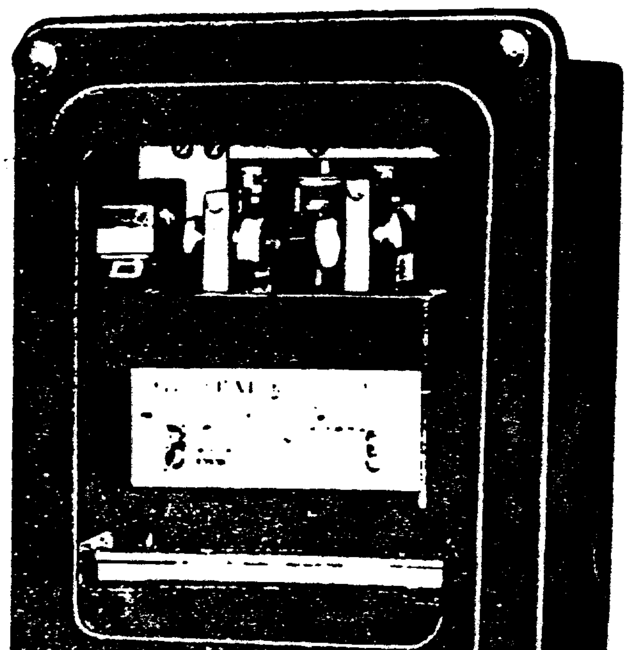
INSTRUCTIONS

GEH-2022
SUPERSEDES GEI-14491

HIGH-SPEED DIFFERENTIAL RELAYS



Types

CFD12A and CFD12B

POWER SYSTEMS MANAGEMENT DEPARTMENT

GENERAL ELECTRIC

PHILADELPHIA, PA.

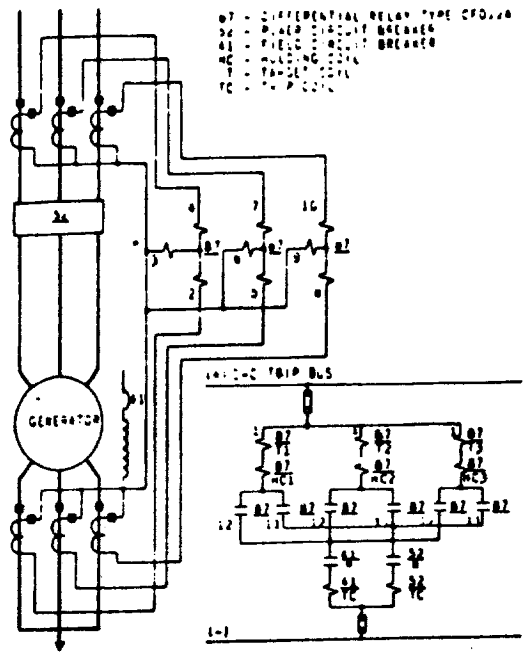


Fig. 1 Typical External Connections For Relay Type CFD12A For Protection Of A Wye Connected Generator With Six Leads Brought Out

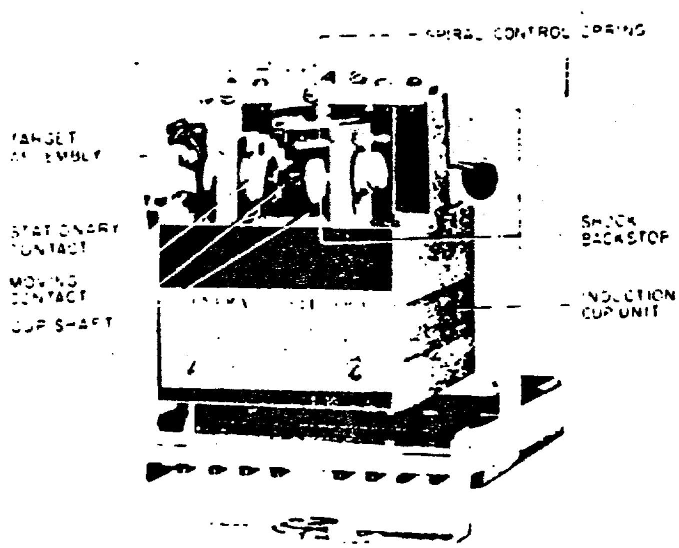


Fig. 2 Type CFD12B Removed From Case (Front View)

