for action

GEI-28764A

INSTRUCTIONS

Switchgear

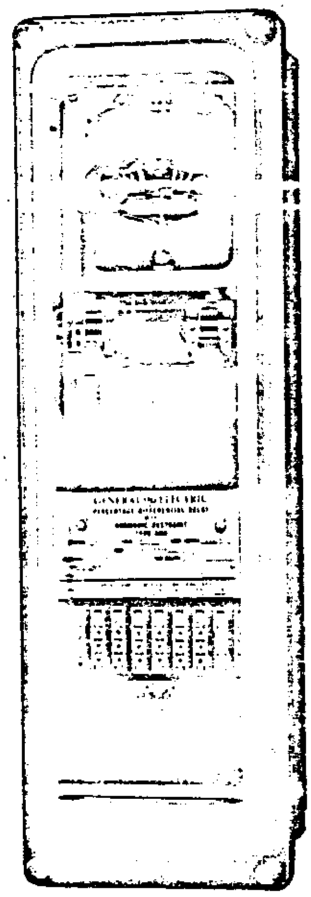
TRANSFORMER DIFFERENTIAL RELAYS

WITH PERCENTAGE AND HARMONIC RESTRAINT

Continuous rating should not exceed ?.U.

Instantaneous unit is marked T should be I

N.C.R. 2-22-51



Types HDD15A and HDD16A

Put in adjustments on this unit

N.C.R. 3-9-51

GENERAL ELECTRIC

CONTENTS

TRANSFORMER DIFFERENTIAL RELAY WITH PERCENTAGE AND HARMONIC RESTRAINT

INTRODUCTION

Relays of the HDD type are transformer differential relays provided with the features of percentage and harmonic restraint. The later enables the relay to distinguish between the differential current due to an internal fault and that due to transformer magnetizing inrush by their difference in waveform. The relay operates with high speed on internal fault currents but is reliably restrained from operating on either magnetizing inrush or through fault currents. The relay is energized by current alone and hence does not require potential transformers.

Each relay is single-phase and has two circuit-closing contacts.

RECEIVING

Immediately upon receipt of Type HDD relays, examine the equipment for any damage that might have been sustained in transit. If injury or rough handling is evident, a damage claim should be filed immediately with the transportation company, and the nearest General Electric Apparatus Sales Office should be notified promptly.

INSTALLATION

CASE

The case is suitable for either surface or semiflush panel mounting and an assortment of hardware is provided for either mounting. The cover attaches to the case and also carries the reset mechanism when one is required. Each cover screw has provisions for a sealing wire.

The case has studs or screw connections at both ends or at the bottom only for the external connections. The electrical connections between the relay units and the case studs are made through spring backed contact fingers mounted in stationary molded inner and outer blocks between which nests a removable connecting plus which completes the circuits. The outer blocks, attached to the case, have the studs for the external connections, and the inner blocks have the terminals for the internal connections.

The relay mechanism is mounted in a steel framework called the cradle and is a complete unit with all leads being terminated at the inner block. This cradle is held firmly in the case with a latch at the top and the bottom and by a guide pin at the back of the case. The cases and cradles are so constructed that the relay cannot be inserted in the case upside down. The connecting plug, besides making the electrical connections between the respective blocks of the cradle and case, also locks the latch in place. The cover, which is fastened to the case by thumbscrews, holds the connecting plug in place.

To draw out the relay unit the cover is first removed, and the plug drawn out. Shorting bars are provided in the case to short the current transformer circuits. The latches are then released, and the relay unit can be easily drawn out. To replace the relay unit, the reverse order is followed.

A separate testing plug can be inserted in place of the connecting plug to test the relay in place on the panel either from its own source of current and voltage, or from other sources. Or, the relay unit can be drawn out and replaced by another which has been tested in the laboratory.

MOUNTING

The relay should be mounted on a vertical surface where it will be free from dirt, moisture, excessive heat and vibration or shock, and where it is well lighted to facilitate periodic inspection and testing. When the relay is mounted on an insulating panel, one of the steel supporting studs should be grounded with a conductor the equivalent of No. 12 B & S gauge copper wire or larger.

DIMENSIONS AND CONNECTIONS

	Type HDD15A	Type HDD16A
Outline and Panel Drilling	Fig.12	Fig.12
Internal Connections	Fig.10	Fig.11
External Connections	Fig. 8	Fig. 9
Testing Connections	Fig. 5	Fig. 5
Application as Ground Fault Dectector	Fig. 7	Fig. 7

ADJUSTMENTS

The relay was adjusted at the factory to obtain proper characteristics, and it is advisable not to disturb these adjustments. If for any reason they have been disturbed, refer to the section titled MAINTENANCE for the procedure to be followed in restoring them.

TABLE A **RATING OF TARGET COILS**

Amperes, a-c or d-c for function below	2.0 Amp Tap (0.10 Ohm). Uses where trip coil current exceeds 2-0 amp.	0.2 Amp Tap (7.0 Ohms). Use where trip coil current ranges between 0.2 and 2.0 amp.
For tripping duty	30	6
Carry Continuously	4	0.8

TABLE B **BURDENS AND PICKUP VALUES**

NOTE: Burdens are substantially independent of the per cent slope settings and are all approximately 100 per cent power factor.

