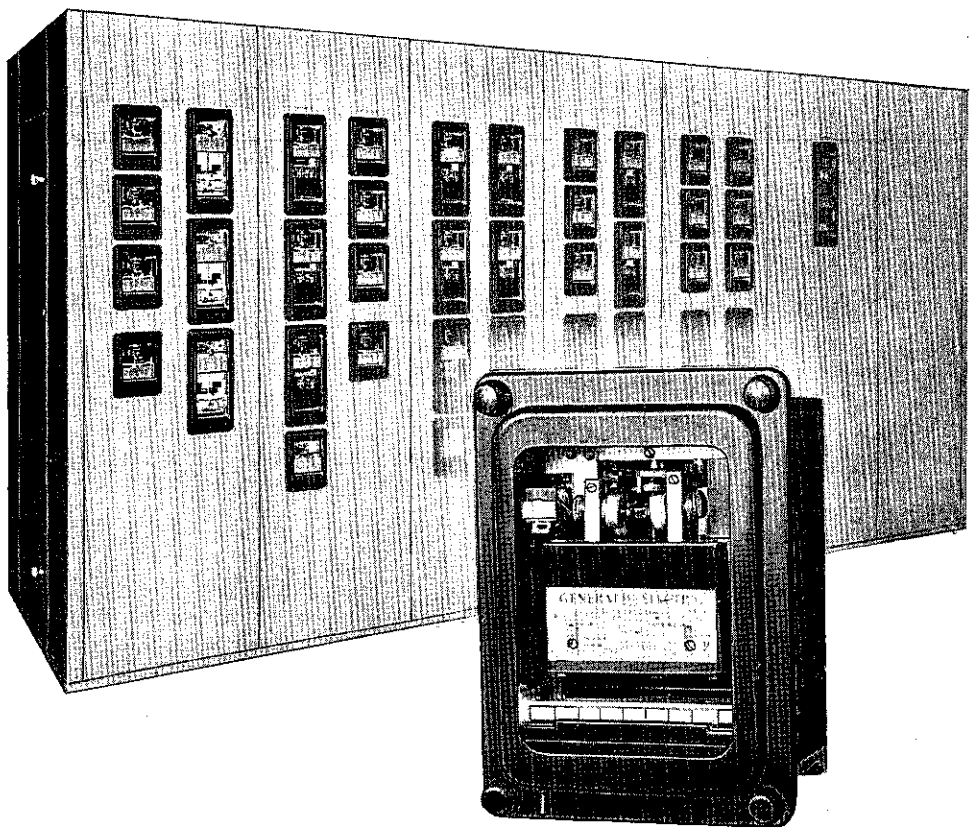
PROTECTIVE RELAYING EQUIPMENT COMPONENTS

TYPE CFD

HIGH-SPEED DIFFERENTIAL RELAYS

Increasing slope (product-restraint) characteristic



For differential protection of a-c generators, frequency converters, synchronous condensers, and motors.

CFD12B single-phase current-differential relay.

GENERAL ELECTRIC

FEATURES

High-speed differential protection for both phase and ground faults.

Product-restraint insures freedom from tripping on external short circuits.

Modern design, utilizing induction-cylinder principle, provides smooth high torque.

Silver-to-silver nonbouncing contacts are easily visible to permit ready inspection.

Spring-mounted jewel bearing reduces friction and minimizes shocks.

All means for making adjustments are readily accessible.

Relays are dustproof.

Drawout construction, for semiflush or surface mounting.

RATINGS

Continuous Rating in Amperes	Frequency in Cycles *	Minimum Pickup Amperes	Contacts Normally Open	Target Amperes	Model No. (Single-phase)	Approx Wt in lb	
						Net	Shipping
5	60	0.2	2	1 0.2	12CFD12B1A 12CFD12B2A	35	50

* For application to machines of other than 60 cycles, refer inquiry to the Switchgear Sales Division, Philadelphia Works.

APPLICATION

Differential protection should be used with attended and unattended machines, whether or not the machine neutral is grounded, and whether or not the machine is connected to a grounded neutral source. This type of protection is recommended for all generators rated 4160 volts and higher, or 1000 kva and above; for generators rated 2200 volts and higher above 500 kva; for motors and synchronous condensers 1500 hp (or kva) and larger if the voltage is 4160 volts or below; and for motors and synchronous condensers rated 501 hp (or kva) and larger if the voltage is above 4160 volts. Differential protection using high-speed Type CFD relays is recommended for all generators rated 2000 kva and above, and for motors and synchronous condensers rated 3000 hp (or kva) and larger.