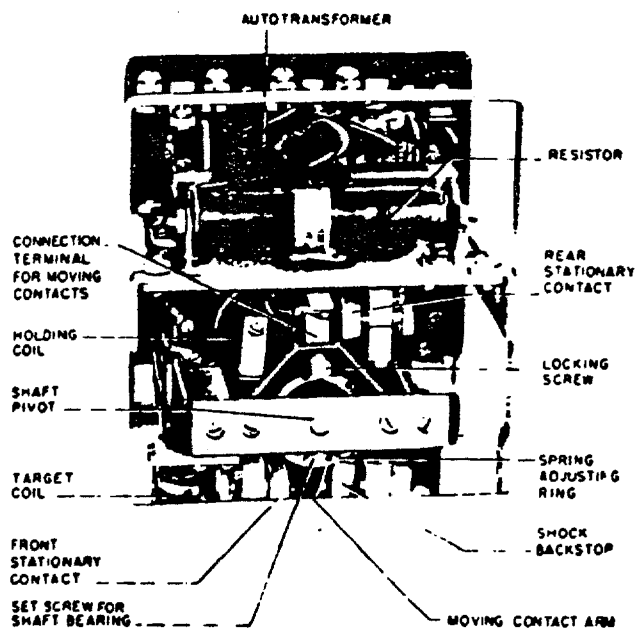


Fig. 3 Type CFD12B Removed From Case (Top View)

Cover (8007103)

Fig. 1 (K-6507930)

HIGH-SPEED DIFFERENTIAL RELAYS
TYPE CFD

INTRODUCTION

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 H.P. (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 affect the difference between current entering and current leaving the winding. Refer to Fig. 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, differential relaying for ground faults only can be obtained. 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.

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 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 backup protection for the generator.

When current-differential protection is provided for a-c 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 of negligible impedance 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

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

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 which 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.

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* Denotes change since superseded issue.

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.

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 other automatic means, since the relay contacts are held closed while the tripping current is flowing.

* The 1 second thermal rating of the restraining coils is 210 amperes.

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, Figs. 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 CFD12A and CFD12B are supplied with two circuit closing contacts. Tripping current in both of these circuits flows through the target and holding coils (see Figs. 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.

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

Function	Amperes AC or DC	
	1.0 Amp Target & Holding Coils (.50 ohm total)	0.2 Amp Target & Holding Coils (14 ohms total)
Min. Target release	1.0	0.2
Carry for tripping duty	30.0	5.0
Carry continuously	2.5	0.5

BURDENS

The burdens of the coils in one phase (one induction unit) at 60 cycles are given below:

Circuit	Continuous rating-Amp	Burden on one CT	
		Power Factor	Volt Amps
Restraining	5	.57	0.9
Operating +	0.5	.81	14.4

* + Calculated unsaturated values (VA at 0.5 amp.)

The operating circuit burden as a function of differential current is given in the table below. The burden is imposed on one current transformer.

Current-Amperes	Multiple of Min. Pickup current	Burden on One CT Impedance-Ohms
0.2	1	58
0.6	3	29
2.0	10	11
4.0	20	6.3
5.0	25	5.4

* Denotes change since superseded issue.

RECEIVING, HANDLING AND STORAGE

These relays, when not included as a part of a control panel, will be shipped in cartons designed to protect them against damage. Immediately upon receipt of the relay, an examination should be made for any damage sustained during shipment. If injury or damage resulting from rough handling is evident, a claim should be filed at once with the transportation company and the nearest Sales Office of the General Electric Company notified promptly.

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

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

DESCRIPTION

RELAY TYPES

* The Type CFD12A 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 CFD12B is similar to the CFD12A 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 light weight aluminium cylinder offers a high ratio of torque to inertia and results in a fast operate time.

CUP AND STATOR

The axis of the cylinder is supported at the lower end by a steel pivot which 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 which 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 Fig. 1). The other set carries the difference current between the two current transformers.

CONTACT STRUCTURE

The contacts are silver-to-silver elements and are constructed with a non-bounce feature to insure a positive circuit closure. Two circuit closing action is obtained by mounting a second stationary contact at the back of the induction unit (see Fig. 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. Fig. 4 shows the arrangement of the contact mechanism. The stationary contact (G) is mounted on a flat spiral spring (F) which 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 which 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.

