1. The maximum external symmetrical fault current through the bus should not exceed 100 amperes rms secondary current.

2. The current transformer burden external to the CA-16 or CA-26 relays should not exceed $(N_P V_{CL})/133$ ohms. Where

   N_P = Proportion of total number of CT turns in use
   V_{CL} = Current transformer 10L accuracy class voltage

   For example, if the 400/5 of a 600/5 multi-ratio CT is used, $N_P = 400/600 = 0.67$. If this CT has a 10L200 rating, $V_{CL} = 200$ and the external burden should not exceed

   $(N_P V_{CL})/133 = (0.67 \times 200)/133 = 1.0$ ohms
   In calculating the burden, use the two way lead burden.

CONTENTS

This instruction leaflet applies to the following types of relays:

CA-16 Bus Differential Relay
CA-26 Transformer Differential Relay

The bus relay should not be utilized for transformer differential applications.

CONSTRUCTION

The type CA-16 relay consists of an indicating contactor switch, autotransformer, three restraint elements, and an operating element. For applications where the CA-16 relay is subjected to shock such as on swinging panels, a sensitive fault detector circuit is provided.

The type CA-26 (in addition to the components of the CA-16 relay) also contains an indicating instantaneous trip unit. The principal component parts of the relay and their location are shown in Figures 1 to 5.

Restraint Elements

Each restraint element consists of an "E" laminated electromagnet with two primary coils and a secondary coil on its center leg. Two identical coils on the outer legs of the laminated structure are connected to the secondary winding in a manner so that the combination of all fluxes produced by the electromagnet results in out-of-phase fluxes in the air gap. The out-of-phase fluxes cause a contact opening torque.

Operating Circuit

The operating circuit consists of an auto-transformer and an operating element. The primary of the auto-transformer, which is the whole winding, is connected to receive the differential or unbalanced current from the various transformers connected to the

SUPERSEDES I.L. 41-337.2B
*Denotes change from superseded issue.

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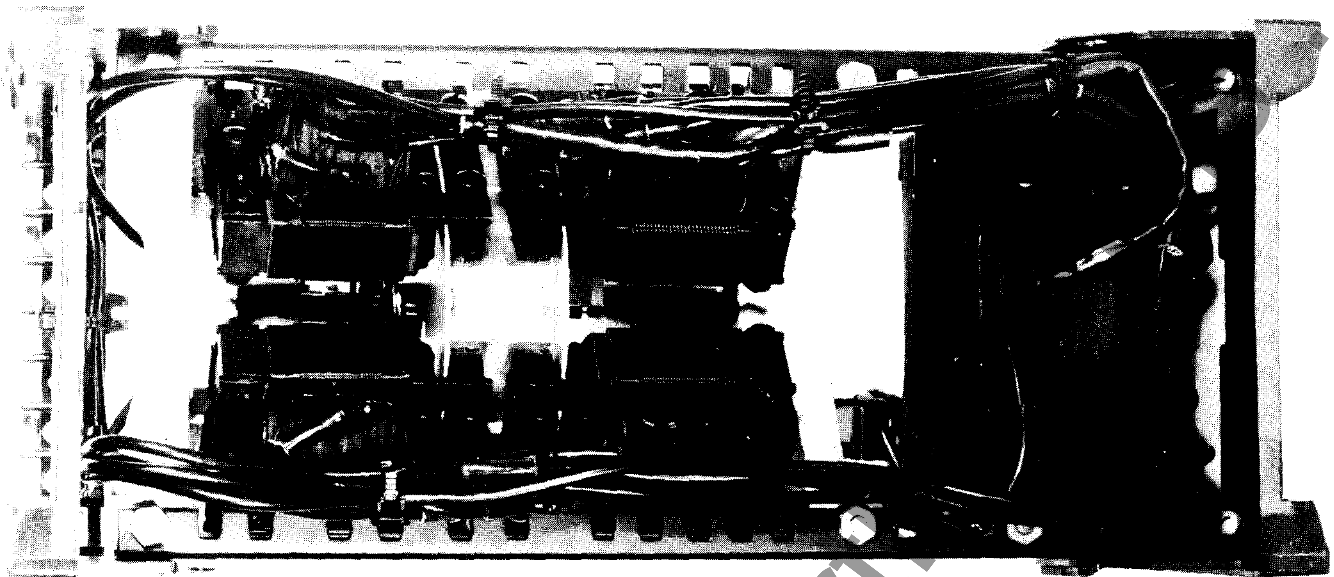


Fig. 2. Types CA-16 Relay (rear view)

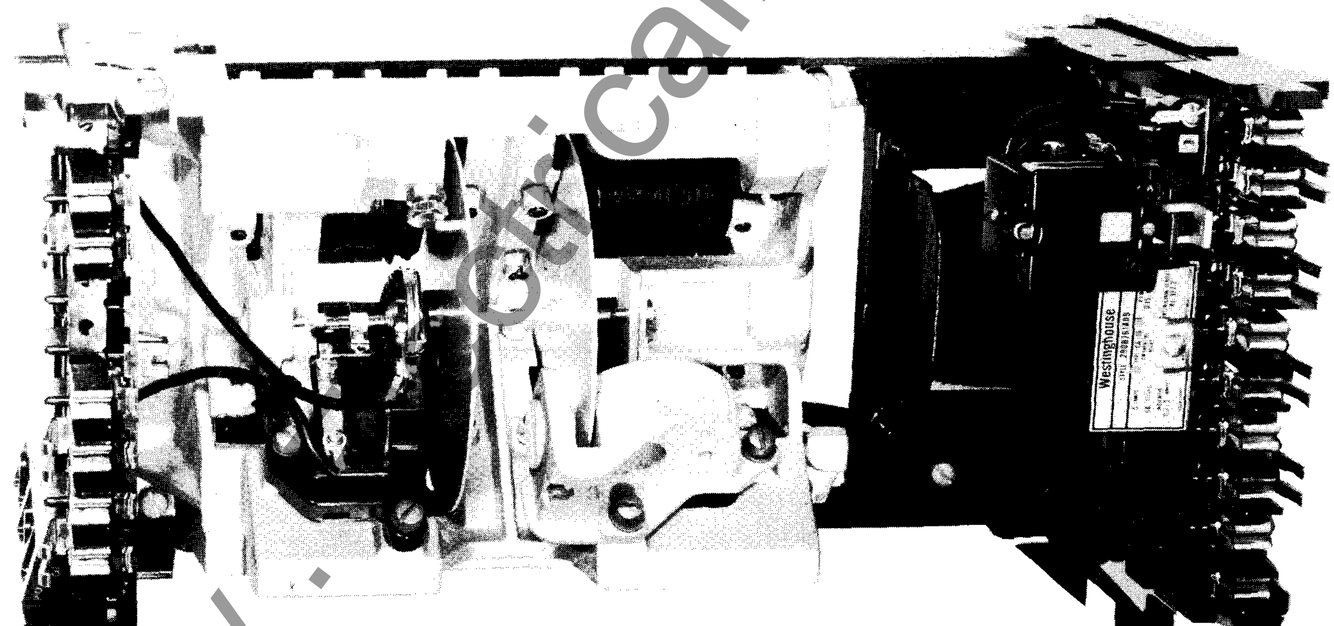


Fig. 1. Types CA-16 Relay (front view)

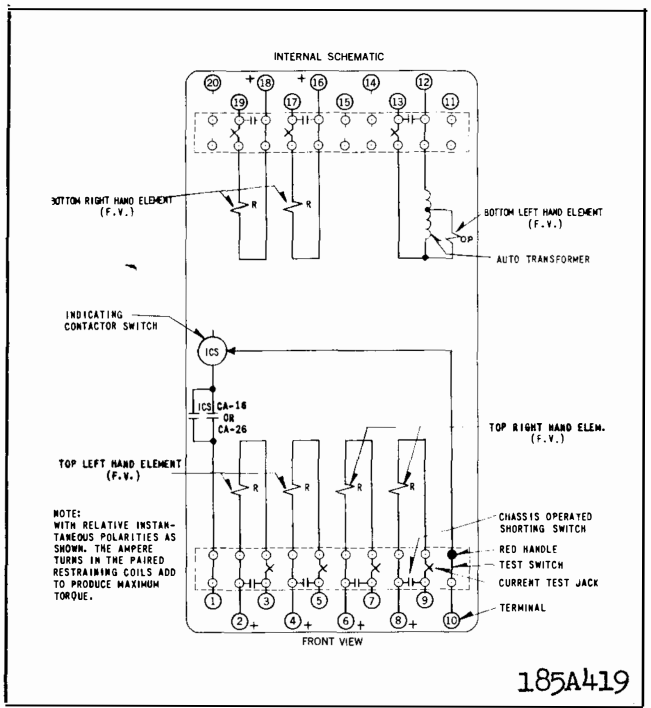


Fig. 3. Internal Schematic of the Type CA-16 Bus Relay

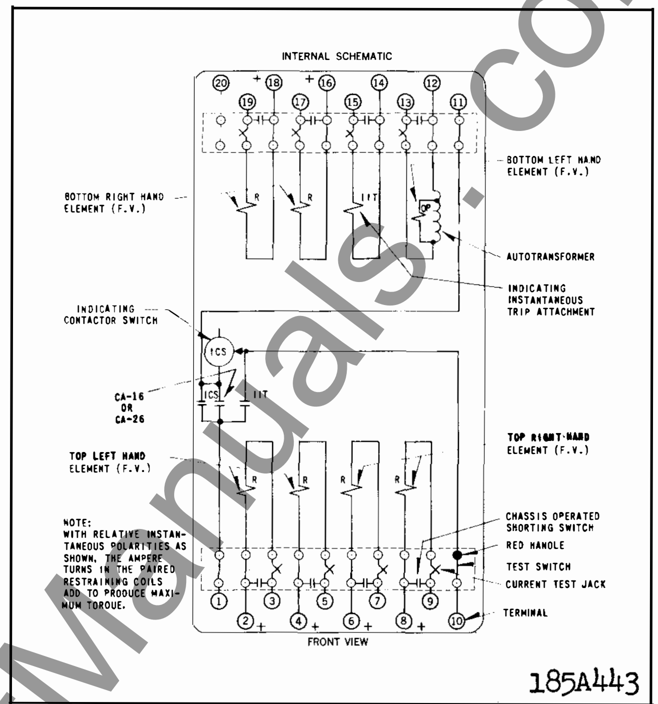


Fig. 4. Internal Schematic of the Type CA-26 Transformer Relay

bus. The secondary winding of the auto-transformer, which is a tapped section of the winding, is connected to the operating element of the relay.

The operating element consists of an "E" type laminated electromagnet with an auto-transformer winding on its center leg. Two identical coils on the outer legs of the laminated structure are connected to the secondary (tapped section) of the auto-transformer winding in a manner so that the combination of all fluxes produced by the electromagnet results in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes cause a contact closing torque.

Sensitive Fault Detector Circuit (where used)

The sensitive fault detector circuit consists of an auto-transformer and a contactor switch. The contactor switch is connected across the secondary (tapped section) of the auto-transformer winding.

The contactor switch is a small solenoid type element. A cylindrical plunger rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core, which in turn screws into the unit frame. A silver disc is fastened to the moving plunger through a helical spring. When the coil is energized, the plunger moves upward carrying the silver disc which bridges three conical-shaped stationary contacts. In this position, the helical spring is compressed and the plunger is free to move while the contact remains stationary. Thus, a-c vibrations of the plunger are prevented from causing contact bouncing. A Micarta disc is fastened to the bottom of the guide rod by two small nuts. Its position determines the pick up current of the element.

The auto-transformer is designed to saturate at high values of current to limit the amount of current to the contactor switch.

Indicating Contactor Switch Unit (ICS)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target,

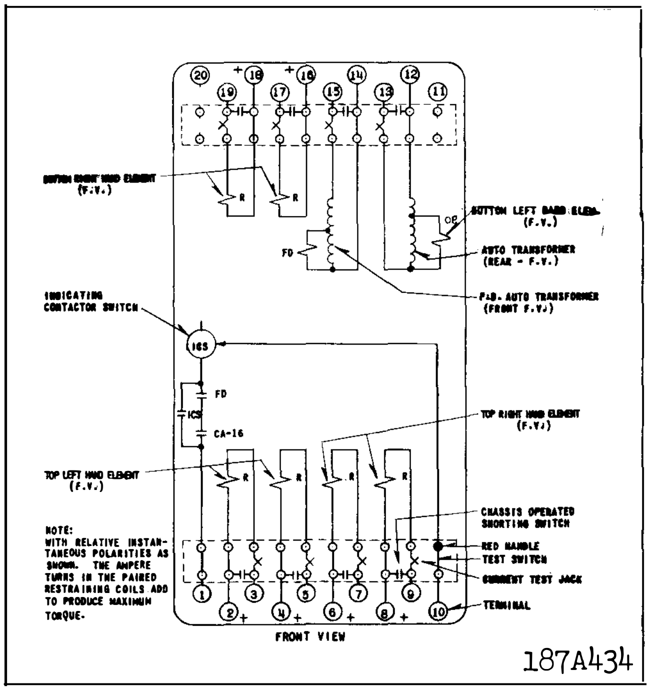


Fig. 5. Internal Schematic of the Type CA-16 Bus Relay with a Sensitive Fault Detector

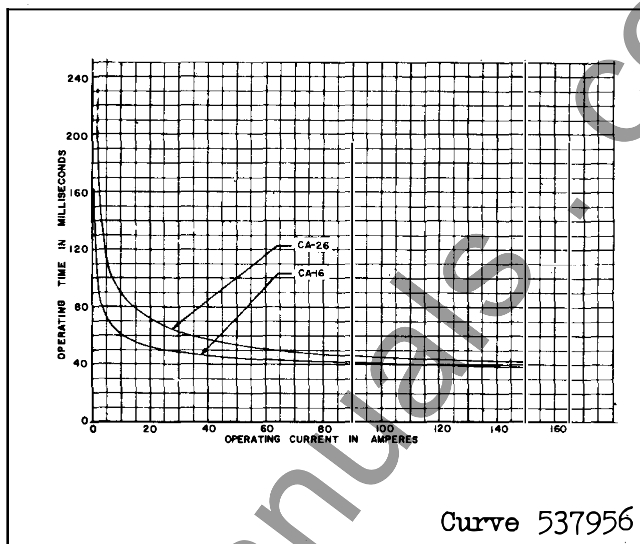


Fig. 6. Typical Time Curves of the CA-16 and CA-26 differential Relays

provides restraint for the armature and thus controls the pick-up value of the switch.

Indicating Instantaneous Trip Unit (IIT)

The instantaneous trip unit is a small a-c operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation, two fingers on the armature deflect a spring located on the front of the switch which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

A core screw accessible from the top of the switch provides the adjustable pick-up range.

OPERATION

The types CA-16 and CA-26 relays are induction disc relays with four electromagnets mounted on two discs that are fastened on a common shaft. One of the electromagnets is the operating element while the other three are restraint elements. The restraint elements are energized from the secondaries of current transformers connected to the bus, and the operating circuit is energized in accordance with the current flowing in the differential connection of the current transformers.

A current of 5 amperes in at terminal 18 and out of terminal 19 will produce a definite amount of restraining torque (see Fig. 3.) Similarly, a current of 5 amperes flowing in at terminal 16 and out of terminal 17 will produce an equal amount of torque. If both of these currents flow at the same time with the polarity as indicated above, their effect will be additive and they will produce the same torque as though 10 amperes were flowing in terminal 16 and out of terminal 17. Conversely, if equal currents flow in these two coils, but in opposite directions, their ampere turns will cancel and no torque will be produced. The same relationship applies for the paired coils of the other two restraining units of the relay.

CHARACTERISTERICS

CA-16 Bus Relay

This relay has variable percentage characteristics which means that the operating coil current required to close the relay contacts, expressed in per cent of the total restraint current, varies with the magnitude of the restraint current. The relay sensitivity is high, corresponding to a low percentage ratio, at light currents, and its sensitivity is low, corresponding to high percentage unbalance, at high currents. The relay is made sensitive at low currents in order to detect light internal faults on the bus being protected. At the same time, however, its reduced sensitivity at

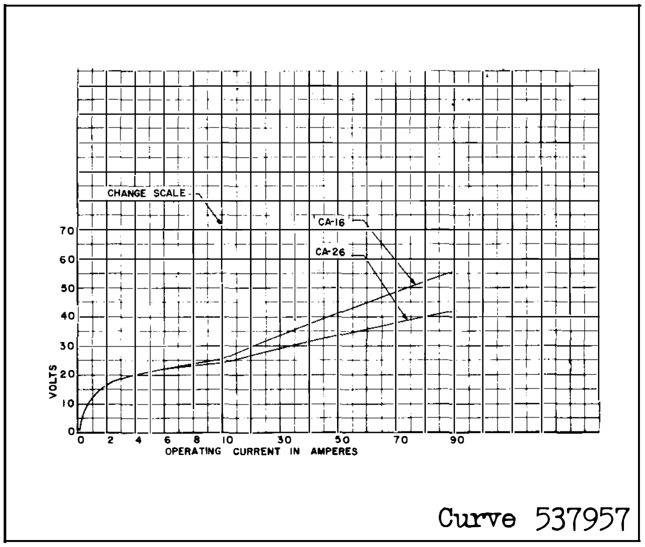


Fig. 7. Typical Burden Characteristic of the Operating Circuit of the CA-16 and CA-26 Differential Relays

the higher currents allows the various current transformers involved to depart from their true ratio to a large extent without causing false tripping of the relay for external faults.

The variable percentage characteristics are particularly advantageous when severe saturation of current transformers is caused by the d-c component of asymmetrical short circuits. In the case of buses located close to generating stations where the d-c components decay slowly, the breakdown in ratio of the current transformers will be much greater than would ever be expected from a consideration of the usual ratio curves of the current transformers involved.

The time of operation of the relays is shown in Figure 6.

CA-26 Transformer Relay

The type CA-26 transformer differential relay includes an indicating instantaneous trip unit (see Fig. 4), which operates on internal faults. The instantaneous unit should have a setting equal to the maximum rms symmetrical external fault current. Such a setting will prevent operation of the instantaneous unit when a current transformer is severely saturated by the d-c component of an asymmetrical external fault current.

Trip Circuit

The main contacts will safely close 30 amperes

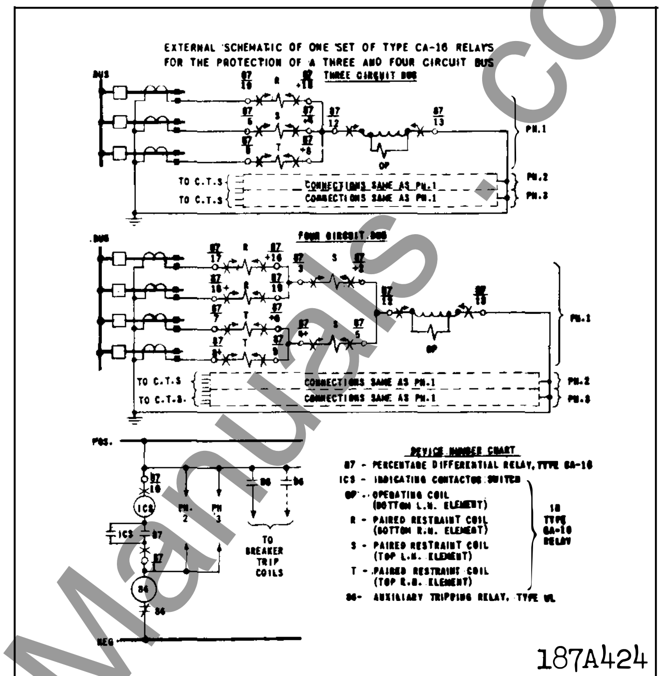


Fig. 8. External Schematic of the Type CA-16 Relays for Three and Four Circuit Bus Protection

at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating instantaneous trip contacts will safely close 30 amperes at 250 volts d-c, and will carry this current long enough to trip breaker.

The indicating contactor switch has two taps that provide a pick-up setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

Trip Circuit Constants

Indicating Contactor Switch (ICS)

0.2 ampere tap	6.5 ohms d-c resistance
2.0 ampere tap	0.15 ohms d-c resistance

ENERGY REQUIREMENTS

Burden of each restraint coil at 5 amperes

VOLT AMPERES	POWER FACTOR
.75	.7
Continuous Rating	14 amperes
1 second rating	460 amperes

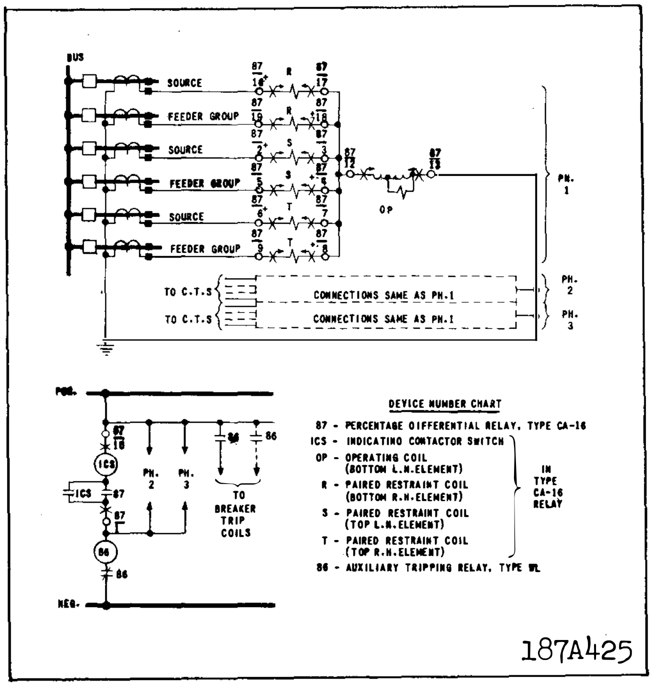


Fig. 9. External Schematic of the Type CA-16 Relays for Protection of a Six Circuit Bus with Three Feeder Groups

Burden of operating circuit

VOLT AMPERES

Variable (See Fig. 7)

Continuous rating 8 amperes

1 second rating 280 amperes

CONNECTIONS

To determine the a-c connections, identify each primary circuit as either a "source" or "feeder". As defined here, a feeder contributes only a small portion of the total fault-current contribution for a bus fault. Otherwise, the circuit is a source. Next lump a number of feeders into a "feeder group" by paralleling feeder CT's, taking the precaution that each feeder group has less than 14 amperes load current (restraint coil continuous rating). Also each feeder group should not contribute more than 10% of the total phase or ground-fault current for a bus fault.

Connect per Fig. 8 with three or four bus "circuit." The term "circuit" refers to a source or to a feeder group. For example, assume a bus consisting of 2 sources and 6 feeders. Further, assume that the feeders are lumped into 2 feeder groups. The bus now reduces to four circuits.

If the bus reduces to more than four circuits, parallel source-circuit CT's or source-and feeder-cir - CT's until only four circuits remain. Then connect these four sets of CT's to the relays per Fig. 8. The exception to this rule occurs when the application consists of three feeder groups. Then, Fig. 9 applies.

With 3 feeder groups and more than 3 sources, parallel source CT's until the application reduces to 6 circuits; then, connect to the relays per Fig. 9.

SETTING CALCULATIONS

No calculations are required to set the CA-16 and CA-26 relays.

SETTING THE RELAY

No settings are required on either the CA-16 or the CA-26 main units.