Burdens imposed on each current transformer at 5.0 amperes

Relay	Tap Setting Amps	Minimum Pickup Amps* (25%Slope)	OPERATING CIRCUIT 60 cyc. Relays Burden	OPERATING CIRCUIT 60 cyc. Relays Imped.	OPERATING CIRCUIT 50 cyc. Relays Burden	OPERATING CIRCUIT 50 cyc. Relays Imped.	RESTRAINT C. 50 & 60 cycles Relays Burden	RESTRAINT C. 50 & 60 cycles Relays Imped.
			V - A	Ohm	V - A	Ohm	V - A	Ohm
	2.9	0.58	29.0	1.16	36.2	1.44	3.5	0.14
12HDD15A1, 2	3.2	0.64	25.2	1.01	31.4	1.26	2.8	0.11
12HDD16A1, 2	3.5	0.70	21.9	0.88	27.4	1.10	2.5	0.10
	3.8	0.76	19.3	0.78	24.1	0.96	2.3	0.09
	4.2	0.84	16.7	0.66	20.9	0.84	2.0	0.08
	4.6	0.96	14.1	0.56	17.6	0.70	1.7	0.07
	5.0	1.00	12.2	0.48	15.3	0.62	1.5	0.06
	8.7	1.74	5.1	0.20	6.5	0.26	0.9	0.04
			V - A	Ohm	V - A	Ohm	V - A	Ohm
	2.9	1.16	8.0	0.32	10.0	0.40	2.8	0.110
12HDD15A3, 4	3.2	1.28	6.9	0.28	8.6	0.34	2.4	0.096
12HDD16A3, 4	3.5	1.40	5.8	0.24	7.[illegible]	0.29	2.2	0.088
	3.8	1.52	5.1	0.20	6.4	0.26	2.0	0.080
	4.2	1.68	4.4	0.18	5.5	0.22	1.7	0.068
	4.6	1.92	3.8	0.15	4.8	0.19	1.5	0.060
	5.0	2.00	3.3	0.13	4.1	0.16	1.3	0.052
	8.7	3.48	1.3	0.05	1.7	0.07	0.83	0.032

* Pick-up amperes are approximately 1 per cent higher on 40 per cent slope tap; 1 per cent lower on 15 per cent slope tap.

≠ Burden of operating coil is zero under normal conditions.

For Operating Time, see Figure 3.

RATINGS AND BURDENS

CURRENT RATING OF COILS

Models 12HDD15A 1, 2, and 12HDD16A 1, 2

Continuous - Tap Rating on Operating Circuit (Stud #6)
2X Tap Rating on Through Current Restraint Circuit (Studs #3, 4 and 5)
1 Second - 110 Amps.
1/4 Second - 220 Amps.

Models 12HDD15A3, 4, and 12HDD16A3, 4

Continuous - Tap Rating On Operating Circuit (Stud #6) - 2X Tap Rating on Through Current Restraint Circuit (Studs #3, 4 and 5)
1 Second - 220 Amps.
1/4 Second - 440 Amps.

See 81TK-44 for cont. ratings on HDD15A5A EX13

OPERATION

The connection diagrams show that current enters the relay through small auxiliary current transformers mounted inside the relay case. One of these, in all models of the relay, is connected in the differential circuit of the line transformers and is called the "differential current transformer." External connection to this winding is made through terminal 6. In the two-winding transformer relay, Type HDD15A, there is a second small auxiliary transformer having two identical primary windings one of which is connected in each of the line current transformer circuits. External connections to these windings are made through terminals 4 and 5. The transformer is called the "through current restraint transformer" since it supplies the restraint on through fault currents which gives the relay its percentage-differential or slope characteristic. In the three-winding transformer relay, Type HDD16A, there are three independent through current restraint transformers each with a single primary winding. External connections to these are made through terminals 3, 4 and 5.

The primary windings of both the differential current and the through current transformers are tapped to permit matching of unequal line current transformer secondary currents. The taps are all brought to a special kind of tap block having either two or three horizontal rows of tap positions, (depending on whether it is a two - or three-winding transformer relay) one for each line current transformer. The tap connections are so arranged that when, in matching the secondary currents, a tap plug is moved from one position to another in a horizontal row, corresponding taps on both the differential current transformer winding and one of the through current transformer windings are simultaneously selected so that the per cent through current restraint remains constant.

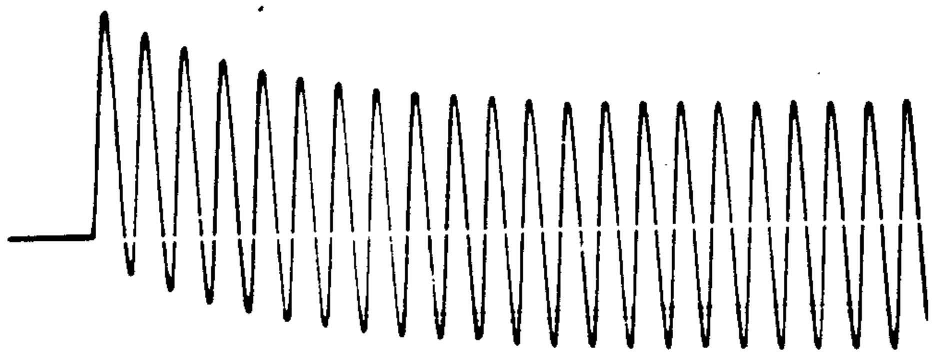
The secondary winding of the differential current transformer supplies current to both the operating and the restraining coils of the relay through two parallel circuits. The operating coil circuit is tuned by means of capacitor C_1 and reactor L_1 to pass currents of the fundamental system frequency and to offer high impedance to currents of other frequencies. The restraining coil circuit includes a wave trap consisting of capacitor C_2 and reactor L_2 connected in parallel, and tuned to block fundamental frequency currents while allowing currents of harmonic frequencies to pass with relatively little impedance. The harmonic currents are rectified before passing through the restraint coils, not only to smooth the restraining pull on the armature, but also to permit the application of similarly rectified current from the secondaries of the through current restraint transformers to the same restraint coils. It will be evident that if the differential current applied to the relay is of sine-wave form and system frequency, it will flow mostly in the operating coil circuit and will cause the relay to operate. If on the other hand, the differential current contains more than a certain proportion of harmonics the relay will be restrained from operating by the harmonic currents flowing in the restraint coils.

The proportion of harmonics in the differential current necessary to restrain the relay is determined by the characteristics of the tuned circuits and by the setting of the adjusting resistor R_3.

Adjustment of the through current restraint is provided by means of the tapped shunting resistor R_2. Taps adjusted for 15, 25, and 40 per cent restraint slope are brought out to a tap block.

