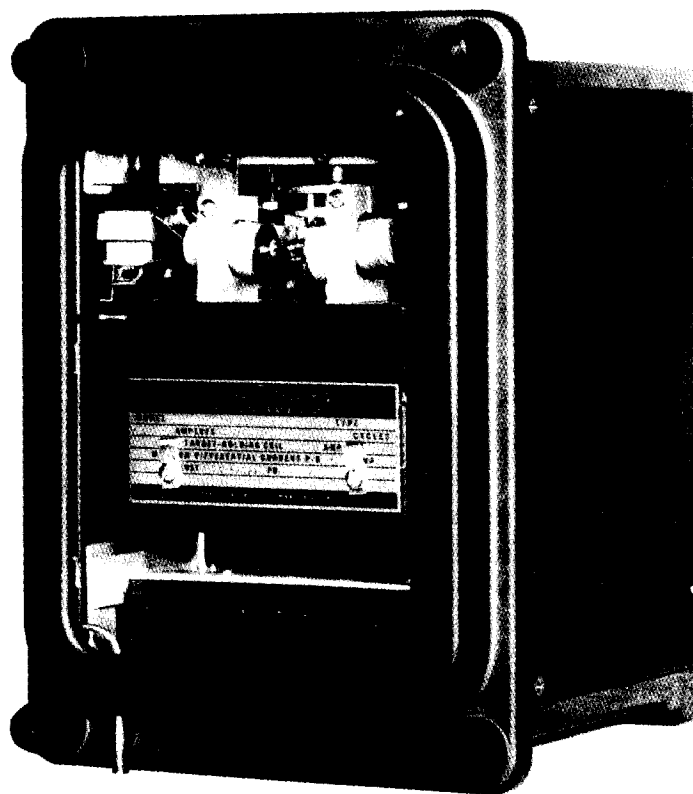




# ***INSTRUCTIONS***

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## **HIGH-SPEED DIFFERENTIAL RELAYS TYPES CFD22A AND CFD22B**



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## HIGH-SPEED DIFFERENTIAL RELAYS

### TYPE CFD

### APPLICATION

High-speed differential relaying such as that afforded by the Type CFD is recommended for protection of generators of 2000 KVA capacity and above, and for motors and synchronous condensers of 3000 horsepower (or KVA) and above. Other forms of differential protection are recommended for the lower ratings of generators, motors and synchronous condensers. It is desirable that if one machine is differentially protected, all machines paralleled with it on the same bus also have similar protection.

The Type CFD relays comprise a group that is used for differential protection of alternating-current machines against both phase-to-phase and phase-to-ground faults. The relays function on the difference between the current entering one end of a winding and that leaving the other end. When the difference exceeds a certain minimum value due to an internal fault, the relay will close its contacts. An external fault will not produce a difference in current and therefore will not cause relay operation. Likewise, the relay will not respond to open circuits or turn-to-turn short circuits, neither of which affects the difference between current entering and current leaving the winding. Refer to Figure 1.

Phase-to-ground protection requires that the neutral of the machine (or another machine operating in parallel) be grounded. A small portion of the winding next to the neutral will not be protected, the amount being determined by the voltage necessary to cause minimum pickup current to flow through the neutral-to-ground impedance. Current-limiting devices in the neutral ground circuit increase this impedance and will decrease the coverage of the relay.

Delta-connected machines with both ends of each winding available can readily be connected for phase-to-phase fault protection. The current transformers in the windings should have the same ratio as the transformers in the lines. Where only four leads, including a neutral, are brought out from a machine, it is only possible to obtain differential relaying for ground faults. If only three leads are brought out, differential protection cannot be obtained. In this case an overcurrent relay may be used to detect ground faults, provided there is a grounded neutral in the bus circuit to which the machine is connected.

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

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

When a generator, and power transformer are operated as a unit, separate relaying is recommended for each. The sensitive protection of a CFD relay can be given to a generator, whereas it would be inadvisable for a power transformer. It is permissible to use one set of current transformers in common between the two differential relays and in such a way, that the transformer protective relay acts as back-up protection for the generator.

When current-differential protection is provided for AC machines, the field switch should be tripped automatically at the same time that the machine is disconnected from the system. Electrically operated field circuit breakers, or contactors, are generally used for this application, but in some cases manually operated field switches, consisting of an air circuit breaker with a shunt trip and a field discharge clip, are employed.

Where the total rms symmetrical current that would flow in a differential relay coil is excessive, high voltage may result with sensitive differential relays, and a Thyrite® limiter may be required across each phase of the current transformer secondaries. Where taps on the current transformer secondary windings are unused or do not exist, currents below 84 amperes are safe without limiters. Where taps are used on the CT secondaries, limiters are not necessary if

$$\text{the current is less than } 84 \times \frac{(\text{Active Turns})^2}{(\text{Total Turns})^2}$$

Installations not shown to be safe by the approximate rule given above should be referred to the General Electric Company with data on the fault currents, CT ratios, and CT excitation characteristics, to determine whether limiters are actually needed.

If the neutral of a machine is grounded, it is advisable to provide a neutral breaker that can be tripped to open the ground-return circuit of the fault current as quickly as possible. It is usually preferable to trip the neutral breaker, main breaker, and field breaker simultaneously, by means of a hand-reset auxiliary relay.

A ground alarm should be provided in each station. This is usually connected through an auxiliary switch on each of the neutral breakers so that the alarm will sound only in case all neutral breakers are open.

## RATINGS

### INDUCTION UNIT

The operating element of the Type CFD relay, the induction cup unit, is rated at 5 amperes continuous current flow in the restraint coils. The operating coils will carry 0.5 ampere continuously without overheating. The 12CFD22B15A relay is rated at 50 hertz, with the restraint coils rated at 1 ampere continuously and the operating coils rated at 0.1 ampere continuously.

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## CONTACTS

The CFD relays are supplied with non-bouncing contacts that provide positive contact closing.

The current-closing rating of the contacts is 30 amperes for voltages not exceeding 250 volts. The current-carrying rating is limited by the two forms of target and holding coils, as described in the next section. If the total tripping current exceeds 30 amperes, an auxiliary relay must be used with the CFD relay. After tripping occurs, the trip circuit must be opened by an auxiliary switch on the circuit breaker, or by another automatic means, since the relay contacts are held closed while the tripping current is flowing.

## TARGET AND HOLDING COILS

There are two ratings of target and holding coils available. The choice between them depends on the current taken by the trip circuit. Separate target and holding coils are provided with these relays, as shown on the internal connection diagrams, Figures 5 and 6.

The 0.2 ampere coils are for use with trip circuits that require currents ranging from 0.2 to 1.0 ampere at the minimum control voltage. If these coils are used in circuits that require 1.0 ampere or more, there is a possibility that the total resistance of the relay circuit will limit the tripping current to so low a value that the breakers will not be tripped.

The 1.0 ampere coils should be used with trip circuits that take 1.0 ampere or more at the minimum control voltage if the current does not exceed 30 amperes at the maximum control voltage. When more than 30 amperes will flow, an auxiliary relay must be used to control the trip circuit. Connections must be such that tripping current does not flow through contact circuit of the Type CFD relay.

Relay Types CFD22A and CFD22B are supplied with two circuit-closing contacts. Tripping current in both these circuits flows through the target and holding coils (see Figures 5 and 6). The total current must therefore be used when determining coil ratings.