Indicating Contactor Switch (ICS)

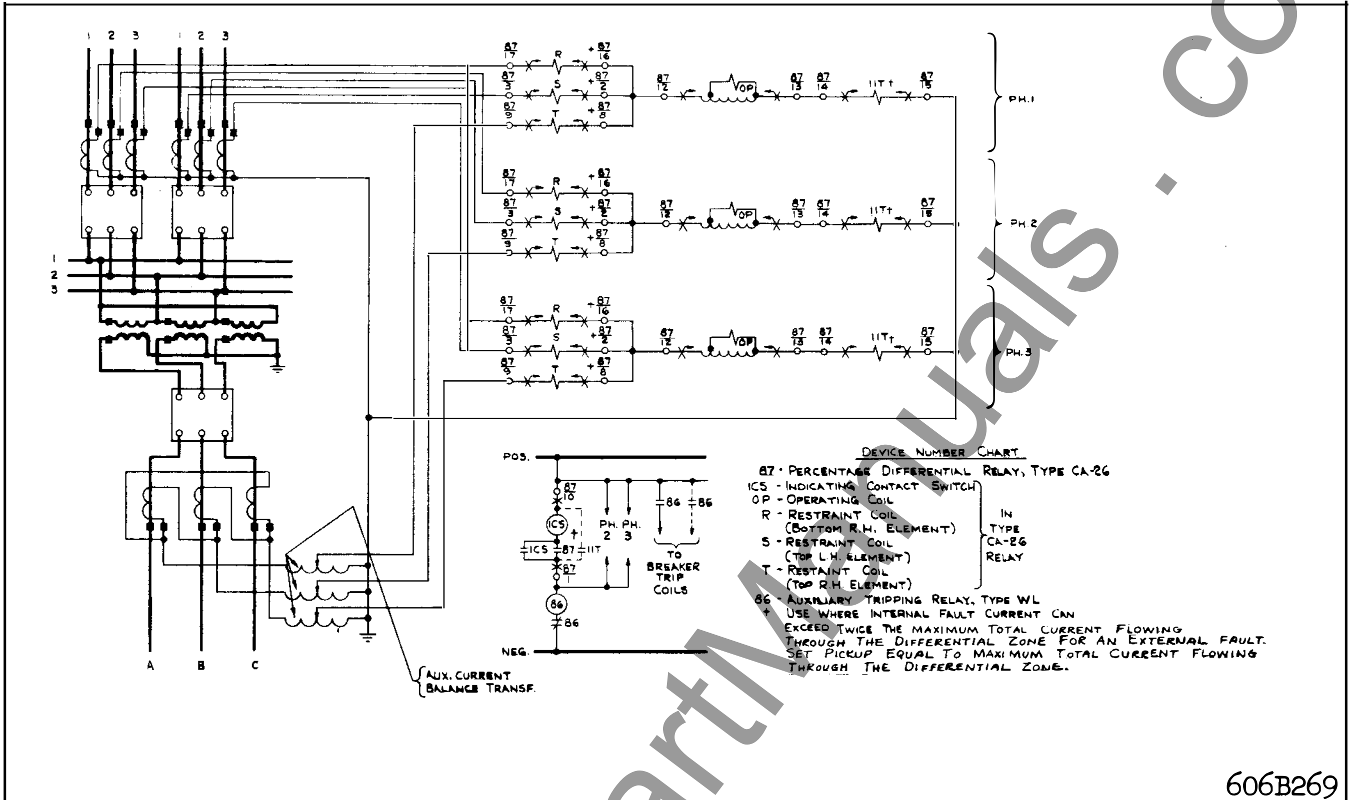
No setting is required on the ICS unit except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a 125 or 250 volt d-c WL relay switch or equivalent, use the 0.2 ampere tap; for 48 volt d-c applications set relay in 2 tap and use WL relay coil S#304-C209G01 or equivalent.

Indicating Instantaneous Trip (IIT)

Since the minimum and maximum markings on the scale only indicate the working range of the core screw must be adjusted to the value of pick-up desired. It is recommended that the IIT be set to pick up at a value of current that is equal to the maximum rms symmetrical external fault current to the relay.

INSTALLATION

The relays should be mounted on a switchboard panel or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting



** Fig. 10. External Schematic of the Type CA-26 Relay for Transformer Protection and Bus Protection*

or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments other than those covered under "SETTINGS" should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order.

A. Minimum Trip Current

Apply current to terminals 12 and 13 of the relay. The relay should operate as follows:

1. CA-16	0.15 amperes ± 5%
2. CA-26	1.25 amperes ± 5%

B. Percentage Differential Characteristic

Apply 19 amperes to terminals 12 and 13 of the CA-16 relay or 38 amperes to terminals 12 and 13 of the CA-26 relay. The contacts should open when the following restraint current is applied to the relay with connections of Fig. 11.

CA-16	16.5 ± 5% amperes
CA-26	14.5 ± 5% amperes

Check each individual restraint winding by applying 20 amperes to each winding. Apply sufficient operating current to the operating circuit until the contacts just close. The operating current should be:

CA-16	1.0 ± 5% amperes
CA-26	3.5 ± 5% amperes

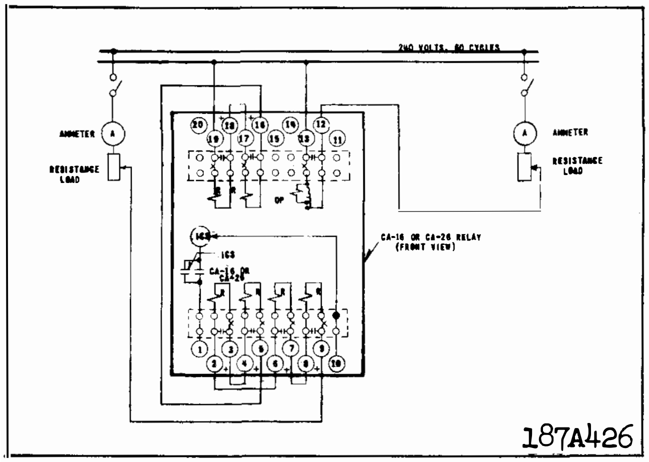


Fig. 11. Diagram of Test Connections for the CA-16 and CA-26 Relays

C. Time Curve

Apply 20 amperes to terminals 12 and 13 of the relays. The contacts should close in the following times:

CA-16	52 ± 5% Milliseconds
CA-26	72 ± 5% Milliseconds

D. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contact of the ICS. This value of current should not be greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

The contact gap should be approximately .047 inch between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

E. Indicating Instantaneous Unit (IIT)-Where supplied)

The core screw which is adjustable from the top of the trip unit determines the pick-up value. The trip unit has a nominal ratio of adjustment of 1 to 4 and an accuracy within the limits of 10%.

The making of the contacts and target indication should occur at approximately the same instant. Position the stationary contact for a minimum of 1/32 inch wipe. The bridging moving contact should touch both stationary contacts simultaneously. Apply sufficient current to operate the IIT.

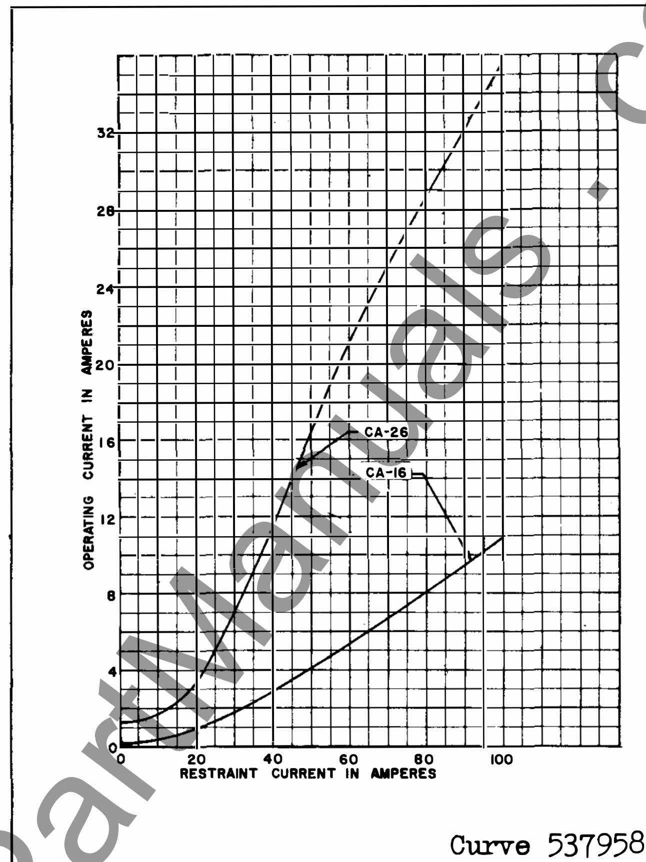


Fig. 12. Percentage Slope Curve of the CA-16 and CA-26 Relays with One Restraint Winding

F. Sensitive Fault Detector (where supplied)

Apply current to terminals 14 and 15 of the relay. The fault detector should operate between the limits of 0.142 to 0.158 amperes.

Routine Maintenance

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order. (See "Acceptance Check").

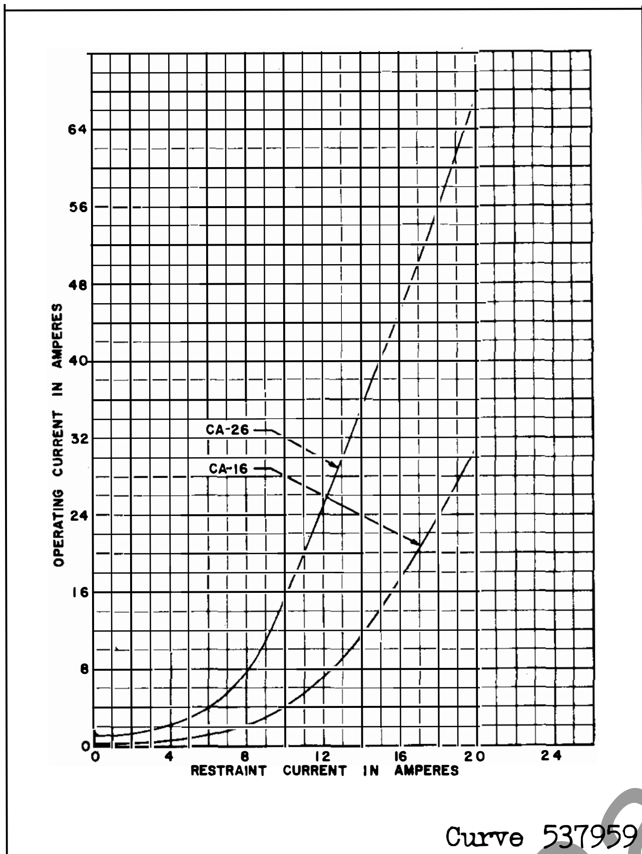


Fig. 13. Percentage Slope Curve of the CA-16 and CA-26 Relays with Six Restraint Windings in Series

1. Contacts

Adjust the adjustable stop screw on the upper disc of the relay so that a contact separation of 0.050 inch is obtained between the moving contact and the stationary contact. Lock the screw with the nut provided for the purpose.

2. Minimum Trip

The relay should be level for this test. Minimum trip current can best be determined with the permanent magnet removed.

Adjust the spring tension until the relay just closes its contacts with the following current applied to terminals 12 and 13 of the relay.

CA-16	0.15 amperes
CA-26	1.25 amperes

3. Percentage Slope Characteristic

Connect the relay per the test circuit of Fig. 11. Pass 19 amperes for the CA-16 and 38 amperes for the CA-26 relay into terminals 12 and 13 of the relay. Adjust the plug in the operating electromagnet until the contacts just close with the following currents into the restraint circuits of the relays.

CA-16	16 to 17 amperes
CA-26	14 to 15 amperes

4. Time Curve

Place the permanent magnet on the relay and apply 20 amperes to terminals 12 and 13 of the relay. Adjust the keeper of the permanent magnet until the contacts just close in the following times:

CA-16	52 ± 5% milliseconds
CA-26	72 ± 5% milliseconds

These times should be the average of 5 readings

5. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

6. Indicating Instantaneous Trip Unit (IIT)

The core screw must be adjusted to the value of pick-up current desired. It is recommended that the IIT be set to pick-up at a value of current that is equal to the maximum rms symmetrical external fault current to the relay.

7. Sensitive Fault Detector

Loosen the lock nut at the top of the element and run the core screw down until it is flush with the top of the lock nut. Back off the Micarta disc by loosening the two lock nuts. Apply 0.15 amperes to terminals 14 and 15. Operate the moving element by hand and allow the current to hold the moving contact disc against the stationary contacts. Now, screw up the core screw slowly. This causes the plunger to move up, compressing the spring until a point of maximum deflection is reached. Further upward motion will cause the plunger to drop part way out of the coil, thus diminishing the spring pressure on the contacts. By thus adjusting the core screw up or down the maximum spring deflection for this value of current may be found. Then lock the core screw in place. Next, adjust the de-energized position of the plunger by raising the Micarta disc until the plunger just picks up electrically at the 0.15 ampere value.

Electrical Checkpoints

Figures 12 and 13 will aid in trouble shooting either the CA-16 or the CA-26 relays. These curves show the operating current to trip the relay for different restraint currents for one restraint element as well as for six restraint elements connected in series.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

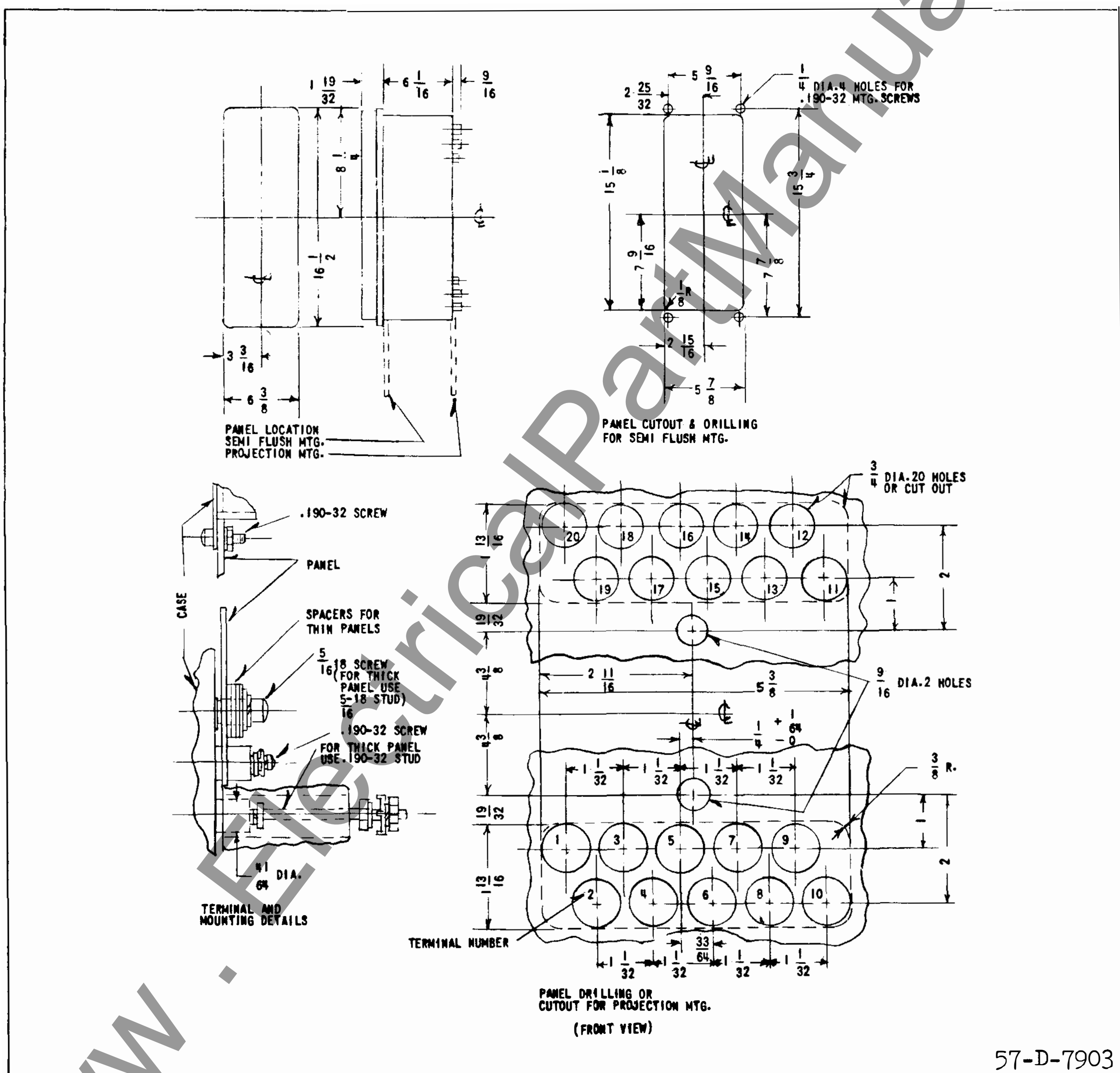


Fig. 14. Outline and Drilling for the CA-16 and CA-26 Relays in FT-32 Case.

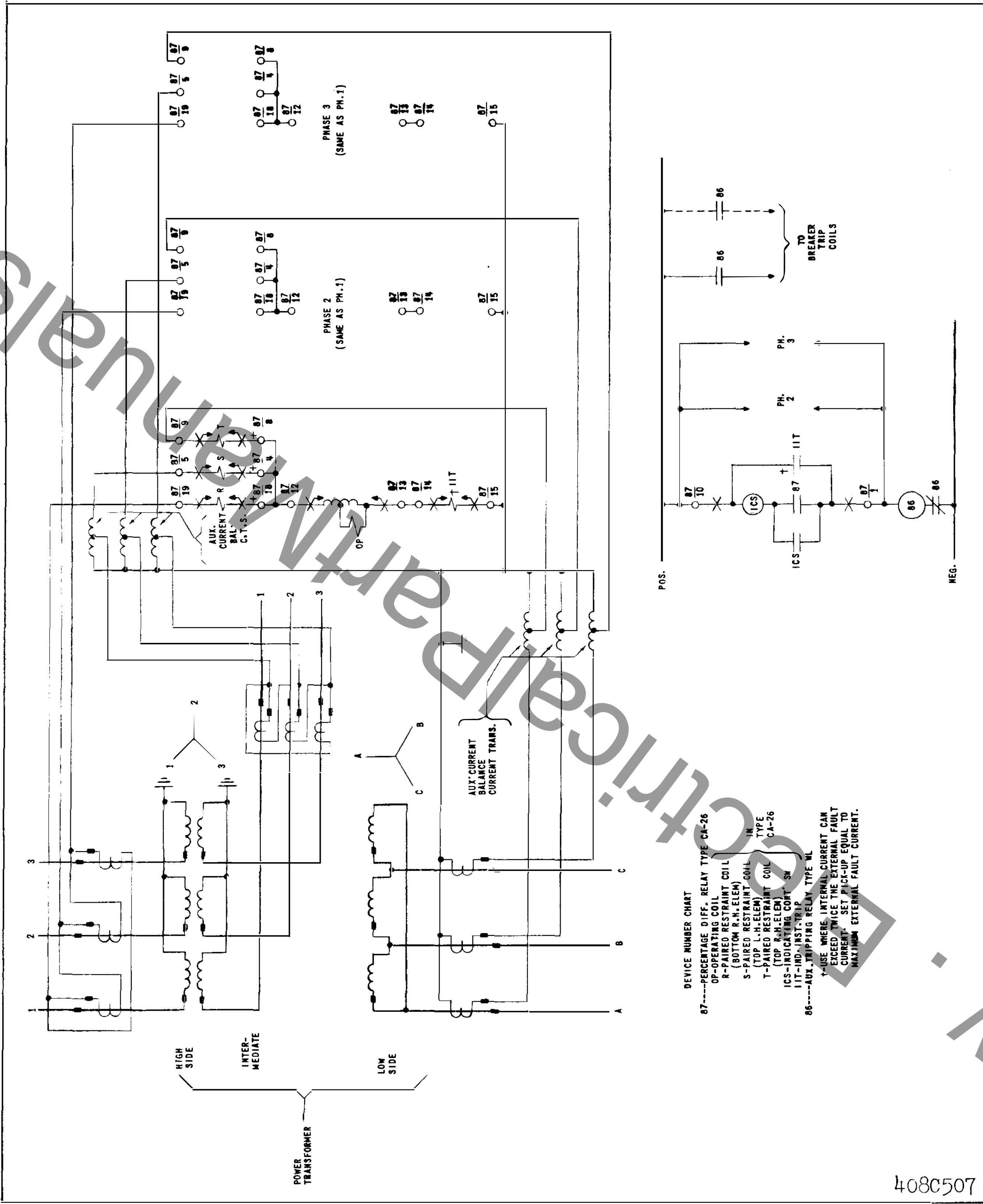


Fig. 15. External Schematic of the Type CA-26 Relay for Wye-Wye-Delta Transformer Protection

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE CA-6 PERCENTAGE DIFFERENTIAL RELAY

FOR BUS AND TRANSFORMER PROTECTION ◆

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The type CA-6 percentage differential relay is usually applied for the differential protection of multi-circuit buses. The application of the CA-6 relays for bus differential protection may be divided into three categories. (In the following discussion an equivalent circuit is defined as a major source or a group of feeder circuits. The fault current contribution of all the paralleled feeders should not exceed 5% of the total phase or ground fault current, with normal bus connections.)

A) GENERATING STATION BUSES - FOUR EQUIVALENT CIRCUITS OR LESS - DC TIME CONSTANT OF 0.6 CYCLES (0.01 Sec.) OR MORE.

If the following requirements are met, the CA-6 may be satisfactorily applied:

1) The maximum external fault current through the bus should not exceed 100 symmetrical RMS secondary amperes.
2) The magnetizing current of the current transformers carrying a total external fault current of 100 symmetrical secondary amperes should not exceed one secondary ampere.

B) GENERATING STATION BUSES - MORE THAN FOUR EQUIVALENT CIRCUITS - DC TIME CONSTANT OF 0.6 CYCLES (0.01 Sec.) OR MORE.

The same requirements as in (A) apply. However, consideration must be given to the restraint coil connections.

Where more than 4 equivalent circuits are present, it is rarely necessary to provide two relays per phase. With little or no compromise in the protection scheme, one relay can handle at least 8 equivalent bus circuits. (See "Connections" for further discussion.)

C) SUBSTATION BUSES - DC TIME CONSTANT OF 0.6 CYCLES (0.01 Sec.) OR LESS.

If the following requirements are met, the CA-6 may be satisfactorily applied:

1) The maximum external fault current through the bus should not exceed 100 symmetrical RMS secondary amperes.
2) The magnetizing current of the current transformers carrying a total external fault current of 100 symmetrical secondary amperes should not exceed *ten secondary amperes.*

Where more than 4 equivalent circuits are present, it is rarely necessary to provide two relays per phase. With little or no compromise in the protection scheme, one relay can handle at least eight equivalent bus circuits. (See "Connections" for further discussion.)

A type CA-6 transformer relay is also available for 3 winding transformer protection. The standard bus relay should not be utilized for transformer differential applications.

CONSTRUCTION

The type CA-6 relay consists of three restraining elements (two restraining windings per element), one operating element, and an indicating contactor switch. The type CA-6 transformer relay also contains an indicating instantaneous trip unit.

SUPERSEDES I.L. 41-337.1C
*Denotes change from superseded issue.

EFFECTIVE SEPTEMBER 1960

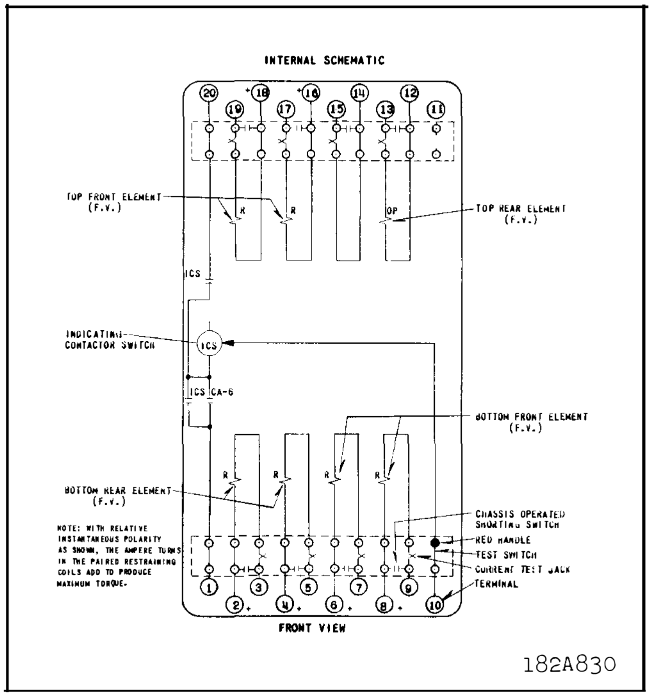


Fig. 1. Type CA-6 Relay for Bus Protection in Type FT-32 Case.