A Thyrite resistor connected across the secondary of the differential current transformer limits any momentary high voltage peaks which may occur, thus protecting the rectifier from damage without materially affecting the characteristics of the relay.

On extremely heavy fault currents, the CT's



TYPICAL OFFSET FAULT CURRENT WAVE

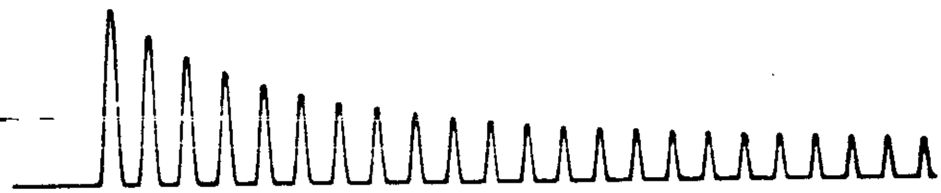


Fig. 1 Typical Current Waves

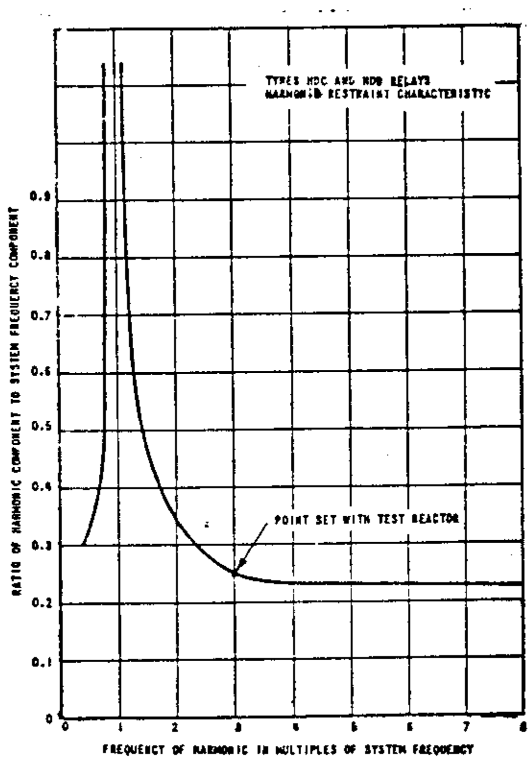


Fig. 2 Type HDD Relays Harmonic Restraint Characteristic

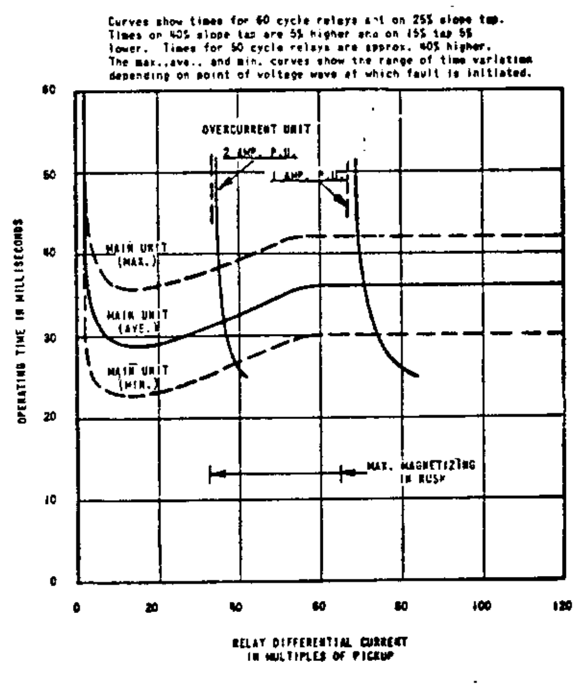


Fig. 3 Type HDD Relays Operating Time vs Current Characteristic

and relay transformers may saturate and produce sufficient harmonics to falsely restrain the relay. In order to circumvent this behavior, the Model HDD15A and HDD16A relays are equipped with an overcurrent relay which operates immediately on a differential current in excess of the maximum magnetizing inrush current.

HARMONIC RESTRAINT

Fault currents on electric power systems, being due to sine-wave system voltage limited by nearly constant circuit impedance, are of nearly pure sine-wave form except that a transient direct current component is present when the fault current is offset. Transformer magnetizing inrush currents, on the other hand, due to the extremely variable exciting impedance caused by transformer core saturation, have a very distorted wave form made up of sharply peaked half-cycle loops of current on one side of the zero axis with practically no current following during the alternate half cycles. These two current waves are illustrated by Fig. 1.

Any current of distorted, nonsinusoidal waveform may be considered as being composed of a direct-current component plus a number of sine-wave components of different frequencies: one of the fundamental system frequency and the others, called "harmonics", having frequencies which are 2, 3, 4, 5, etc., times the fundamental frequency. The relative magnitudes and phase positions of the harmonics with reference to the fundamental determine the wave form. When analyzed in this manner the typical fault current wave is found to contain only a very small percentage of harmonics while the typical magnetizing inrush current wave contains a considerable amount. The harmonic analysis of a typical magnetizing inrush current wave is given below.

The high percentages of harmonic currents in the magnetizing inrush current wave afford an excellent means of distinguishing it electrically from the fault current wave. In the HDD type relays, the harmonic components are separated from the fundamental component by means of suitable electric filters. The harmonic current components are passed through the restraining coils of the relay while the fundamental component is passed through the operating coils. The direct current component present in both the magnetizing inrush and offset fault current waves is largely blocked by the auxiliary differential current transformer inside the relay and produces only a slight momentary restraining effect. Relay operation occurs on differential current waves (like the internal fault current wave) in which the ratio of harmonics to fundamental is lower than a given predetermined value for which the relay is set, and is restrained on differential current waves (like the magnetizing inrush current wave) in which the ratio exceeds this value.