When it is desirable to adopt one type of relay as standard to be used anywhere on a system, relays with the 1.0-ampere target and holding coil should be chosen. These relays should also be used where it is impossible to obtain trip-coil data, but attention is called to the fact that **the target may not operate if used in connection with trip coils taking less than 1.0 ampere.**

## GEK-34124

The ratings of the two forms of target and holding coils are as follows:

FUNCTION	AMPERES AC or DC	
	1.0 Amp Target and Holding Coils (0.50 ohm total)	0.2 Amp Target and Holding Coils (14 ohms total)
Minimum target release	1.0	0.2
Carry for tripping duty	30.0	5.0
Carry continuously	2.5	0.5

## BURDENS

The burden of the restraint coils at rated amps is given below. The burden is shared by the two current transformers.

RATED FREQUENCY	CONTINUOUS RATING--AMPS	ONE-SECOND RATING--AMPS	R	X	Z	VA	PF
60	5.0	220	0.040	0.057	0.070	1.75	0.57
50	5.0	220	0.034	0.048	0.059	1.47	0.58
50	1.0	42	1.14	1.64	2.00	2.00	0.57

The burden of the operating circuit at minimum pickup is given below:

RATED FREQUENCY	CONTINUOUS RATING--AMPS	MINIMUM PICKUP	ONE-SECOND RATING--AMPS	R	X	Z	VA	PF
60	0.5	0.2	140	29	50	58	2.3	0.5
50	0.5	0.2	140	24	42	48	1.9	0.5
50	0.1	0.04	25					

The operating circuit saturates as the current increases. The circuit impedance is given below:

CURRENT AMPERES	MULTIPLES OF MINIMUM PICKUP	IMPEDANCE IN OHMS	
		60 HERTZ RELAY	50 HERTZ RELAY
0.2	1.0	58	48
0.6	3.0	29	24
2.0	10	11	9.1
4.0	20	6.3	5.2
5.0	25	5.4	4.5

### RECEIVING, HANDLING AND STORAGE

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

Reasonable care should be exercised in unpacking the relay in order that none of the parts are injured nor the adjustments disturbed.

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

### DESCRIPTION

#### RELAY TYPES

The Type CFD22A relay is a three-unit relay for providing differential protection for a three-phase generator. Each unit is provided with a double contact arrangement, which allows tripping of two circuit breakers without paralleling the trip circuits. If only one breaker is to be controlled, the contacts should be connected in parallel.

The Type CFD22B is similar to the CFD22A except that it has only one unit and is applicable to only one phase. It can be used for single-phase generator protection provided that one line is grounded, or for a three-phase generator application where flexible panel mounting is required.

## INTERNAL CONSTRUCTION

The CFD relays are of the induction cylinder construction. The unit consists of a multi-pole stator, a stationary central core, and a cup-like induction rotor. The cup rotates about a vertical axis in the air gap between the stator and core. The lightweight aluminum cylinder offers a high ratio of torque to inertia and results in a fast operation time.

## CUP AND STATOR

The axis of the cylinder is supported at the lower end by a steel pivot that rotates against a selected sapphire jewel. The jewel is spring mounted to protect it from shocks. The upper end of the shaft is held in place by a polished steel pivot that projects down through a bronze guide bearing mounted in the end of the shaft.

The stator of the induction unit is of the eight-pole construction, but uses only six of the poles in two sets of three. One set carries the currents from the current transformers in one phase on each side of the generator winding (see Figure 1). The other set carries the differential current between the two current transformers.

## CONTACT STRUCTURE

The contacts are silver-to-silver elements and are constructed with a non-bounce feature to ensure a positive circuit closure. Two-circuit closing action is obtained by mounting a second stationary contact at the back of the induction unit (see Figure 3). This makes contact with a rear extension of the moving contact arm. A shock backstop absorbs shock and reduces the tendency of the moving contact to close if the mounting panel is jarred. Figure 4 shows the arrangement of the contact mechanism. The stationary contact (G) is mounted on a flat spiral spring (F) that is spaced from a thin diaphragm (C) by a washer (D). The cap (E) holds these in place on a slightly inclined tube (A), which contains a close fitting stainless steel ball (B). The energy of the moving contact is transferred to the spring and steel ball with the result that there is little or no rebound or vibration of the closing contacts.

The moving contacts are supported on a molded plastic arm that is attached to the rotor shaft through a clutch arrangement. The clutch acts as a shock absorber when the contacts close under fault conditions, and reduces their tendency to rebound. It consists of a felt-lined cylinder between the shaft and moving contact arm. The amount of frictional resistance to slippage is controlled by adjusting the pressure between the felt surface and the shaft by means of a screw on the side of the contact arm.

The contact arm is held from rotating freely by a control spring. This spring determines the minimum differential current that will operate the relay. It serves to keep the contact circuit open when the relay is de-energized.

## TARGET

The target mechanism (Figure 2) drops on an orange-colored surface when the relay trips a breaker. This indicator is unlatched by a solenoid through which the tripping current flows. It is reset manually by a reset lever which extends through the lower edge of the relay cover.



## HOLDING COIL

The holding coil is used to hold the contacts in the closed position while current is flowing through them. It acts on an armature that is carried by the moving contact arm. The coil is connected in series with the trip circuit, and therefore must be de-energized by opening the trip circuit at a point external to the relay.

## **INSTALLATION**

### LOCATION

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

### MOUNTING

The relay should be mounted on a vertical surface. The outline and panel drilling for either surface or semi-flush panel mounting is shown in Figure 10 for the three-unit case, (CFD22A), and in Figure 11 for the single-unit case (CFD22B).

### CONNECTIONS

The internal connection diagrams are shown in Figures 5 and 6 for the Types CFD22A and CFD22B respectively. Studs 13, 15 and 17 on the double-end cases are used for test purposes only. A typical external-wiring diagram is shown in Figure 1.

The contact circuits should be paralleled when only one trip circuit is controlled. This can be done by jumpering terminals 11 and 12 on the CFD22A or terminals 2 and 3 on the CFD22B.

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

### CURRENT TRANSFORMERS

Proper differential protection requires that the current transformers to which Type CFD relays are connected be accurate to within 1% or 2%, up to twice (2x) normal current. Above twice normal current, accuracy is not so important because of the CFD characteristics. See **PRINCIPLES OF OPERATION**.

### ADJUSTMENTS

#### Minimum Pickup

These relays are adjusted at the factory to close their left front contacts with 0.2 ampere or more in one current circuit and no current in the other.

Apply current, at rated frequency and good wave form, to the appropriate studs listed below for the relay model under test. The current magnitude for setting pickup is

Relay Model	Stud Connections			Contact Studs	
	Top	Middle	Bottom	Left Front	Right Rear
CFD22A	3-13	6-15	9-17	1-12	1-11
CFD22B	-	6-8		1-2	1-3

determined from the nameplate stamping under "Minimum Differential Pickup" for the unit/s under test.

To close the right rear contact, a current as high as 0.25 ampere may be required. If greater sensitivity is desired, it can be obtained by reducing the tension of the spiral control spring. To do this, it is necessary to loosen the hexagonal locking screw that holds the back of the adjusting ring. The operating ring can then be rotated to change the restraint offered by the control spring. Friction from a spring wire around the adjusting ring prevents unintentional motion of the ring. The hexagonal locking screw should again be **tightened** after the adjustment has been made. It is **not** recommended that the pickup be set less than 0.1 ampere (this may be as high as 0.18 ampere for the rear contact to close) in any case. If the relay is mounted on a swinging panel, the pickup should **not** be reduced at all.

### Contacts

The contact gap may be adjusted by loosening the locking screws that clamp the contact and backstop barrels in place. The screw should be loose enough only to allow the barrels to rotate in their sleeves. The shock backstop should be positioned so that it holds the moving contact arm pointing directly forward. The stationary contact barrel should be rotated until it just closes the contact circuit, and then backed away 3.2 revolutions. This will provide a gap of approximately 0.100 inch. Adjust the rear stationary contact barrel so that the circuit is completed at the same time the front contacts close. Tighten the screws that secure the shock stop and contact barrels.