All General Electric a-c machines with ratings for which differential relaying is recommended in accordance with the above paragraph normally have both ends of each winding brought out to separate terminals. Machines for lower voltages or those having lower hp or kva ratings may not have such provision unless it is definitely specified.

Differential protection is also recommended for smaller machines than those listed above when such machines operate in parallel on the same bus with differentially protected machines. If a fault occurring in a small machine is not promptly removed, it may prove just as detrimental to service as a similar fault occurring in a large machine. Also, differential protection may be necessary for small machines on the basis of the importance of the machine to the system and on the degree of relaying that is required for a particular installation.

The CFD relays function on the product-restraint principle, which gives very little, or zero, restraining torque on single-end-feed internal faults, and an operating torque from the restraint coils on internal faults, with an external source of power. The relay gives sensitive operation over the normal current range, and has an increasing slope characteristic, which prevents undesired operation on excessive through currents.

These relays provide protection against phase-to-phase and phase-to-ground short circuits which produce more than a certain minimum amount of current; they will not protect against open circuits, or turn-to-turn short circuits. If the neutral of the system is not grounded, protection against grounds in the machine winding is provided only upon the occurrence of a second ground in another phase of the system.

With zero neutral impedance, differential protective equipment will function on ground short circuits in any part of the winding, except a small portion very close to the neutral point (relay operation, of course, being limited by the magnitude of the short-circuit current and the sensitivity of the relay). If current-limiting devices are used in a grounded neutral, the effectiveness of differential protection in the event of ground short circuits will be diminished, because there will be a somewhat greater portion of the winding next to the neutral point in which ground short circuits will not cause the relay to function.

Automatic Tripping of Machine Field Switch

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.

Automatic Tripping of Neutral Breakers

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.

Selection of Current Transformers

Current transformers must be accurate within 1 or 2 per cent to twice normal current. Above twice normal current accuracy is not so important.

OPERATION

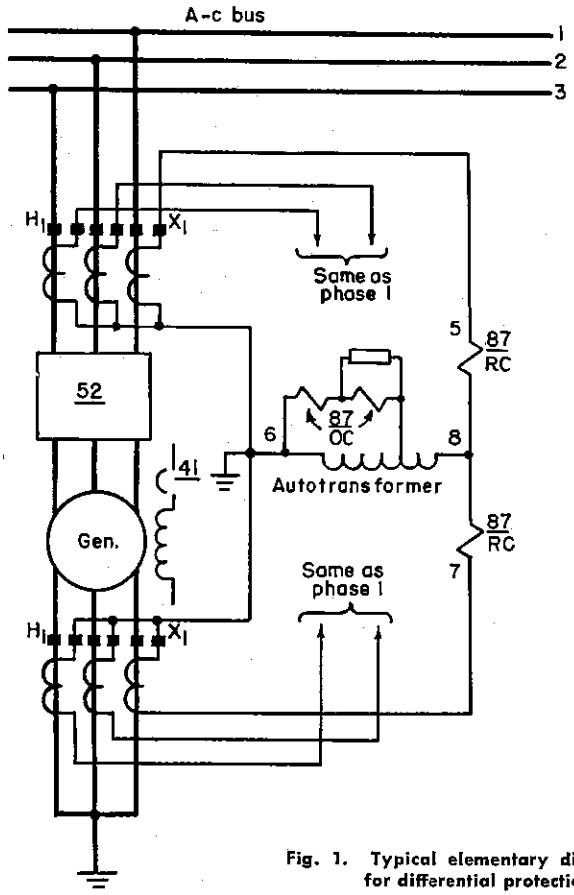
The operation of these relays can be easily understood by referring to Fig. 1. It will be noted that the secondaries of the current transformers are connected in series with the restraining coils of the relay. The operating coils are connected to an autotransformer which saturates at a relatively low current and provides a greatly increasing slope characteristic as the through-fault current increases.