A harmonic restraint characteristic curve for HDD type relays is shown in Fig. 2. This shows the proportion of any given harmonic required to restrain the relay when that harmonic only is present with the fundamental in the differential current. When several harmonics are present, as is usually the case, their restraining effects do not add directly as might be expected. Actually, due to the presence of the rectifier, the restraining effects combine in a complex way roughly approximating the result obtained by taking the square root of the sum of the squares of the individual restraining effect.

Comparison of the harmonic percentages shown for a typical magnetizing inrush current wave with the harmonic percentages required for restraint as given by the curve in Fig. 2 indicates that there is a sufficient amount of either the second or the third harmonic, acting alone, to restrain the relay. This seemingly-excessive margin is necessary to insure proper restraint under certain inrush conditions in applications where delta-connection of either the power transformer or the current transformers is employed. Reduction of the harmonic percentages due to combination of the delta currents occurs, leaving only a reasonable margin for restraint.

The general slope of the harmonic restraint characteristic curve in Fig. 2 is determined by the relay filter circuits, while its height is determined by the setting of the harmonic restraint adjusting resistor R_3. This resistor is adjusted in test to obtain the characteristic curve as shown in Fig. 2 by means of a special testing reactor calibrated to draw a test current which has exactly 25 per cent third harmonic component and negligible percentages of other harmonics. (See section on "Repair - Harmonic Current Restraint".)

Harmonic Analysis Of a Typical Transformer Magnetizing Inrush Current Wave

Wave Component	Ratio of Amplitude of Harmonic Component to Amplitude of Fundamental
Fundamental	100.0%
Direct Current	57.7%
2nd Harmonic	63.0%
3rd Harmonic	26.8%
4 th Harmonic	5.1%
5 th Harmonic	4.1%
6 th Harmonic	3.7%
7 th Harmonic	2.4%

TABLE C SAMPLE APPLICATION CALCULATIONS

CALCULATION OF TAP SETTINGS	A	B	C
1. Full capacity line current (KVA / $\sqrt{3}$ KV)	251	30.1	50.2
2. CT ratio *	300/5	80/5	60/5
3. CT Secondary Current (line 1 / line 2)	4.18	1.88	4.18
4. Relay current ($\sqrt{3}$ x line 3 for $\triangle$ - conn.) 7.5 amps must be reduced or used on 8.7 tap.	4.18	3.26	7.25
5. Tap value required (same ratio as line 4)	5.01	3.91	8.7
6. Tap selected (within 5% of line 5)	5.0	3.8	8.7
APPLICATION CHECK			
7. 13 times tap rating (13 x line 6)	65.0	49.4	113.1
8. Corresponding CT Current (line 7 x $\sqrt{3}$ / 3 for $\triangle$ - conn.)	65.0	28.5	65.4
9. Burden (total ohms for each CT) * Using lines 8, 9, and CT ratio curve - calculate line 10	0.64	2.81	0.92
10. CT secondary error current in % of line 8 (7.5% limit)*	7.0	2.4	6.1
SLOPE SETTING			
11. Contribution of Trans. to maximum external fault *	5020	470	1000
12. CT error in % (Calculated as for line 10) *	29.4	2.5	19.2
13. Current distribution for worst case in line 12 *	5020	376	377
14. CT secondary current (from ratio curve) *	59.1	23.1	30.8
15. Relay current ($\sqrt{3}$ x line 14 for $\triangle$ - conn.)	59.1	40.0	53.3
16. Pickup current for tap (from Table B)	1.0	0.76	1.74
17. Relay currents as multiple of pickup	59.1	52.6	30.6
18. Total incoming current (line 17, B + C for fault on A)		83.2 x pickup	
19. Total outgoing current (line 17, A for fault on A)		59.1 x pickup	
20. Through current (smaller of line 18, 19)		59.1 x pickup	
21. Differential current (difference of lines 18, 19)		24.1 x pickup	
22. Restraint Tap required (values from lines 20, 21 applied in Fig. 6.		40%	

* - conditions and values assumed for this example.

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APPLICATION

The application of Type HDD relays is very similar to that of other transformer protective relays of the percentage differential type. External connection diagrams showing typical circuits for the protection of two-winding and three-winding transformer banks employing the Type HDD15A and HDD16A relays respectively, are shown at the back of the book.

CURRENT TRANSFORMERS

The current transformers in the various winding circuits of the power transformer should be selected with high enough ratios that their secondary currents will not damage the relay under maximum through fault conditions. On the other hand, the ratios should not be too high to obtain the required sensitivity on internal faults in the power transformer, - refer to the section on ratings. It is preferable also to select such ratios as will provide the same secondary currents for a given kva flowing in each winding of the power transformer.

The transformers chosen must be able to supply the relay with 13 time the rated tap current with an error current of less than 7.5%.

RATIO-MATCHING TAPS

Since it is rarely possible to match the secondary currents exactly by selection of current transformer ratios, ratio-matching taps are provided on the relay by means of which the currents may usually be matched within 5 per cent. Taps rated at 8.7, 5.0, 4.6, 4.2, 3.8, 3.5, 3.2 and 2.9 amperes are provided on both the HDD15A and HDD16A relays. When the protected transformer is equipped with load-ratio control it is obvious that a close match cannot be obtained at all points of the ratio-changing range. In this case the secondary currents are matched at the middle of the range and the percentage-differential characteristic of the relay is relied on to prevent relay operation on the unbalanced current which flows when the load-ratio control is at the ends of the range.

UNBALANCE CURRENT MEASUREMENT

Type HDD relays have a special arrangement for measuring the unbalanced differential current flowing in the relay at any time without disturbing the relay connections. This arrangement consists in momentarily connecting a 5-volt scale high-resistance a-c voltmeter (1000 ohms per volt) across terminals 7 and 8. (See the internal connection diagrams). Small rectifier-type a-c voltmeters such as the DO-45, DO-46, or DO-55 are suitable for this purpose. The voltmeter should not be left permanently connected since the shunt current it draws reduces the relay sensitivity. This arrangement automatically takes care of the normal difference in the secondary currents matched by the relay taps. When the match is perfect the voltmeter will read zero, indicating no equivalent unbalance current. When the volt-meter does not read zero the equivalent unbalance current in amperes referred to any relay tap is approximately equal to the current rating of the tap in amperes multiplied by 0.06 times the volt-meter reading in volts.