Relays are shipped from the factory with contacts set for 0.100 inch gap. If relays are not to be mounted on swing doors and are free from shock, the contact gap can be reduced to 0.050 inch, and the time will be as shown by the lower curve in Figure 8.

Should it be necessary to change the stationary contact mounting spring, remove the contact barrel and sleeve as a complete unit, and unscrew the cap. The contact and spring may then be removed.

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

### Clutch

If for any reason the moving contact arm has been removed or loosened from the rotor shaft, it will be necessary to readjust the clutch pressure. The adjustment is made with the test connections shown in Figure 9 with the current  $I_0$  equal to zero (switch open). With 20 amperes flowing in the restraint circuit, the screw on the side of the moving contact arm should be loosened from a "no-slip" position until the rotor shaft does slip. The clutch should remain tight enough so that, as the current is reduced, slipping stops at a minimum of 10 amperes.

### INSPECTION

The relay should be inspected at the time of installation for tarnished contacts and loose screws that may have resulted from storage and handling. No further adjustments should be necessary. The adjustment procedures need be followed only in special cases of recalibration or contact replacement. Any trouble should be corrected as described under **MAINTENANCE**.

## PRINCIPLES OF OPERATION

Differential protective relays, Type CFD, function on a product-restraint principle. The restraint torque is proportional to the product of the current entering one side of the protected equipment and the current leaving the other side. The operating torque is proportional to the square of the difference between the two currents.

The operating and restraining torques balance when the differential current is 10% of the smaller of the other two, up to approximately normal current. This 10% "slope," as it is called, allows small differences to exist, due primarily to current transformer errors. Above normal current the differential-current circuit will saturate before enough operating torque is produced to close contacts on a 10% slope basis (see Figure 7). This characteristic increases the margin for current transformer error at high currents due to external faults.

Should the current at either terminal of the protected equipment reverse direction with respect to the current at the other, the product-restraint principle causes the restraining torque to reverse direction also, and it becomes an operating torque. This condition exists in the case of an internal fault in a generator paralleled with another power source. Under these circumstances saturation of the operating circuit is immaterial, since the relay does not depend on this circuit to operate its contacts. Figure 7 illustrates the fault conditions covered by the relay.

The Type CFD relay is a cup-type induction unit. This type of construction results in a fast-operate protective device, even at currents only slightly in excess of pickup value. A typical time-current characteristic is shown in Figure 8.

## MAINTENANCE

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

### SHAFT AND BEARINGS

The lower jewel screw may be removed, and the jewel tested for cracks by exploring its surface with the point of a fine needle. The bearing should then be screwed all the way in until its head engages the end of the threaded core support. The upper bearing should be adjusted to allow 1/64 inch end play to the shaft.

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

### CUP AND STATOR

If it is necessary to remove the rotor from the unit, the following procedure should be followed:

The leads should first be disconnected and tagged for identification in reconnecting. The unit can then be removed with its mounting plate attached.

The saturating transformer should next be removed from the back of the mounting plate so that the upper of the three flat-head screws holding the unit to the mounting plate can then be removed. Then the entire top structure can be taken off, after removal of the four corner screws holding the unit together. This will give access to the cup and stator assembly.

To remove the shaft and rotor from the contact-head assembly, the spring clip at the top of the shaft must be pulled out and the clutch-adjusting screw and spring taken out of the molded contact arm.

The rotor should be handled carefully while it is out of the unit, and the stator should be protected to keep it free from dust or metallic particles.

In reassembly, the rotor will go into the air gap easily if the parts are held in the proper alignment.

### CONTACT CLEANING

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

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

The burnishing tool described above is included in the standard relay tool kit obtainable from the factory.

### PERIODIC TESTING

An operation test is recommended. The test connections are shown in Figure 9. The restraint-circuit currents  $I_1$  and  $I_2$  correspond to the same current shown on the operating characteristic given in Figure 7.  $I_0$  represents the differential current. The direction of current through the restraint-circuit should be reversed and a second check of the operational characteristic made. The target operation should be checked by passing 85% of rated current through the contact circuits.

### **RENEWAL PARTS**

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

When ordering renewal parts, address the nearest Sales Office of the General Electric Company, specify quantity required, name of part wanted, and give the complete nameplate data. Refer to renewal parts publication GEF-3569. If possible, give the General Electric Company requisition number on which the relay was furnished.

Since the last edition, the Periodic Testing section and Figures 1, 8 and 10 have been changed.

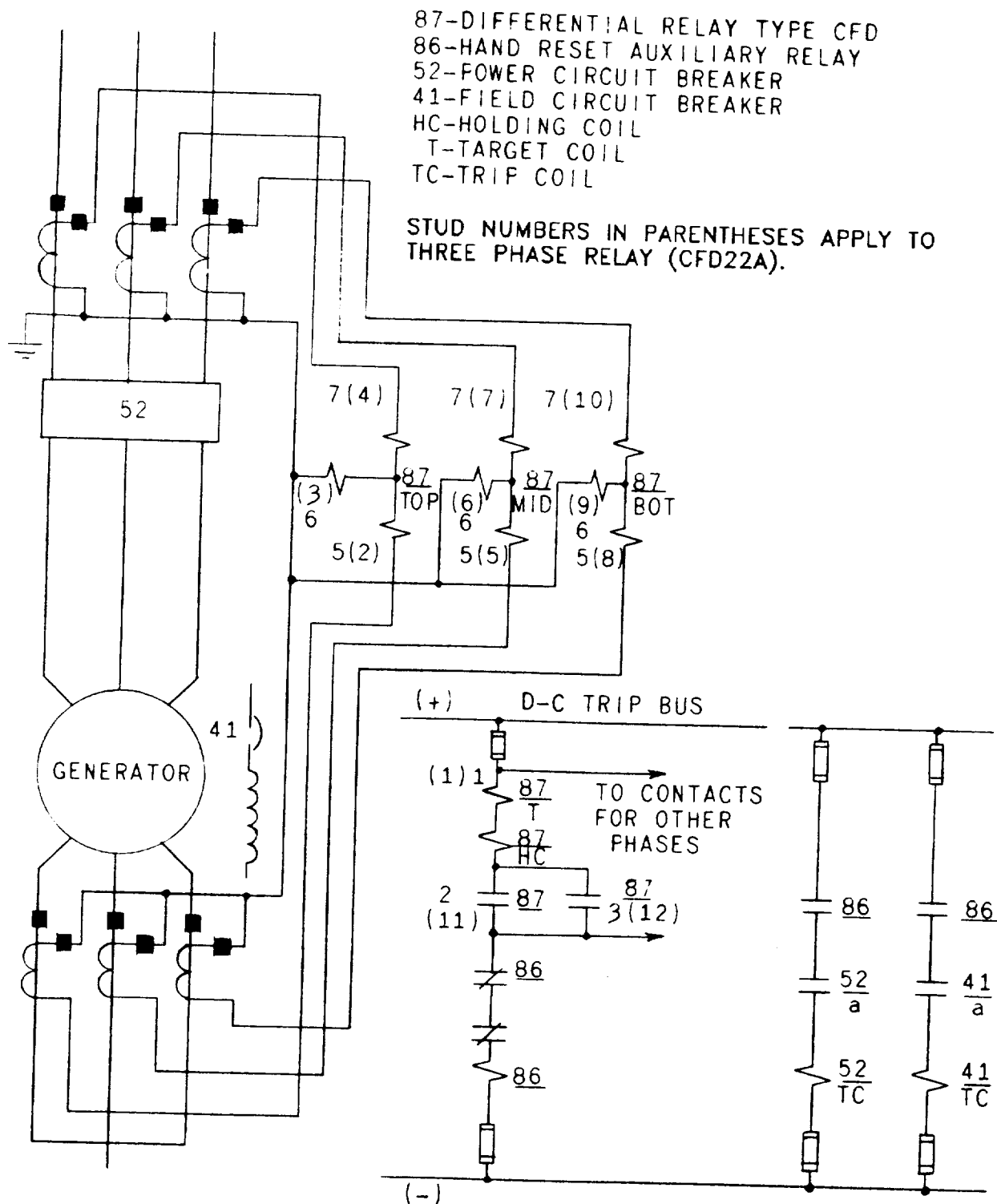


Figure 1 (K-6507930 [4]) Typical External Connections for one Type CFD22A Relay or three Type CFD22B Relays for Protection of a Wye-Connected Generator with Six Leads Brought Out