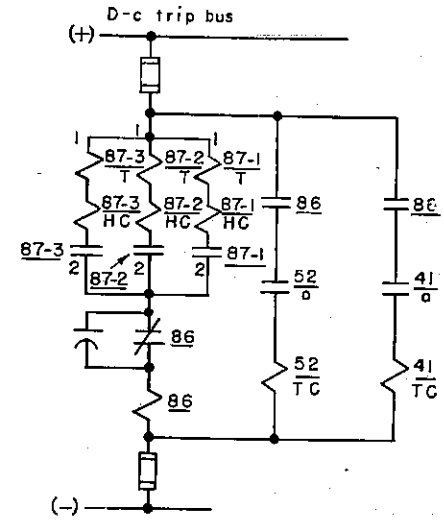
Under normal conditions the two secondary currents should be equal but they may differ due to current transformer errors. The "difference" or "error" current will flow in the operating coil. For currents up to full load of the machine the error current will be less than the 10 per cent "difference" current required to operate the relay. With an external fault the current in the current transformers can be high and the "error" current may be well over 10 per cent. For this reason, the slope of the relay characteristic is made to increase as the current increases.

If a current flows from the neutral side into the generator and another current flows from the generator to the bus, then the restraining coils produce a RESTRAINING torque that is proportional to the product of these two currents and the cosine of the angle between them. These are the conditions that will exist during normal operation, during external faults, and during internal faults when the generator continues to supply some current to the bus.

Conversely, if a current flows from the neutral side into the generator and another current flows from the bus into the generator, then the restraining coils produce an OPERATING torque that is proportional to the product of these two currents and the cosine of the angle between them. These are the conditions that will exist during an internal fault when part of the fault current comes from the bus.

This relay restrains in response to the product of the currents entering and leaving the protected zone, and, consequently, the new principle is called "product-restraint." In addition, the relay has a slope which increases very rapidly above approximately twice normal current. This feature eliminates the necessity for close "matching" of the current transformers.





Device Function Numbers

1, 2 etc.	— Relay stud numbers
41	— Field circuit breaker
52	— Power circuit breaker
86	— Lockout relay, hand reset, Type HEA
87	— Differential relay, Type CFD
a	— Auxiliary switch, closed when circuit breaker is closed.
HC	— Holding coil
OC	— Operating coil
RC	— Restraining coil
TC	— Trip coil
T	— Target

Fig. 1. Typical elementary diagram of three Type CFD12B relays for differential protection of a 3-phase a-c generator

Type CFD Relays WILL NOT Function for:

(1) Turn-to-turn faults in the machine windings.
(2) Open circuits in the machine windings.
(3) High currents caused by external overloads or short-circuits.
(4) Line power surges.
(5) Ground between windings and machine frame, if system is ungrounded, unless a second ground occurs in another phase of the system.

Type CFD Relays WILL Function for:

(1) Internal machine faults, except turn-to-turn.
(2) Faults in primary cables within the protected differential zone.
(3) Ground short-circuits in any part of the machine winding, except a portion very close to the neutral, provided there is no neutral impedance to limit ground current to a value below the relay pickup calibration.

CONSTRUCTION

Steel cradle consists of a light, sturdy structure for supporting the relay unit and the inner contact blocks.

Control spring determines the minimum pickup current required to operate the relay and holds the moving contact open when the relay is de-energized.

Target displays an orange-colored surface when the relay operates. It is unlatched when tripping current flows through the target coil. Target is reset manually, by means of a push button which extends through lower edge of relay cover.

Silver-to-silver, nonbouncing contacts are easily visible to permit ready inspection. Stationary contacts are individually adjustable.

Shock backstop reduces tendency of the moving contact to close if the relay, or the panel on which it is mounted, is bumped or jarred.

Driving element of the CFD relay consists of a multi-pole stator, a stationary central core, and a cup-like induction rotor, which operates in the air gap between the stator and core. The available poles permit both the differential-operating and the product-restraining functions to be accomplished in a single unit.

Clips hold identification or data card.

Numbering strip of dull white may be used for circuit identification. Pen or pencil may be used.

Drawout feature provides a quick, easy means of removing the unit for inspection or test. By using a test plug the unit can easily be tested without removing it from the panel. For general construction details of the drawout case, refer to publication GEC-456.