This feature is very useful in checking the best tap setting when matching current transformer ratios in the field. It is also useful for detecting errors or faults in the current transformer wiring or even small faults within the power transformer itself when the fault current is too low to operate the relay.

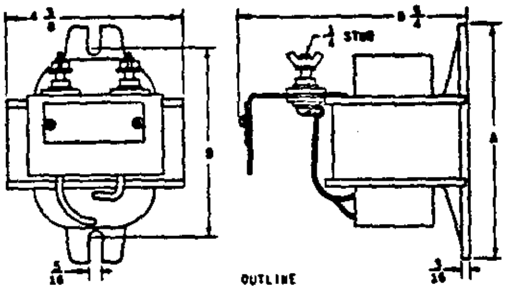
PERCENTAGE-DIFFERENTIAL CHARACTERISTICS

Type HDD relays are provided with percentage differential or slope characteristics. That is to say, in addition to the operating coils which are energized by the differential current of the several current transformers they are equipped with restraining coils which are energized by the current transformer secondary currents directly. In order to operate the relay, the current transformer secondary currents must be unbalanced by at least a certain percentage, determined by the relay slope setting. This characteristic is necessary to prevent false operation of the relay on extremely high through fault currents which saturate the cores of the current transformers, causing their ratios to change with the result that the secondary currents become unbalanced. Percentage restraint is also needed to prevent operation on the unbalance currents due to imperfect matching of the secondary currents as described under "Ratio-Matching Taps".

Taps for 15, 25, and 40 per cent slope setting are provided in both the HDD15A and HDD16A relays. It is common practice to use the 25 per cent setting unless special conditions make it advisable to use one of the others.

HARMONIC RESTRAINT

Relays of the HDD type are provided with an additional feature called "Harmonic Restraint" the chief function of which is to prevent false operation of the relay on magnetizing inrush currents. Since magnetizing inrush currents flow in the primary but not in the secondary winding of the power



GR NO	CAT. NO.	NAME PLATE	REACTOR DWG. NO.	GR	COIL SPEC.	RATING V	RATING CYC	A	B
4	6174403-4	78242	L-6193350	7	K-6174506 G-1	115	60	$6\frac{1}{16}$	$4\frac{3}{4}$
5	6174403-5	78242	L-6193350	8	K-6275001 G-1	115	50	$6\frac{13}{16}$	$5\frac{1}{2}$
6	6174403-6	78242	L-6193350	13	K-6275069 G-1	115	60	$7\frac{5}{8}$	$6\frac{1}{8}$
7	6174403-7	78242	L-6193350	14	K-6275069 G-2	115	50	$6\frac{13}{16}$	$7\frac{9}{16}$

Fig. 4 Outline and Index of Harmonic Adjusting Reactor

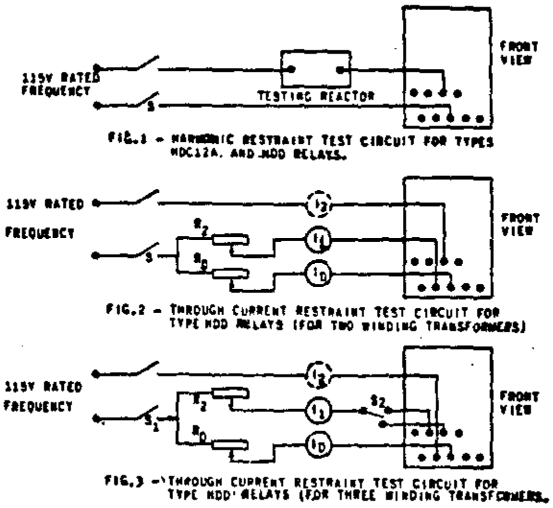


Fig. 5 Type HDD Relay Testing Connections

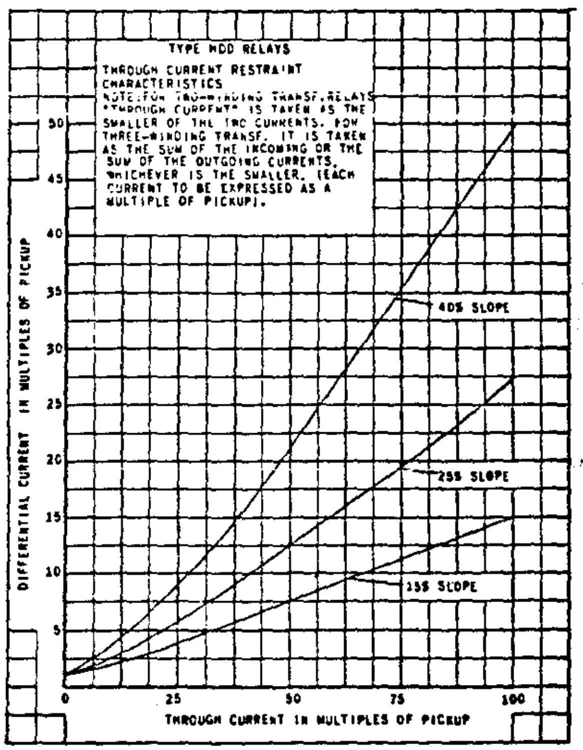
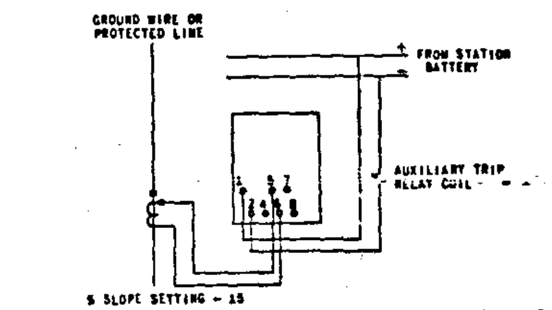