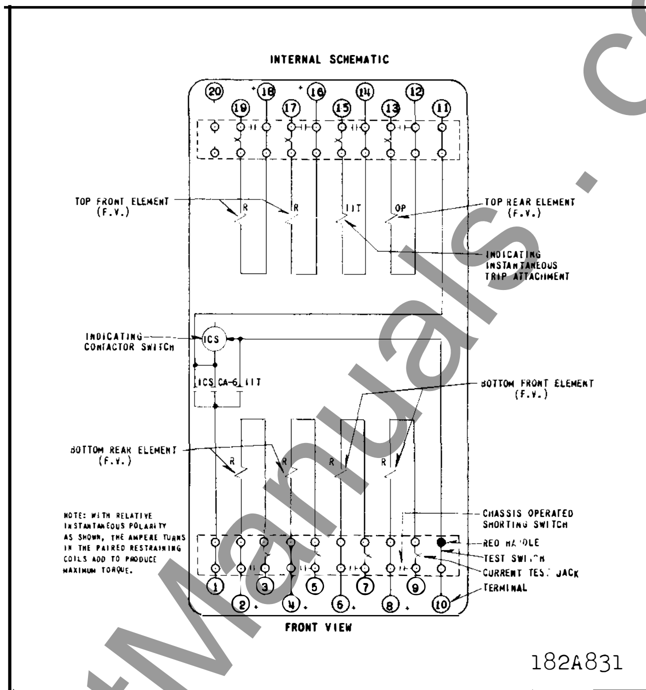


Fig. 2. Type CA-6 Relay for Transformer Protection, With Indicating Instantaneous Trip in FT-32 Case.

The relay operates on the induction-disc principle and consists of four electromagnets operating on two discs which are fastened to the same shaft. Three of the electromagnets are restraining elements with two separate restraining windings connected to receive the secondary currents from the various current transformers (Fig. 1 & 2). The fourth electromagnet is the operating element with its winding connected to receive the differential or unbalance current thru an auxiliary current transformer. Taps are provided on this current transformer to control the sensitivity of the relay.

The two induction discs are mounted on a vertical shaft. The lower bearing for the shaft is a steel ballriding between concave sapphire jewel surfaces. A pin bearing is used on the upper end of the shaft.

The moving contact assembly is attached to a Micarta bushing on the disc shaft. When the moving contact strikes the stationary contact, the moving contact spring deflects to provide a wiping action. The electrical connection from the moving contact is made thru the spiral spring to the spring adjuster.

INDICATING CONTACTOR SWITCH UNIT (ICS)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contact, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup value of the switch.

INDICATING INSTANTANEOUS TRIP UNIT (IIT)

The instantaneous trip unit is a small a-c operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts completing the trip circuit. Also during the operation two fingers on the armature deflect a spring located on the front of the switch which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

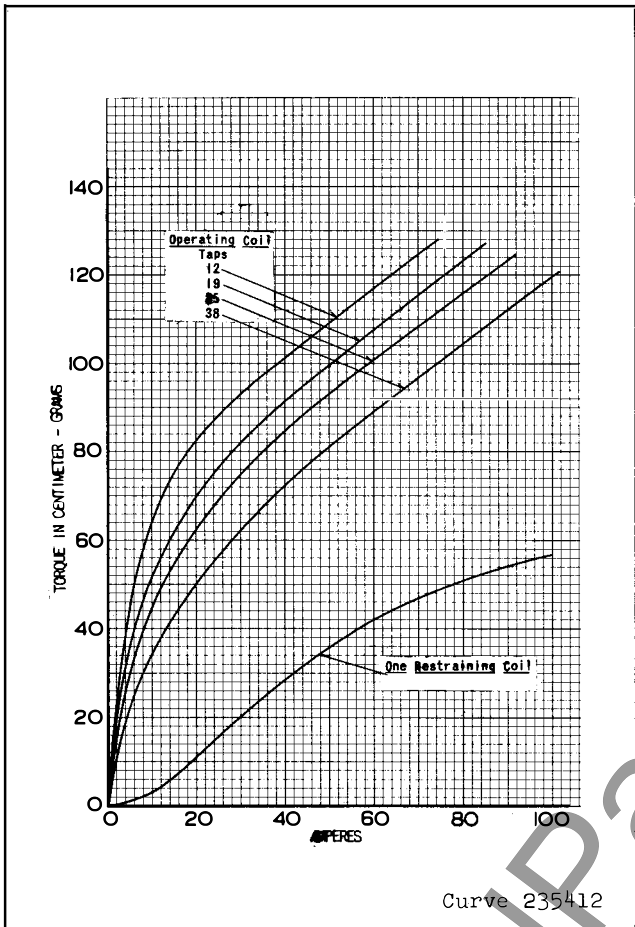


Fig. 3. Typical Torque Curves of the Operating & Restraint Coils.

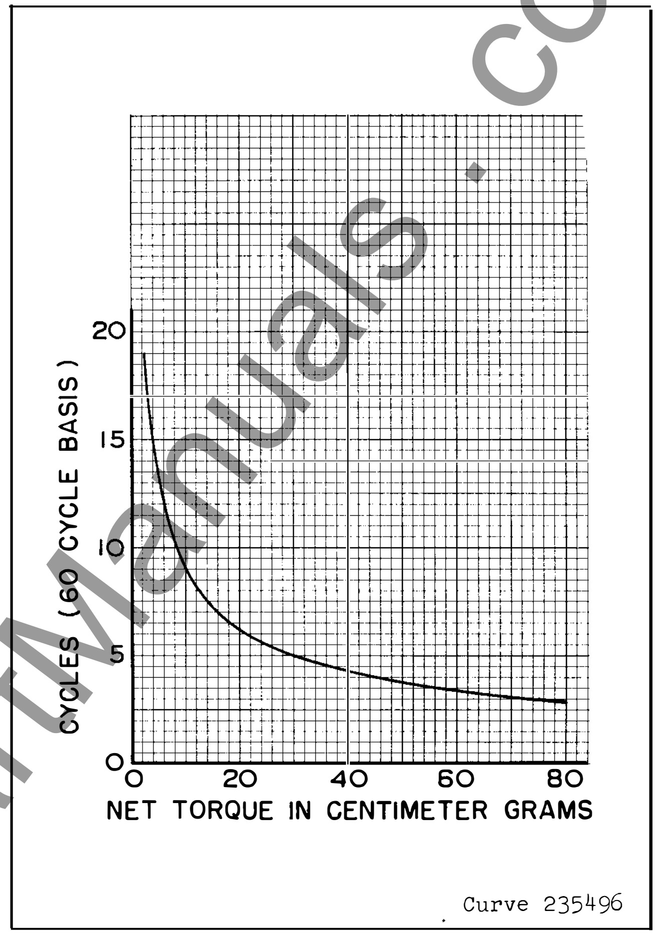


Fig. 4. Typical Differential Unit Time Curve.

* A core screw accessible from the top of the switch provides the adjustable pickup range.

OPERATION

The CA-6 relay has three restraining elements, each with two windings which are energized from the secondaries of current transformers connected to the bus. The relay has one operating electromagnet energized through an external auxiliary current transformers in accordance with the current flowing in the differential connection of the current transformers.

Refer to the internal schematic, Fig. 1. A current of 5 amperes in at terminal 18 and out of terminal 19 will produce a definite amount of restraining torque as indicated in Fig. 3. Similarly, a current of 5 amperes flowing in at terminal 16 and out of terminal 17 will produce an equal amount of torque. If both of these currents flow at the same time with the polarity as indicated above, their effect will be additive and they will produce the same torque as though 10 amperes were flowing in one winding alone. Conversely, if equal currents flow in these two coils, but in opposite directions, their ampere turns will cancel and no torque will be produced. The same relationship applies for the other two restraining units of the relay.

This relay has variable percentage characteristics which means that the operating coil current required to close the relay contacts, expressed in percent of the total restraint current, varies with the magnitude of the restraint current. The relay sensitivity is high, corresponding to a low percentage ratio, at light currents, and its sensitivity is

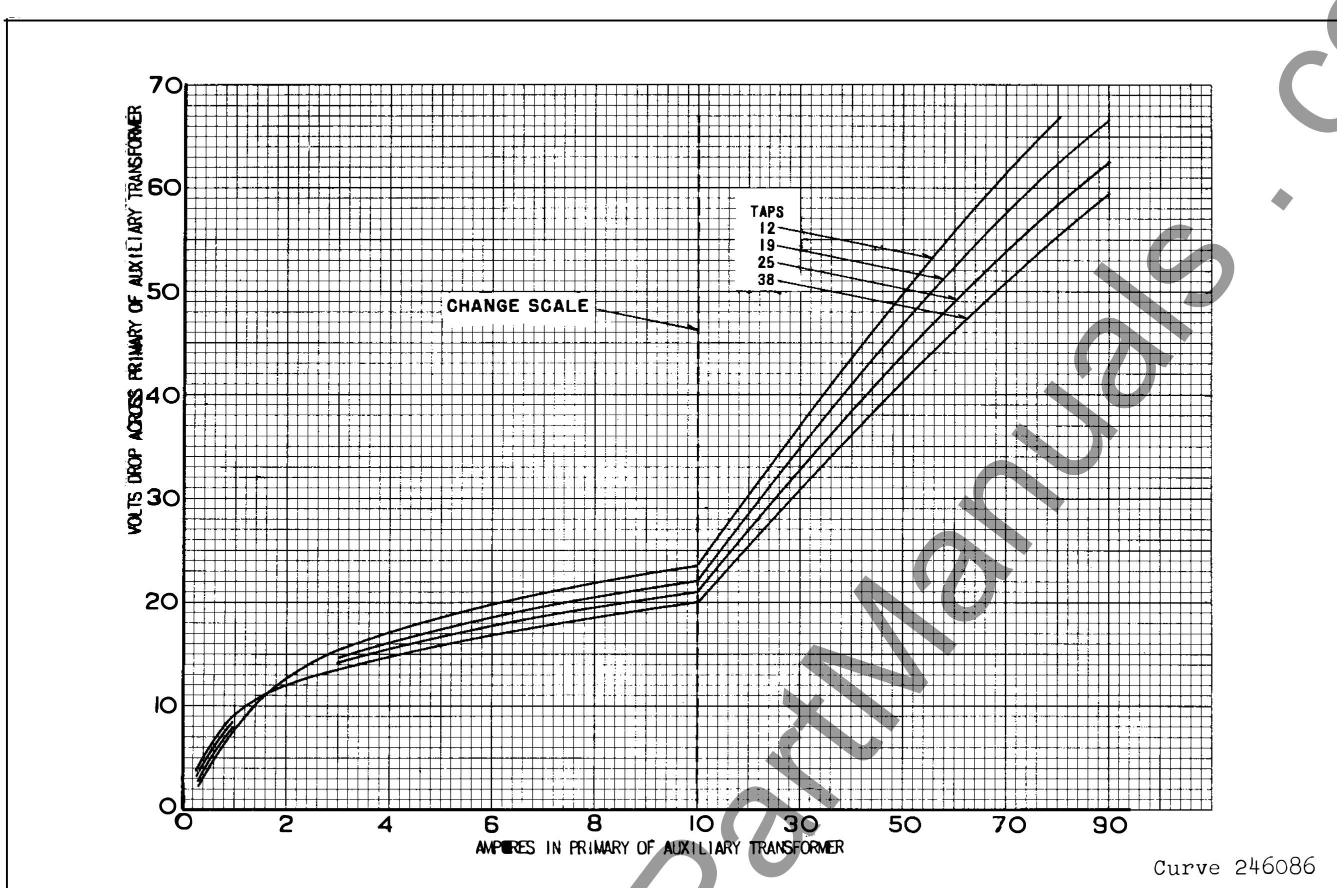


Fig. 5. Typical Burden Characteristics of The Operating Coil Circuit

low, corresponding to high percentage unbalance, at high currents. The relay is made sensitive at low currents in order that it will detect light internal faults on the bus being protected. At the same time, however, its reduced sensitivity at the higher currents allows the various current transformers involved to depart from their true ratio to a large extent without causing false tripping of the relay for external faults.

The variable percentage characteristics are particularly advantageous when severe saturation of current transformers is caused by the d-c component of asymmetrical short circuits. In the case of buses located close to generating stations where the d-c component decays slowly, the breakdown in ratio of the current transformers will be much greater than would ever be expected from a consideration of the usual ratio curves of the current transformers involved.

CHARACTERISTICS

There are no taps inside the relay case. Taps controlling the sensitivity of the relay are incorporated in the external current transformer (see Fig. 11 for internal wiring.) The tap markings are: 12 - 19 - 25 - 38. These tap values, as indicated on the torque curves of Fig. 3, are the 60 cycle amperes required in the operating coil circuit to close the relay contacts against a 70 cmg. restraint torque.

Time of operation of the relay is shown in Fig. 4. To use this curve, determine the total restraining torque and substract this from the operating coil torque to determine the net torque in cmg. This curve applies only for a contact spacing of 1/4 inch.

TRANSFORMER RELAY

The type CA-6 transformer differential relay includes an indicating instantaneous trip unit (See Fig. 2) and has a stronger spiral control spring than the bus differential relay. The instantaneous trip unit is intended to operate on internal faults on the order of 100 amps. (secondary) or higher because, when a transformer bank is connected to a high

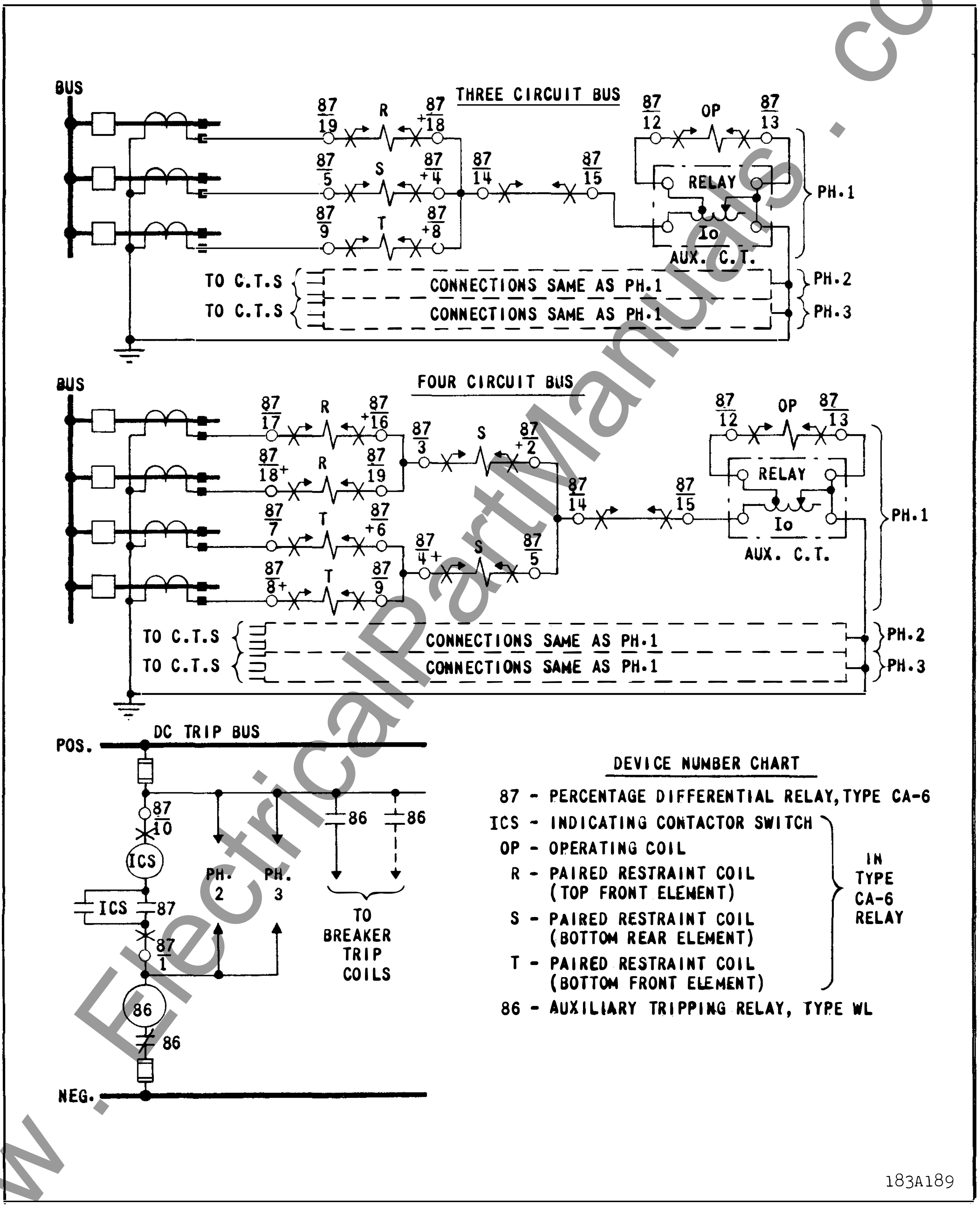


Fig. 6. External Schematic of One Set of Type CA-6 Relays for Three and Four Circuit Bus Protection.

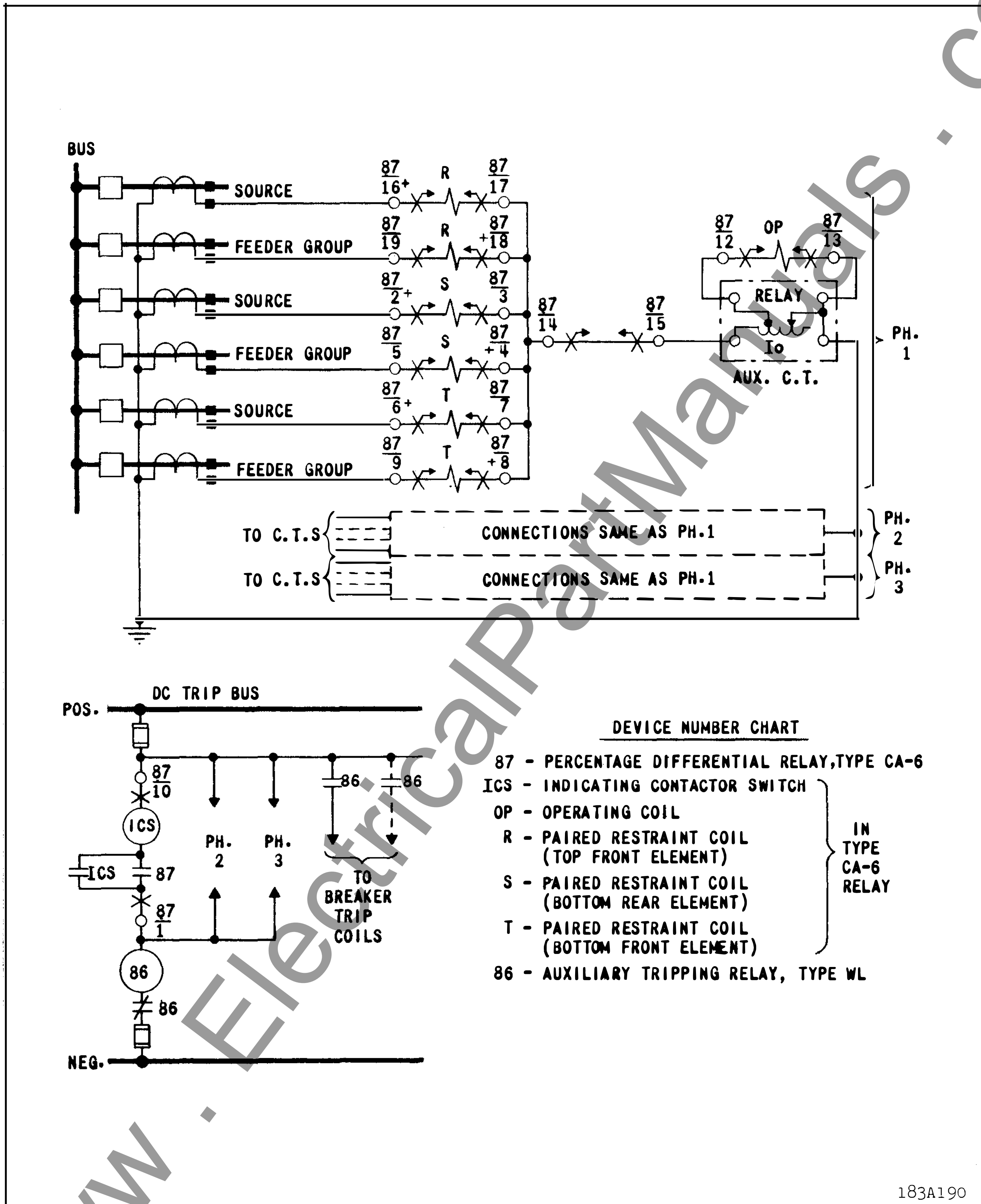


Fig. 7. External Schematic of One Set of Type CA-6 Relays for Protection of a Six Circuit Bus With Three Feeder Groups.

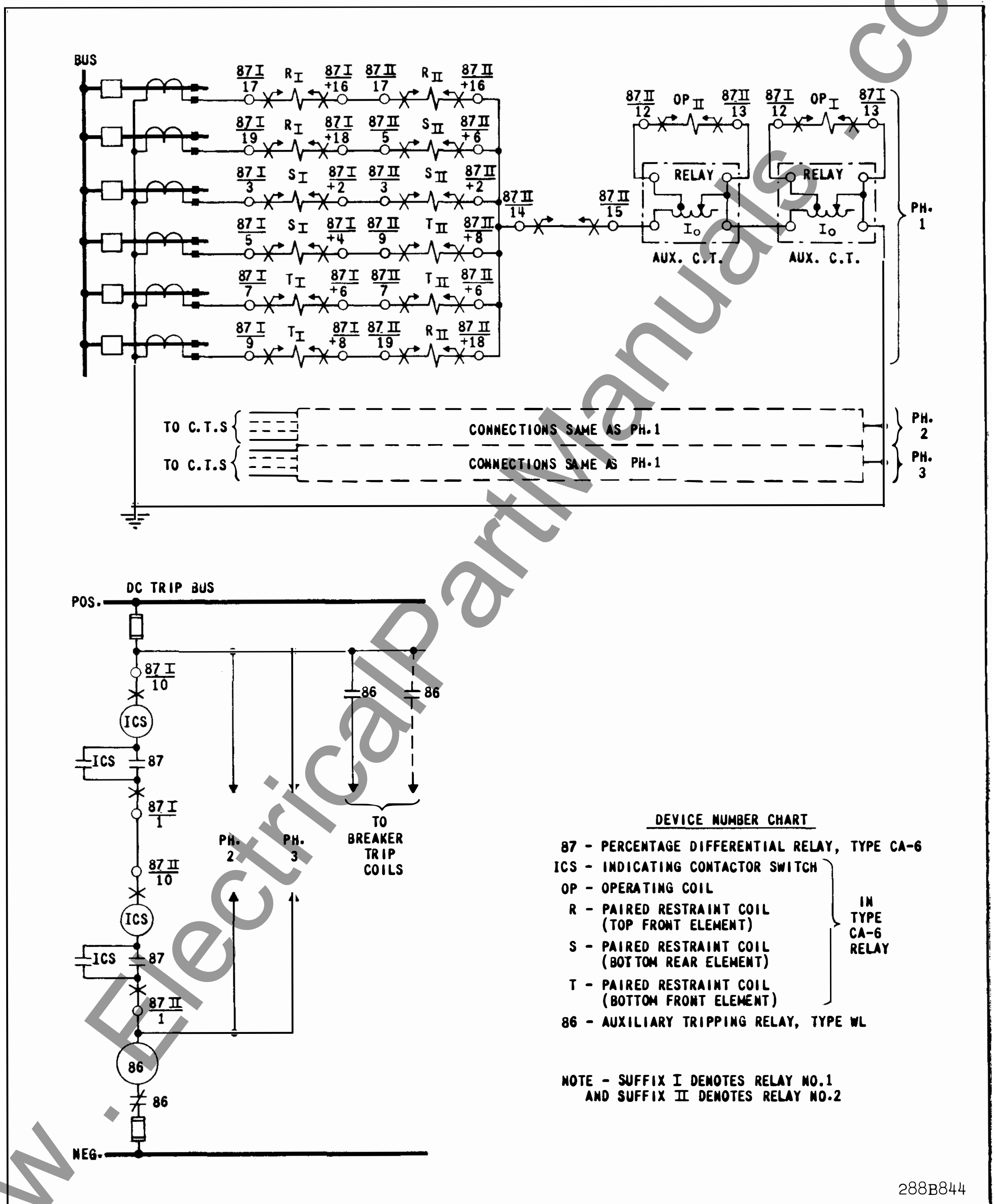


Fig. 8. External Schematic of Two Sets of Type CA-6 Relays for Six Circuit Bus Protection.

