TOSHIBA

取扱説明書 INSTRUCTIONS FOR

CURRENT DIFFERENTIAL RELAY

TYPE GBT2D-BT4

&

GBT3D-BT3

株式会社東芝
TOSHIBA CORPORATION
TOKYO JAPAN

CONTENTS

		Page
1.	Introduction	1
2.	Rating	1
3.	Construction and connections	3
4.	Operation	6
5.	Application	8
6.	Settings	10
7.	Adjustment and test	18
8.	Installation	21
9.	Maintenance	21
10.	Ordering	22
	Appendix (Check terminal)	34

DIFFERENTIAL RELAYS
WITH
PERCENTAGE AND HARMONIC RESTRAINT

TYPES GBT2D & GBT3D

1. Instruction

Types GBT2D and GBT3D relays are differential relays provided with the features of percentage and harmonic restraint. The Type GBT2D are used for the protection of two-winding transformers and the Type GBT3D for three-winding transformers.

Using the high-sensitivity polarized relay as the operating element, the relay has small burdens and operate with high speed on internal fault currents.

Percentage restraint permits accurate determination between internal and external faults at high currents. Harmonic restraint enables the relay to distinguish, by the difference in wave form, between the differential current caused by an internal fault and that caused by transformer magnetizing inrush.

2. Ratings

Standard relays are as follows:

Table 1 Standard relays

Type	Form	Current (A)	Frequency (Hz)	Control Voltage (V)	% Slope (%)	Target	Case	Weight (kg)
GBT2D	BT4	5 or 1	50 or 60	DC 100 or 110 or 125 or 220	15-25-40	Yes	D-4A	13
GBT3D	BT3							

Contacts

Current closing rating of the contacts, unless limited by the target rating, is 20 amperes for voltages not exceeding 250 volts DC. Current breaking rating under non-inductive load is 0.4 ampere at 220 volts DC and 0.8 ampere at 110 volts DC.

If the current exceeds the contact rating, an auxiliary relay must be used with the type GBT relay. After tripping occurs, it is necessary that the tripping current of these relays be opened by an auxiliary switch or by other automatic means.

Current circuit

The through-current transformer and the differential current transformer will continuously stand twice tap value but not exceeding 10 amperes. The one-second rating is 320 amperes. The one-second rating for 1A rating is 64 amperes. C.T. burdens at various taps are as shown in Table 2.

Table 2

Type	Tap value (A)		Zero restraint pickup (A)		Operating circuit burden (VA)	Restraining circuit burden (VA)
	(5A)	(1A)	(5A)	(1A)		
GBT2D GBT3D	2.9	0.58	0.87	0.17	3.2	1.3
	3.2	0.64	0.96	0.19	2.7	1.2
	3.5	0.7	1.05	0.21	2.4	1.1
	3.8	0.76	1.14	0.23	2.0	1.0
	4.2	0.84	1.26	0.25	1.9	0.9
	4.6	0.92	1.38	0.28	1.6	0.8
	5.0	1.0	1.50	0.3	1.5	0.7
	8.7	1.73	2.61	0.52	0.7	0.5

Notes: 1. Burden of operating coil is zero under normal condition.

2. Burden of 50 cycle relay is the same or slightly lower.

3. Burdens and minimum pickup values are substantially independent of the percent slope setting.

4. Burdens are approximately 100 percent power factor.

5. Figures given are burdens imposed on each current transformer at 5 ampere.

Auxiliary relay control circuit

An auxiliary relay controlled by polarizing relay contacts is built in. The control circuit voltage is shown in Table 1.

Target

Standard coils for target type UE3 are shown in Table 3.

Table 3

Coil current	DC resistance	Maximum trip current	Continuous current capacity	Operating current
0.2A	7.5 ohms	2A	0.2A	0.2A
1 A	0.44 ohms	10	1 A	1

3. Construction and connections

A type GBT2D or GBT3D relay is a single phase unit. Each of these relays are contained in a Toshiba standard drawout relay case type D-4A.

Internal Components

Fig. 1 shows an internal connection diagrams for differential relay Type GBT2D for the protection of two-winding power transformers. Fig. 2 shows an internal connection diagrams for differential relay Type GBT3D for the protection of three-winding power transformers.

Current transformers built into relay

In the Type GBT2D relay, the through-current current transformer (TT) has two primary windings, one for each line current transformer circuit. In the Type GBT3D relay there are three separate through-current transformers (TT1, TT2, and TT3), with only one primary winding that connect to the line current transformer circuit. In either type relay, there is a differential current transformer (DT) with one primary lead brought out to terminal 5.

The primary circuits of these current transformer is completed through a special tap blocks arrangement. Two or three horizontal rows of tap positions are provided, one row for each through current transformer winding.

Through current restraint circuit components

To obtain percentage restraint characteristics, a full-wave bridge rectifier receives the output of the secondary of each through current restraint transformer. The output is applied to the restraint coil of polarized relay. In the Type GBT3D, the DC output of all three units are connected in parallel.

The total output is fed to a tapped resistor (R_3) through the slope tap plate at the front of the relay.

Differential current circuit component

Differential current transformer secondary output current is supplied the instantaneous unit (X_3) directly and the operating coils of palarized relay through the series tuned circuit, and also the harmonic restraint circuit through the parallel resonant trap.

Current which pass the trap are rectified in a full wave bridge rectifier. The instantaneous unit consist of a rectifier (REC) and auxiliary relay (X_3). The target is reset by pressing the button located at lower part of the cover.

The rectifier is in series with the calibrating resistor R_2, which can be adjusted to give the desired amount of harmonic restraint. The output of the rectifier is paralleled with the through-current restraint currents, and applied to the restraint coil of polarized relay.

Main operating unit

The main operating unit of the type GBT relay is a sensitivity polarized relay (p-Ry). This relay has one operating and restraining coil. This unit has 1C contacts, and its contacts are provided with auxiliary relay X_1 and X_2. The contact of X_1 is brought out to stud for connection in an external circuit. The circuit containing the target (at the upper left side of the relay) which indicates when the current flows through the relay X_1 contacts, connects to terminal 2, and the circuit which combines readily with the overcurrent unit contacts to form the standard direct current circuit, described later, connects to terminals 3 and 4. The targets are provided with contacts which serve to seal-in the relay X_1 and X_2 contacts. The target can be reset by hand through the reset button.

4. Operation

Percentage differential characteristics

The percentage differential characteristics, that is, the relation between through-current and differential current at operating limits when these currents are expressed as a multiple of tap values, are shown on Fig. 3.
When the through-current flows separately from two external terminals, if their sum is shown, the characteristics will not be affected materially. Pick-up at zero restraint is approximately 30% of tap value.

Overcurrent unit characteristics

This unit is adjusted to pick-up when the differential current transformer ampere turns are eight times the ampere turns produced by rated tap current flowing in that tap.

If the ratio matching taps are chosen so that rated CT current is not greater than the tap rating the overcurrent unit will not pick-up on magnetizing inrush current. If CT current is greater than the tap rating, there is danger that the unit may be pick-up under certain circumstance. In such a case, it is recommended that the CT ratio or relay tap setting be increased rather than increasing pick-up of the overcurrent unit. The purpose of the overcurrent unit is to give out trip order such as during internal fault when the CT error becomes large, resulting in the harmonic restraint making the main operating unit inoperative.

Harmonic restraint characteristics

When the power transformer is energized, magnetizing inrush current is supplied to the primary which establishes the required flux in one core. This current flows only through the current transformer in the primary winding. This causes an unbalance current to flow in the differential relay which would cause false operation if means were not provided to prevent it.

The fault current are of a nearly pure sine wave form plus a direct current transient components.

Types GBT2D and GBT3D relays are provided with harmonic restraint characteristics to permit discrimnation between magnetizing inrush current and internal fault current through the magnitude of harmonics component. This characteristic is shown in Fig. 4.

Operating time

The operating time characteristics of the main operating unit and overcurrent unit are shown in Fig. 5, plotted against differential current.

5. Application

Current transformers

The current transformers must be connected in Wye at the delta-connection of power transformer windings, and in delta at the Wye-connection of power transformer windings. When connecting, make sure that the phases are in correct. (Refer to Figs. 6 and 7).

The current transformers should be selected with the following points in mind.

1. Current transformation ratios should be high enough that the relay will not be damaged at maximum internal fault current. (Refer to ratings).
2. The relay current corresponding to rated kVA of the power transformer (on self-cooled basis) should not exceed the relay tap value selected (magnetizing inrush current might operate the instantaneous over current unit).
3. The relay current corresponding to maximum kVA (on a forced cooled basis) should not exceed twice tap value. (CT secondary current should not exceed the continuous current) rating of the CT secondary winding.
4. The current transformer tap chosen must be able to supply the relay with 8 times rated relay tap current with an error less than 20 percent.