Fig. 6 Type HDD Relays Through Current Restraint Characteristic



CURRENT TAP SETTING	2.9	3.2	3.5	3.8	4.2	4.6	5.0	8.7
PICKUP AMPS (1A RELAYS)	0.57	0.63	0.69	0.75	0.83	0.91	0.99	1.72
PICKUP AMPS (2A RELAYS)	1.15	1.27	1.38	1.50	1.66	1.82	1.98	3.46

Fig. 7 Type HDD Relays Application as a Harmonic Restrained Ground Fault Detector or Overcurrent Relay

The contact assemblies should then be rotated on their mounting studs until the contacts are opened approximately 0.030" when the armature is down against the lower stop and closed with a wipe of 0.010" or more when the armature is lifted against the upper stop.

PICK-UP

Pick-up is adjusted by screwing the nut, which holds the lower end of the armature spring, in or out on its stud. This varies the leverage of the spring, which also serves to hold the back end of the armature down in its bearings. Pick-up should be 1 ampere for 12HDD15A1, 2 or 12HDD16A1, 2 relays, and 2 amperes for 12HDD15A3, 4 or 12HDD16A3, 4 relays, with current flowing into the relay through terminals 5 and 6, with the tap plugs in the 5 ampere positions and the 25 per cent restraint position.

HARMONIC CURRENT RESTRAINT

The harmonic restraint is adjusted to have the characteristic shown in Fig. 2 by means of a special reactor shown in Fig. 4, using the test circuit shown in Fig. 5. These reactors have been designed and adjusted at the factory to draw a current having 25 per cent third harmonic and negligible percentages of other harmonics when the reactor is used as indicated on a voltage source of the rated frequency and within the range of 105-130 volts. The current drawn at 115 volts is approximately 10 amperes rms. for group 4 and 5 reactors and 20 amperes rms. for group 6 and 7 reactors. This current changes rapidly as the applied voltage varies within the indicated range but the harmonic percentage remains constant. No resistor or other current-limiting device should ever be used in series with the reactor and relay nor should the reactor be used on any other voltage or frequency source since this would change the harmonic percentage and result in an improper harmonic restraint setting of the relay.

Relay Model	Use Reactor
12HDD15A1, 16A1	6174403-4
2 2	-5
3 3	-6
4 4	-7

When the relay is properly set with the reactor current flowing through it, the armature should buzz noisily but should not pick up. This test is to be made on the steady-state current of the reactor, not its transient switching current. The armature may tend to pick up on the transient switching current since, owing to the special design of the reactor, the transient current may have lower harmonic content than the steady-state current. To avoid this, the relay armature should be held down by hand while the switch is being closed.

If the relay is slightly out of adjustment it may be corrected by adjusting the position of the band on resistor R3. This resistor is located at the top right side of the relay case, behind the relay unit. If the relay is badly out of adjustment, as might be caused by disturbing the mechanical adjustments of the relay armature, the band on R3 should be placed at about the center of the resistor and the air gap between the armature and the lower magnet poles should be adjusted by means of the lower armature stop screw, with the test reactor current flowing in the relay. Following this adjustment, it will be necessary to readjust the through-current restraint resistor band settings as described below.

THROUGH CURRENT RESTRAINT (PER CENT SLOPE)

The through-current restraint, which gives the relay its percentage differential or per cent slope characteristics as shown in Fig. 6 may be checked and adjusted using the circuit illustrated by Fig. 5. Ammeter I_1 reads the smaller of the two through currents, I_D reads the differential current and I_2 reads the larger of the two through currents. Since the current in I_2 is the sum of the currents in I_1 and I_D, this meter is not necessary in making the test. In testing HDD16A relays the setting should be checked with the switch in first one position and then the other, thus checking all the restraint coils. With the current tap plugs in the 2.9 ampere positions and the per cent slope tap plug in the 40 per cent position, adjust the upper band on the resistor R2 (located at the top left side of the case, behind the relay unit) until the relay just picks up for the values of the I_1 and I_D currents indicated in the table below. Repeat with the per cent slope tap plug in the 25 per cent position and in the 15 per cent position. These currents should be permitted to flow for only a few seconds at a time, with cooling periods, between, otherwise the coils with be overheated.

When the setting is made, the 40 per cent slope band should be very near the upper end of the resistor with the 25 and 15 per cent bands well spaced below. If in making the adjustment, it is found that the 40 per cent band comes too low down so that the bands are crowded, or too high up so that the 40 per cent setting cannot be obtained even with the band at the extreme top end of the resistor, then the band should be placed at the top end and the air gap between the armature and the lower magnet poles of the relay should be adjusted by means of the lower armature stop to obtain the 40 per cent slope adjustment. Following this, the 25 per cent and 15 per cent slope bands may be adjusted and finally the band on the harmonic restraint resistor