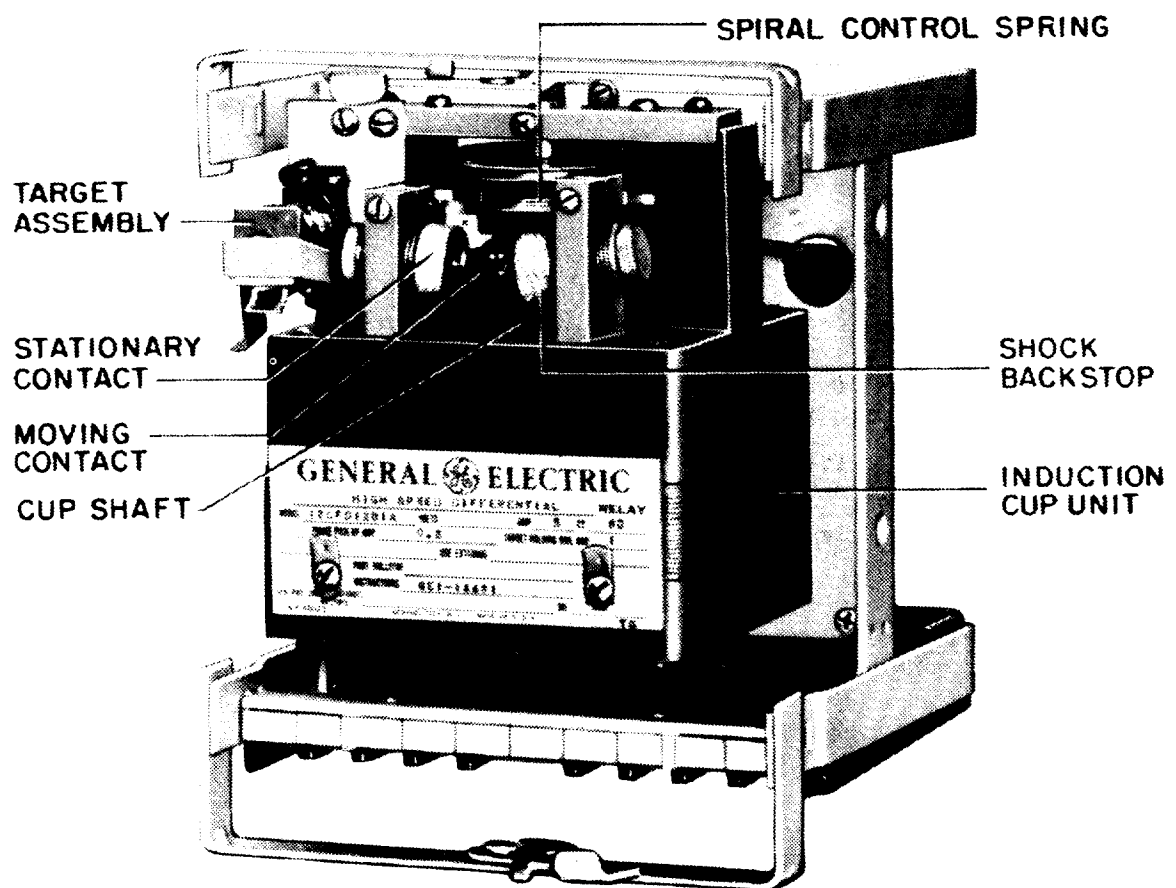


Figure 2 (8010627) Type CFD22B Relay Removed from Case (Front View)

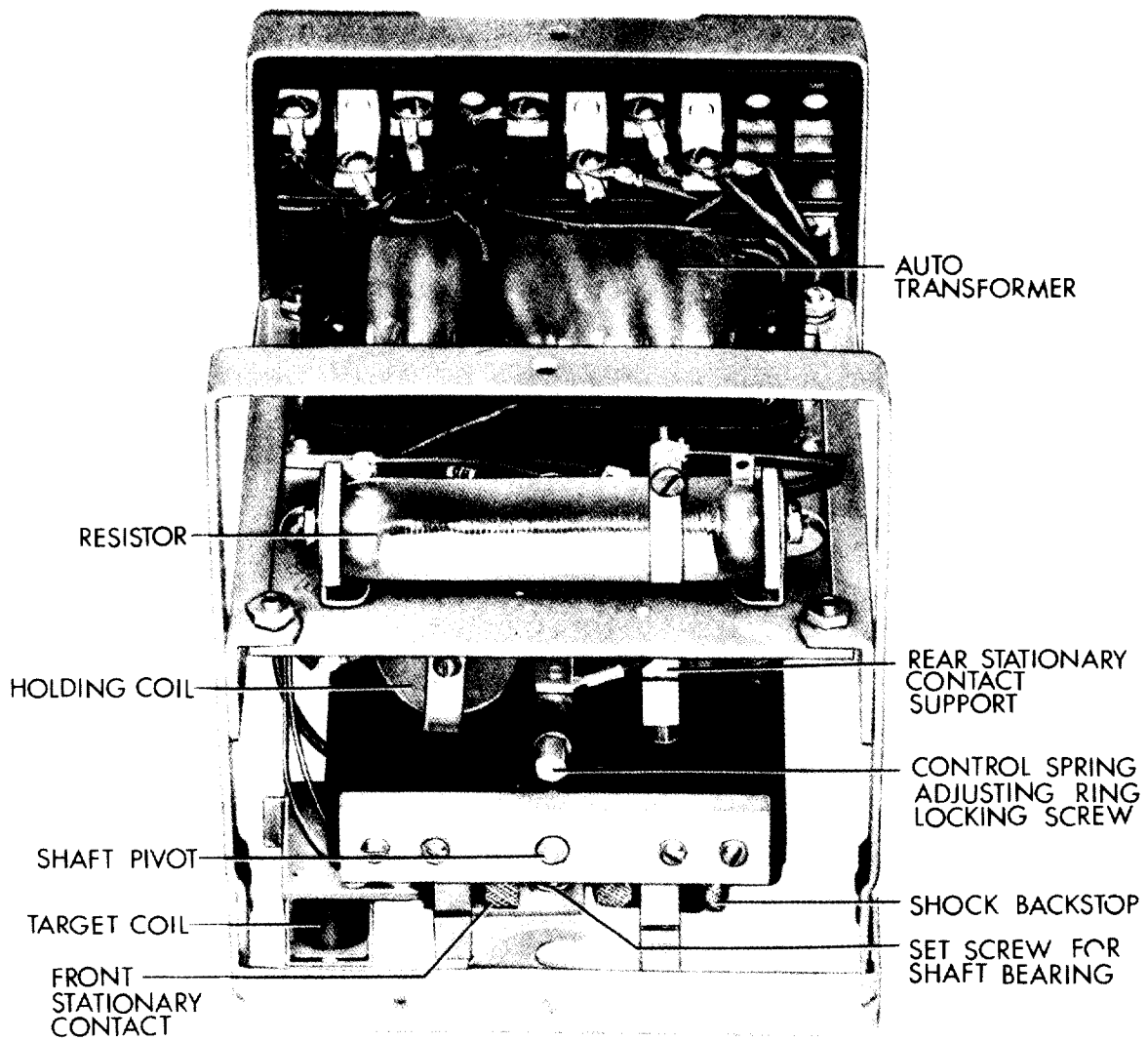
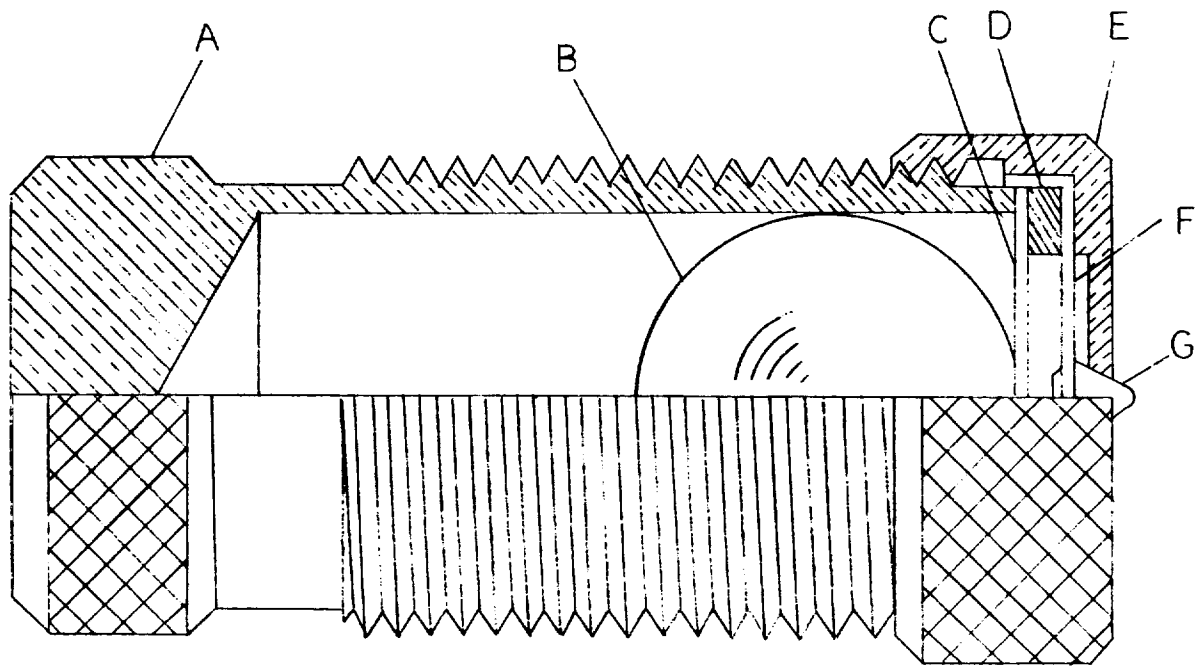