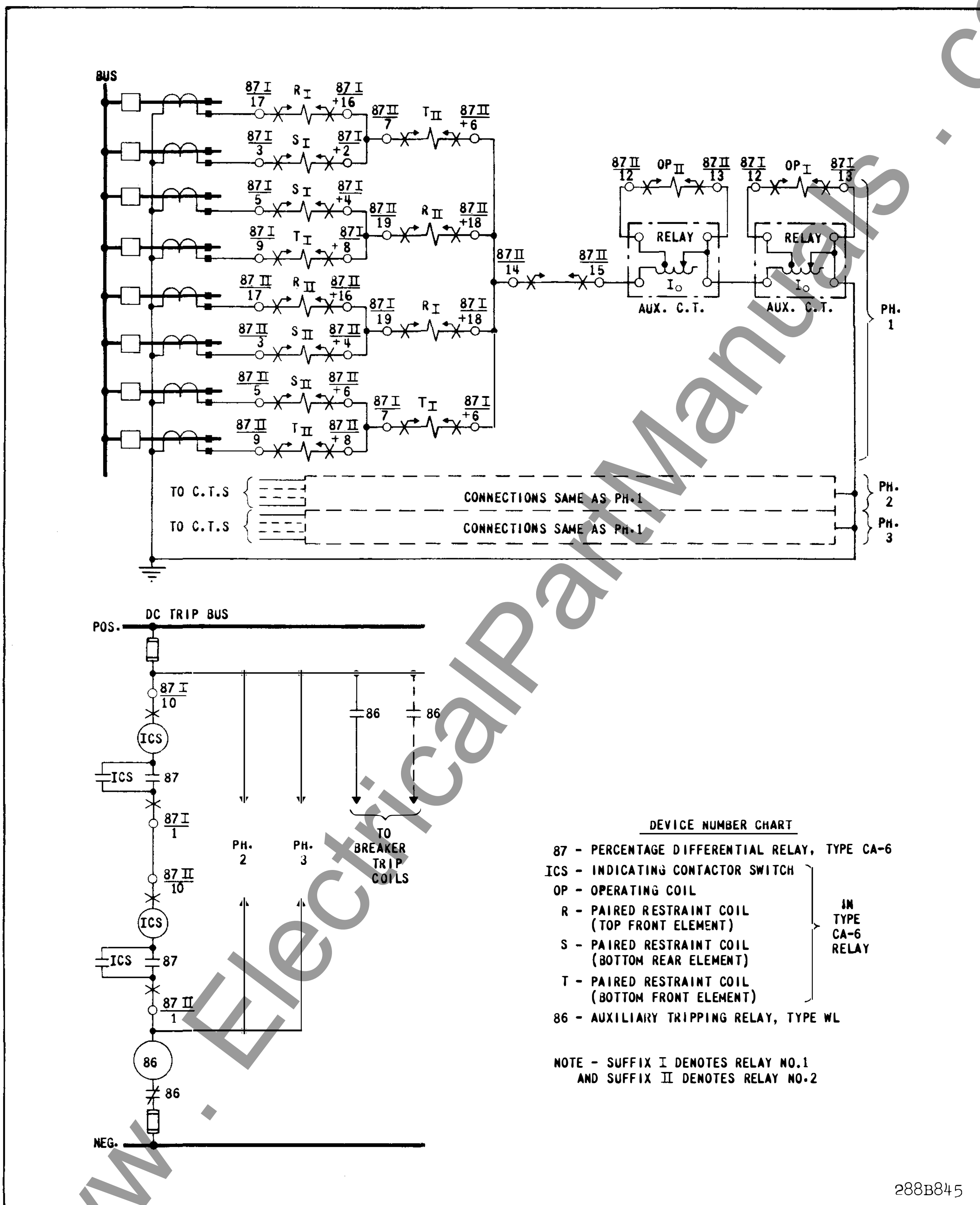
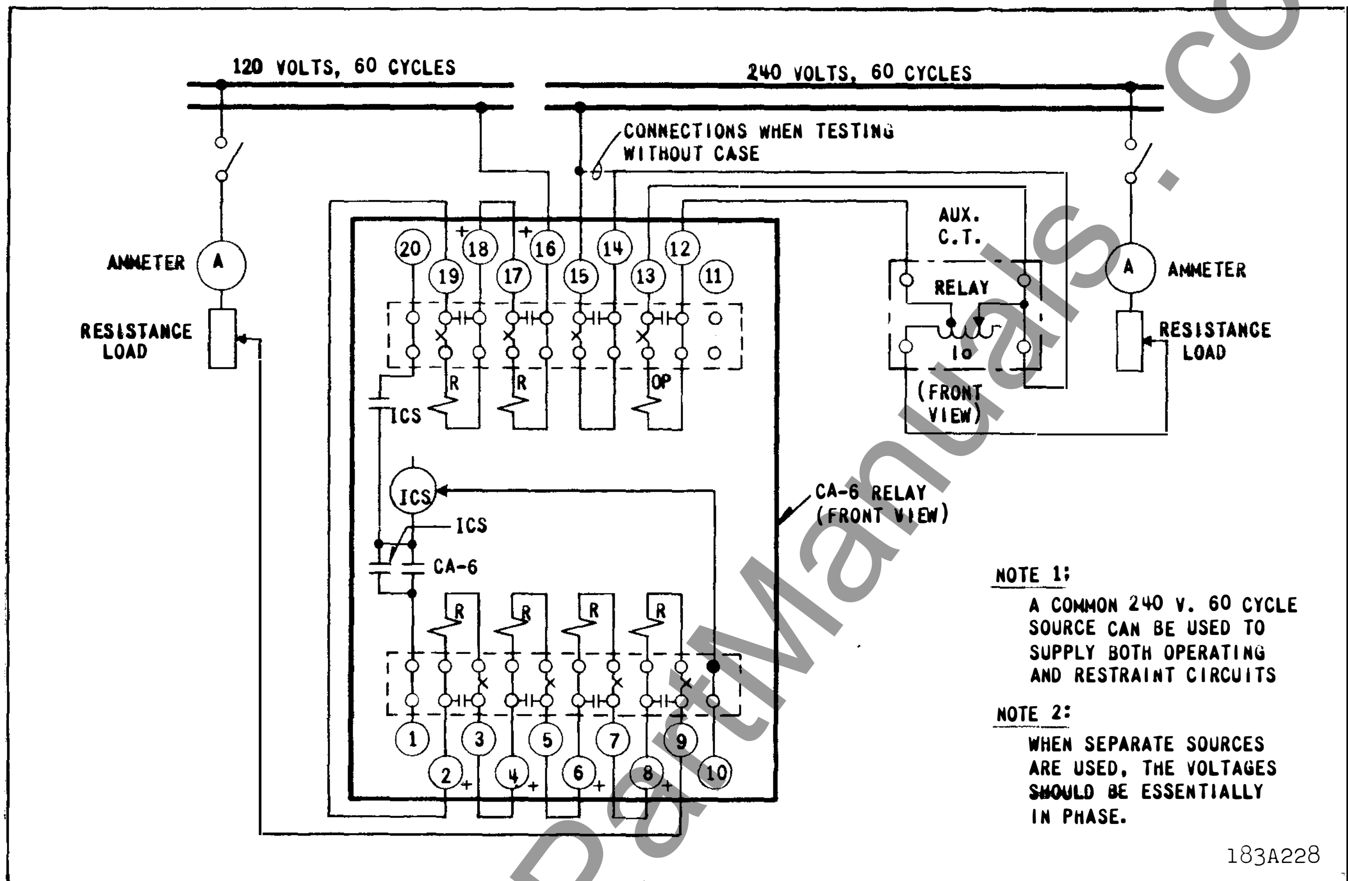


Fig. 9. External Schematic of Two Sets of Type CA-6 Relays for Eight Circuit Bus Protection.



✱ Fig. 10. Diagram of Test Connections for the type CA-6 Relay.

capacity bus, it is difficult to keep the maximum internal fault currents down to a 100 ampere value. Thus, the instantaneous unit assures prompt tripping at excessively high current values. At the same time, the instantaneous unit should not have a setting substantially lower than 100 amperes (secondary) in order to avoid a possible false operation for external faults. The stronger spiral control spring is provided in order that the relay maybe given a higher minimum trip setting, as noted under "Adjustments and Maintenance".

TRIP CIRCUIT

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating instantaneous trip contacts will safely close 30 amperes at 250 volts d-c, and will carry this current long enough to trip a breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

TRIP CIRCUIT CONSTANT

Indicating Contactor Switch (ICS)

0.2 ampere tap 6.5 ohms d-c resistance
2.0 ampere tap 0.15 ohms d-c resistance

✱ ENERGY REQUIREMENTS

Burden of each Restraint Coil at 5 amps.

VOLT AMPERES	POWER FACTOR
.75	.7

Continuous Rating	10 Amperes
1 Second Rating	250 Amperes

Burden of Operating Circuit

VOLT AMPERES

Variable See Fig. 5

Continuous Rating	5 Amperes
1 Second Rating	150 Amperes

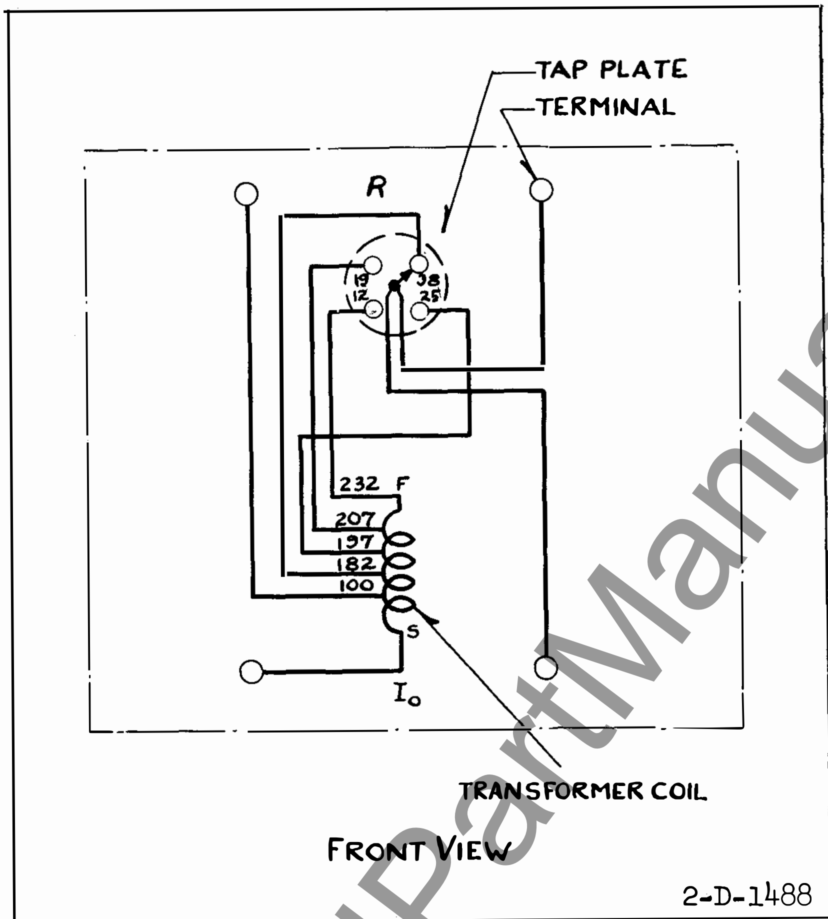


Fig. 11. Internal Wiring Diagram of the Auxiliary Current Transformer.

CONNECTIONS

One relay per phase is normally recommended for the protection of buses with up to 8 "equivalent circuit" connections. An "equivalent circuit" is defined as major source or a group of feeder circuits. The grouped feeder circuits' fault contribution should not exceed 5% of the total phase or ground fault current, with normal bus connections. In paralleling current transformers for the feeder group or groups, the load current distribution should be examined to insure that the 10 ampere continuous rating of the relay restraint windings is not exceeded.

The recommended connections are outlined in Table I.

TABLE I

Case	Total No. of Eq. Ckts.	No. of Feeder Groups	Connections
I	3	0-2	Fig. 6
II	4	0-3	Fig. 6
III	5	0-1	Note 1
IV	5	2-4	Fig. 7
V	6	0-1	Note 1
VI	6	2-5	Fig. 7
VII	7	0-6	Note 1
VIII	8	0-7	Note 1

Note 1 -- Same as 4 circuit bus of Fig. 6 except parallel CT's in pairs. (1 set in parallel for 5 ckt. bus, 2 for 6 ckt. bus, etc.)

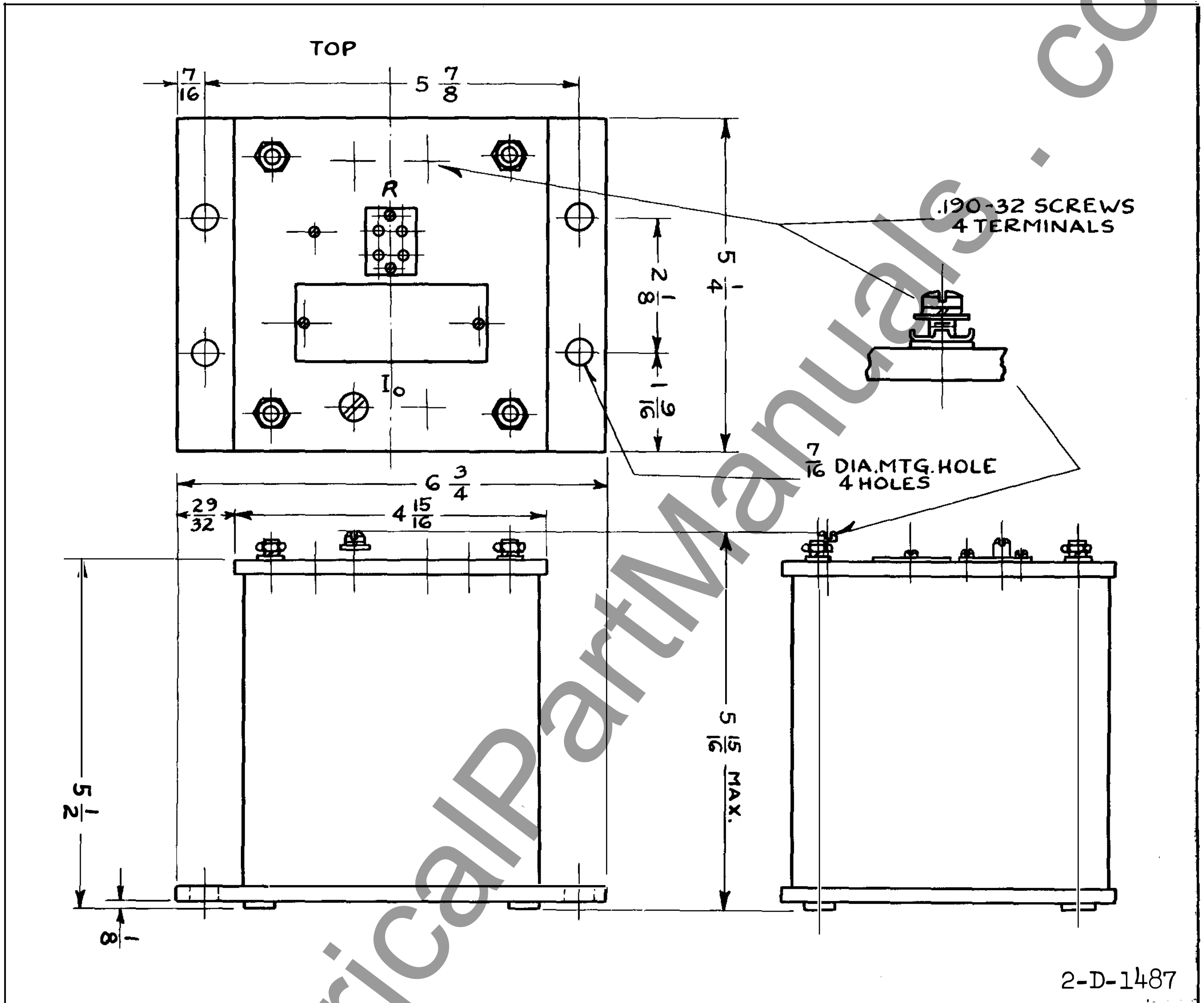


Fig. 12. Outline & Drilling Plan of the Auxiliary Current Transformer.

In cases III, V, VII, and VIII of Table I, at least one pair of current transformers is paralleled. Almost complete restraint cancellation will occur on an external fault, if all but two of the circuits are out of service and if the remaining circuits have their current transformers paralleled. In selecting the circuits to be paired, the following points should be observed:

1) Parallel circuits which are not likely to be left alone on the bus.
2) Where sources are to be paired, parallel the smaller sources, if there are less than 8 equivalent circuits.
3) Avoid pairing the two largest sources.
4) If feasible, parallel matched current transformers.

In case IV, with two feeder groups one of the restraint elements must be connected to 2 source circuits. These 2 source circuits should be selected so that they are the least likely to be left alone on the bus and are not the two largest sources.

Where the nature of the bus application is such that nearly complete restraint cancellation is very likely to occur for cases III, V, VII, and VIII of Table I, two relays per phase should be employed to insure restraint under all possible external fault conditions. Connections for 6 and 8 equivalent circuit buses, using 2 relays per phase, are shown in Figs. 8 and 9, respectively.

Where there are more than 8 equivalent circuits, the connections in Fig. 9 should be employed by pairing current transformers in the same manner as outlined for single relay per phase applications.

SETTING CALCULATIONS

No calculations are required to set the CA-6 relay.

SETTING THE RELAY

BUS DIFFERENTIAL RELAY

The external current transformer taps are the only setting required. Where the d-c time constant is 0.6 cycles or less and where the current transformer ratio error as a result of a-c saturation exceeds 5%, it is recommended that the No. 38 tap be used. In all other cases, the No. 19 tap is recommended.

If the minimum internal fault current is greater than .14 amperes, the pickup of the relay may be increased by means of the spring adjuster. The spring tension can be increased such that a maximum pickup of .4 amperes can be obtained. The pickup current is to be measured when only the operating circuit is energized.

TRANSFORMER DIFFERENTIAL RELAY

Set the external current transformer tap. The following settings are recommended for mismatch of the main current transformers:

Percent † Mismatch	Minimum Pickup Setting	Minimum Tap
0-5	.75 Amp.	19
5-10	1.00 Amp.	38
10-15	1.25 Amp.	38

† Includes error due to power transformer tap changing.

The pickup of the relay is varied by means of the spring adjuster.

INDICATING CONTACTOR SWITCH (ICS)

No setting is required on the ICS unit except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a type WL relay switch, or equivalent, use the 0.2 ampere tap.

INDICATING INSTANTANEOUS TRIP (IIT)

* The core screw must be adjusted to the value of pick-up desired. It is recommended that a pickup of 100 amperes be used.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information refer to I.L. 41-076.

The total resistance of the leads, connecting relay terminals 12 and 13 to the R terminals of the auxiliary current transformer, must not exceed 0.05 ohm.

* ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay no customer adjustments, other than those covered under "SETTINGS" should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order. Relays and transformers of matching serial numbers should be connected together. Use tight screw connections. No clip leads should be used. The total resistance of leads, connecting relay terminals 12 and 13 to the R terminals of the auxiliary current transformer, must not exceed 0.05 ohms.

A. Minimum Trip Current

Apply current to the primary of the external transformer. The relay should operate as follows on the 19 tap.

1. Bus Differential Relay — 0.145 ± 5% amp.
2. Transformer Differential Relay — 1.0 ± 5% amp.

B. Torque Curves

Connect the relay as shown in the test circuit of figure 10. Apply tap value current to the external transformer. The contacts should open when the following restraint current is applied to the relay.

1. Bus Differential Relay
   16-1/2 ± 5% amperes
2. Transformer Differential Relay
   15-1/2 ± 5% ampere

Care should be taken not to overheat the relay and external transformer during the test.

The restraint current of the transformer differential relay is less than that of the bus differential relay in order to compensate for the stronger spring used on the transformer relay.

C. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should not be greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

The contact gap should be approximately .047 inch between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

D. Indicating Instantaneous Unit (IIT) – (Where Supplied)

The core screw which is adjustable from the top of the trip unit determines the pickup value. The trip unit has a nominal ratio of adjustment of 1 to 4 and an accuracy within the limits of 10%.

The making of the contacts and target indication should occur at approximately the same instant. Position the stationary contact for a minimum of 1/32 inch wipe. The bridging moving contact should touch both stationary contacts simultaneously.

Apply sufficient current to operate the IIT. This current should be applied with the external transformer excluded from the circuit.

Routine Maintenance

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order. (See "Acceptance Check").

1. Clearance – Adjust the top bearing screw to have approximately .002 to .006 inch clearance between it and the shaft.

2. Contacts – Adjust the stationary contact so that 1/4 inch contact separation is obtained when the moving contact is held in the maximum open position.

3. Minimum Trip – With operating current applied to the external transformer, adjust the spring tension until the relay just operates with following currents in the 19 tap.:

1. Bus Differential Relay	0.145 amp.
2. Transformer Differential Relay	1.0 amp.

4. Torque Check – Connect the relay per the test circuit of figure 10. Pass tap value current of the external transformer into the operating circuit of the relay. The contacts should open when the following restraint current is applied:

a) Bus Differential Relay	16-1/2 ± 5% amp.
b) Transformer Differential Relay	15-1/2 ± 5% amp.

5. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

6. Indicating Instantaneous Trip Unit (IIT)

The core screw must be adjusted to the value of pickup current desired. It is recommended that the IIT be set to pickup at 100 amperes. This setting should be made with the external transformer excluded from the test circuit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

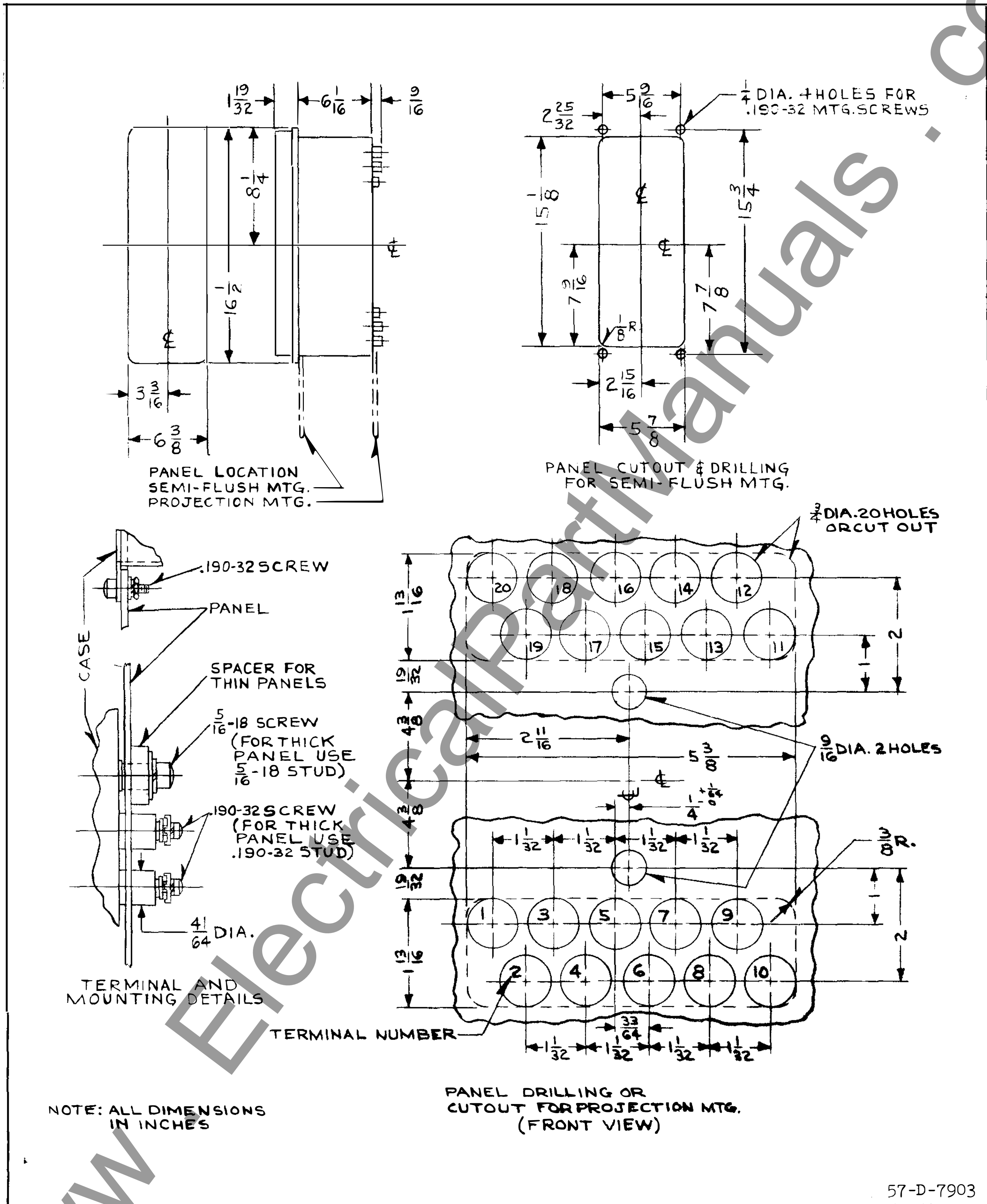


Fig. 13. Outline & Drilling Plan for the Type CA-6 Relay in the type FT-32 Case.