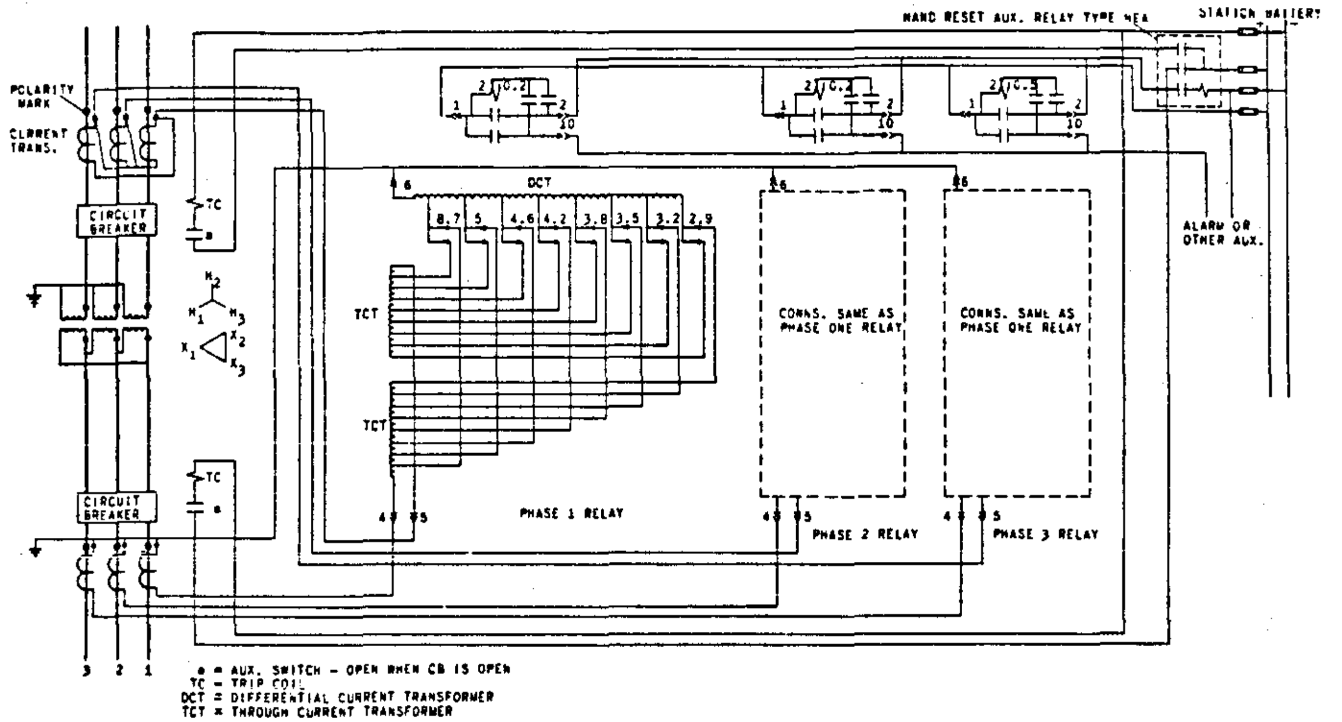


Fig. 8 External Connections of Type HDD15A Relay for Protection of Two Winding Transformer

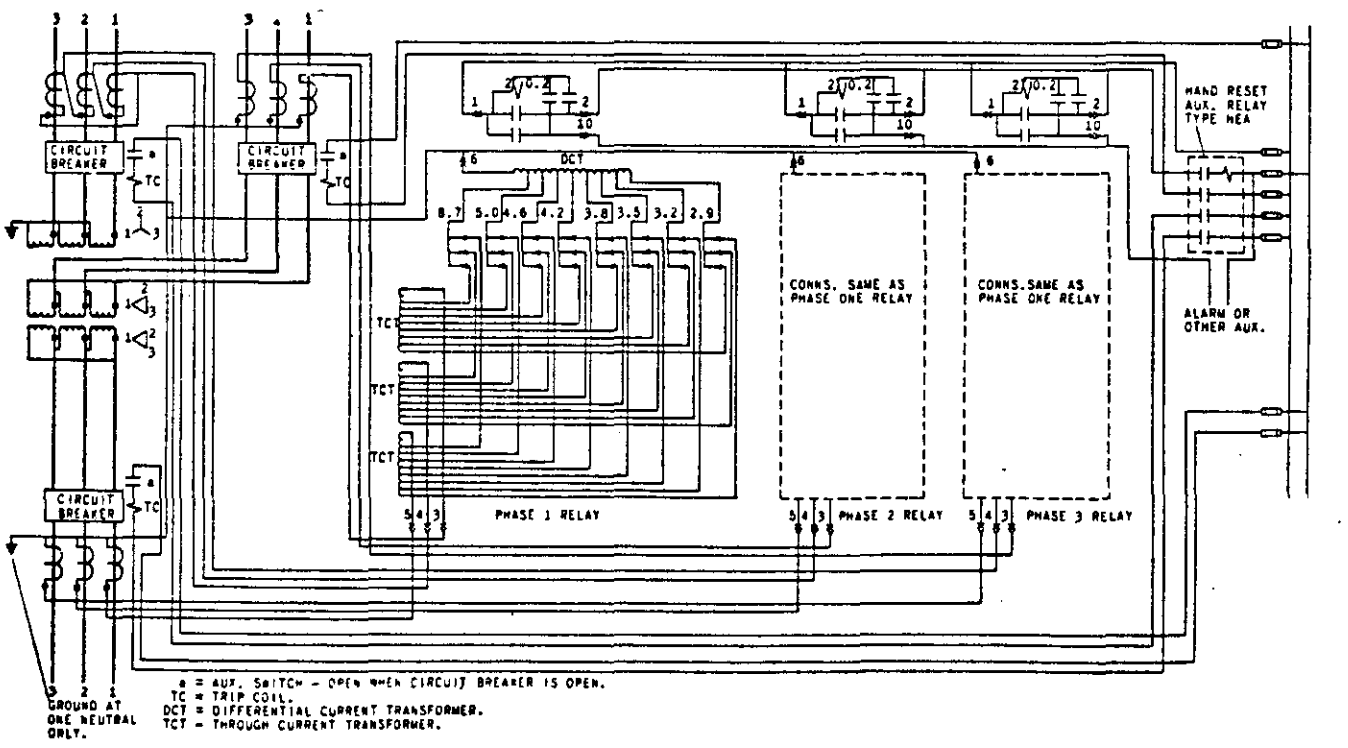


Fig. 9 External Connections of Type HDD16A Relay for Protection of Three Winding Transformer

R_3 should be reset as described in the section above.

INSTANTANEOUS OVERCURRENT UNIT

This unit is located in the ~~central~~ right hand side of the case and marked "T" I Its setting may be checked by passing a high current of rated frequency through terminals #5 and #6. The unit should pick up at 13.4 times the tap rating. If the setting is not correct, it may be adjusted by loosening the locknut at the top of the unit and turning the cap screw until the proper pickup is obtained. In making this adjustment, the current should not be allowed to flow for more than approximately one half second at a time.