Ratio matching taps

Since it is rarely impossible to match the secondary currents exactly by selection of current transformer ratios, ratio-matching tap provided on the relay means of which the current may be usually with in 5 percent.

If the protected transformer is equipped with load ratio control, it is obvious that a close match can not be obtain at all point of the ratio changing range. In this case, the secondary currents are matched at the center value of the tap range and the percentage differential characteristic is selected such that relay will not operate incorrectly at the ends of the range.

External connections

The AC circuits are shown in Figs. 6 and 7.

Standard DC circuit is shown in Fig. 8. In this case three-phase transformer is shown.

6. Settings

Calculation required for determining of ratio matching taps and % slope tap are outlined below. The representative capacity is the largest capacity of each power transformer windings. For example, in a three-phase transformer where the primary is 2,700 kVA, secondary 3,000 kVA, and the tertiary 500 kVA, the representative capacity is the 3,000 kVA of the secondary.

<u>Determination of current transformer and realy tap setting</u>

1. Determine maximum line current current (Max I_p) on the basic that each power transformer winding may carry the maximum forced cooled rated kVA of the transformer.

$$\text{Max } I_p = \frac{\text{Max kVA}}{\sqrt{3}\ (\text{line kV})}$$

2. Determine the full load rated line currents (Rated I_p) on the basis that each power transformer winding may carry the full self-cooled rated kVA of the transformer.

$$\text{Rated } I_p = \frac{\text{Rated kVA}}{\sqrt{3}\ (\text{line kV})}$$

3. Taking the CT ratio as N, obtain the secondary current Max I_s and Rated I_s of Max I_p and Rated I_p respectively.

$$\text{Max } I_s = \frac{\text{Max } I_p}{N}$$

$$\text{Rated } I_s = \frac{\text{Rated } I_p}{N}$$

4. Determine the CT ratio N so that Max I_s does not exceed the rated secondary current (5 amperes), and also that the relay current I_R can be properly matched by means of the relay tap. (Highest current not more than 3 times lowest current).

   I_R = Rated I_s (if current transformers are connected in Wye)

   $I_R = \sqrt{3}$ Rated I_s (if current transformers are connected in delta)

5. Check for matching of relay current I_R to the relay taps to keep the mismatch error as low as possible. This error is recommended with in 5 percent. (Refer to chapter on % slope tap setting.)

To calculate the percent of mismatch on two-winding transformer, first determine the ratio of the two relay current and the ratio of the two tap values selected. The percent of mismatch is the difference between these ratios divided by the smaller ratio. For example, if taps T_A and T_B are selected to the relay current I_{RA} and I_{RB} for the A and B windings, the ratios are

$$\frac{I_{RA}}{I_{RB}} \text{ and } \frac{T_A}{T_B}$$

The percent of mismatch is

$$\frac{\frac{I_{RA}}{I_{RB}} - \frac{T_A}{T_B}}{\frac{T_A}{T_B}} \quad \text{if} \quad \frac{I_{RA}}{I_{RB}} > \frac{T_A}{T_B}$$

$$\frac{\frac{T_A}{T_B} - \frac{I_{RA}}{I_{RB}}}{\frac{I_{RA}}{I_{RB}}} \quad \text{if} \quad \frac{T_A}{T_B} > \frac{I_{RA}}{I_{RB}}$$

For the three-winding transformer, this calculation should be checked for all combinations of the currents and the taps.

If the tap can not be selected to keep this percentage error with in allowable limits it will be necessary to chose a different CT ratio on one or more lines to obtain a better match between relay current and relay tap.

6. Check to see that the sum of the relay current that will be applied to the relay for a fault at the terminal of the power transformer is less than 220 amperes for 1 second.

Current transformer ratio errors

As described before, at current of 8 times the tap value, the current transformation ratio error must be less than 20%. This calculations are made as follows:

This calculation listed below are for the worst fault condition, as far as CT performance is concerned, which is an internal ground fault between the CT and transformer winding with none of the fault current supplied through the neutral of the protective transformer.

1. Determine the burden on each CT, by the following equations:

   a) For current transformers in Wye-connection

   $$Z = Z_G + Z_r + Z_L$$

   b) For current transformers in delta connection

   $$Z = 2Z_G + Z_r + Z_L$$

where: Z_G = Current transformer burden. Sum of the operating coil burden and the restraining coil burden for tap setting shown in Table 2 divided by 25 (ohms).

Z_T = Current transformer winding resistance (ohms)

Z_L = Current circuit resistance (ohms) to and from current transformer and relay.

2. Determine CT secondary current for 8 times tap setting.

I_s = 8 x tap setting

3. Determine CT secondary voltage (E_s) required at 8 times tap setting.

$E_s = I_s Z$

4. From the current transformer secondary excitation characteristics, obtain the exciting current I_E corresponding to this secondary voltage E_s.

5. Determine the percent error in each CT by the expression

$$\% \text{ error} = \frac{I_E}{I_s} \times 100$$

This should not exceed 20% of any set of CT's, if it does, it will be necessary to change the current transformers.

<u>% slope tap setting</u>

The proper percent slope is determined by the sum of the following causes of differential current.

a) The maximum range of load ratio control in percent.

b) The maximum percent of mismatching of the relay taps.

c) During external faults, the maximum differential current caused by current transformer saturation.

The % slope tap selected should be greater than the ratio of maximum total error current to smaller of the through currents. In general, the 15% slope tap is selected if the total error current does not exceed 10%, 25% slope tap if it does not exceeded 17%, and 40% slope tap if it does not exceeded 27%.

Sample Calculation

Using the protected transformer shown in Fig. 9 as example, the calculation of the setting will be done.

1. Determination of current transformer and relay tap setting.

		A	B	C
1.	Transformer and line	A	B	C
2.	Max I_p = A, B : 48MVA/$\sqrt{3}$ (line kv); C : 12MVA/$\sqrt{3}$ (line kV)	180	420	630
3.	Rated I_p = 40 MVA/$\sqrt{3}$ (line kV)	150	350	2100
4.	C.T. ratio	300:5	600:5	1200:5
5.	Max I_s (less than 5 amperes)	3.00	3.50	2.63
6.	Rated I_s	2.50	2.92	8.75
7.	C.T. connection	delta	delta	Wye
8.	I_R	4.32	5.05	8.75
9.	Ideal relay taps (set C = 8.7)	4.30	5.02	8.70
10.	Actual relay tap (T)	4.2	5.0	8.7

11. Check mismatch error:

	Ratio of I	Ratio of T	Mismatching
Lines A-B	$\frac{4.32}{5.05} = 0.858$	$\frac{4.20}{5.00} = 0.840$	$\frac{0.858-0.840}{0.840} = 2.12\%$
Lines B-C	$\frac{5.05}{8.75} = 0.577$	$\frac{5.00}{8.70} = 0.575$	$\frac{0.577-0.575}{0.575} = 0.04\%$
Lines C-A	$\frac{8.75}{4.32} = 2.02$	$\frac{8.70}{4.20} = 2.07$	$\frac{2.07-2.02}{2.02} = 2.48\%$

(Mismatch error is not excessive, as all are less than 5%)

12. Assumed that the sum of the maximum relay current is less than 220 amperes for one second.

II. Current transformer ratio error

1. Burden on CT's

   a) Line A $Z = (2 \times 0.112) + 0.400 + 0.5 = 1.124$

   b) Line B $Z = (2 \times 0.088) + 0.450 + 0.5 = 1.126$

   c) Line C $Z = 0.048 + 0.670 + 0.5 = 1.218$

	Relay	CT internal resistance	Cable resistance

		A	B	C
2.	Transformer and line	A	B	C
3.	Impedance (ohm)	1.124	1.126	1.218
4.	I_S (amperes)	33.6	40.0	69.5
5.	E_S (volts)	37.8	45.0	84.5
6.	I_E (amperes): from excitation curve	I_{EA}	I_{EB}	I_{EC}
7.	Current transformation ratio error (%)	$100I_{EA}/33.6$	$100I_{EB}/40.0$	$100I_{EC}/69.5$

If exciting current (I_E) is too high and ratio error is larger than 20%, the current transformer should be replaced and the above calculations repeated so as to bring the current within the permissible error.

III. "% slope" setting

1. Assume load ratio control maximum range 10.00%
2. Relay tap mismatch : From I-11 .... 2.48%
3. Assume current transformer error for external fault .. 4.00%
4. Total error 16.48%
5. Use tap 25%

<u>Note</u>: Current transformer error for external fault can be calculated if the excitation curve of each current transformer and the maximum current for external fault are known.

7. Adjustments and test

In testing the relay, remove the cover, and pull out the plug at the top and bottom of the relay inside. Then start the test after inserting the test plug (Type XRT) or pulling out the relay itself. When using the test plug, be sure to short the outer-case side terminals of current transformer circuit. In case the adjustment is being disordered, readjust it in accordance with the adjustment items to be mentioned hereafter.