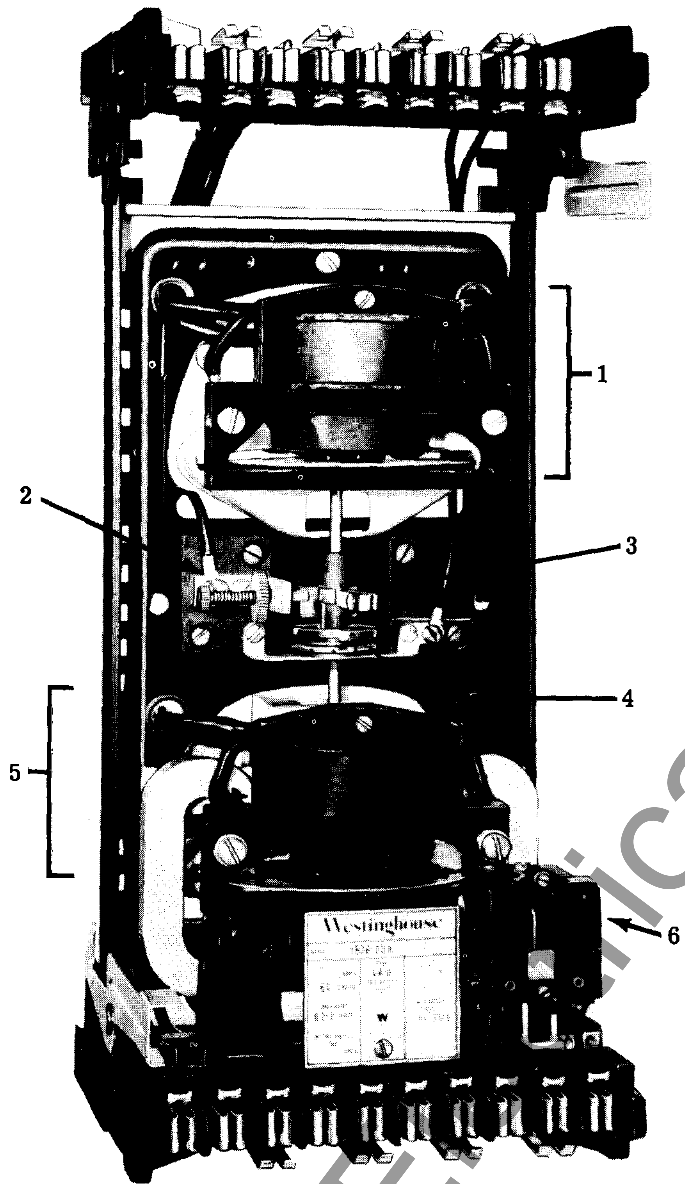


Fig. 14. Type CA-6 Relay Without Case (Front View). 1 - Top Front Restraining Element. 2 - Stationary Contact. 3 - Moving Contact. 4 - Control Spring Assembly. 5 - Bottom Front Restraining Element. 6 - Indicating Contactor Switch (ICS).

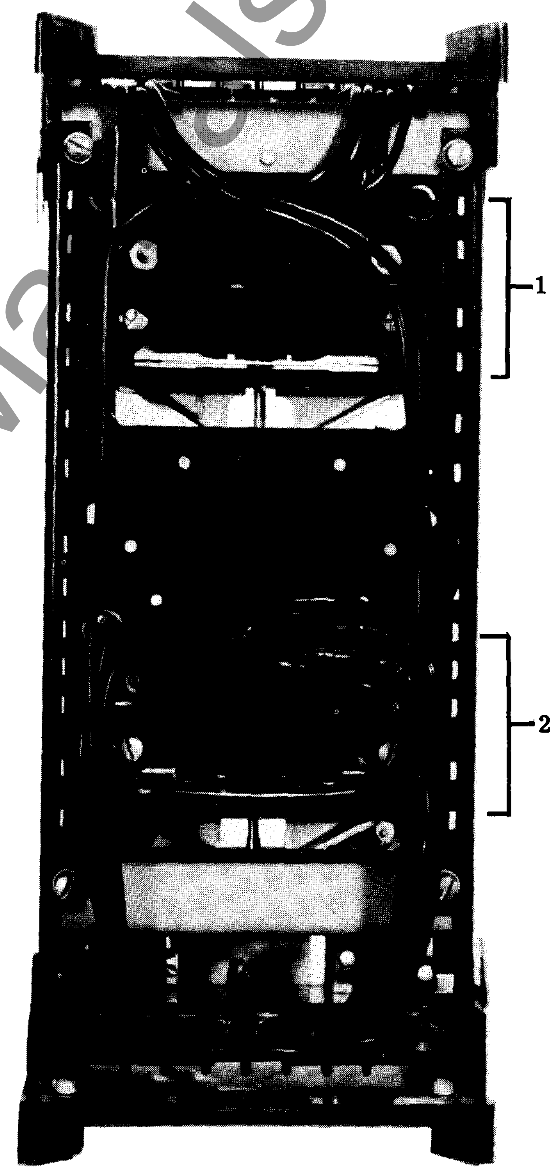


Fig. 15. Type CA-6 Relay Without Case (Rear View). 1 - Top Rear Operating Element. 2 - Bottom Rear Restraining Element.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY DEPARTMENT **NEWARK, N. J.**

Printed in U. S. A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES CA-16 and CA-26 PERCENTAGE DIFFERENTIAL RELAYS FOR BUS AND TRANSFORMER PROTECTION

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The current transformers should not saturate when carrying the maximum external symmetrical fault current (i.e., exciting current should not exceed one secondary ampere, rms). This requirement is met if the burden voltage does not exceed $N_P V_{CL}/133$, where:

N_P = proportion of total CT turns in use

V_{CL} = current transformer 10L accuracy-class voltage

The burden voltage is described as:

Case 1: Fault current maximum of 100A rms in CT secondary — drop across 2-way lead burden and relays (CA-16 and CA-26 restraint-coil burden is negligible).

Case 2: Fault current greater than 100A rms in CT secondary — drop across 2-way lead burden and relays plus:

$(I_{EXT} - 100)\ R_{CT}$

where I_{EXT} = max. external symmetrical fault current in secondary rms amperes.

R_{CT} = CT resistance, ohms

For example, if the 400/5 tap of 600/5 10L200 wye-connected CT's are used $N_P = 400/600 = 0.67$; if $I_{EXT} = 100A$, the burden (excluding CT resistance) should not exceed:

$N_P V_{CL}/133 = (0.67 \times 200)/133 = 1.0$ ohms.

◆ CONTENTS

This instruction leaflet applies to the following types of relays:

CA-16 Bus Differential Relay
CA-26 Transformer Differential Relay

The CA-16 relay should not be utilized for transformer differential applications. Likewise the CA-26 relay should not be used for bus protection with the "four-circuit bus" connections of Fig. 8. The CA-26 relay is suitable for combination bus-transformer applications. See "Connections".

CONSTRUCTION

The type CA-16 relay consists of an indicating contactor switch, autotransformer, three restraint elements, and an operating element. For applications where the CA-16 relay is subjected to shock such as on swinging panels, a sensitive fault detector circuit is provided.

The type CA-26 (in addition to the components of the CA-16 relay) also contains an indicating instantaneous trip unit. The principal component parts of the relay and their location are shown in Figures 1 to 5.

Restraint Elements

Each restraint element consists of an "E" laminated electromagnet with two primary coils and a secondary coil on its center leg. Two identical coils on the outer legs of the laminated structure are connected to the secondary winding in a manner so that the combination of all fluxes produced by the electromagnet results in out-of-phase fluxes in the air gap. The out-of-phase fluxes cause a contact opening torque.

Operating Circuit

The operating circuit consists of an auto-transformer and an operating element. The primary of the auto-transformer, which is the whole winding, is connected to receive the differential or unbalanced current from the various transformers connected to the bus. The secondary winding of the auto-transformer, which is a tapped section of the winding, is connected to the operating element of the relay.

The operating element consists of an "E" type

SUPERSEDES I.L. 41-337.3A
*Denotes change from superseded issue.

EFFECTIVE FEBRUARY 1969

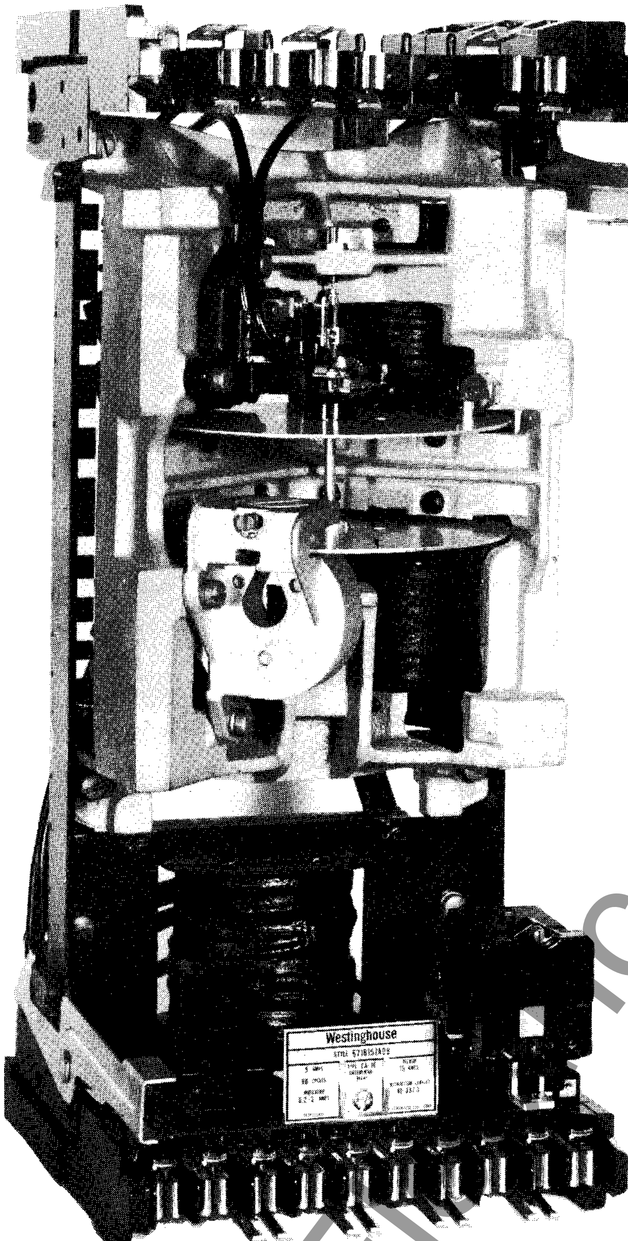


Fig. 1. Types CA-16 Relay (front view)

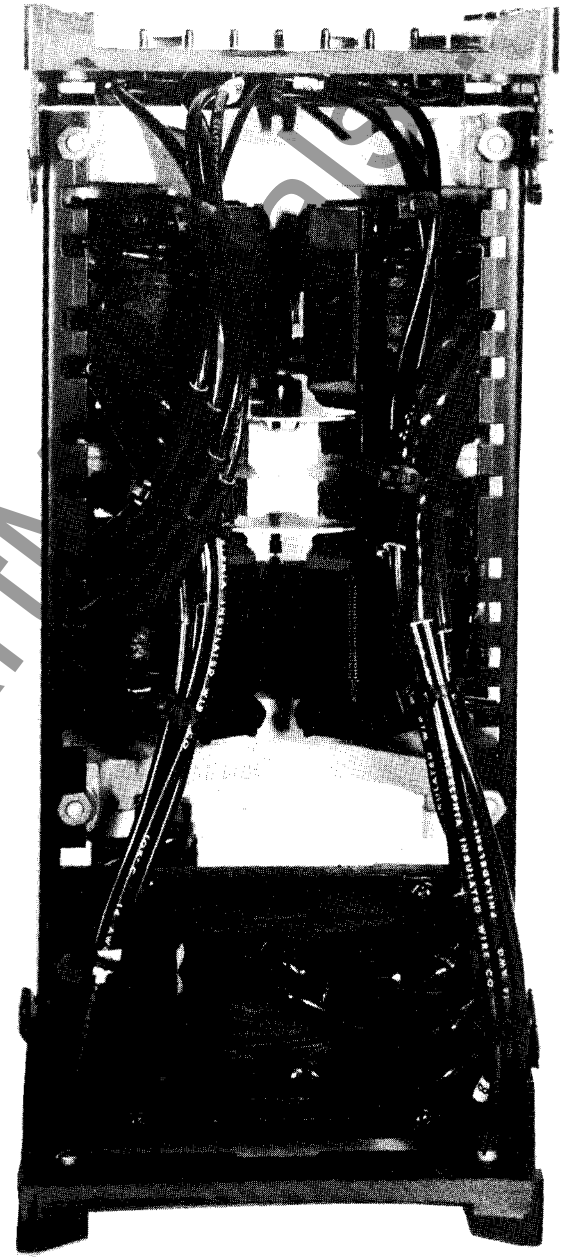


Fig. 2. Types CA-16 Relay (rear view)

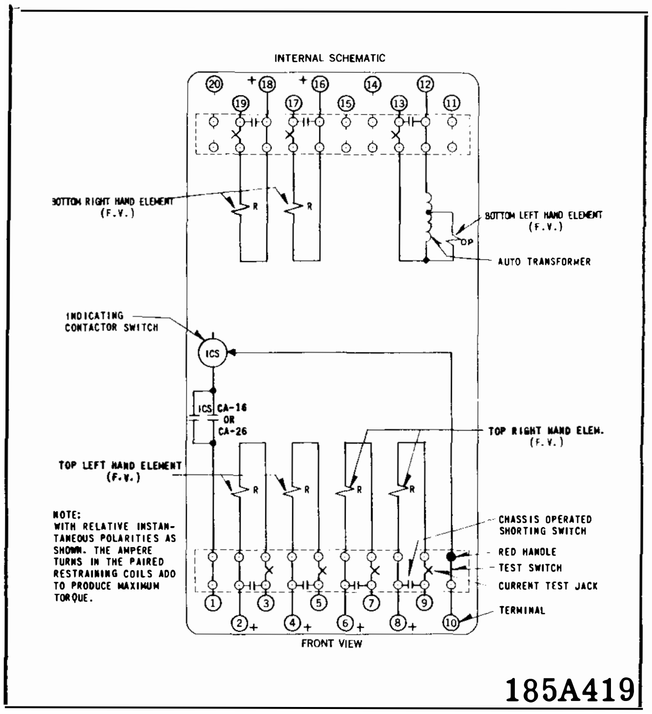


Fig. 3. Internal Schematic of the Type CA-16 Bus Relay

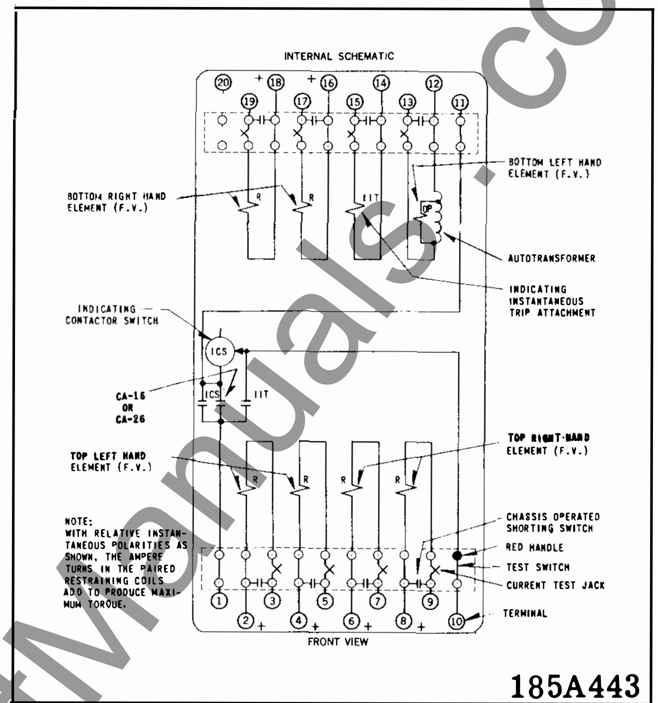


Fig. 4. Internal Schematic of the Type CA-26 Transformer Relay

laminated electromagnet with an auto-transformer winding on its center leg. Two identical coils on the outer legs of the laminated structure are connected to the secondary (tapped section) of the auto-transformer winding in a manner so that the combination of all fluxes produced by the electromagnet results in out-of-phase fluxes in the air gap. The out-of-phase air gap fluxes cause a contact closing torque.

Sensitive Fault Detector Circuit (where used)

The sensitive fault detector circuit consists of an auto-transformer and a contactor switch. The contactor switch is connected across the secondary (tapped section) of the auto-transformer winding.

The contactor switch is a small solenoid type element. A cylindrical plunger rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core, which in turn screws into the unit frame. A silver disc is fastened to the moving plunger through a helical spring. When the coil is energized, the plunger moves upward carrying the silver disc which bridges three conical-shaped stationary contacts. In this position, the helical spring is compressed and the plunger is free to move while the contact remains stationary. Thus, a-c vibrations of. the plunger are prevented from causing contact bouncing. A Micarta disc is fastened to the bottom of the guide rod by two small nuts. Its position determines the pick up current of the element.

The auto-transformer is designed to saturate at high values of current to limit the amount of current to the contactor switch.

Indicating Contactor Switch Unit (ICS)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pick-up value of the switch.

Indicating Instantaneous Trip Unit (IIT)

The instantaneous trip unit is a small a-c operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the

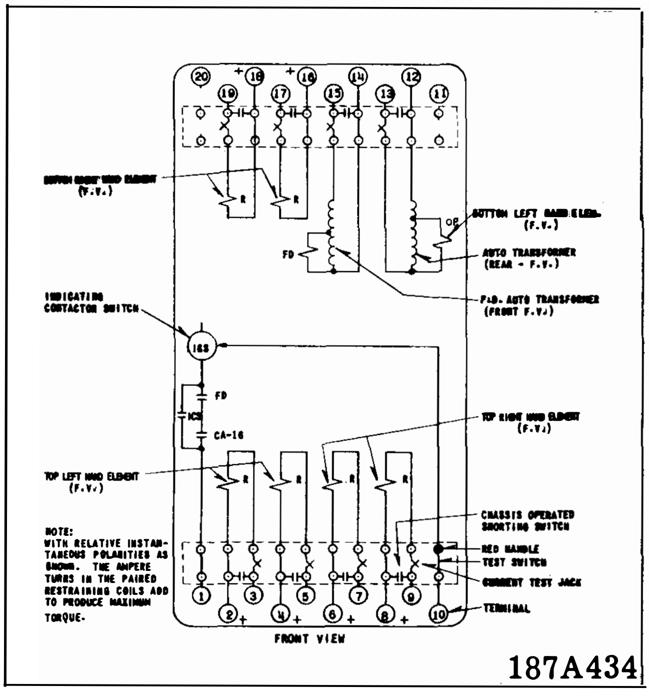


Fig. 5. Internal Schematic of the Type CA-16 Bus Relay with a Sensitive Fault Detector

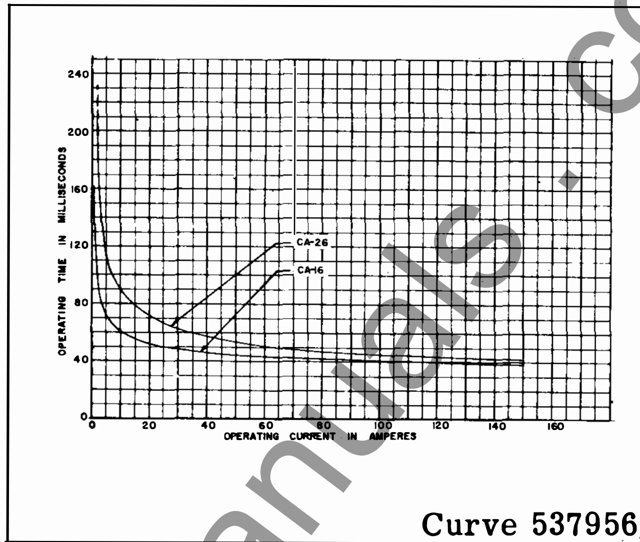


Fig. 6. Typical Time Curves of the CA-16 and CA-26 differential Relays

switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during this operation, two fingers on the armature deflect a spring located on the front of the switch which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

A core screw accessible from the top of the switch provides the adjustable pick-up range.

OPERATION

The types CA-16 and CA-26 relays are induction disc relays with four electromagnets mounted on two discs that are fastened on a common shaft. One of the electromagnets is the operating element while the other three are restraint elements. The restraint elements are energized from the secondaries of current transformers connected to the bus, and the operating circuit is energized in accordance with the current flowing in the differential connection of the current transformers.

A current of 5 amperes in at terminal 18 and out of terminal 19 will produce a definite amount of restraining torque (see Fig. 3.) Similarly, a current of 5 amperes flowing in at terminal 16 and out of terminal 17 will produce an equal amount of torque. If both of these currents flow at the same time with the polarity as indicated above, their effect will be additive and they will produce the same torque as though 10 amperes were flowing in terminal 16 and out of terminal 17. Conversely, if equal currents flow in these two coils, but in opposite directions, their ampere turns will cancel and no torque will be produced. The same relationship applies for the paired coils of the other two restraining units of the relay.

CHARACTERISTERICS

CA-16 Bus Relay

This relay has variable percentage characteristics which means that the operating coil current required to close the relay contacts, expressed in per cent of the total restraint current, varies with the magnitude of the restraint current. The relay sensitivity is high, corresponding to a low percentage ratio, at light currents, and its sensitivity is low, corresponding to high percentage unbalance, at high currents. The relay is made sensitive at low currents in order to detect light internal faults on the bus being protected. At the same time, however, its reduced sensitivity at the higher currents allows the various current transformers involved to depart from their true ratio to a large extent without causing false tripping of the relay for external faults.

The variable percentage characteristics are particularly advantageous when severe saturation of current transformers is caused by the d-c component of asymmetrical short circuits. In the case of buses located close to generating stations where the d-c components decay slowly, the breakdown in ratio of the current transformers will be much greater than

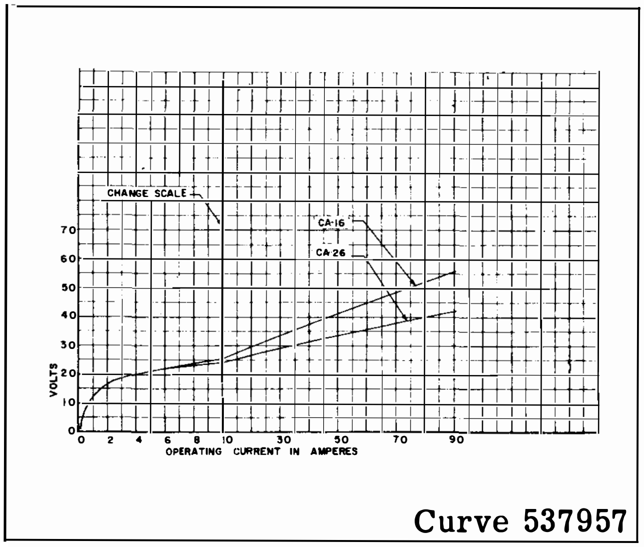


Fig. 7. Typical Burden Characteristic of the Operating Circuit of the CA-16 and CA-26 Differential Relays

would ever be expected from a consideration of the usual ratio curves of the current transformers involved.

The time of operation of the relays is shown in Figure 6.