RENEWAL PARTS

When ordering renewal parts on the nearest General Electric Sales Office describe each part in detail and give the model number and rating of the relay as they appear on the nameplate.

Relay Model	Per Cent Slope Tap	Band on Res. R_2	Amperes I_1	Amperes I_D
12HDD15A1, 2 12HDD16A1, 2	40 25 15	Upper Middle Lower	25 30 30	10.0 7.5 4.5
12HDD15A3, 4 12HDD16A3, 4	40 25 15	Upper Middle Lower	50 60 60	20.0 15.0 9.0

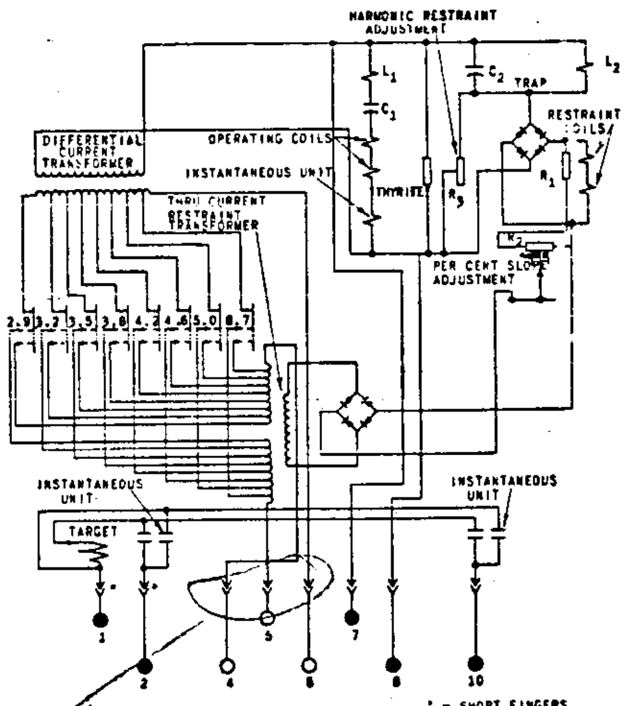


Fig. 10 Internal Connections of Type HDD15A Relay

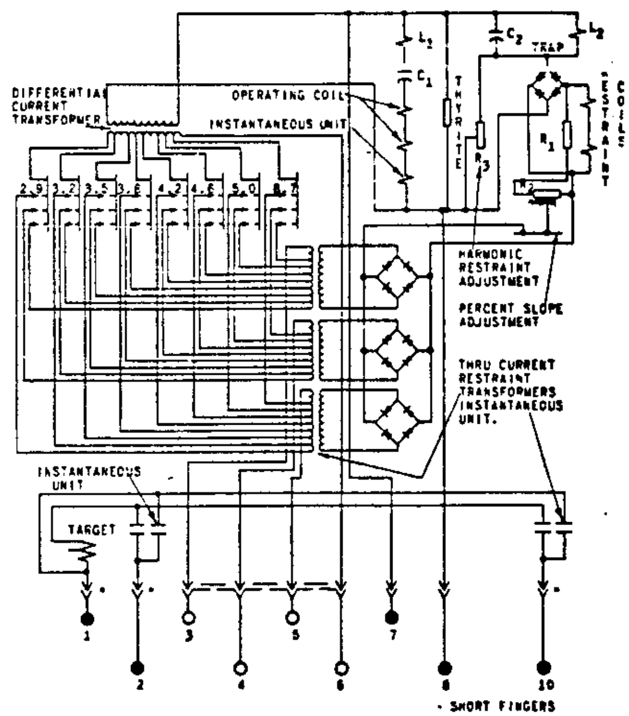


Fig. 11 Internal Connections of Type HDD16A Relay

IF YOU REQUIRE SERVICE

IF AT ANY TIME you find it necessary to repair, recondition, or rebuild your G-E apparatus, there are 29 G-E service shops whose facilities are available day and night for work in the shops or on your premises. Factory methods and genuine G-E renewal parts are used to maintain the original performance of your G-E apparatus. If you need parts only, immediate shipment of many items can be made from warehouse stock.

The services of our factories, engineering divisions, and sales offices are also available to assist you with engineering problems. For full information about these services, contact the nearest service shop or sales office listed below:

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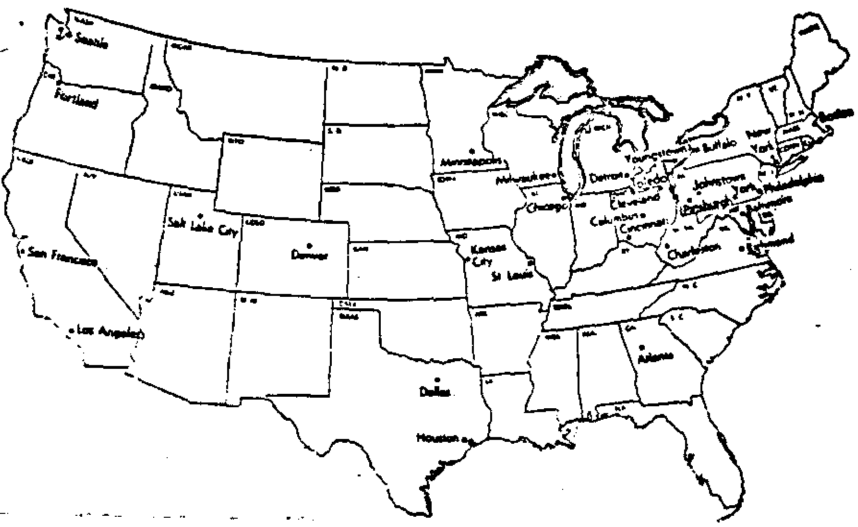

*Convenient G-E Renewal Parts Center for-over-the-counter purchases of industrial parts, located at same address.

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