To make the tests and adjustments, a high harmonics power source for harmonic restraint tests as well as a rated frequency power source is required. In addition, the current must be supplied to the relays through high resistances. It is required that the fluctuation of the rated frequency does not exceed 2%. If the fluctuations is large, it is difficult to judge the test results. As an example, the pick-up curve to frequency is shown in Fig. 10. It is also required that the voltage wave form contains high harmonics less than 2%. Less than 0.5% will be desirable if it is possible.

The relay calibration is accomplished by a adjusting resistors R_1, R_2 and R_3. Change made in any one of these resistors will affect all characteristics.

Pick-up

Pick-up should be take place 30% tap rating with the current following in terminals 5 and 6, when minimum tap is used. Since the relay uses a polarized unit with a very low energy level, the minimum pick-up setting may vary as much as ± 15%, depending upon the previous history, of its magnetic circuit. But this will have no effect on its application.

If pick-up is found to be out of adjustment it may be corrected by adjusting the position of the band on resistor R_1.

Harmonic current restraint

For harmonic restraint test, a rated frequency power source and a high harmonic power source are required, and the currents from these sources are flowed in terminals 5 and 6.

If the relay is out of adjustments it may be corrected to have the characteristic shown in Fig. 4 by adjusting the position of the band on resistor R_2. In doing this adjustment, fundamental wave current of approximately 10 amperes are flowed and the harmonic current changes very gradually to find out the pick-up limit.

Through current restraint

Through current restraint may be checked and adjusted using the circuit shown in Fig. 12. It is recommended that the inflowing current I_1, outflowing current I_2, and differential current I_D be measured to check the current phase. In testing the "% slope" setting, I_D/I_T will match the setting when the through current I_T is more than five times the tap setting. If the relay is out of adjustment it may be corrected by adjusting the particular band on resistor R_3. In this case, it will have small effect upon minimum pick-up and harmonic restraint. It is necessary to re-check on these points.

Overcurrent unit

An overcurrent unit equipped with indicator is located at the upper right hand side of the relay and is marked I. This unit should pick-up at 8 times the tap rating, when current of rated frequency passes through terminals 5 and 6.

Target and seal in element

The rating is selected either 0.2A or 1A corresponding to the magnitude of the trip current.

Check terminal (refer to appendix)

The check terminal is used for measuring the secondary voltage of Auxiliary current transformer (DT), which is connected across the differential junction point. The voltage is in proportion to the differential current. Therefore, if the cover is removed, the differential current can be checked by measuring the voltage.
The check terminal is provided with the front of the relay.
Differential current secondary voltage characteristics is shown in Fig. 13.
Difference current is difference between the inflow and outflow current, which are respectively represented by the multiples of setting tap values. (Outflow current; GBT2D : 6 - 7 , GBT3D : 6 , 7 , 8)

8. Installation

During unpacking, be careful for no damage for all parts, and no disturb to the adjusted portions. When the relay is not used immediately, pack it again, and store in a place free from the moisture, dust and dirt.

(1) Location

The place to install the relay should be clean and free from dust and dirt and excessive vibration. It should be convenient for the usual inspection.

(2) Mounting

The relay should be mounted on a vertical surface. Refer to the Toshiba standard draw-out case D-4A diagram of Fig. 14 for the outline and the panel drilling diagram.

9. Maintenance

(1) Periodic test

It is recommended to test the relay characteristics periodically, say once a year. For the testing, remove the case cover, draw out the connecting plug at the lower portions of the relay inside, and insert the type XRT test plug or draw out the relay body. When the connecting plug is drawn out, the current transformer circuit is short-circuited before the relay circuit is opened, and no fear can exist for the current transformer secondary opening. When the test plug is used, however, the current transformer circuit side terminal should be shorted previously. For the details of pick up test, percentage differential characteristics, and overcurrent unit test, see 7. Adjustment and test.

(2) Inspection

Inspect and confirm the following:

(1) No loosening of screws and taps

(2) No intrusion of foreign matters

(3) No abnormality on the control portions

(4) No insecure soldering parts

(5) No disconnection and shorting

10. Ordering

In ordering the relay or its parts, contact to the Toshiba office informing the following clearly.