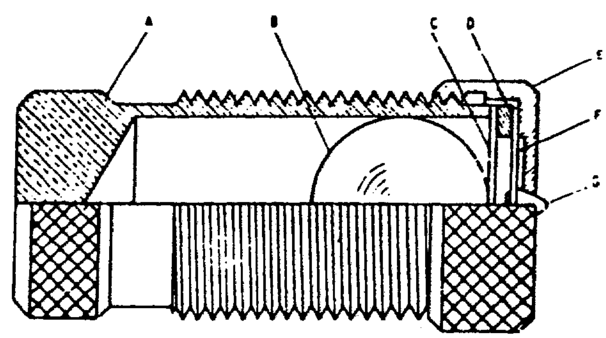


Fig. 4 Stationary Contact Assembly For Type CFD Relays

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

* Denotes change since superseded issue.

TARGET

The target mechanism (Fig. 2) drops 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 which 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 semiflush panel mounting is shown in Fig. 10 for the three unit case, (CFD12A), and in Fig. 13 for the single unit case (CFD12B).

CONNECTIONS

The internal connection diagrams are shown in Figs. 5 and 6 for the Types CFD12A and CFD12B 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 Fig. 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 CFD12A or terminals 2 and 3 on the CFD12B.

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 per cent up to twice 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. 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 which holds the back of the adjusting ring. The adjusting ring can 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 which 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 .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 which secure the shock stop and contact barrels.

Relays are shipped from factory with contacts set for .100 inch gap. If relays are not mounted on swing doors and are free from shock, the contact gap can be reduced to 0.050 inches and the time will be as shown by the lower curve in Fig. 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 which 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 Fig. 9 with the current I_o 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 that as the current is reduced, slipping stops at a minimum of 10 amperes.

* Denotes change since superseded issue.

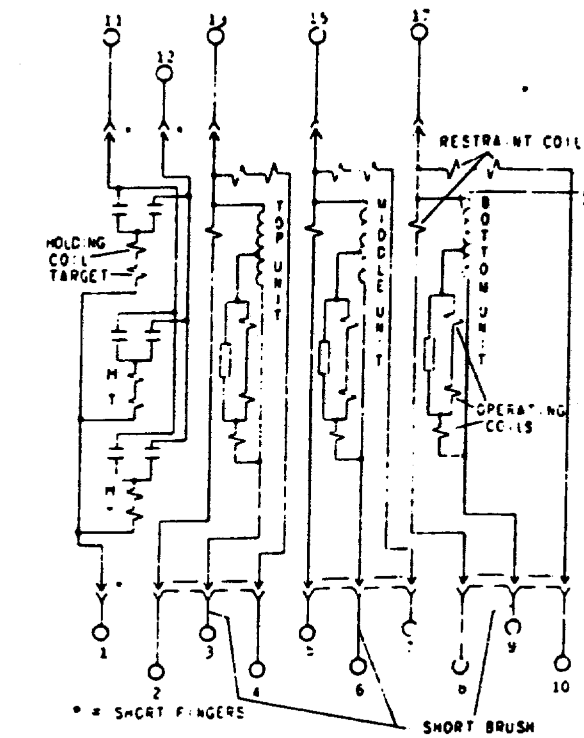
INSPECTION

The relay should be inspected at the time of installation for tarnished contacts and loose screws that may have resulted from storage and handling.

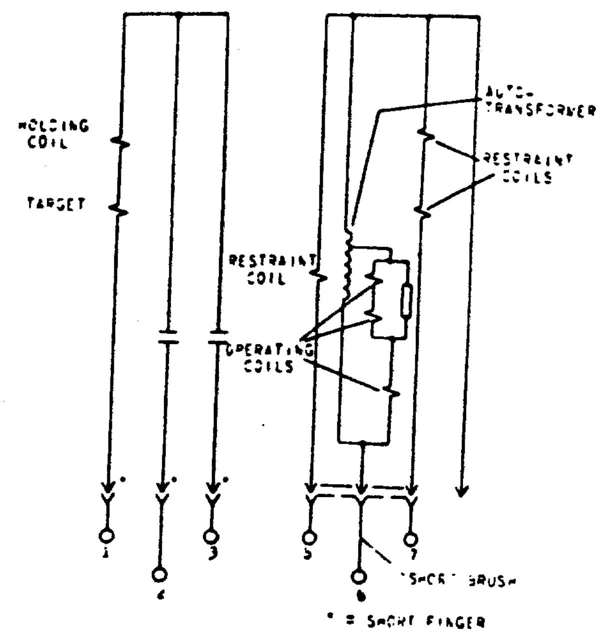
No further adjustments should be necessary. Th above precedures need be followed only in specia cases of recalibration or contact replacement. An trouble should be corrected as described unde MAINTENANCE.