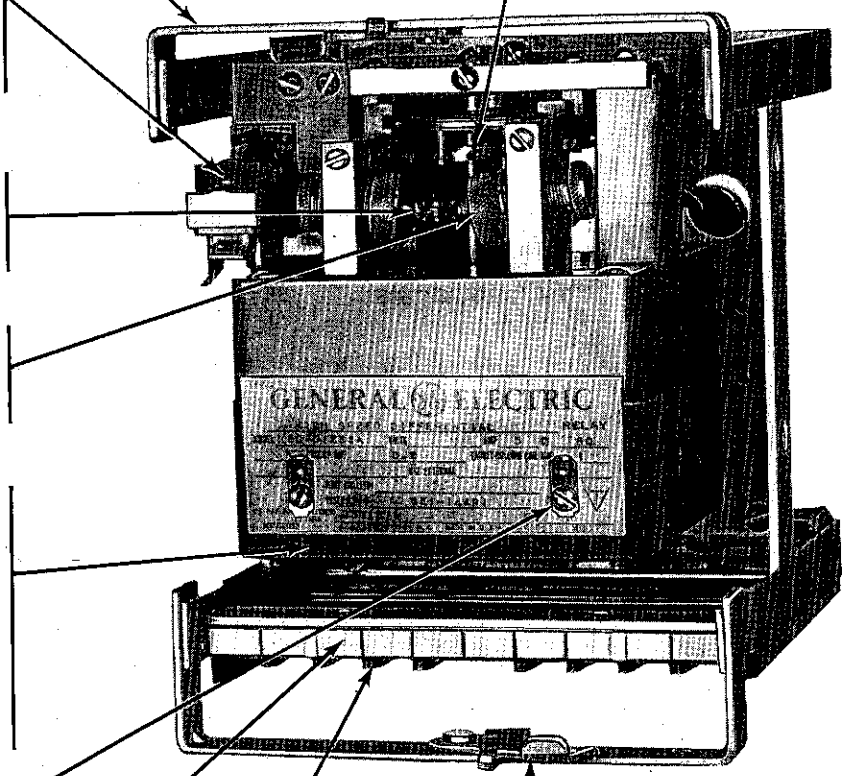


Fig. 2. CFD12B high-speed differential relay unit removed from case

Inner contact block supports contact fingers of the removable unit. The connecting plug makes connection between these fingers and the contact fingers in the case.

Latches at the top and bottom of the cradle lock the relay unit securely in place. The connecting plug must be withdrawn before the bottom latch can be released.

Heating. Under normal operating conditions, no part of these relays will exceed the heating limits specified by the AIEE and ASA Standards.

Insulation is equal to or better than that necessary to meet the requirements of the AIEE and ASA Standards.

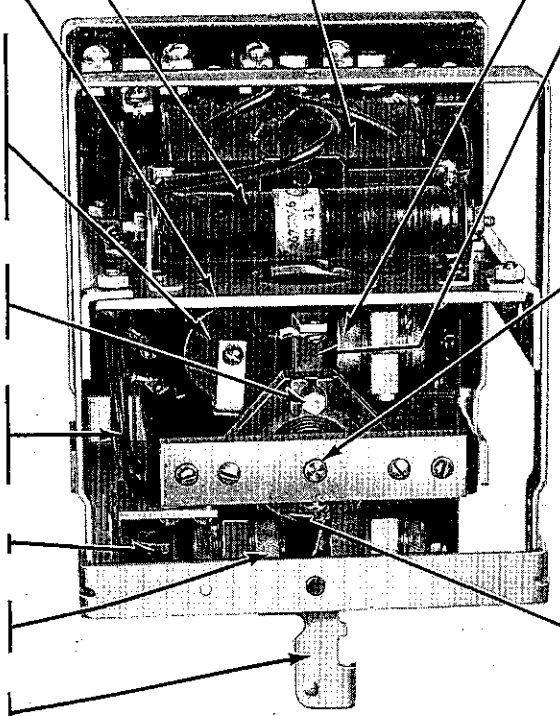


Fig. 3. Top view of Type CFD12B relay unit removed from case.

Target and Holding Coils

These coils are available with ratings of 0.2 or 1.0 ampere, as indicated in the table below. The choice of rating depends on the current taken by the tripping circuit. Separate target and holding coils are provided with these relays, as shown by the internal connection diagram.