(1) Type and name of the relay

(2) Rated current

(3) Rated frequency

(4) Target rated current

(5) DC control voltage

(6) Case color finish

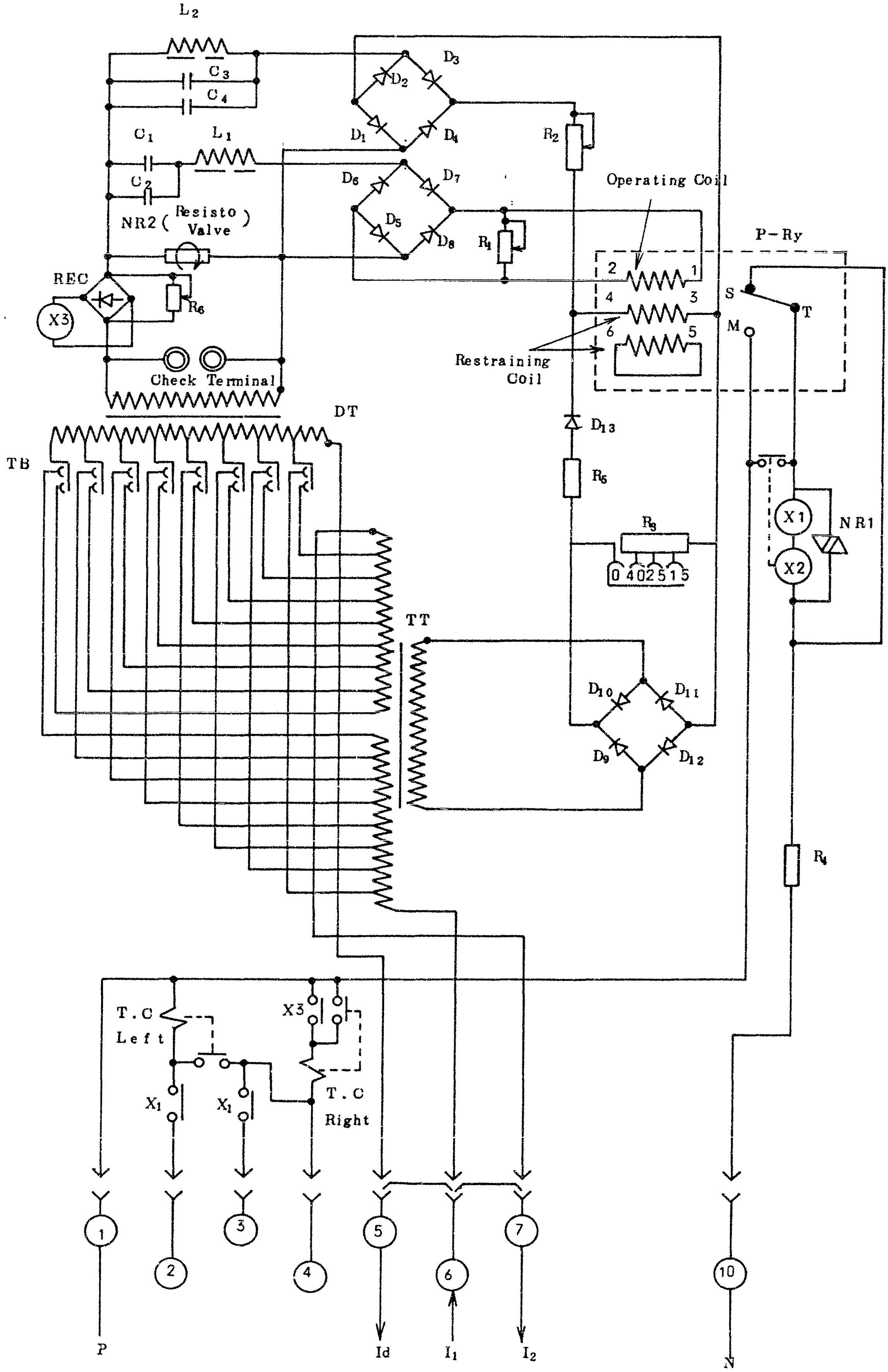


Fig. 1 Internal Connections for GBT2D-BT4

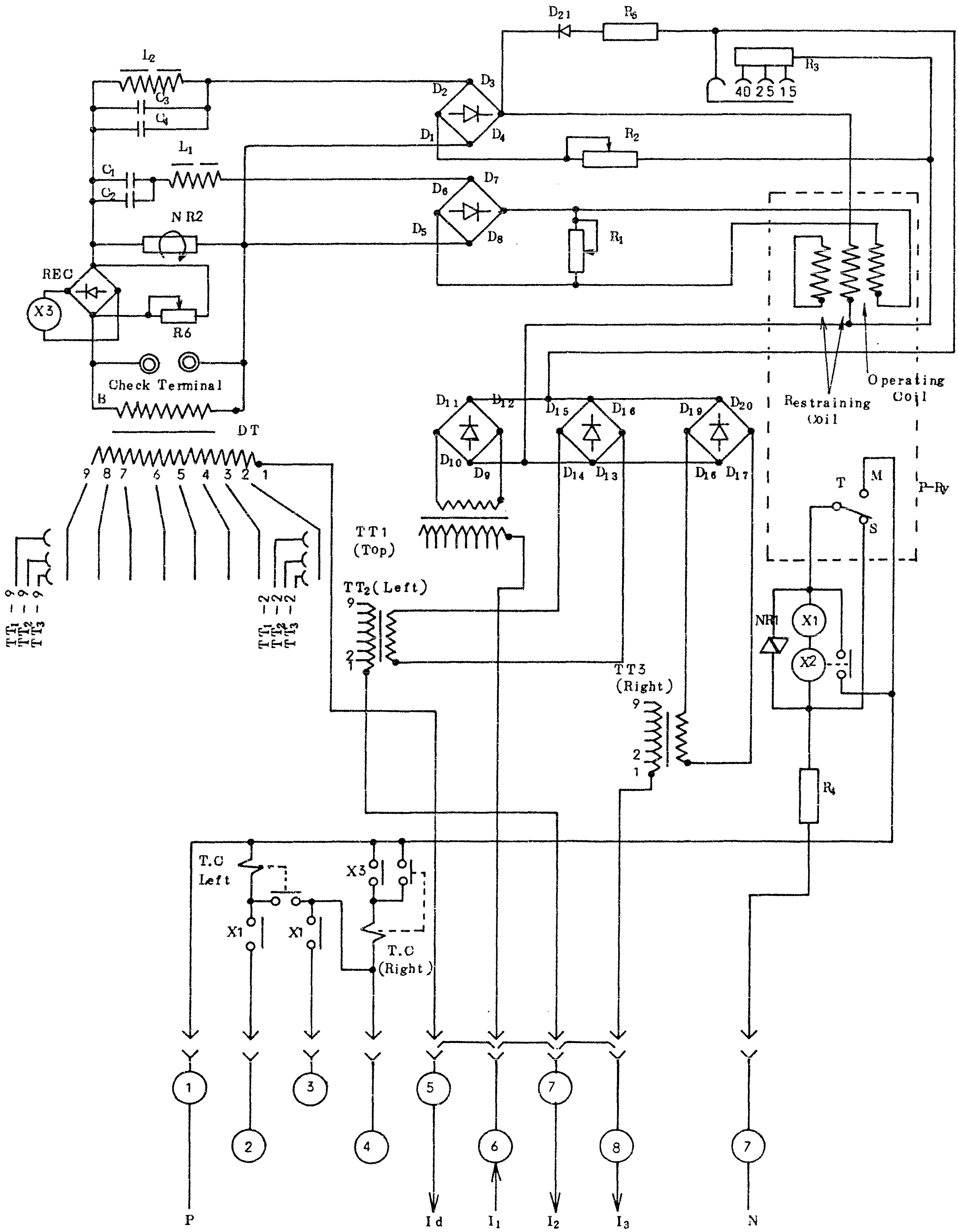
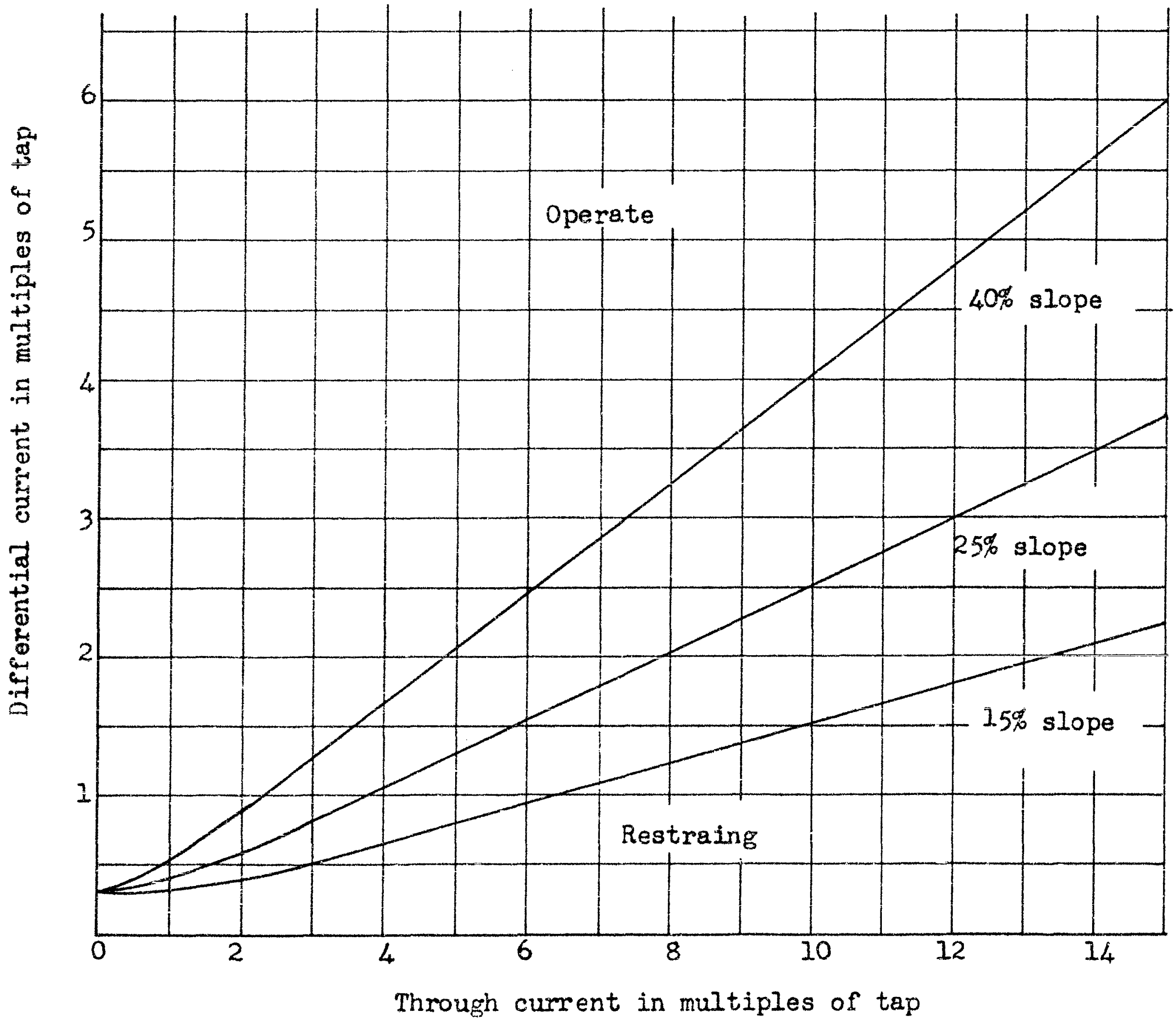


Fig. 2 Internal Connection for GBT3D-BT3



For two-winding transformer relays "through current" is taken as the smaller of the two currents. For three winding transformer, it is taken as the sum of the inflow or outflow currents whichever is the smaller. (Each current to be expressed as a multiple of tap)