Figure 3 (8041410) Type CFD22B Relay Removed from Case (Top View)



- |                          |                        |
|--------------------------|------------------------|
| A - INCLINED TUBE        | D - SPACER             |
| B - STAINLESS STEEL BALL | E - CAP                |
| C - DIAPHRAM             | F - FLAT SPIRAL SPRING |
| G - CONTACT              |                        |

Figure 4 (K-6077069-4) Stationary-Contact Assembly for Type CFD Relays



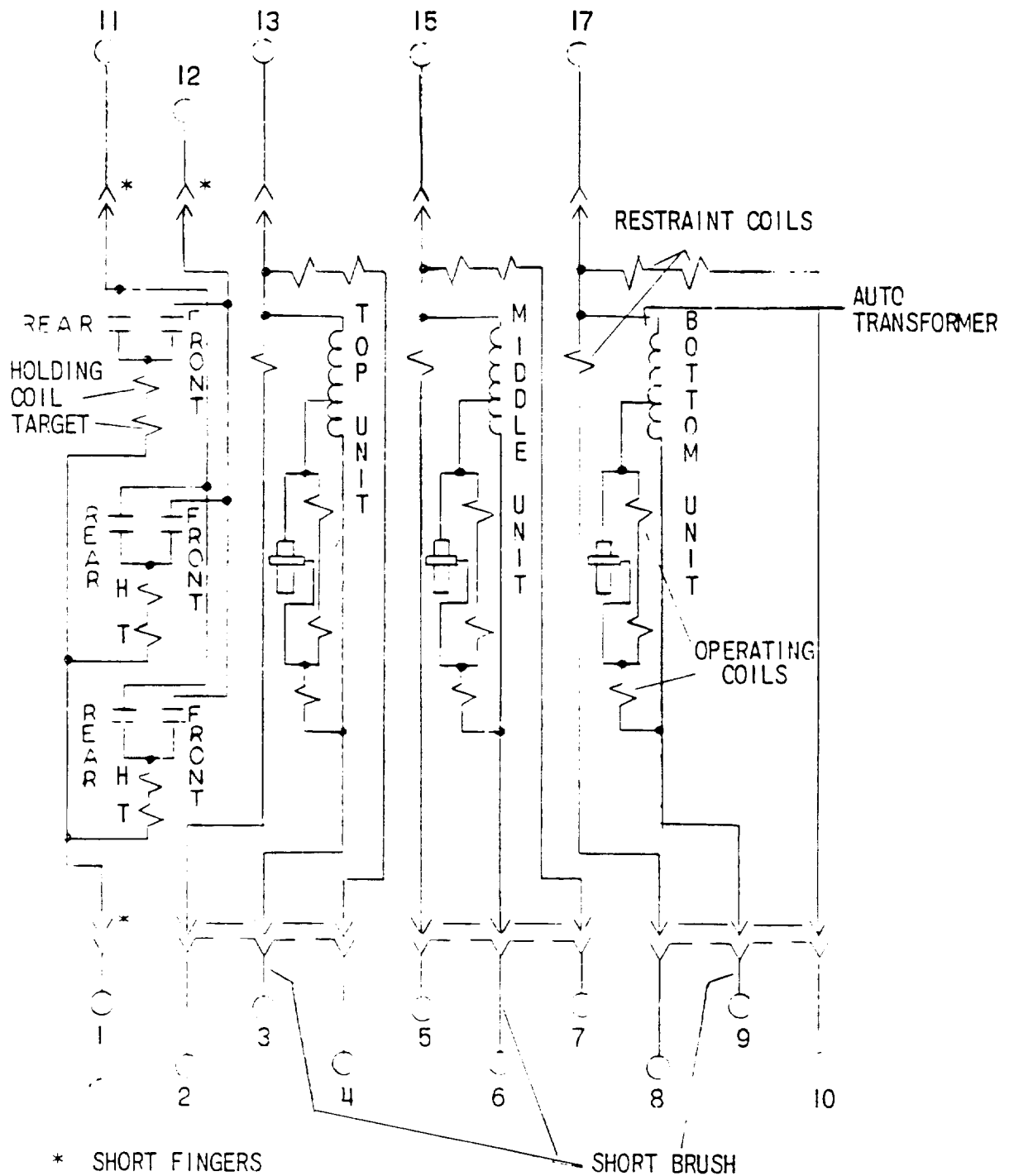
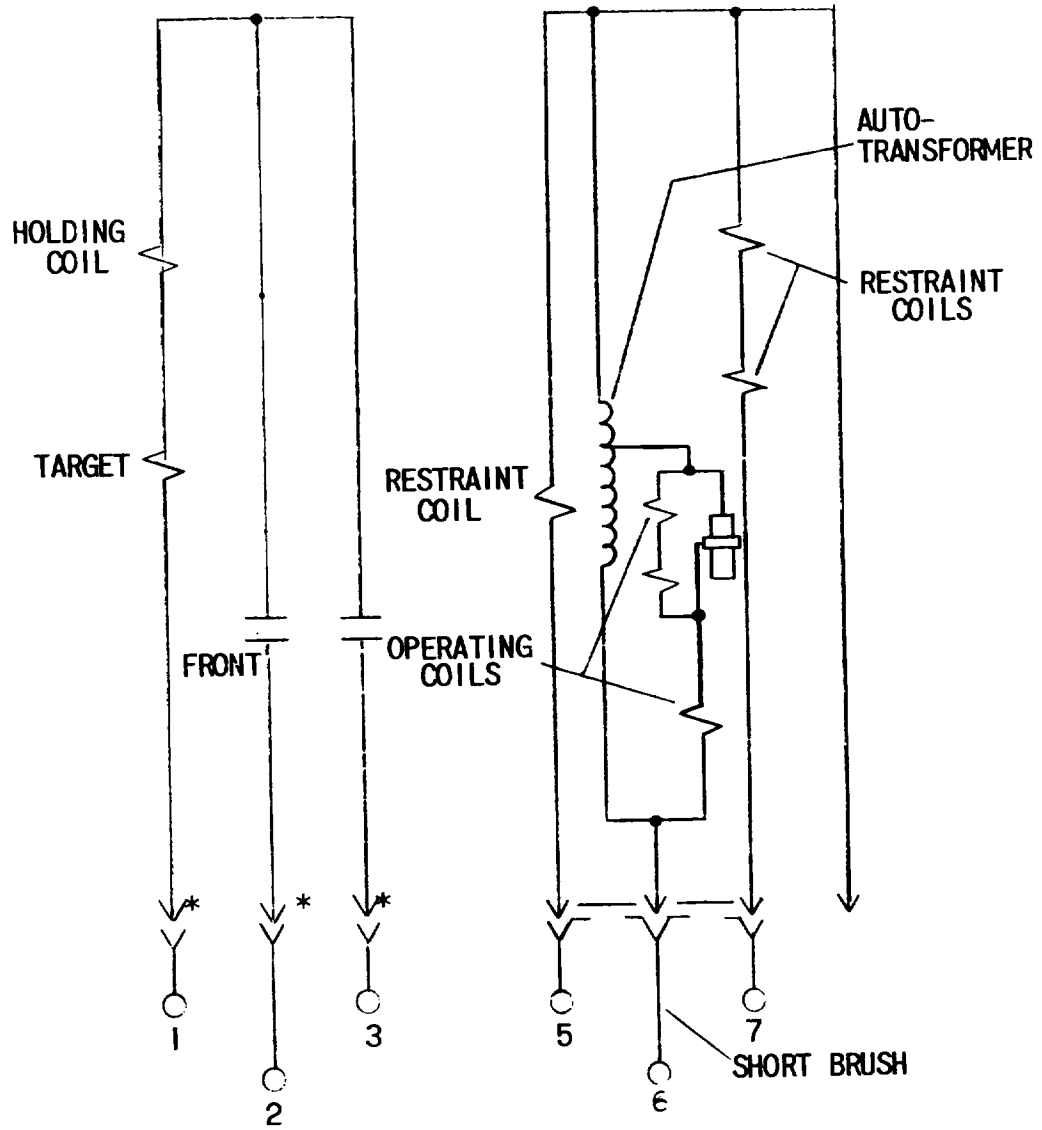