When it is desirable to adopt one type of relay as standard for use anywhere on a system, relays with 1.0-ampere target and holding coils 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 with trip coils that take less than 1.0 ampere.

Function	AMPERES A-C OR D-C	
	1-amp Target and Holding Coils (0.50 Ohm for Both Coils)	0.2-amp Target and Holding Coils (14 Ohms for Both Coils)
Minimum target operating current	1.0	0.2
Minimum holding current	1.0	0.2
Carry for tripping duty	30.0	5.0
Carry continuously	2.5	0.5

Contacts

The CFD relays are supplied with nonbouncing 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 shown in the table. If the total tripping current exceeds 30 amperes, an auxiliary relay must be used with the CFD relay. After tripping occurs, the tripping circuit must be opened by an auxiliary switch on the circuit breaker, or by other automatic means, because the relay contacts are held closed while the tripping current is flowing.

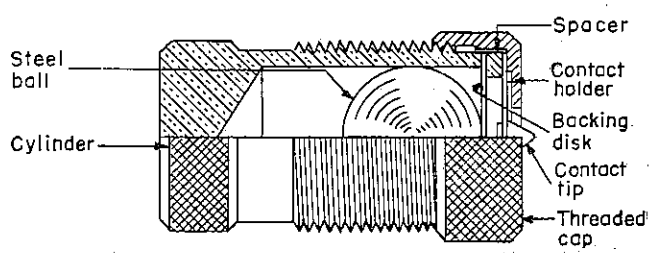


Fig. 4. Assembly of nonbouncing contact unit for CFD12B differential relay.