Fig. 3 Percentage Differential Characteristics

Note: Through current Zero

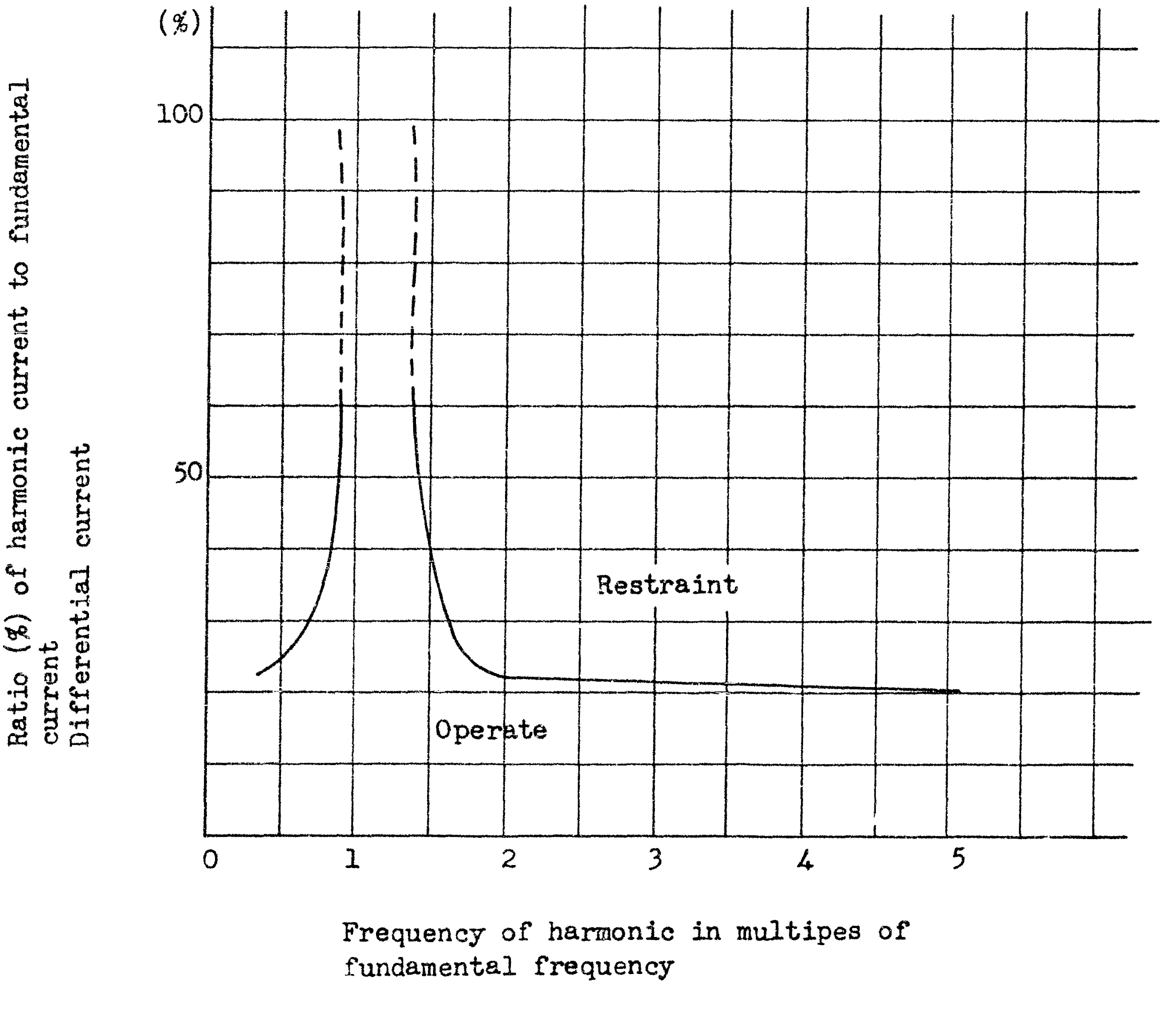


Fig. 4 Harmonic restraint characteristics

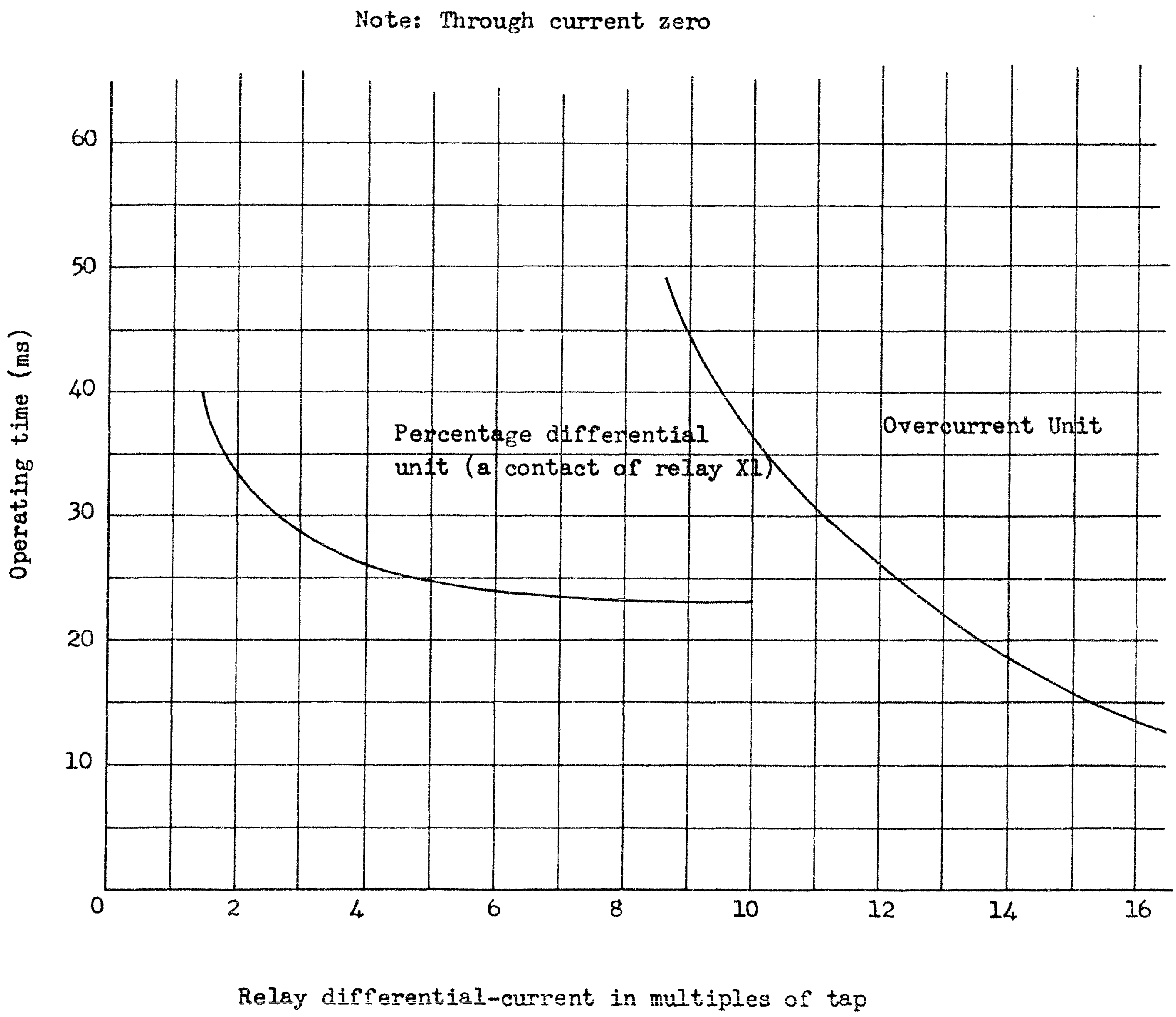


Fig. 5 Operating time characteristies