CA-26 Transformer Relay

The type CA-26 transformer differential relay includes an indicating instantaneous trip unit (see Fig. 4), which operates on internal faults. The instantaneous unit should have a setting equal to the maximum rms symmetrical external fault current. Such a setting will prevent operation of the instantaneous unit when a current transformer is severely saturated by the d-c component of an asymmetrical external fault current.

Trip Circuit

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating instantaneous trip contacts will safely close 30 amperes at 250 volts d-c, and will carry this current long enough to trip breaker.

The indicating contactor switch has two taps that provide a pick-up setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

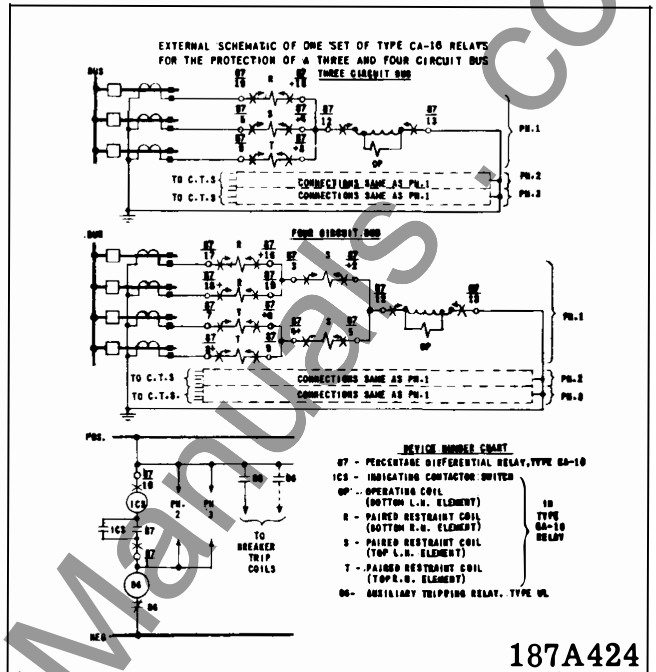


Fig. 8. External Schematic of the Type CA-16 Relays for Three and Four Circuit Bus Protection

Trip Circuit Constants

Indicating Contactor Switch (ICS)

0.2 ampere tap	6.5 ohms d-c resistance
2.0 ampere tap	0.15 ohms d-c resistance

ENERGY REQUIREMENTS

Burden of each restraint coil at 5 amperes

VOLT AMPERES	POWER FACTOR
.75	.7
Continuous Rating	14 amperes
1 second rating	460 amperes

Burden of operating circuit

VOLT AMPERES

Variable (See Fig. 7)

Continuous rating 8 amperes

1 second rating 280 amperes

CONNECTIONS

CA-16

To determine the a-c connections, identify each

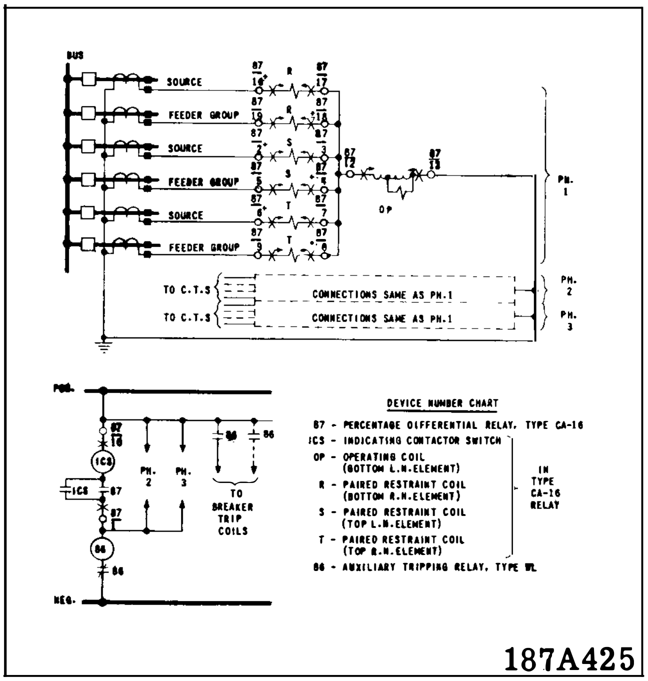


Fig. 9. External Schematic of the Type CA-16 Relays for Protection of a Six Circuit Bus with Three Feeder Groups

primary circuit as either a "source" or "feeder". As defined here, a feeder contributes only a small portion of the total fault-current contribution for a bus fault. Otherwise, the circuit is a source. Next lump a number of feeders into a "feeder group" by paralleling feeder CT's, taking the precaution that each feeder group has less than 14 amperes load current (restraint coil continuous rating). Also each feeder group should not contribute more than 10% of the total phase or ground-fault current for a bus fault.

Connect per Fig. 8 with three or four bus "circuit." The term "circuit" refers to a source or to a feeder group. For example, assume a bus consisting of 2 sources and 6 feeders. Further, assume that the feeders are lumped into 2 feeder groups. The bus now reduces to four circuits.

If the bus reduces to more than four circuits, parallel source-circuit CT's or source-and feeder-cir - CT's until only four circuits remain. Then connect these four sets of CT's to the relays per Fig. 8. The exception to this rule occurs when the application consists of three feeder groups. Then, Fig. 9 applies.

With 3 feeder groups and more than 3 sources, parallel source CT's until the application reduces to 6 circuits; then, connect to the relays per Fig. 9.

Fig. 10 shows the CA-26 relay connections for a 3 circuit bus. Where additional circuits are present use the Fig. 9 connections; where there are more than three sources the source CT's should be paralleled to reduce the effective number of source connections to three. The "four-circuit bus" connections of Fig. 8 must not be used with the CA-26. Otherwise the connection considerations are as described above for the CA-16.

SETTING CALCULATIONS

No calculations are required to set the CA-16 and CA-26 relays.

SETTING THE RELAY

No settings are required on either the CA-16 or the CA-26 main units.

Indicating Contactor Switch (ICS)

No setting is required on the ICS unit except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a 125 or 250 volt d-c WL relay switch or equivalent, use the 0.2 ampere tap; for 48 volt d-c applications set relay in 2 tap and use WL relay coil S#304-C209G01 or equivalent.

Indicating Instantaneous Trip (IIT)

Since the minimum and maximum markings on the scale only indicate the working range of the core screw must be adjusted to the value of pick-up desired. It is recommended that the IIT be set to pick up at a value of current that is equal to the maximum rms symmetrical external fault current to the relay.

INSTALLATION

The relays should be mounted on a switchboard panel or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the

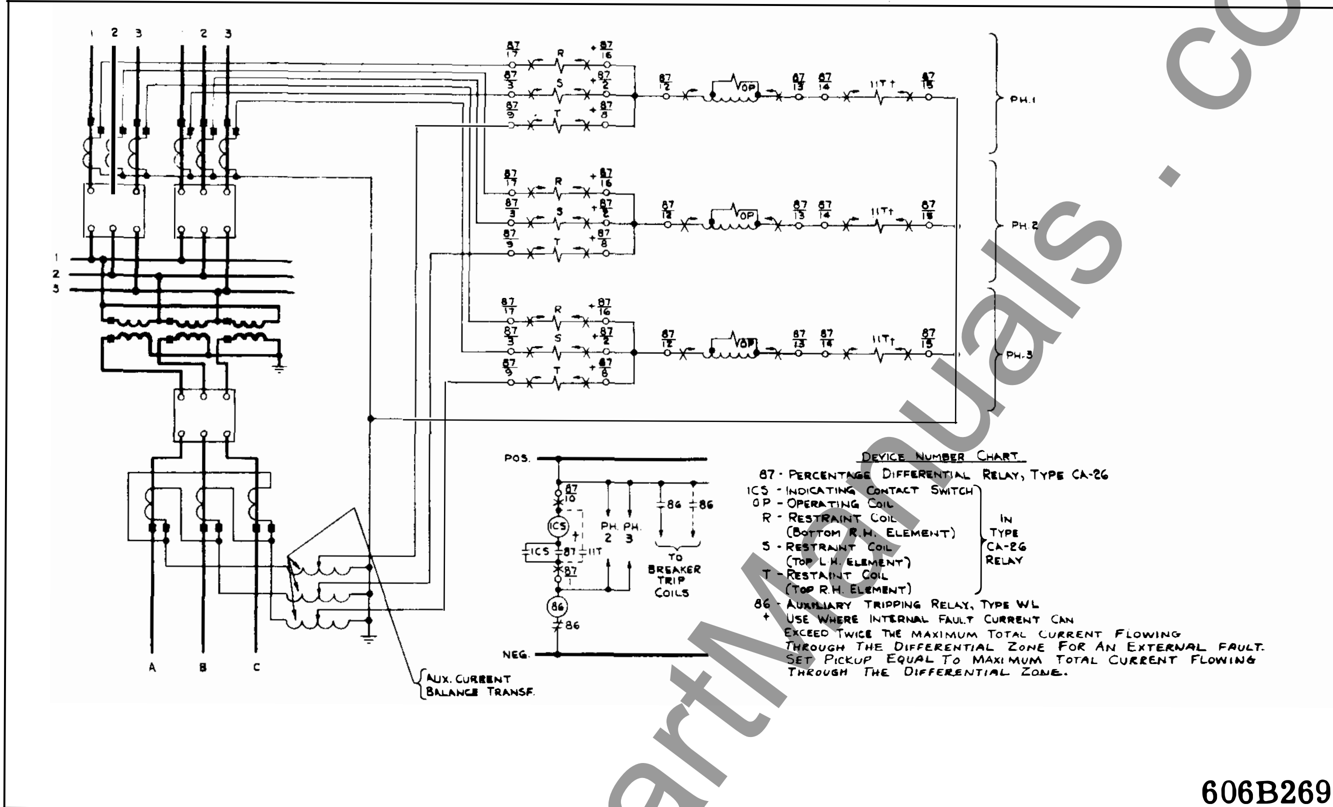


Fig. 10. External Schematic of the Type CA-26 Relay for Transformer Protection and Bus Protection

stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments other than those covered under "SETTINGS" should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order.

A. Minimum Trip Current

Apply current to terminals 12 and 13 of the relay. The relay should operate as follows:

1. CA-16	0.15 amperes ± 5%
2. CA-26	1.25 amperes ± 5%

B. Percentage Differential Characteristic

Apply 16 amperes to terminals 9 and 19 of the CA-16 relay or 14 amperes to terminals 9 and 19 of the CA-26 relay. The contacts should open when the following operating current is applied to the relay with connections of Fig. 11.

CA-16	17.0 ± 7% amperes
CA-26	38.0 ± 7% amperes

* Check each individual restraint winding by applying 50 amperes to each winding. Apply sufficient operating current to the operating circuit until the contacts just close. The operating current should be:

CA-16	3.9 to 5.1 Amperes
CA-26	15.8 to 18.2 Amperes *

C. Time Curve

Apply 20 amperes to terminals 12 and 13 of the relays. The contacts should close in the following times:

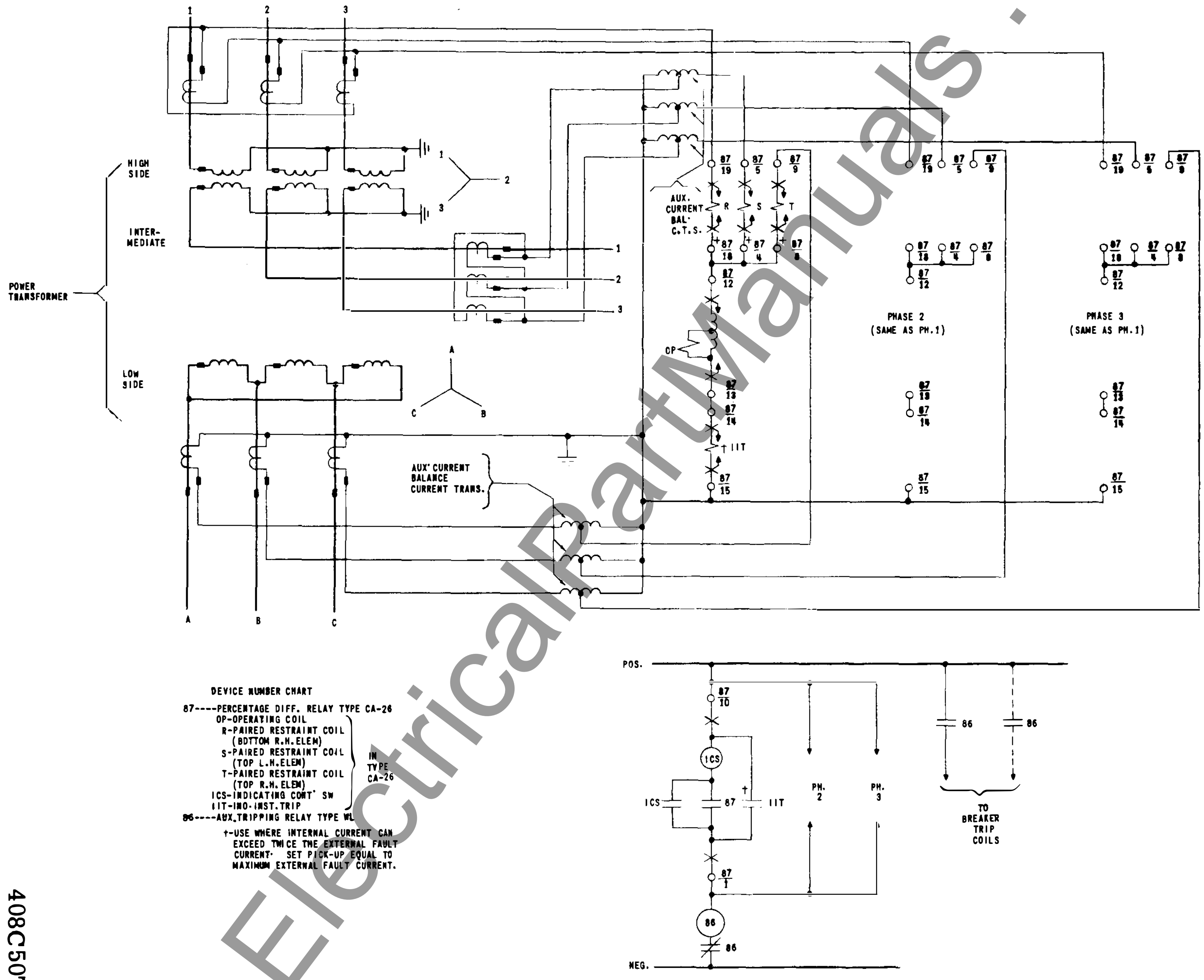


Fig. 15. External Schematic of the Type CA-26 Relay for Wye-Wye-Delta Transformer Protection

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE CA-6 PERCENTAGE DIFFERENTIAL RELAY

FOR BUS AND TRANSFORMER PROTECTION

CAUTION Before putting relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The type CA-6 percentage differential relay is usually applied for the differential protection of multi-circuit buses. The application of the CA-6 relays for bus differential protection may be divided into three categories. (In the following discussion an equivalent circuit is defined as a major source or a group of feeder circuits. The fault current contribution of all the paralleled feeders should not exceed 5% of the total phase or ground fault current, with normal bus connections.)

A) GENERATING STATION BUSES - FOUR EQUIVALENT CIRCUITS OR LESS - DC TIME CONSTANT OF 0.6 CYCLES (0.01 Sec.) OR MORE.

If the following requirements are met, the CA-6 may be satisfactorily applied:

1) The maximum external fault current through the bus should not exceed 100 symmetrical RMS secondary amperes.
2) The magnetizing current of the current transformers carrying a total external fault current of 100 symmetrical secondary amperes should not exceed one secondary ampere.

B) GENERATING STATION BUSES - MORE THAN FOUR EQUIVALENT CIRCUITS - DC TIME CONSTANT OF 0.6 CYCLES (0.01 Sec.) OR MORE.

The same requirements as in (A) apply. However, consideration must be given to the restraint coil connections.

Where more than 4 equivalent circuits are present, it is rarely necessary to provide two relays per phase. With little or no compromise in the protection scheme, one relay can handle at least 8 equivalent bus circuits. (See "Connections" for further discussion.)

C) SUBSTATION BUSES - DC TIME CONSTANT OF 0.6 CYCLES (0.01 Sec.) OR LESS.

If the following requirements are met, the CA-6 may be satisfactorily applied:

1) The maximum external fault current through the bus should not exceed 100 symmetrical RMS secondary amperes.
2) The magnetizing current of the current transformers carrying a total external fault current of 100 symmetrical secondary amperes should not exceed *ten secondary amperes.*

Where more than 4 equivalent circuits are present, it is rarely necessary to provide two relays per phase. With little or no compromise in the protection scheme, one relay can handle at least eight equivalent bus circuits.
(See "Connections" for further discussion.)

A type CA-6 transformer relay is also available for 3 winding transformer protection. The standard bus relay should not be utilized for transformer differential applications.

CONSTRUCTION

The type CA-6 relay consists of three restraining elements (two restraining windings per element), one operating element, and an indicating contactor switch. The type CA-6 transformer relay also contains an indicating instantaneous trip unit.

SUPERSEDES I.L. 41-337.1C
*Denotes change from superseded issue.

EFFECTIVE SEPTEMBER 1960

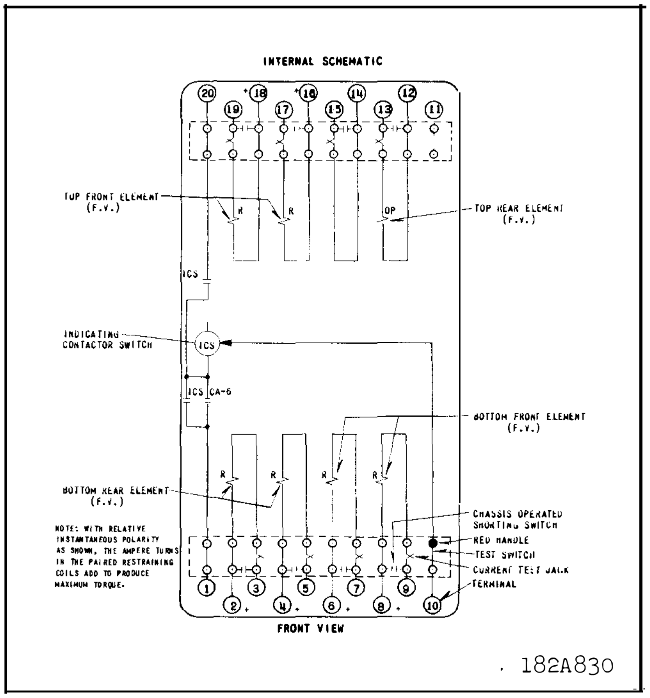


Fig. 1. Type CA-6 Relay for Bus Protection in Type FT-32 Case.

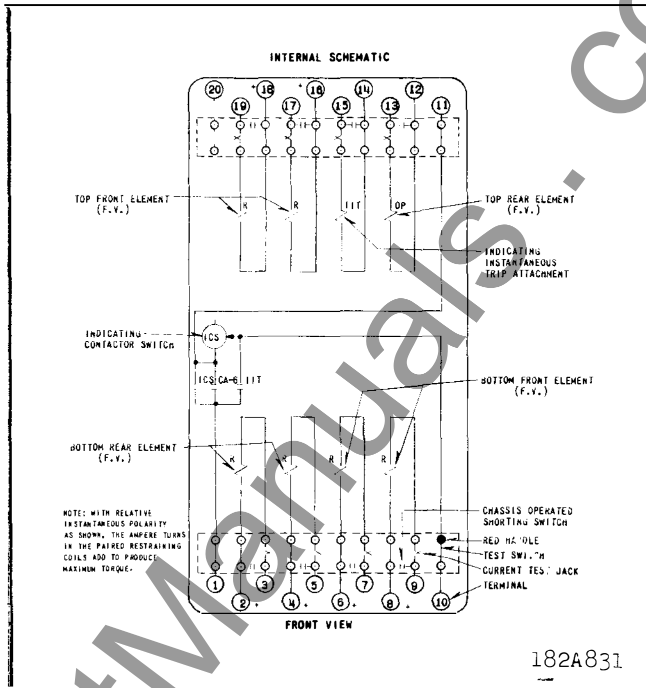


Fig. 2. Type CA-6 Relay for Transformer Protection, With Indicating Instantaneous Trip in FT-32 Case.

The relay operates on the induction-disc principle and consists of four electromagnets operating on two discs which are fastened to the same shaft. Three of the electromagnets are restraining elements with two separate restraining windings connected to receive the secondary currents from the various current transformers (Fig. 1 & 2). The fourth electromagnet is the operating element with its winding connected to receive the differential or unbalance current thru an auxiliary current transformer. Taps are provided on this current transformer to control the sensitivity of the relay.

The two induction discs are mounted on a vertical shaft. The lower bearing for the shaft is a steel ball riding between concave sapphire jewel surfaces. A pin bearing is used on the upper end of the shaft.

The moving contact assembly is attached to a Micarta bushing on the disc shaft. When the moving contact strikes the stationary contact, the moving contact spring deflects to provide a wiping action. The electrical connection from the moving contact is made thru the spiral spring to the spring adjuster.

INDICATING CONTACTOR SWITCH UNIT (ICS)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contact, completing the trip circuit. Also during this operation two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pickup value of the switch.

INDICATING INSTANTANEOUS TRIP UNIT (IIT)

The instantaneous trip unit is a small a-c operated clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts completing the trip circuit. Also during the operation two fingers on the armature deflect a spring located on the front of the switch which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

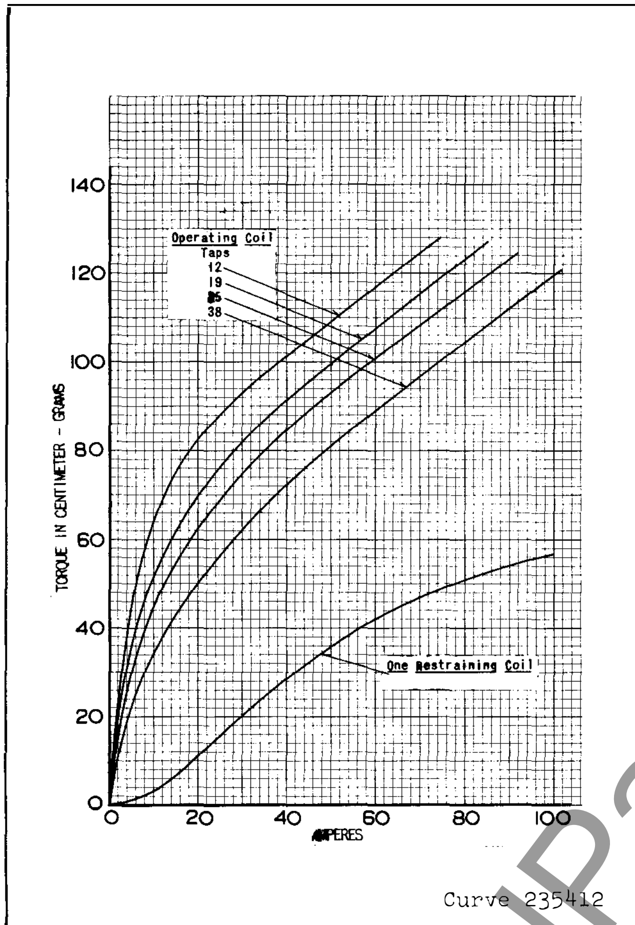


Fig. 3. Typical Torque Curves of the Operating & Restraint Coils.