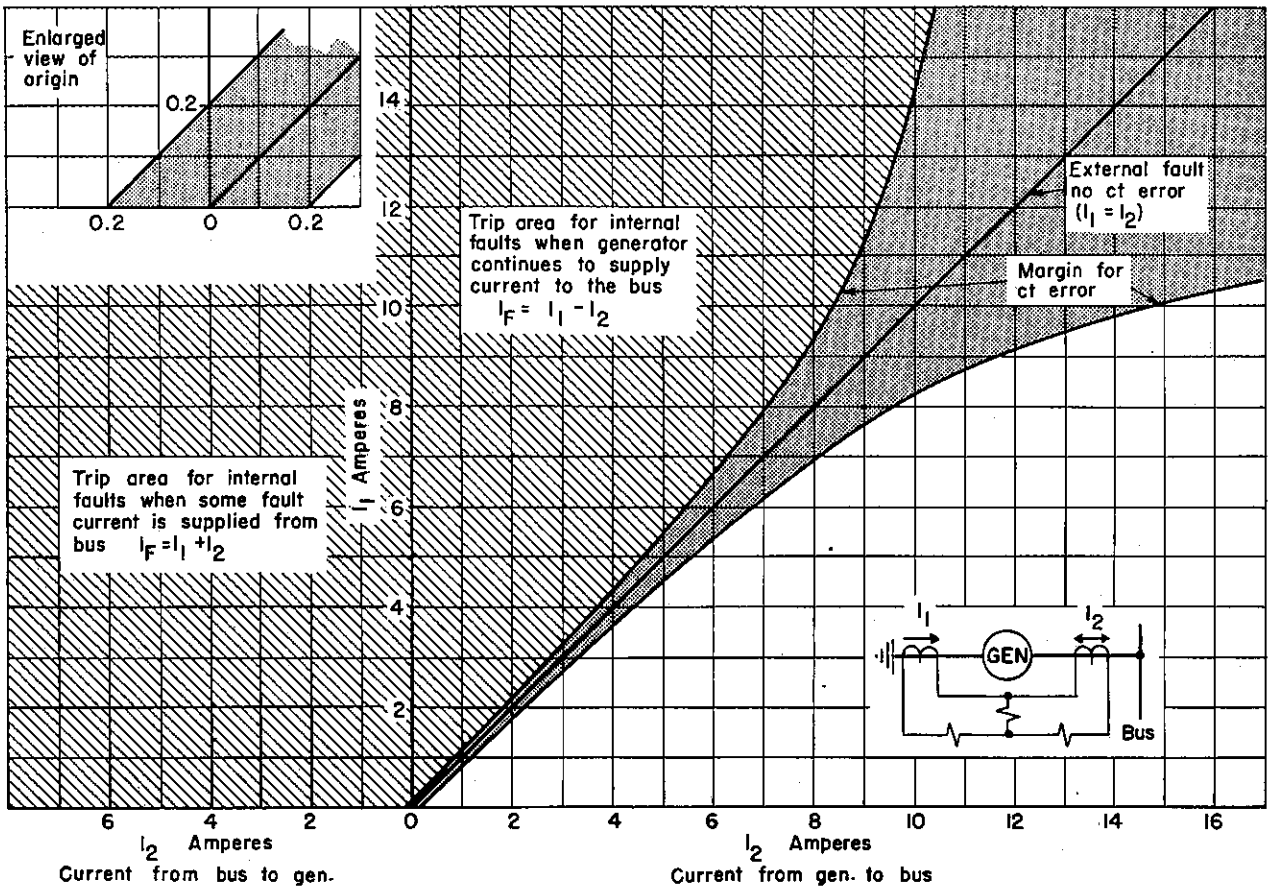


Fig. 5. Typical operating characteristic of the CFD12B differential relay

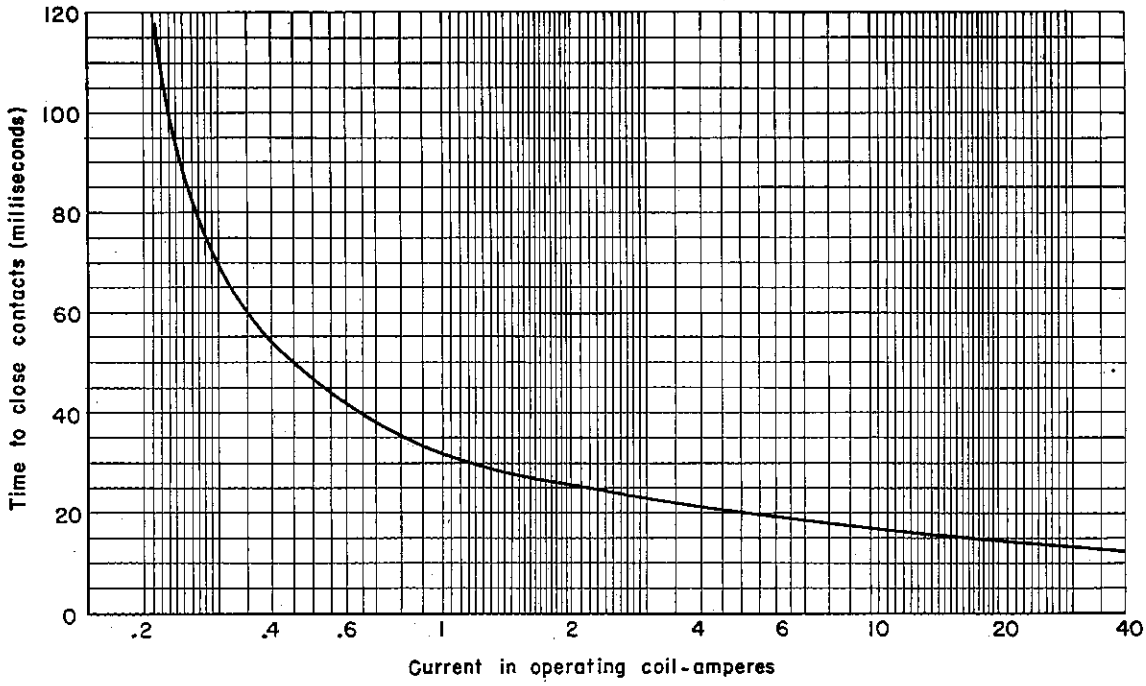


Fig. 6. Typical time-current characteristic of CFD12B differential relay
(Current in one restraining circuit only)

BURDENS

BURDENS OF RESTRAINING COILS AT 5 AMPERES

Relay	Frequency, Cycles	RATINGS IN AMPERES		Effective Resistance in Ohms	Reactance in Ohms	Impedance in Ohms	Power Factor	Volt-amperes
		Continuous	One Second					
CFD12B	60	5	220	0.04	0.06	0.07	0.57	1.75*

BURDENS OF OPERATING CIRCUIT

Relay	Frequency, Cycles	RATINGS IN AMPERES		Minimum Pickup in Amp	AT MINIMUM PICKUP					BURDENS IN OHMS IMPEDANCE AT		VOLT-AMPERES	
		Continuous	One Second		Effective Resistance in Ohms	Reactance in Ohms	Impedance in Ohms	Power Factor	Volt-amperes †	3 Times Pickup	10 Times Pickup	Measured at 5 Amp	Calculated at 5-amp from Min. Pickup
CFD12B	60	0.5	140	0.2	29	50	58	0.5	2.3	29	11	135	1440

†Some companies list their relay burdens only as the volt-ampere input, to operate at minimum pickup, and this column is included so that a direct comparison can be made. It should not be used in calculating volt-ampere burdens.