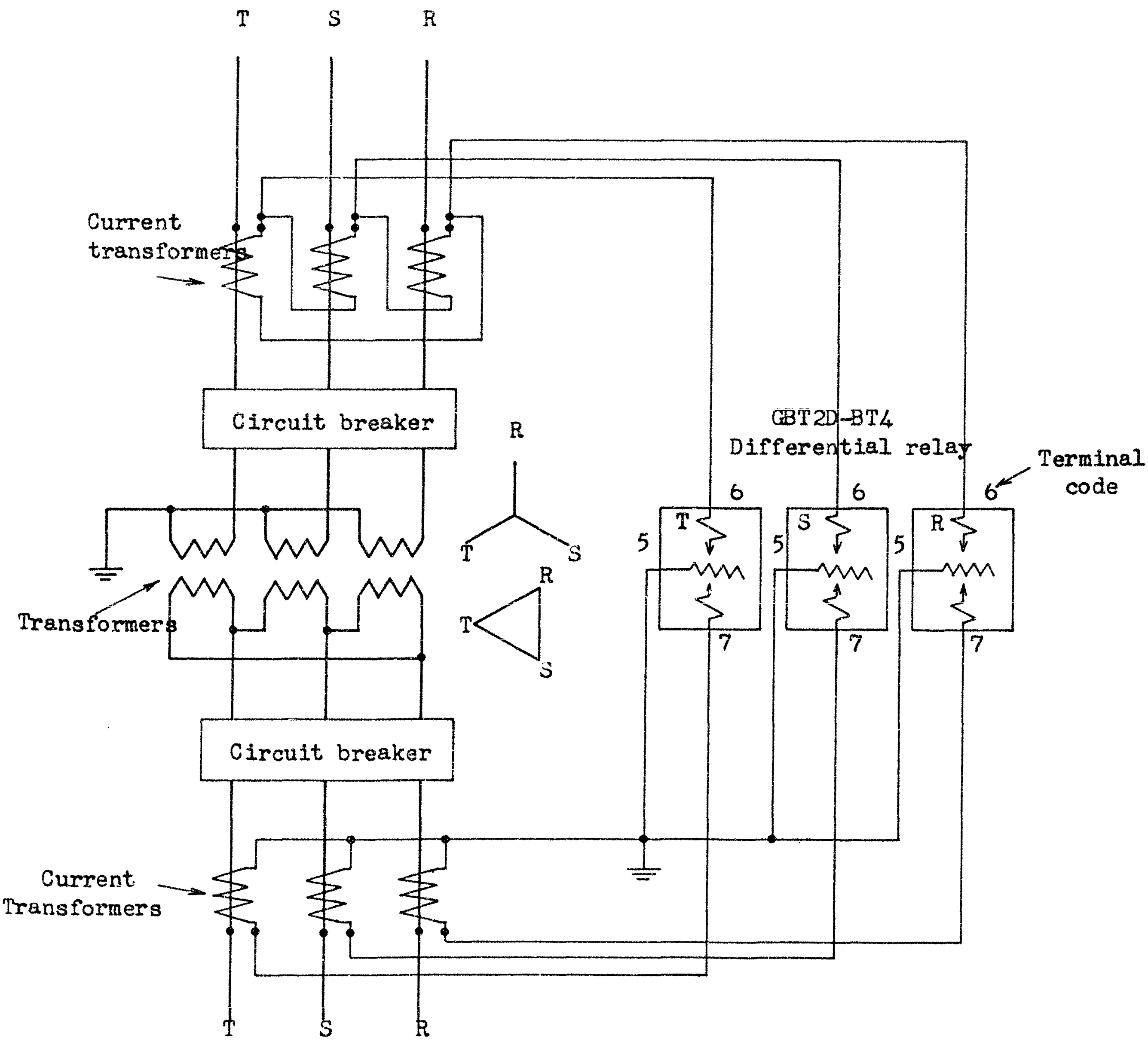


Fig. 6 Connection diagram of differential protection using Type GBT2D relays for two-winding transformer

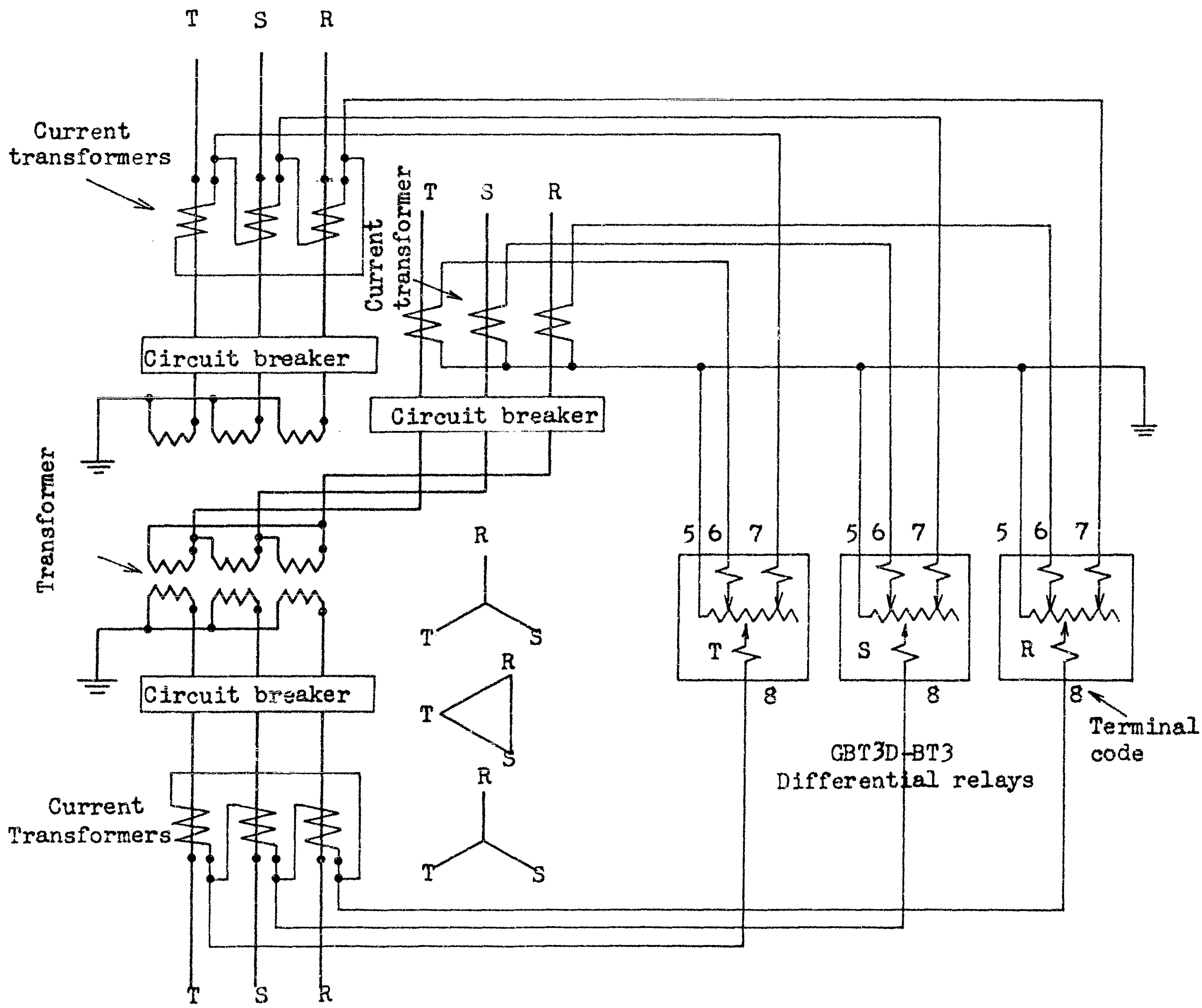
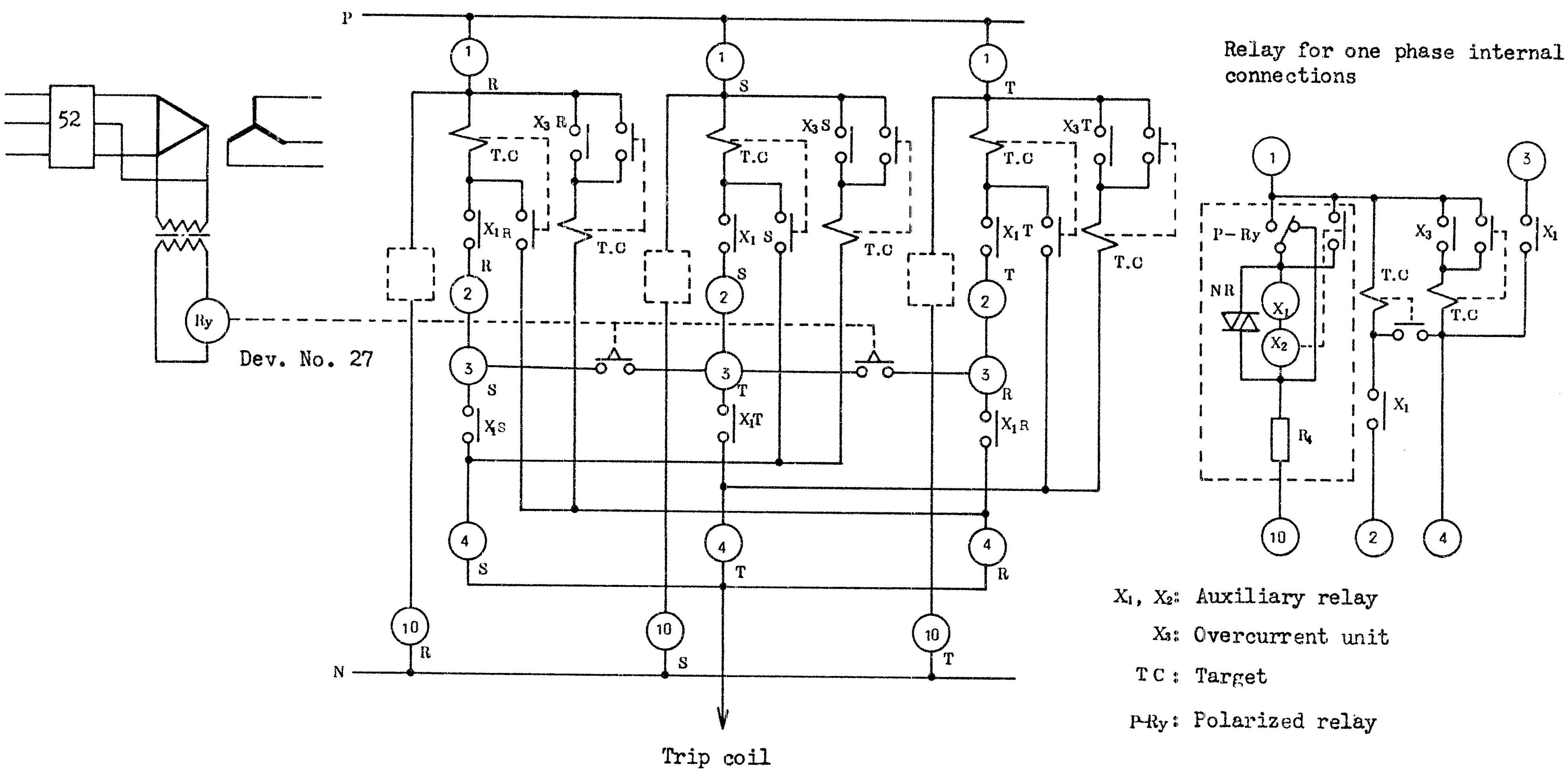
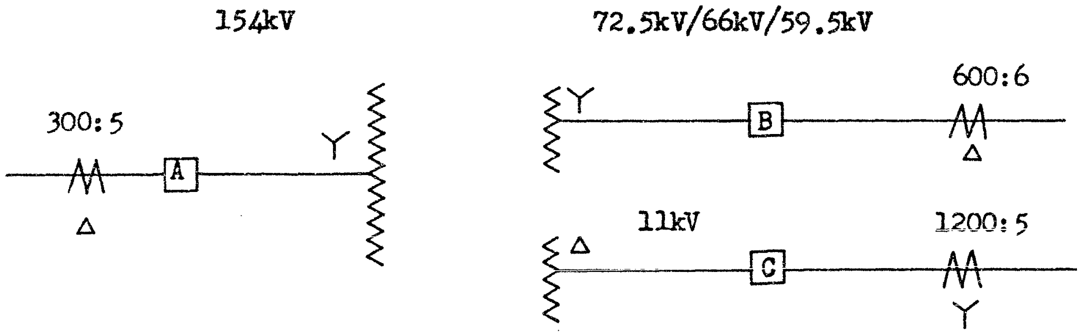