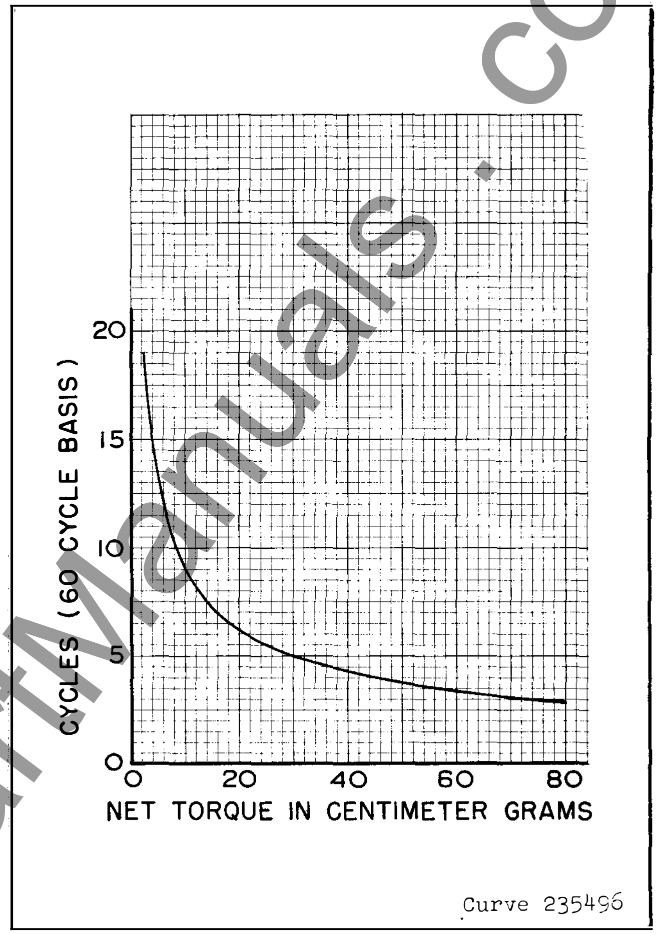


Fig. 4. Typical Differential Unit Time Curve.

* A core screw accessible from the top of the switch provides the adjustable pickup range.

OPERATION

The CA-6 relay has three restraining elements, each with two windings which are energized from the secondaries of current transformers connected to the bus. The relay has one operating electromagnet energized through an external auxiliary current transformers in accordance with the current flowing in the differential connection of the current transformers.

Refer to the internal schematic, Fig. 1. A current of 5 amperes in at terminal 18 and out of terminal 19 will produce a definite amount of restraining torque as indicated in Fig. 3. Similarly, a current of 5 amperes flowing in at terminal 16 and out of terminal 17 will produce an equal amount of torque. If both of these currents flow at the same time with the polarity as indicated above, their effect will be additive and they will produce the same torque as though 10 amperes were flowing in one winding alone. Conversely, if equal currents flow in these two coils, but in opposite directions, their ampere turns will cancel and no torque will be produced. The same relationship applies for the other two restraining units of the relay.

This relay has variable percentage characteristics which means that the operating coil current required to close the relay contacts, expressed in percent of the total restraint current, varies with the magnitude of the restraint current. The relay sensitivity is high, corresponding to a low percentage ratio, at light currents, and its sensitivity is

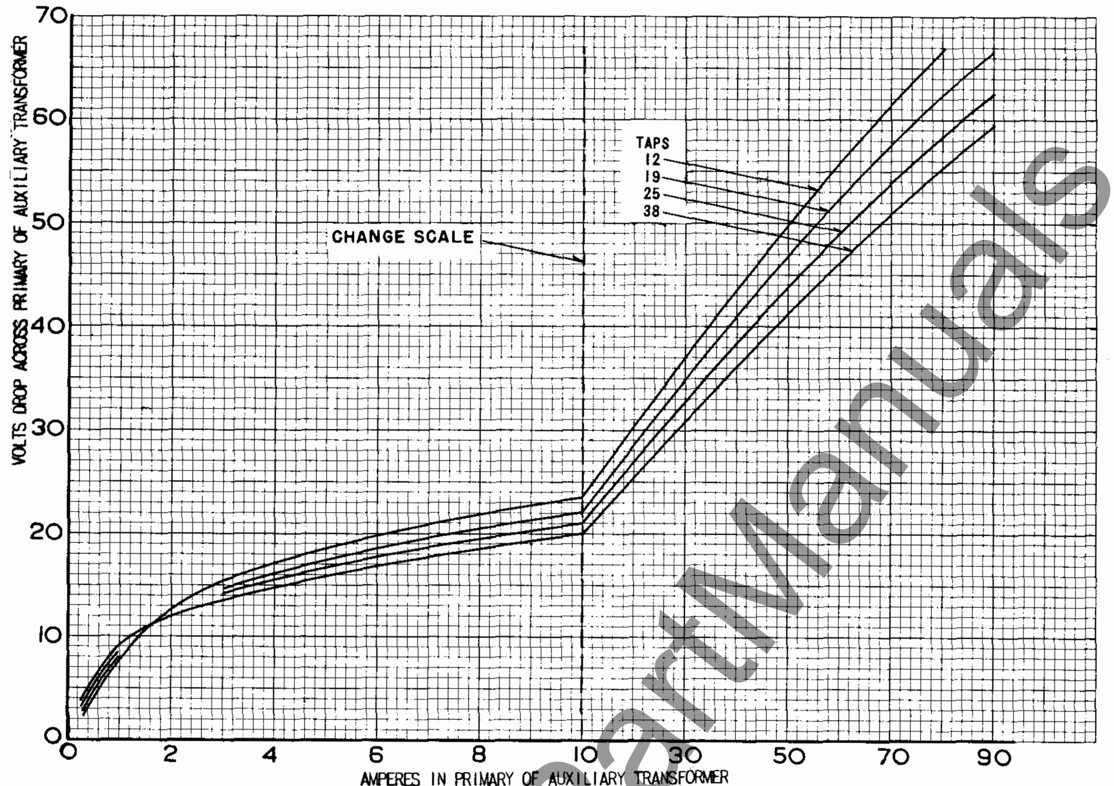


Fig. 5. Typical Burden Characteristics of The Operating Coil Circuit

low, corresponding to high percentage unbalance, at high currents. The relay is made sensitive at low currents in order that it will detect light internal faults on the bus being protected. At the same time, however, its reduced sensitivity at the higher currents allows the various current transformers involved to depart from their true ratio to a large extent without causing false tripping of the relay for external faults.

The variable percentage characteristics are particularly advantageous when severe saturation of current transformers is caused by the d-c component of asymmetrical short circuits. In the case of buses located close to generating stations where the d-c component decays slowly, the breakdown in ratio of the current transformers will be much greater than would ever be expected from a consideration of the usual ratio curves of the current transformers involved.

CHARACTERISTICS

There are no taps inside the relay case. Taps controlling the sensitivity of the relay are incorporated in the external current transformer (see Fig. 11 for internal wiring.) The tap markings are: 12 - 19 - 25 - 38. These tap values, as indicated on the torque curves of Fig. 3, are the 60 cycle amperes required in the operating coil circuit to close the relay contacts against a 70 cmg. restraint torque.

Time of operation of the relay is shown in Fig. 4. To use this curve, determine the total restraining torque and substract this from the operating coil torque to determine the net torque in cmg. This curve applies only for a contact spacing of 1/4 inch.

TRANSFORMER RELAY

The type CA-6 transformer differential relay includes an indicating instantaneous trip unit (See Fig. 2) and has a stronger spiral control spring than the bus differential relay. The instantaneous trip unit is intended to operate on internal faults on the order of 100 amps. (secondary) or higher because, when a transformer bank is connected to a high

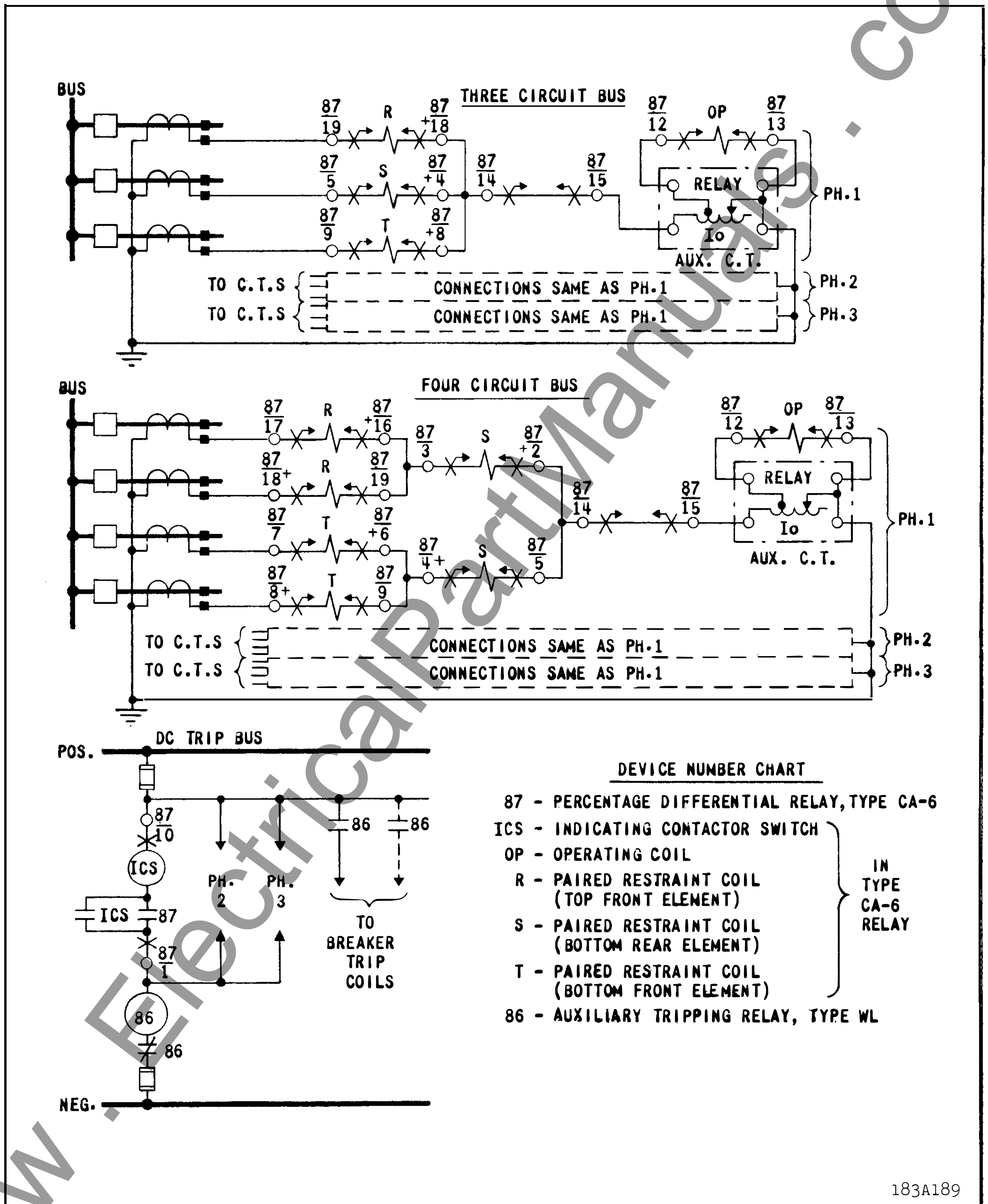


Fig. 6. External Schematic of One Set of Type CA-6 Relays for Three and Four Circuit Bus Protection.

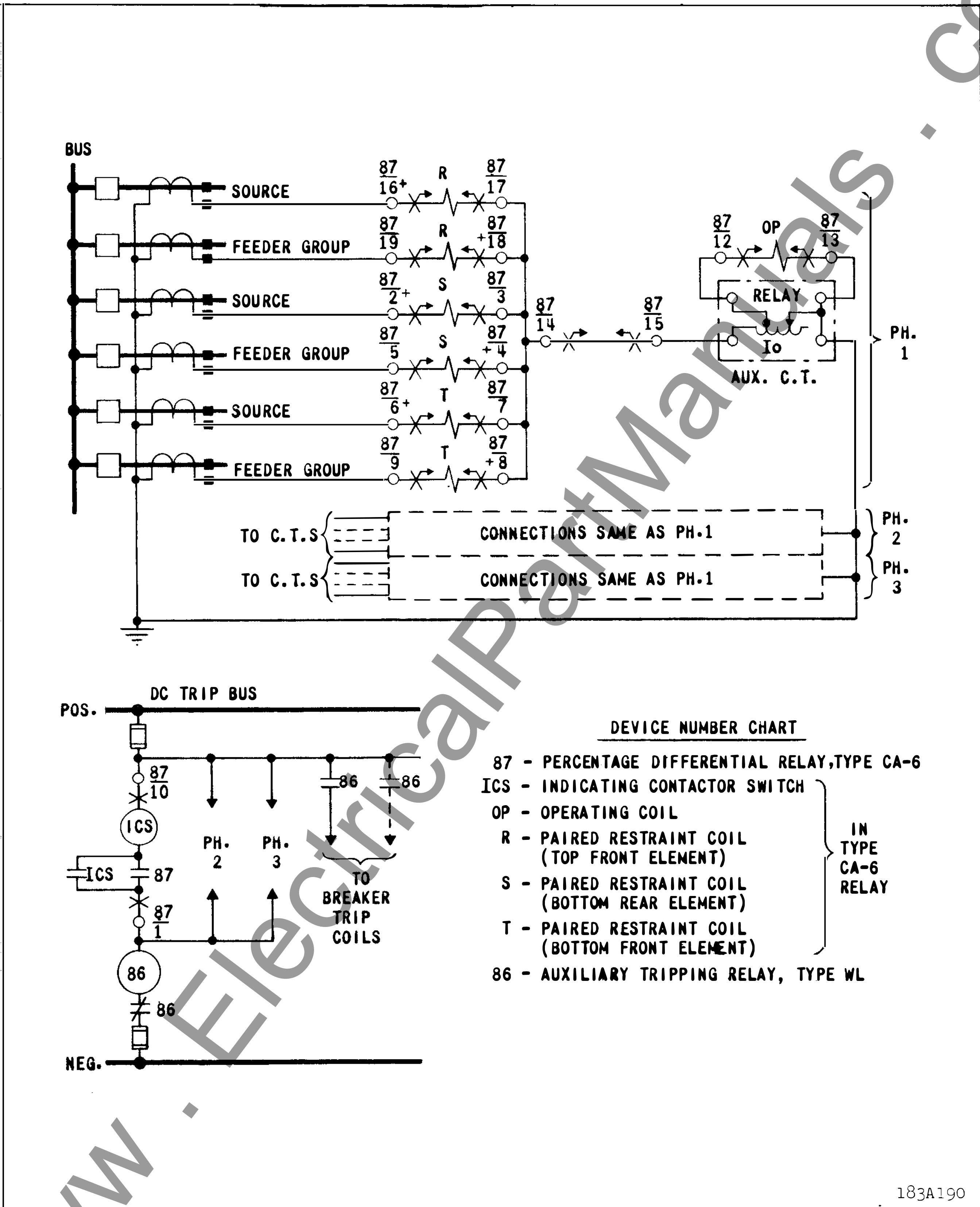


Fig. 7. External Schematic of One Set of Type CA-6 Relays for Protection of a Six Circuit Bus With Three Feeder Groups.

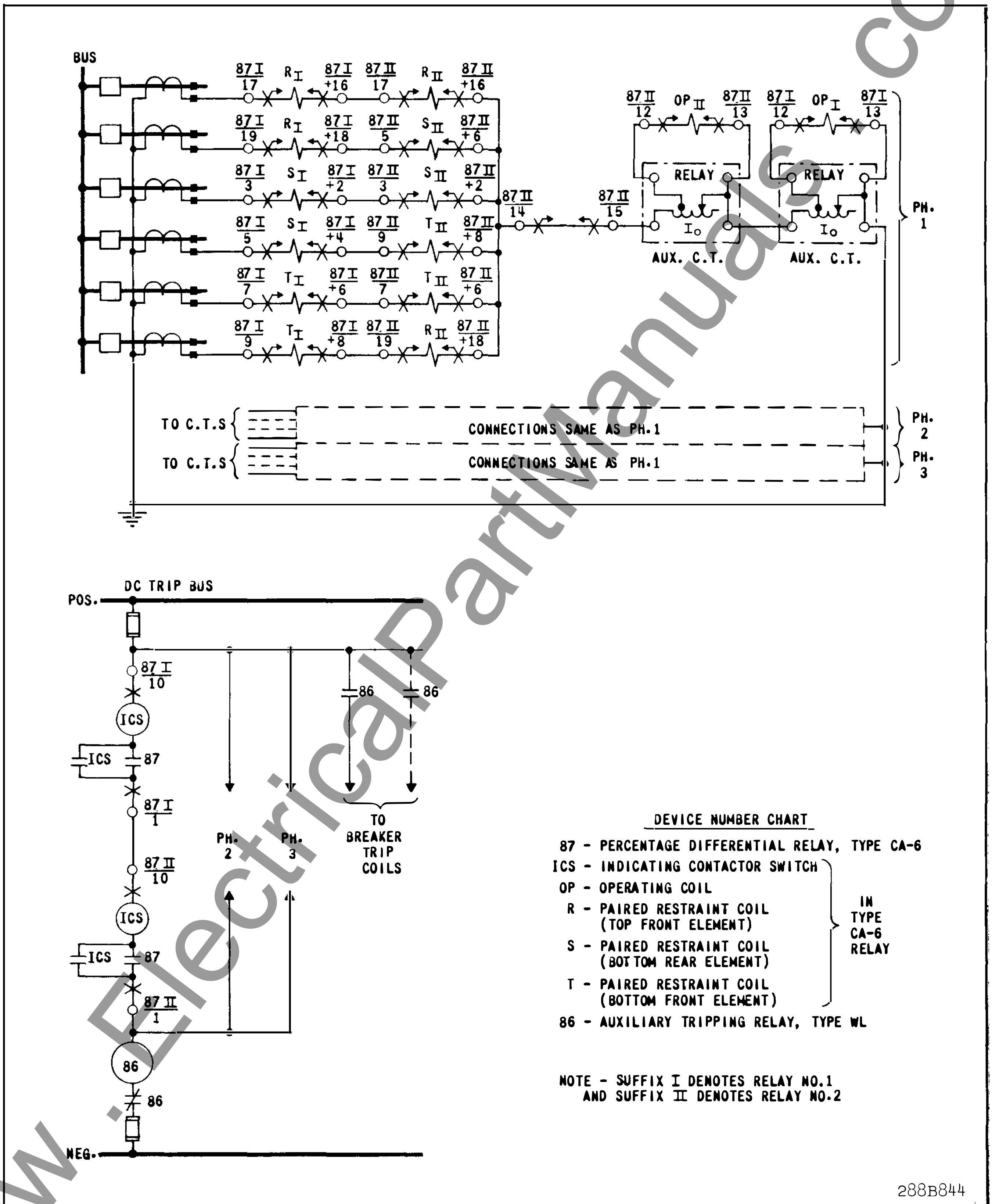


Fig. 8. External Schematic of Two Sets of Type CA-6 Relays for Six Circuit Bus Protection.

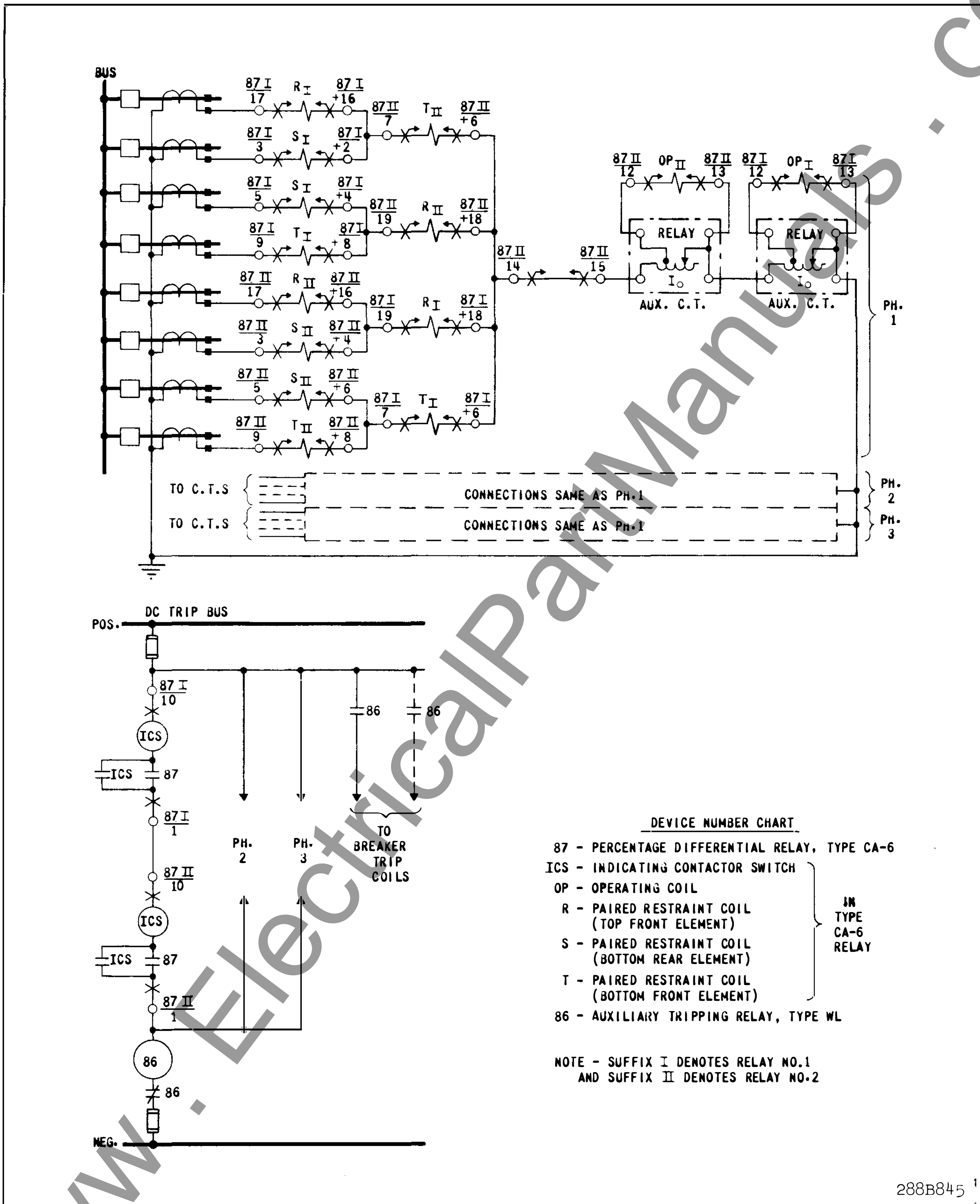
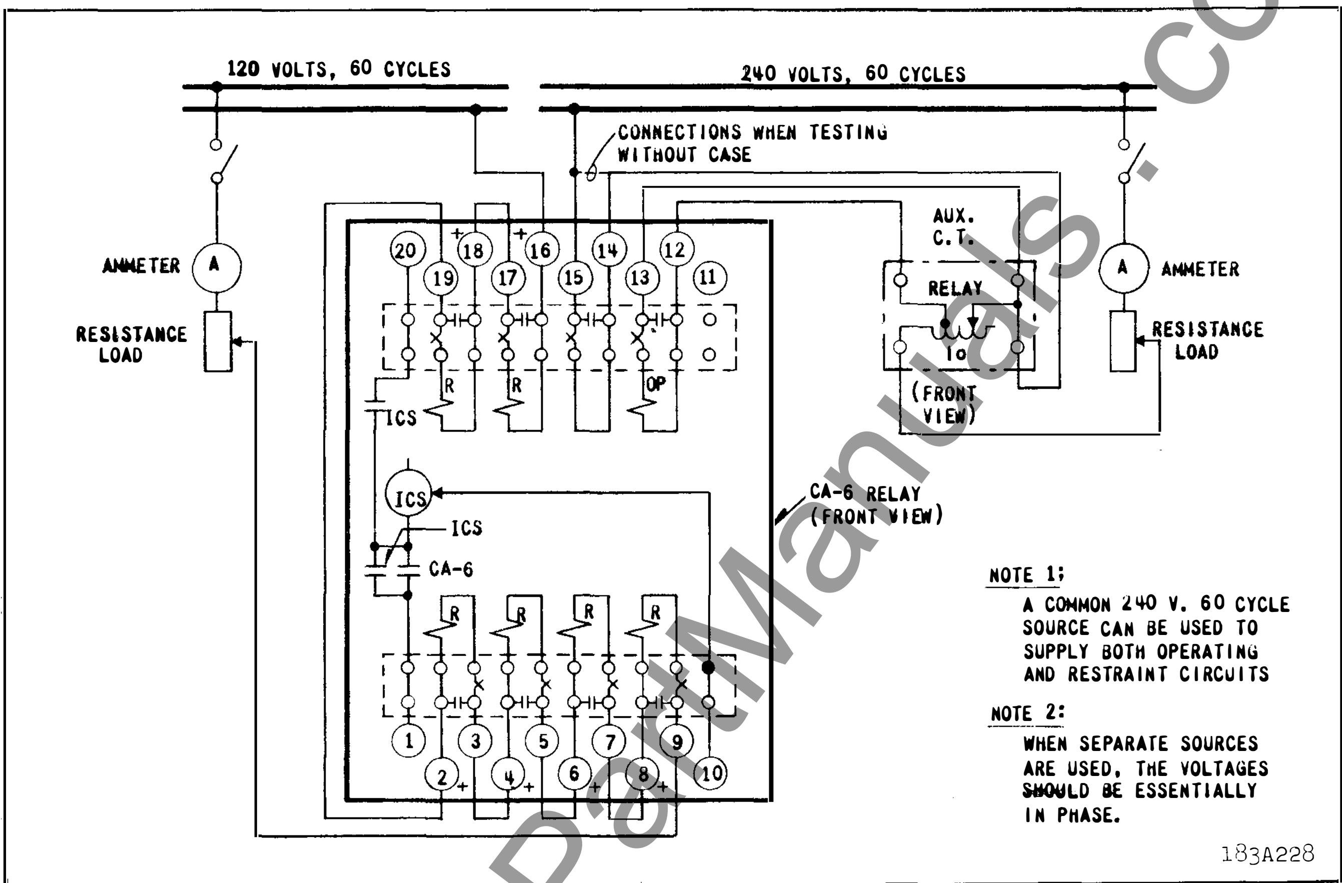


Fig. 9. External Schematic of Two Sets of Type CA-6 Relays for Eight Circuit Bus Protection.