Figure 5 (0227A7154-1) Internal Connections for the Type CFD22A Relay (Front View)



\* SHORT FINGER

Figure 6 (0227A7153-1) Internal Connections for the Type CFD22B Relay (Front View)

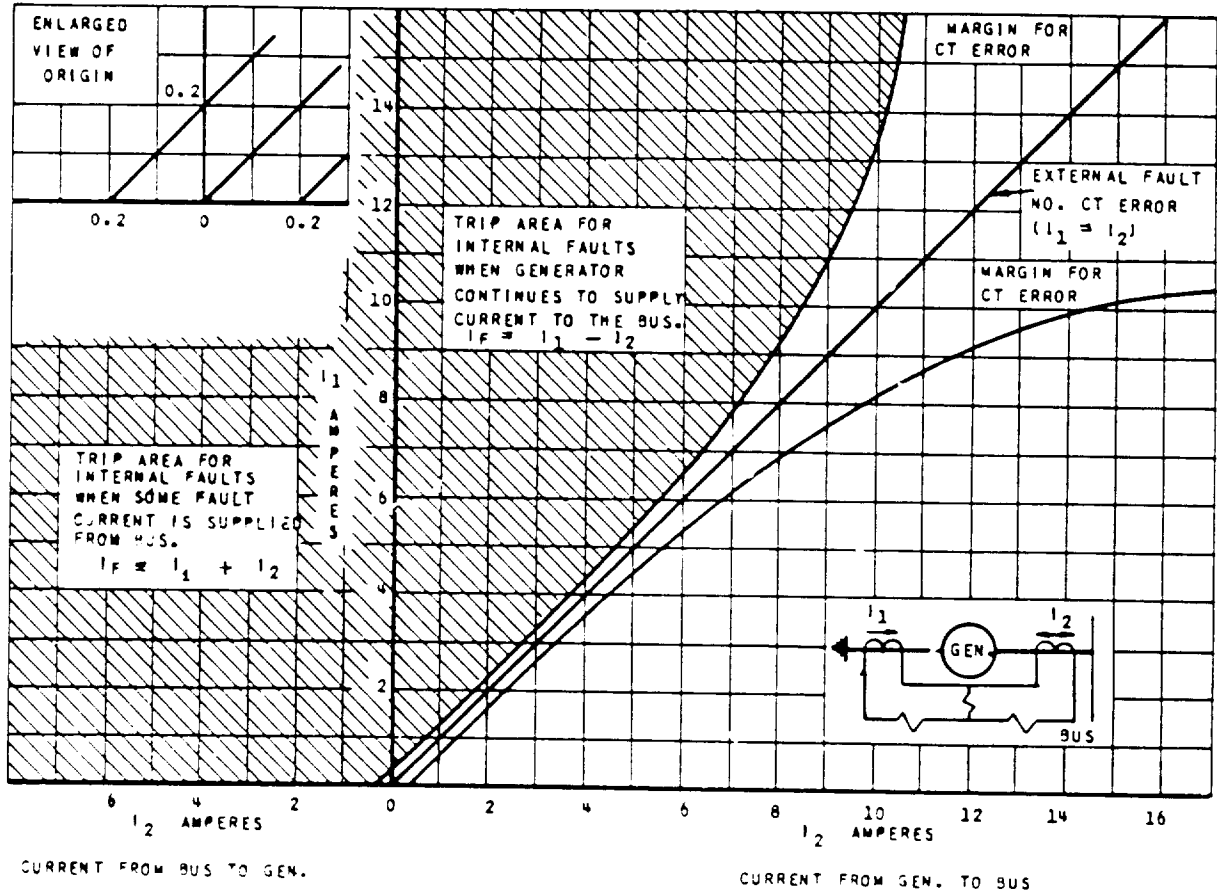


Figure 7 (K-6507942-0) Typical Operating Characteristics for Type CFD Relay

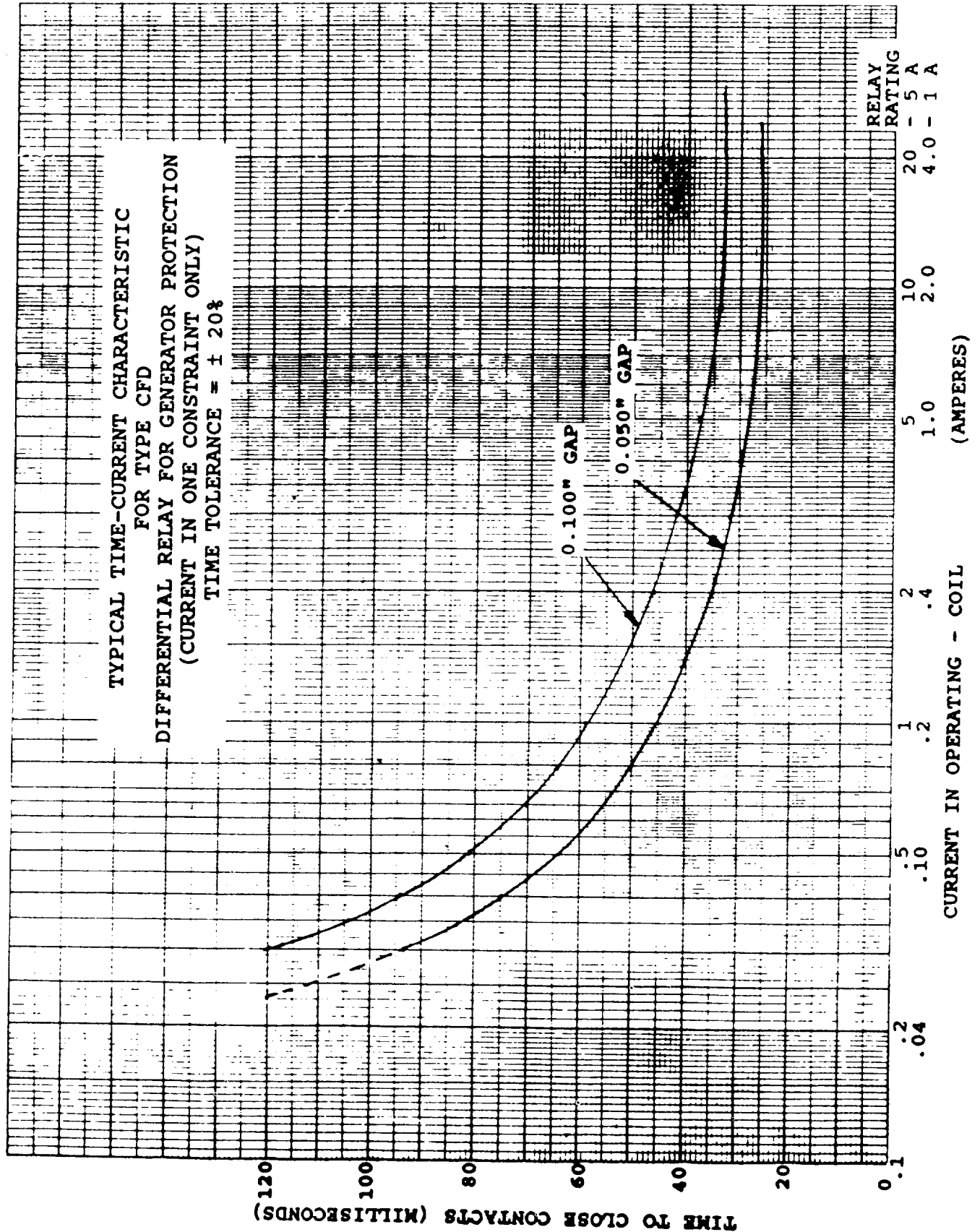


Figure 8 (0286A3830 [1]) Typical Time-Current Characteristic for the Type CFD Relay