Fig. 5 (K-6209740)

Fig. 6 (K-6209519)



• Fig. 5 Internal Connections For Type CFD12A Relay (Front View)



• Fig. 6 Internal Connections For Type CFD12B Relay (Front View)

PRINCIPLES OF OPERATION

Differential protective relays Type CFD function on a product restraint principle. The restraining 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 1.6 times normal current. This 10% "slope", as it is called, allows small differences to exist due primarily to current transformer errors. Above 1.6 times normal current the differential current circuit will saturate before enough operating torque is produced to close contacts on a 10% slope basis (see Fig. 7). This characteristic increases the margin for current transformer error at high currents due to external faults.

• Denotes change since superseded issue.

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. Fig. 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 Fig. 8.

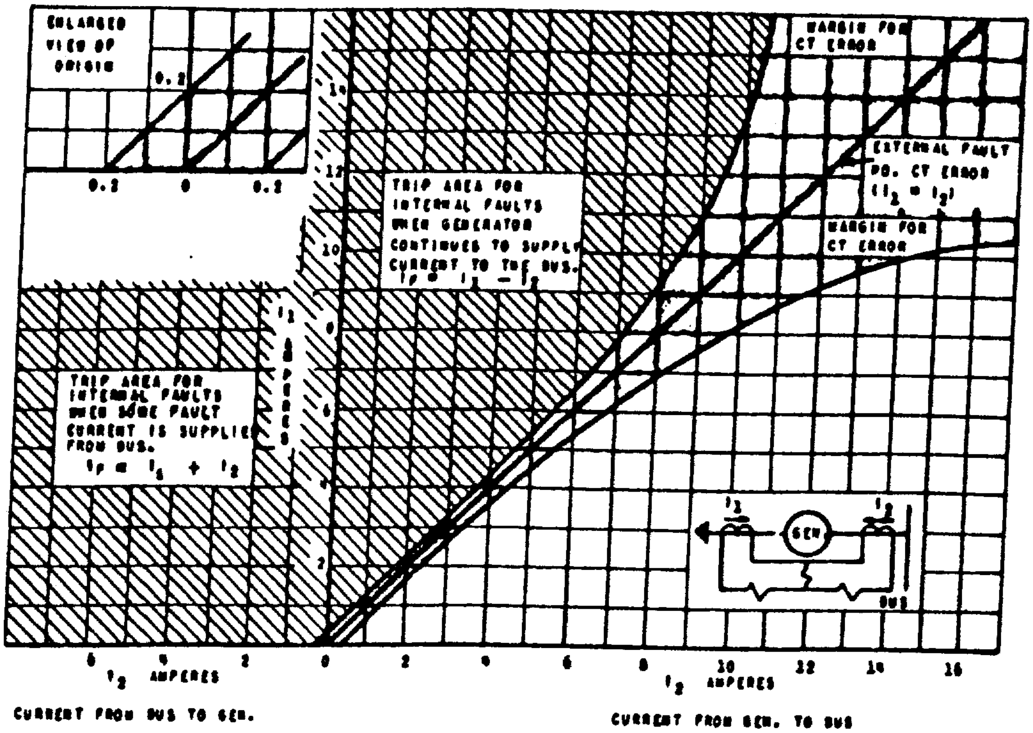


Fig. 7 Typical Operating Characteristics For Relays Type CFD

TYPICAL TIME-CURRENT CHARACTERISTIC
FOR TYPE CFD
DIFFERENTIAL RELAY FOR GENERATOR PROTECTION
(CURRENT IN ONE RESTRAINT CIRCUIT ONLY)