* *Fig. 10. Diagram of Test Connections for the type CA-6 Relay.*

capacity bus, it is difficult to keep the maximum internal fault currents down to a 100 ampere value. Thus, the instantaneous unit assures prompt tripping at excessively high current values. At the same time, the instantaneous unit should not have a setting substantially lower than 100 amperes (secondary) in order to avoid a possible false operation for external faults. The stronger spiral control spring is provided in order that the relay maybe given a higher minimum trip setting, as noted under "Adjustments and Maintenance".

TRIP CIRCUIT

The main contacts will safely close 30 amperes at 250 volts d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating instantaneous trip contacts will safely close 30 amperes at 250 volts d-c, and will carry this current long enough to trip a breaker.

The indicating contactor switch has two taps that provide a pickup setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

TRIP CIRCUIT CONSTANT

Indicating Contactor Switch (ICS)

0.2 ampere tap 6.5 ohms d-c resistance
2.0 ampere tap 0.15 ohms d-c resistance

* **ENERGY REQUIREMENTS**

Burden of each Restraint Coil at 5 amps.

VOLT AMPERES	POWER FACTOR
.75	.7

Continuous Rating	10 Amperes
1 Second Rating	250 Amperes

Burden of Operating Circuit

VOLT AMPERES

Variable See Fig. 5

Continuous Rating	5 Amperes
1 Second Rating	150 Amperes

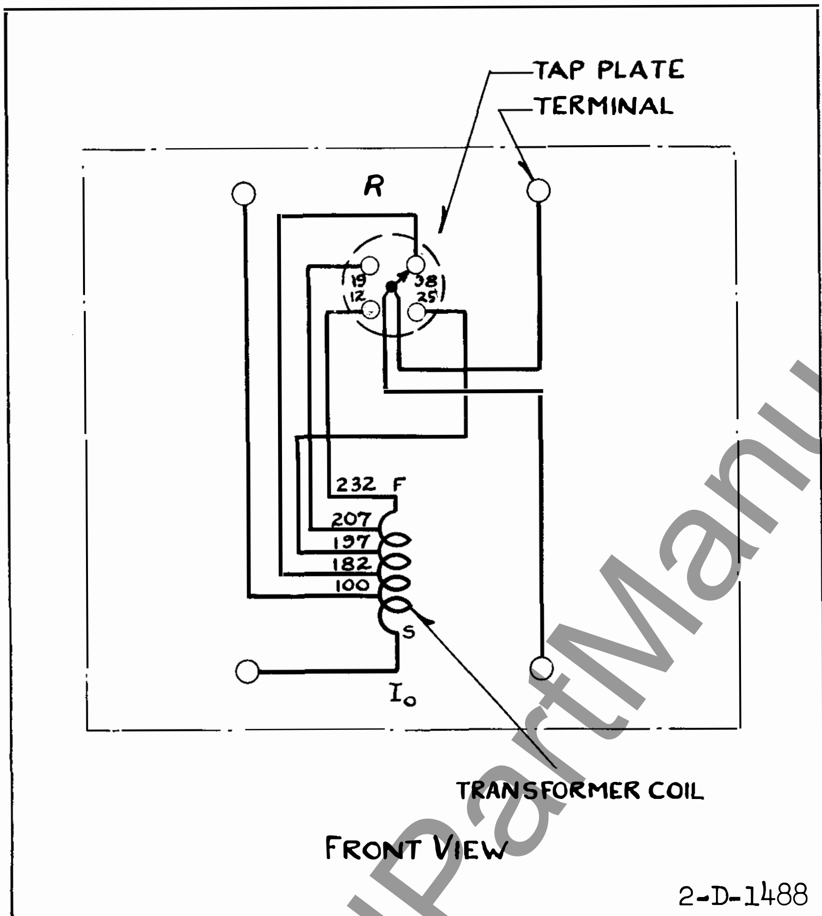


Fig. 11. Internal Wiring Diagram of the Auxiliary Current Transformer.

CONNECTIONS

One relay per phase is normally recommended for the protection of buses with up to 8 "equivalent circuit" connections. An "equivalent circuit" is defined as major source or a group of feeder circuits. The grouped feeder circuits' fault contribution should not exceed 5% of the total phase or ground fault current, with normal bus connections. In paralleling current transformers for the feeder group or groups, the load current distribution should be examined to insure that the 10 ampere continuous rating of the relay restraint windings is not exceeded.

The recommended connections are outlined in Table I.

TABLE I

Case	Total No. of Eq. Ckts.	No. of Feeder Groups	Connections
I	3	0-2	Fig. 6
II	4	0-3	Fig. 6
III	5	0-1	Note 1
IV	5	2-4	Fig. 7
V	6	0-1	Note 1
VI	6	2-5	Fig. 7
VII	7	0-6	Note 1
VIII	8	0-7	Note 1

Note 1 -- *Same as 4 circuit bus of Fig. 6 except parallel CT's in pairs. (1 set in parallel for 5 ckt. bus, 2 for 6 ckt. bus, etc.)*

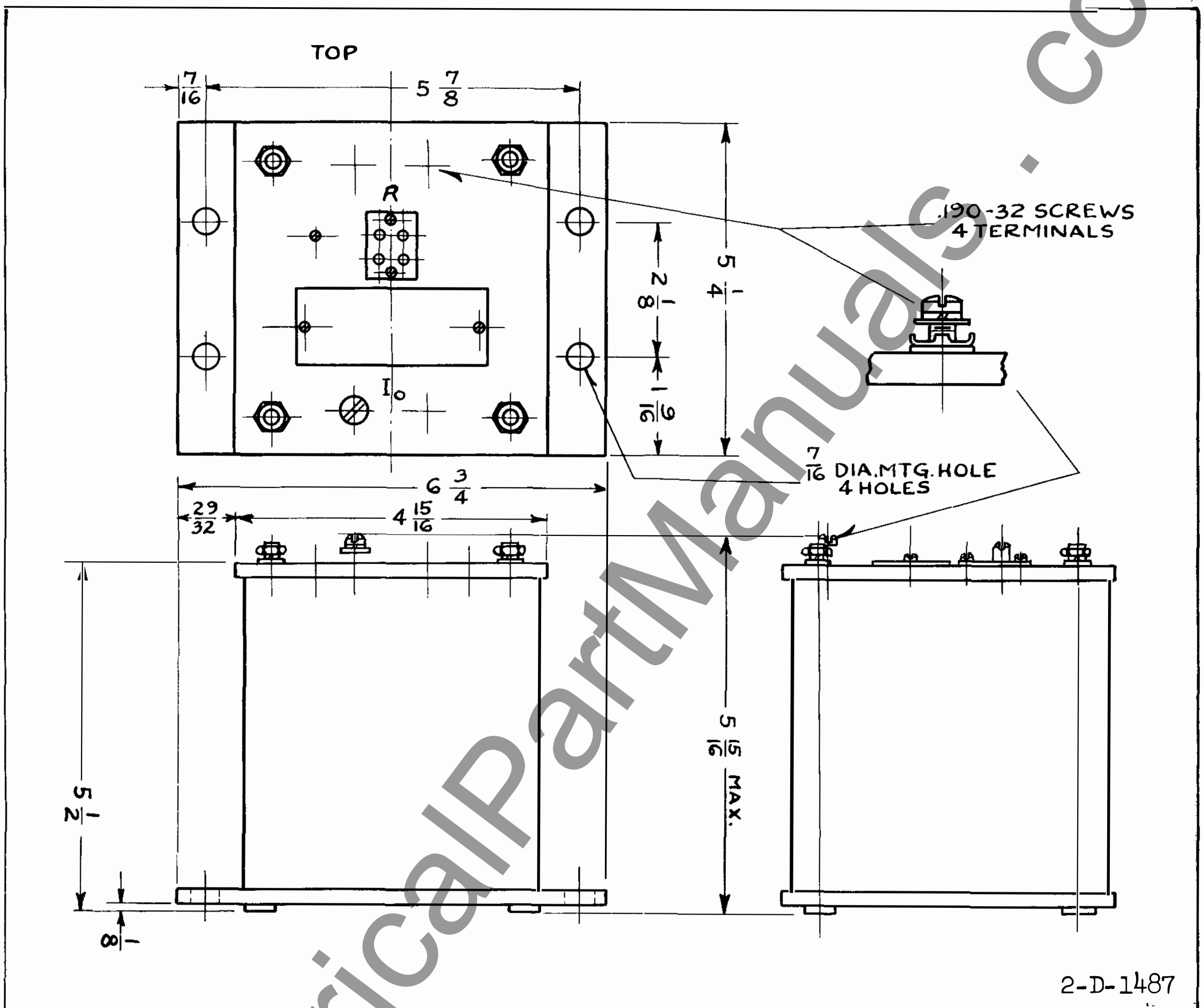


Fig. 12. Outline & Drilling Plan of the Auxiliary Current Transformer.

In cases III, V, VII, and VIII of Table I, at least one pair of current transformers is paralleled. Almost complete restraint cancellation will occur on an external fault, if all but two of the circuits are out of service and if the remaining circuits have their current transformers paralleled. In selecting the circuits to be paired, the following points should be observed:

1) Parallel circuits which are not likely to be left alone on the bus.
2) Where sources are to be paired, parallel the smaller sources, if there are less than 8 equivalent circuits.
3) Avoid pairing the two largest sources.
4) If feasible, parallel matched current transformers.

In case IV, with two feeder groups one of the restraint elements must be connected to 2 source circuits. These 2 source circuits should be selected so that they are the least likely to be left alone on the bus and are not the two largest sources.

Where the nature of the bus application is such that nearly complete restraint cancellation is very likely to occur for cases III, V, VII, and VIII of Table I, two relays per phase should be employed to insure restraint under all possible external fault conditions. Connections for 6 and 8 equivalent circuit buses, using 2 relays per phase, are shown in Figs. 8 and 9, respectively.

Where there are more than 8 equivalent circuits, the connections in Fig. 9 should be employed by pairing current transformers in the same manner as outlined for single relay per phase applications.

SETTING CALCULATIONS

No calculations are required to set the CA-6 relay.

SETTING THE RELAY

BUS DIFFERENTIAL RELAY

The external current transformer taps are the only setting required. Where the d-c time constant is 0.6 cycles or less and where the current transformer ratio error as a result of a-c saturation exceeds 5%, it is recommended that the No. 38 tap be used. In all other cases, the No. 19 tap is recommended.

If the minimum internal fault current is greater than .14 amperes, the pickup of the relay may be increased by means of the spring adjuster. The spring tension can be increased such that a maximum pickup of .4 amperes can be obtained. The pickup current is to be measured when only the operating circuit is energized.

TRANSFORMER DIFFERENTIAL RELAY

Set the external current transformer tap. The following settings are recommended for mismatch of the main current transformers:

Percent † Mismatch	Minimum Pickup Setting	Minimum Tap
0-5	.75 Amp.	19
5-10	1.00 Amp.	38
10-15	1.25 Amp.	38

† Includes error due to power transformer tap changing.

The pickup of the relay is varied by means of the spring adjuster.

INDICATING CONTACTOR SWITCH (ICS)

No setting is required on the ICS unit except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a type WL relay switch, or equivalent, use the 0.2 ampere tap.

INDICATING INSTANTANEOUS TRIP (IIT)

* The core screw must be adjusted to the value of pick-up desired. It is recommended that a pickup of 100 amperes be used.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information refer to I.L. 41-076.

The total resistance of the leads, connecting relay terminals 12 and 13 to the R terminals of the auxiliary current transformer, must not exceed 0.05 ohm.

* ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay no customer adjustments, other than those covered under "SETTINGS" should be required.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order. Relays and transformers of matching serial numbers should be connected together. Use tight screw connections. No clip leads should be used. The total resistance of leads, connecting relay terminals 12 and 13 to the R terminals of the auxiliary current transformer, must not exceed 0.05 ohms.

A. Minimum Trip Current

Apply current to the primary of the external transformer. The relay should operate as follows on the 19 tap.

1. Bus Differential Relay 0.145 ± 5% amp.
2. Transformer Differential Relay 1.0 ± 5% amp.

B. Torque Curves

Connect the relay as shown in the test circuit of figure 10. Apply tap value current to the external transformer. The contacts should open when the following restraint current is applied to the relay.

1. Bus Differential Relay
   16-1/2 ± 5% amperes

2. Transformer Differential Relay
   15-1/2 ± 5% ampere

Care should be taken not to overheat the relay and external transformer during the test.

The restraint current of the transformer differential relay is less than that of the bus differential relay in order to compensate for the stronger spring used on the transformer relay.

C. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should not be greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

The contact gap should be approximately .047 inch between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

D. Indicating Instantaneous Unit (IIT) – (Where Supplied)

The core screw which is adjustable from the top of the trip unit determines the pickup value. The trip unit has a nominal ratio of adjustment of 1 to 4 and an accuracy within the limits of 10%.

The making of the contacts and target indication should occur at approximately the same instant. Position the stationary contact for a minimum of 1/32 inch wipe. The bridging moving contact should touch both stationary contacts simultaneously.

Apply sufficient current to operate the IIT. This current should be applied with the external transformer excluded from the circuit.

Routine Maintenance

All contacts should be periodically cleaned. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order. (See "Acceptance Check").

1. Clearance — Adjust the top bearing screw to have approximately .002 to .006 inch clearance between it and the shaft.

2. Contacts — Adjust the stationary contact so that 1/4 inch contact separation is obtained when the moving contact is held in the maximum open position.

3. Minimum Trip — With operating current applied to the external transformer, adjust the spring tension until the relay just operates with following currents in the 19 tap.:

1. Bus Differential Relay	0.145 amp.
2. Transformer Differential Relay	1.0 amp.

4. Torque Check — Connect the relay per the test circuit of figure 10. Pass tap value current of the external transformer into the operating circuit of the relay. The contacts should open when the following restraint current is applied:

a) Bus Differential Relay	16-1/2 ± 5% amp.
b) Transformer Differential Relay	15-1/2 ± 5% amp.

5. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

6. Indicating Instantaneous Trip Unit (IIT)

The core screw must be adjusted to the value of pickup current desired. It is recommended that the IIT be set to pickup at 100 amperes. This setting should be made with the external transformer excluded from the test circuit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

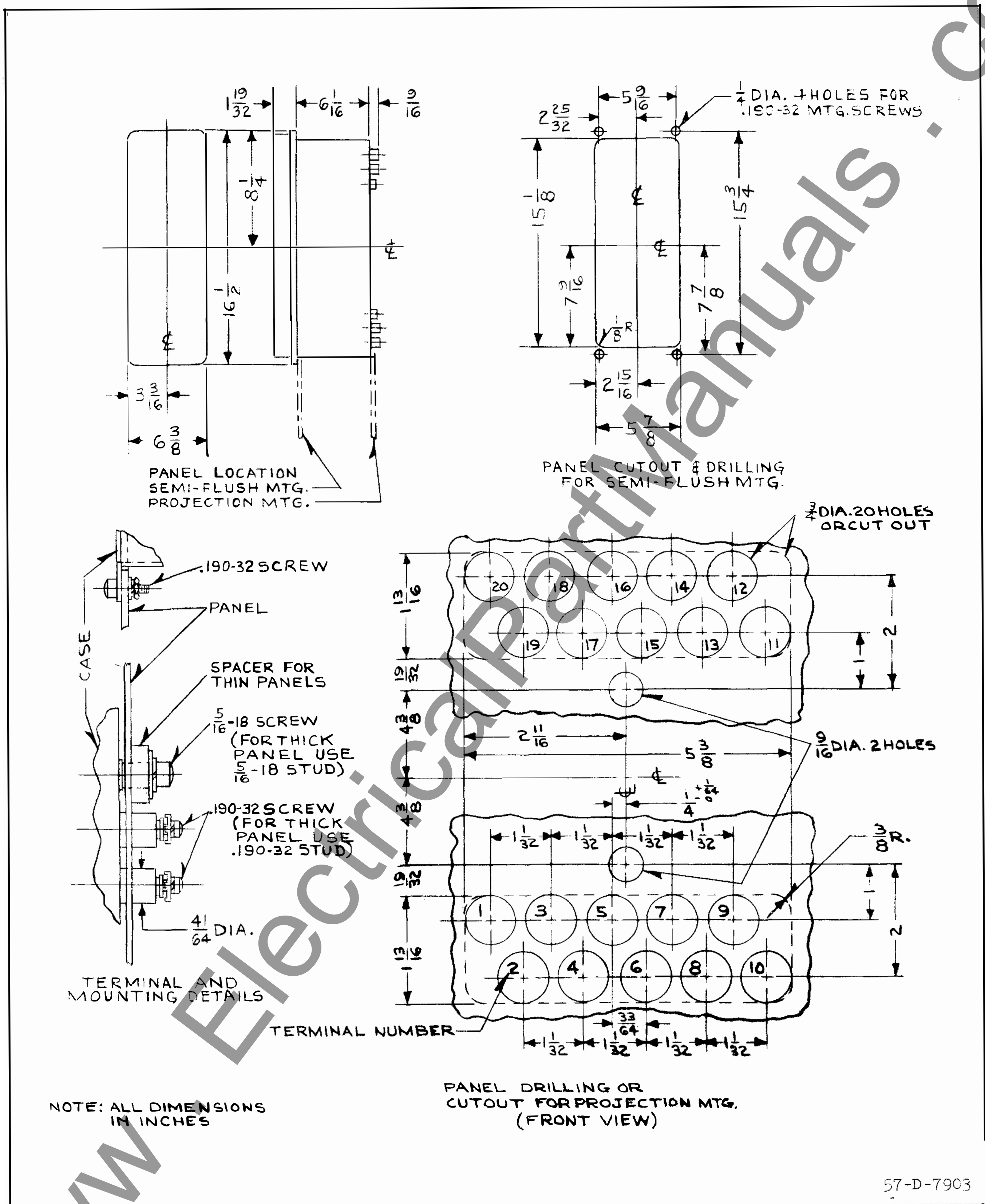


Fig. 13. Outline & Drilling Plan for the Type CA-6 Relay in the type FT-32 Case.

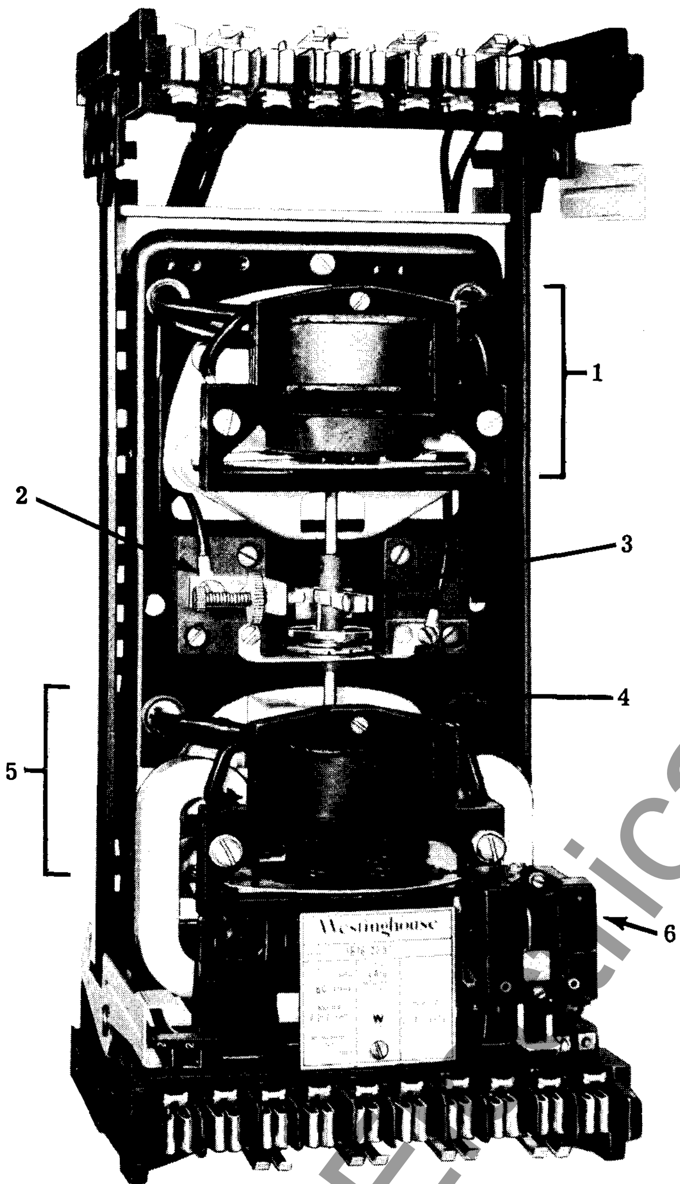


Fig. 14. Type CA-6 Relay Without Case (Front View). 1 - Top Front Restraining Element. 2 - Stationary Contact. 3 - Moving Contact. 4 - Control Spring Assembly. 5 - Bottom Front Restraining Element. 6 - Indicating Contactor Switch (ICS).

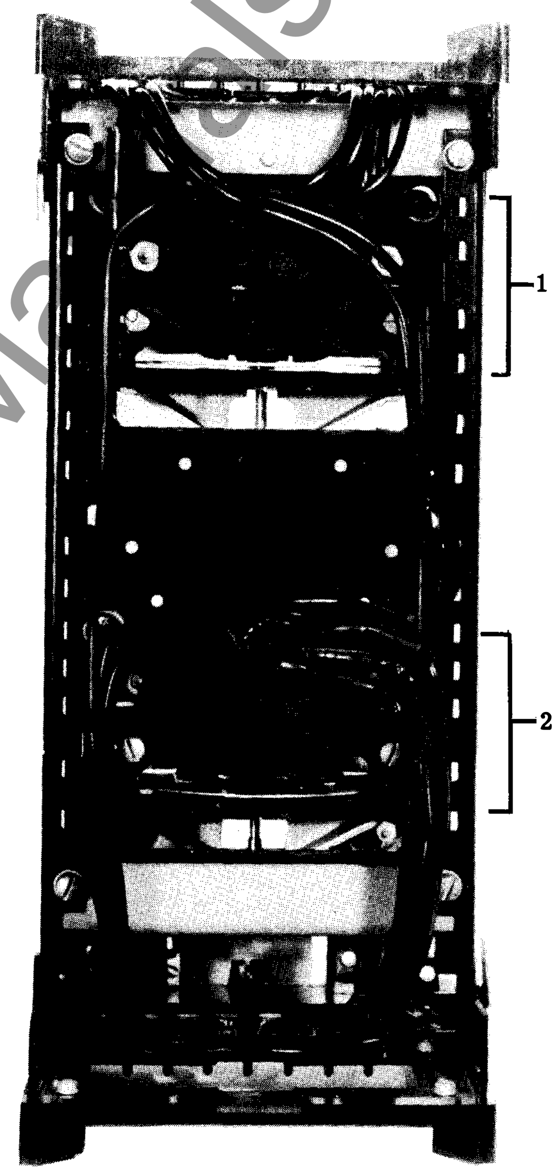


Fig. 15. Type CA-6 Relay Without Case (Rear View). 1 - Top Rear Operating Element. 2 - Bottom Rear Restraining Element.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

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