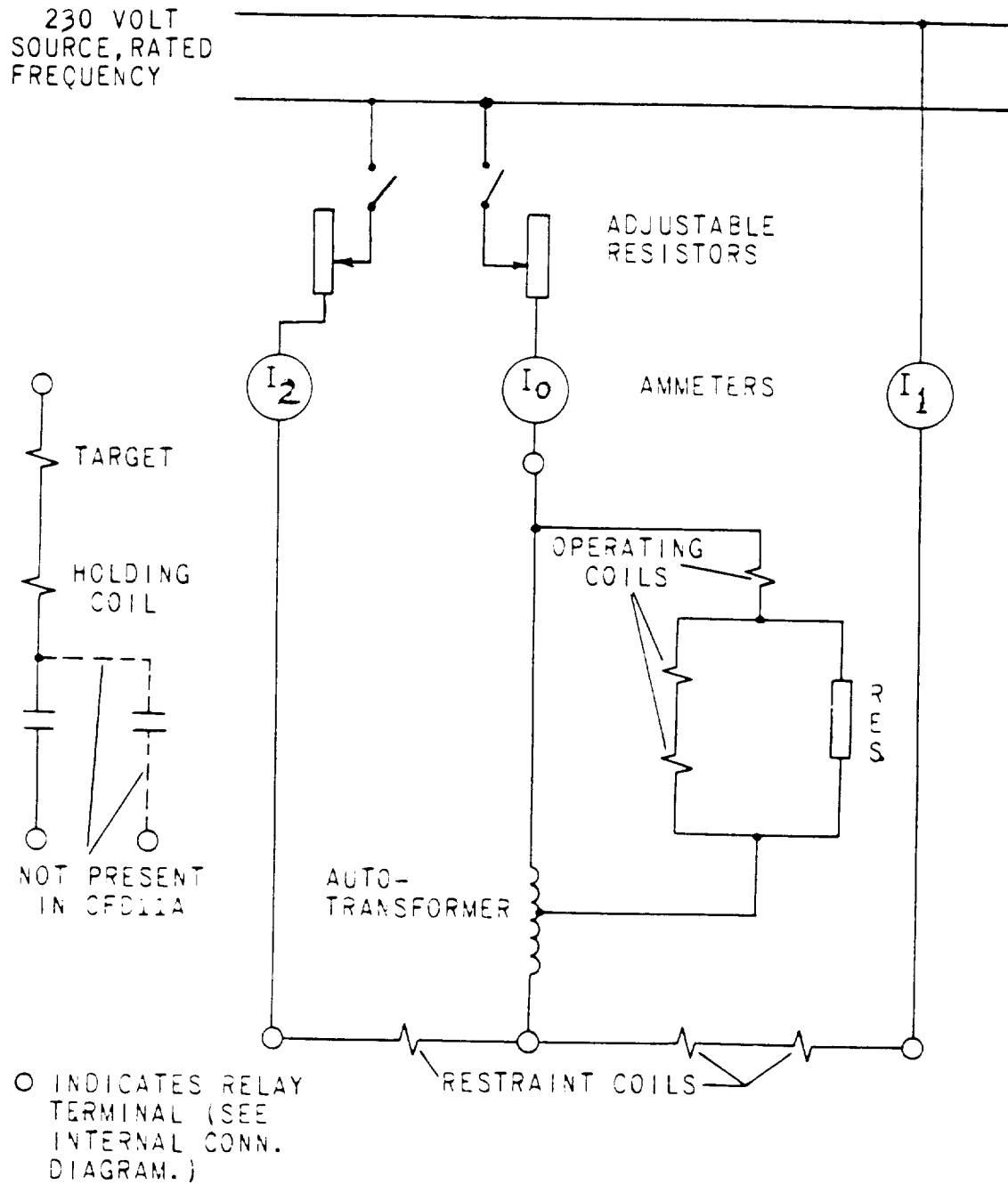


Figure 9 (K-6507933-5) Test Connections for the Type CFD Relay

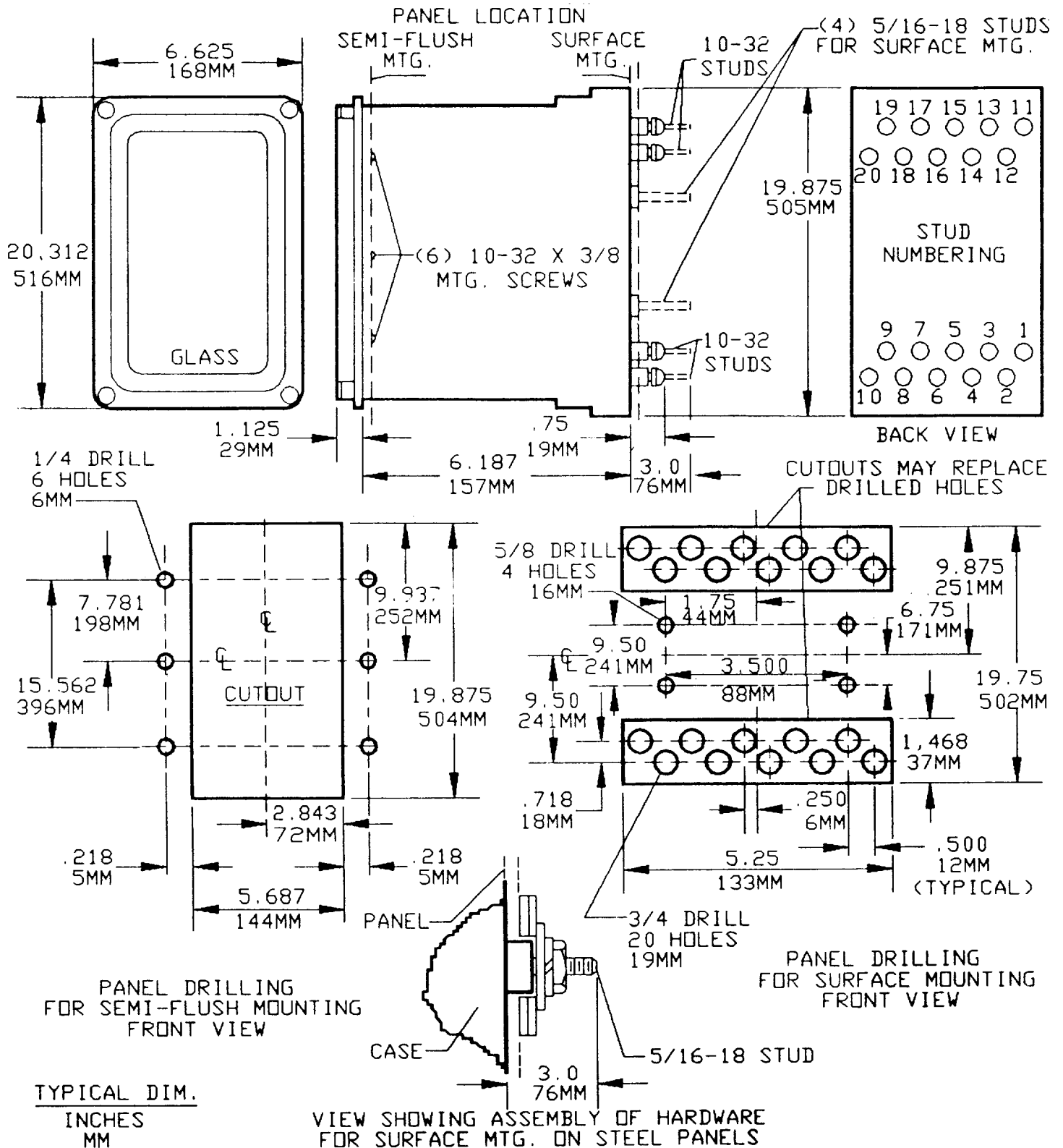


Figure 10 (K-6209276 [5]) Outline and Panel Drilling for the Type CF22A Relay