Fig.7 Connection diagram of differential protection using Type GBT3D relays for three-winding transformer



In the above diagram, suffix letters R, S and T indicate that these parts are included in the each relays for three phase

Fig.8 Standard DC ciruit of transformer differential protection



Winding	Self-cooled rated capacity	Forced-cooled rated capacity
A	40 MVA	48 MVA
B	40 MVA	48 MVA
C	10 MVA	12 MVA

(Representative capacity is the maximum self-cooled capacity, that is, 40 MVA)

<u>Data</u>

One way resistance from current transformer to relay	0.250 ohm
Internal resistance of current transformer A	0.400
Internal resistance of current transformer B	0.450
Internal resistance of current transformer C	0.670

<u>Note:</u> 1. If the secondary winding resistance is R_c per one turn and the lead resistance is R_L from the number of secondary winding turns n, current transformer internal resistance is

$$n R_c + R_L$$

2. The resistance value is taken on the safe side for the temperature rise.

Fig.9 Transformer used in sample calculations

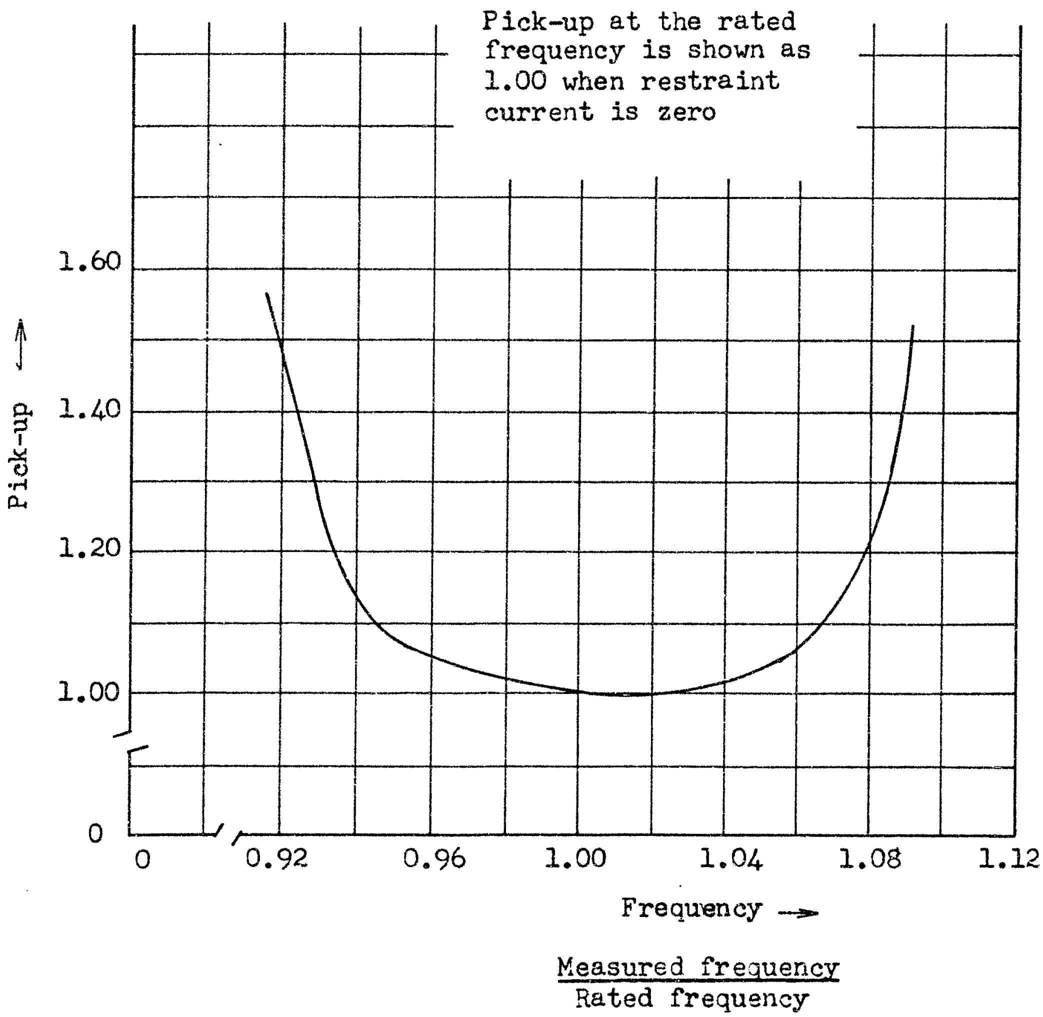
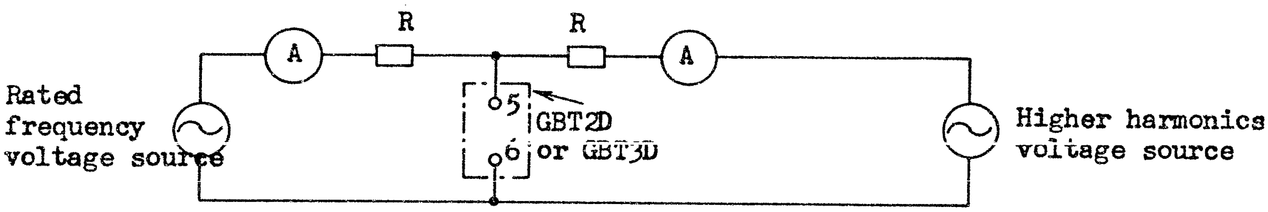
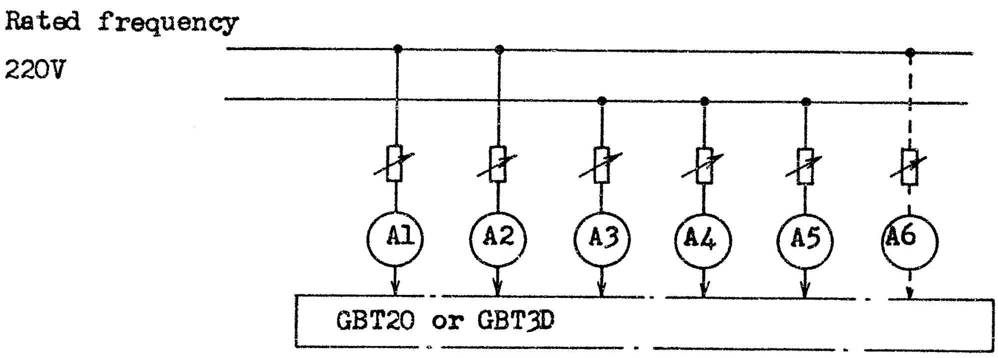


Fig. 10. Frequency characteristics



R : 10 ohms or larger

Fig. 11 Test connection of harmonic restraint



Circuit connection sample

	Current Circuit					Current Conditions (Diff. A5)	I_1	I_2	I_T & I_D	
	A1	A2	A3	A4	A5				$I_1 > I_2$	$I_1 < I_2$
Relay terminal	6		7		5	A1 $\geqq$ A3	$\frac{A1}{T1}$	$\frac{A3}{T2}$	$I_D = I_1 - I_2$ $I_T = I_2$	$I_D = I_2 - I_1$ $I_T = I_1$
	7		6		5	A1 $\geqq$ A3	$\frac{A1}{A2}$	$\frac{A3}{T1}$		
	6	7	8		5	A1+A2 $\geqq$ A3	$\frac{A1}{T1}+\frac{A2}{T2}$	$\frac{A3}{T3}$		
	6		7	8	5	A1 $\geqq$ A3+A4	$\frac{A1}{T1}$	$\frac{A3}{T2}+\frac{A4}{T3}$		

Notes:
1. T_1, T_2, and T_3 indicates the tap setting at No.1, No.2, and No.3 tap block respectively.
2. If it is necessary to reverse the unequality signs in current condition column, terminal 5 must be connected to the A_6 current circuit. (Differential becomes A_6)
3. By following the above table, the other combinations can be made when required.