*Total burden of restraining coil, which is shared equally by two current transformers. This coil does not saturate.

INTERNAL CONNECTIONS

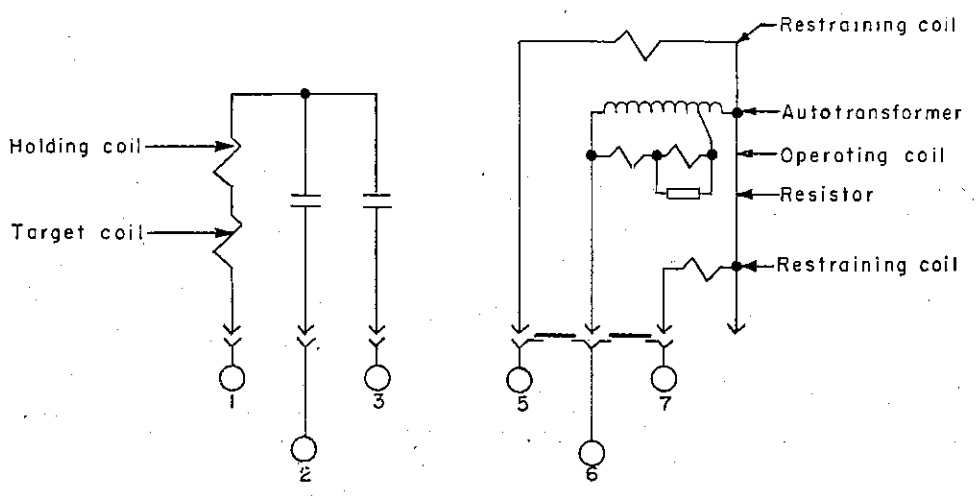


Fig. 7. Internal connections of Type CFD12B relay (front view).

DIMENSIONS

(Dimensions are subject to change and should not be used for construction without approval.)

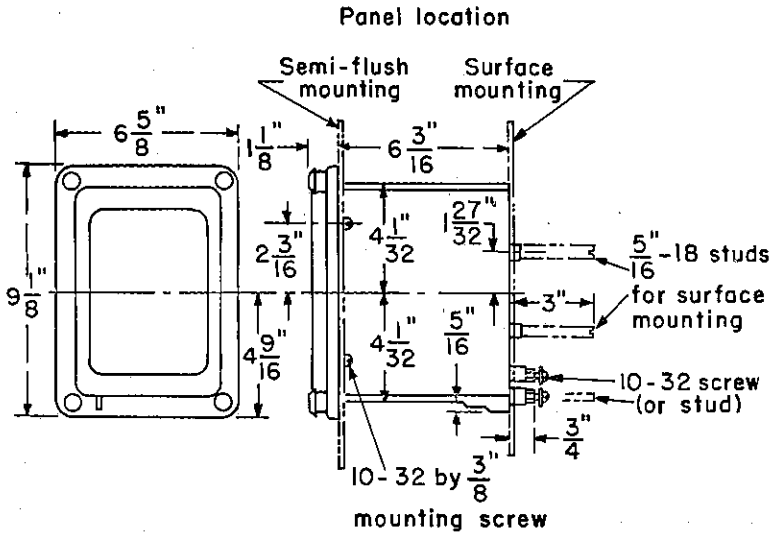


Fig. 8. Dimensions of Type CFD12B relays in drawout case for semiflush or surface mounting.

Note: Horizontal spacing (center to center) of adjacent relays should be 6¾ in. or more.

GENERAL ELECTRIC

SCHENECTADY, N. Y.

12-49 (4M) 7600
7-50 (3M)
1-52 (4M)

Handbook Reference 7266

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