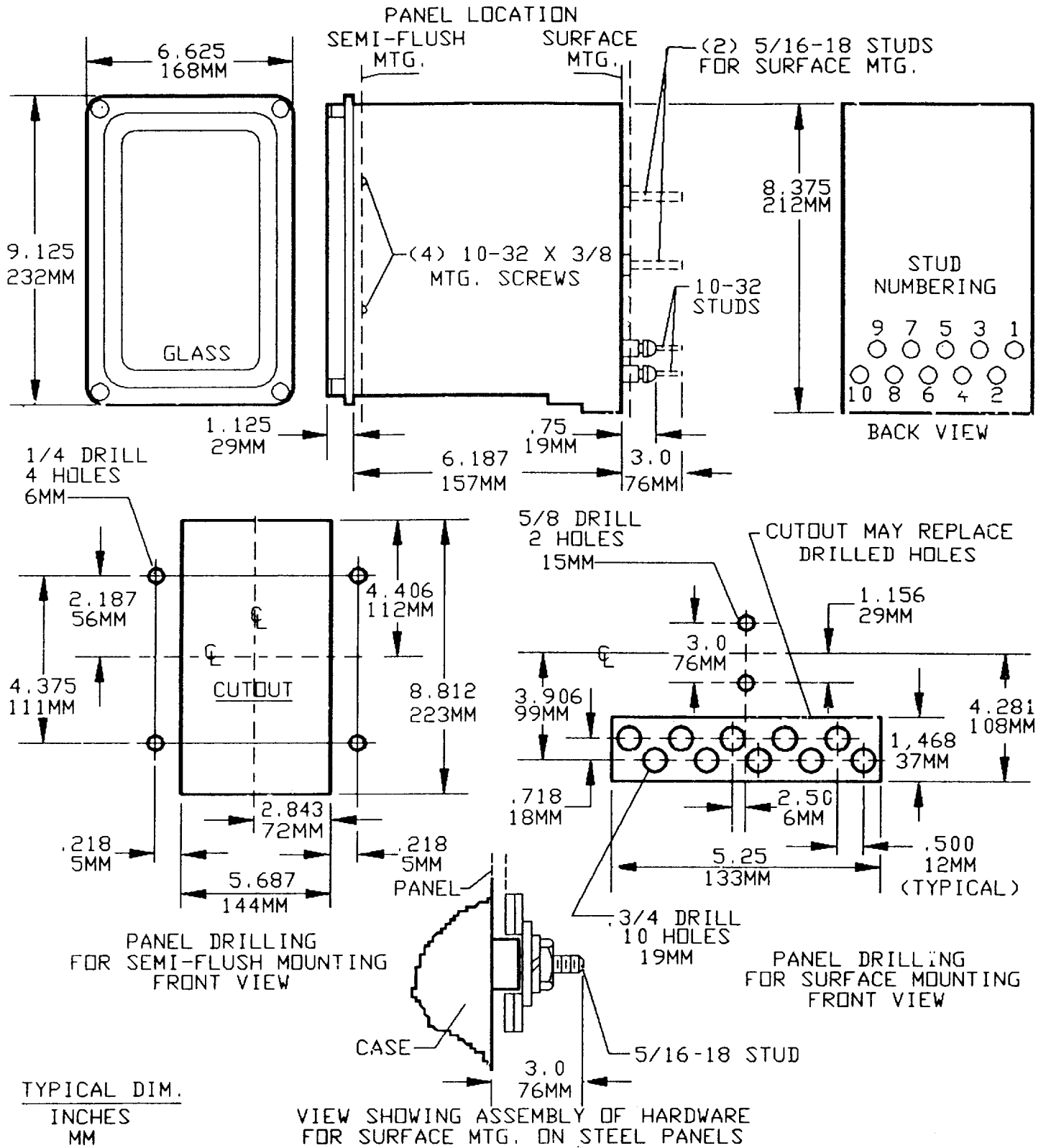


Figure 11 (K-6209271-8) Outline and Panel Drilling for the Type CFD22B Relay



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