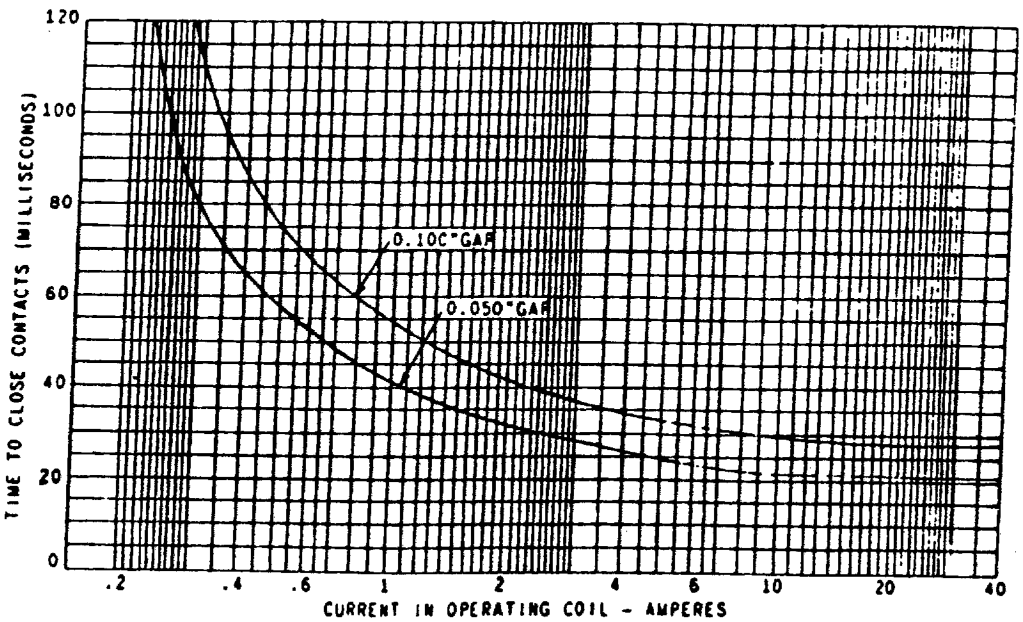


Fig. 8 (K-6375775)

Fig. 8 Typical Time-Current Characteristics For Type CFD Relay

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 and 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 of 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 insures 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 and thus prevent closing.

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

PERIODIC TESTING

An operation test and inspection of the relay at intervals of six months is recommended. The test connections are shown in Fig. 9. The restraint circuit currents I_1 and I_2 correspond to the same currents shown on the operating characteristic given in Fig. 7. I_o 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.

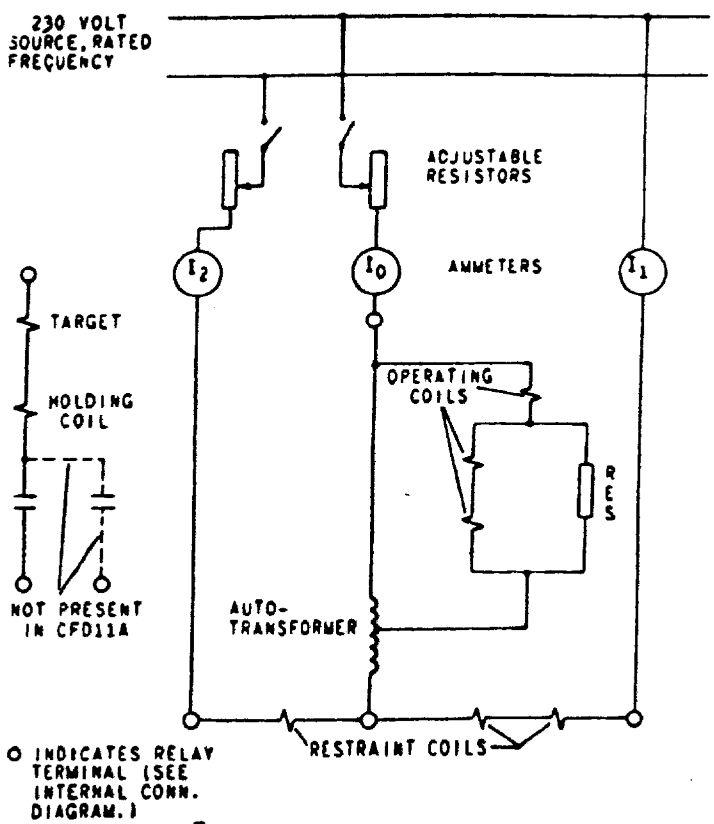


Fig. 9 Test Connections for Type CFD Relays

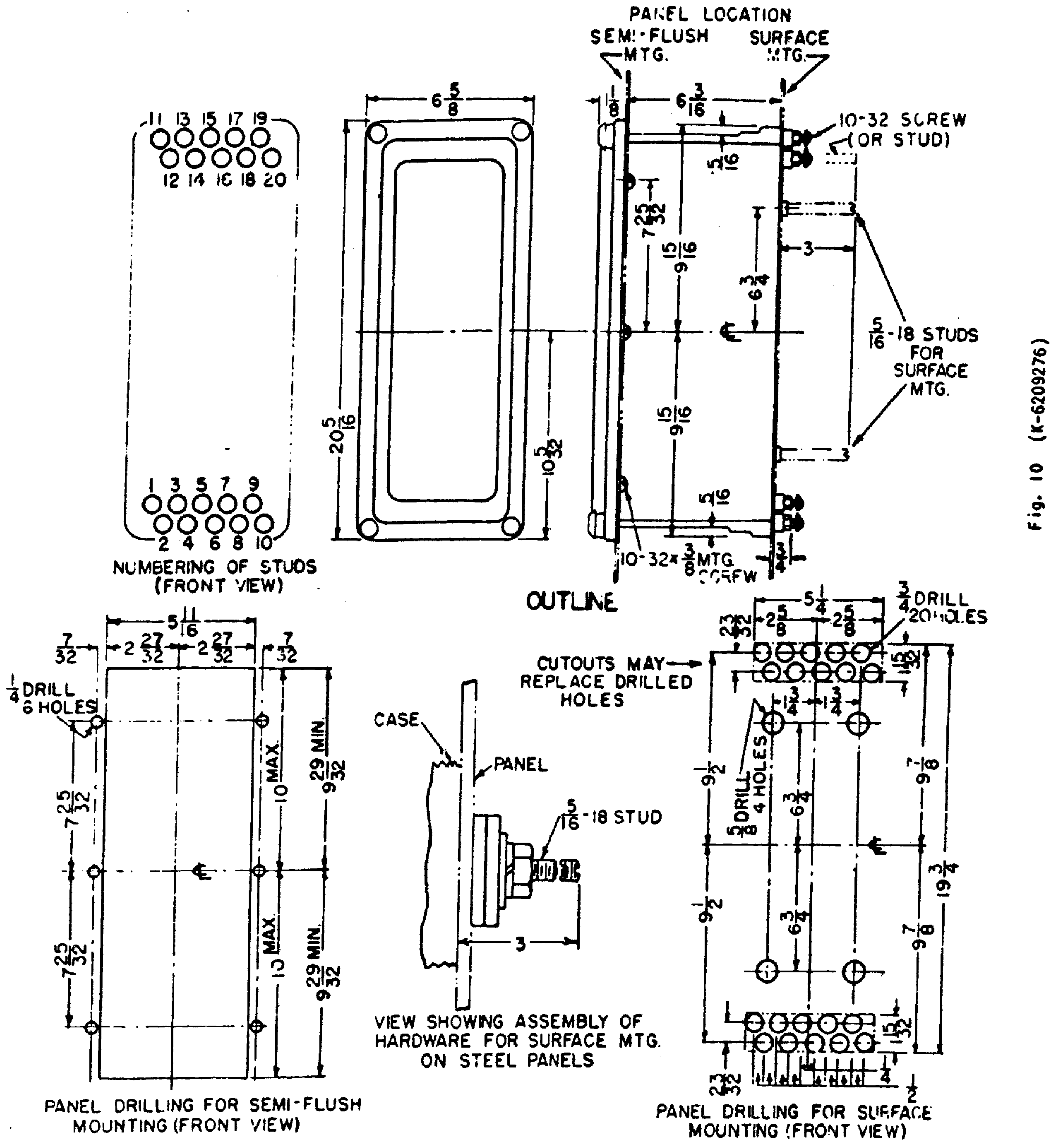


Fig. 10 Outline and Panel Drilling for Relay Type CFD12A

RENEWAL PARTS

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

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

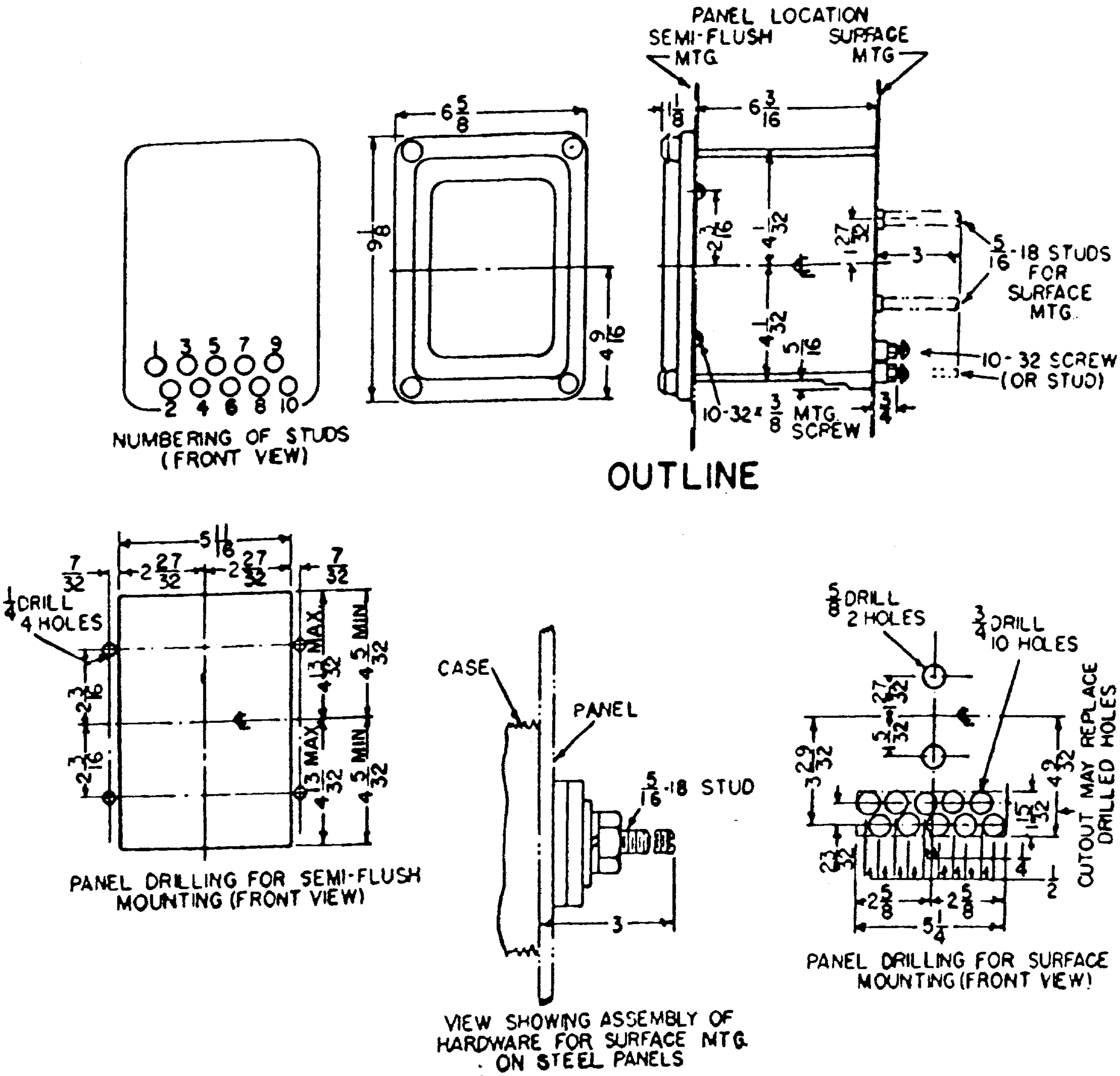


Fig. 11 (K-6209271)

Fig. 11 Outline and Panel Drilling for Type CFD12B Relay

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