Fig. 12 Test connection of percentage differential characteristics

Appendix;

Check terminal

This terminal is provided to measure the voltage induced across the secondary winding of auxiliary current transformer in a differential circuit.

The induced voltages are in about proportional to the differential current as shown in Figure 12.

Whether the relay is in normal condition or not can be checked by measuring the voltage of the check terminal in service.

How to use the check terminal

The terminal is mounted on the front panel of the relay. The measurement can be performed by inserting tester leads into the terminal.

Beforehand, a reference voltage for judgement is calculated by Table 4.

The relays condition is judged by comparing the calculated voltage and the actually-measured voltage at the check terminal as shown in Table 4.

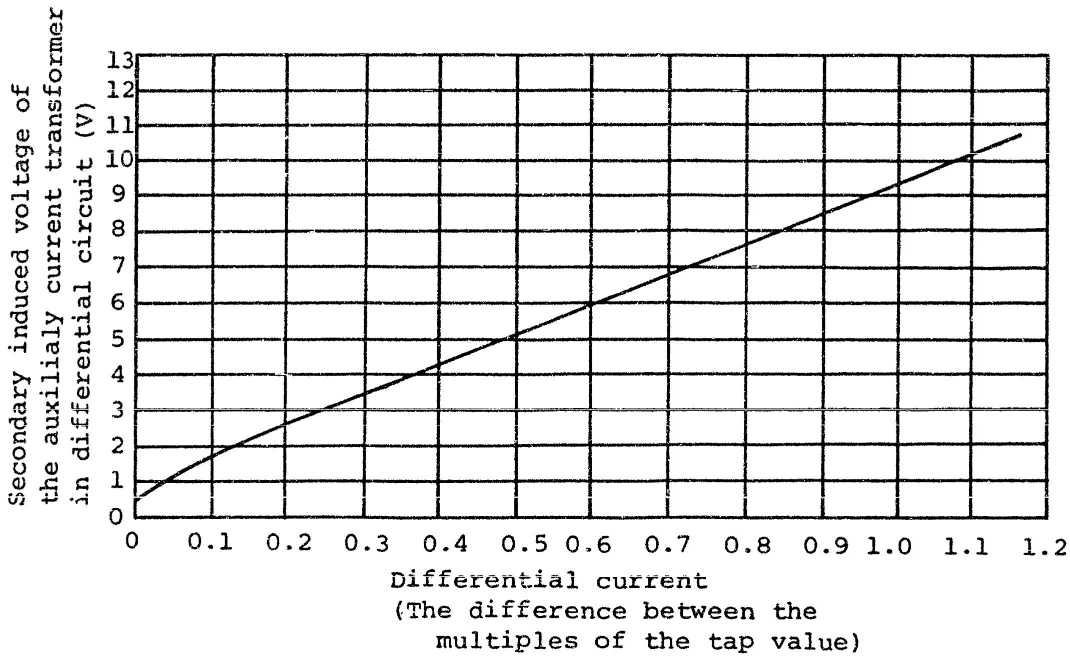
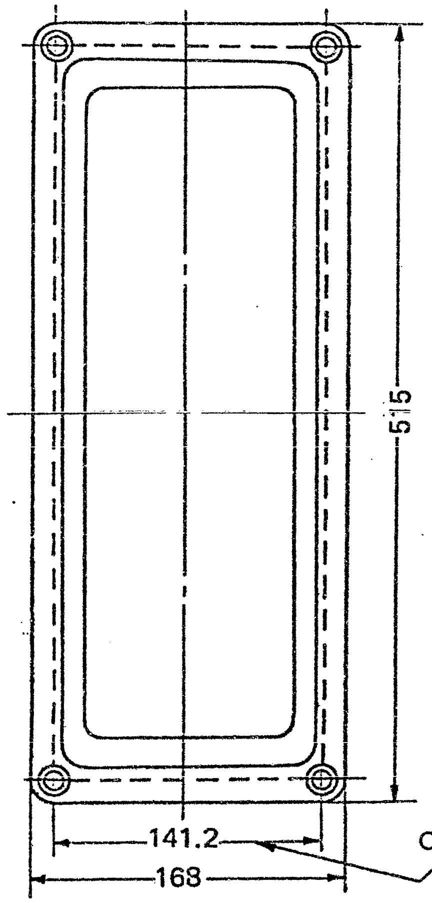


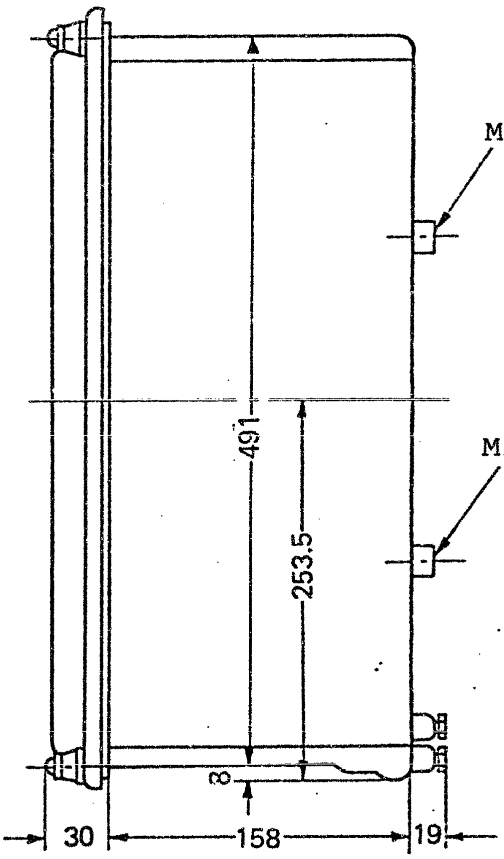
Fig.13 Differential current-voltage characteristics of the auxiliary current transformer in differential circuit

Table 4 Calculation step of a reference voltage for judgement

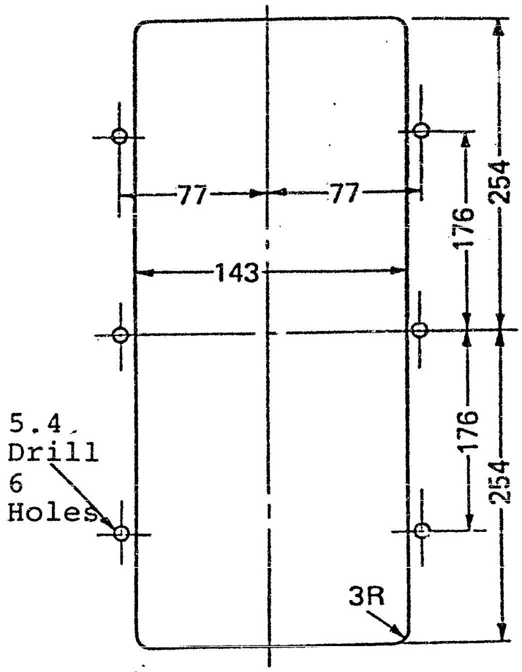
STEP	ITEM	CALCULATION: PRIMARY	CALCULATION: SECONDARY	CALCULATION: TERTIARY
1	RATED CAPACITY	P = MVA		
2	RATED VOLTAGE AT MIDDLE TAP	$V_1=$ (KVA)	$V_2=$ (KVA)	$V_3=$ (KVA)
3	RATED LINE CURRENT	$I_{P1}=\frac{P \times 10^3}{\sqrt{3} \times V_1}=$ (A)	$I_{P2}=\frac{P \times 10^3}{\sqrt{3} \times V_2}=$ (A)	$I_{P3}=\frac{P \times 10^3}{\sqrt{3} \times V_3}=$ (A)
4	C.T.RATIO	N_1 =	N_2 =	N_3 =
5	C.T. SECONDARY CURRENT AT RATED LINE CURRENT	$I_{S1}=\frac{1}{N1} \times I_{P1}=$ (A)	$I_{S2}=\frac{1}{N2} \times I_{P2}=$ (A)	$I_{S3}=\frac{1}{N3} \times I_{P3}=$ (A)
6	C.T. SECONDARY CONNECTION	⅄ OR △	⅄ OR △	⅄ OR △
7	RELAY CURRENT VALUE — ⅄ CONNECTION	$I_{RY1}=I_{S1}=$ (A)	$I_{RY2}=I_{S2}=$ (A)	$I_{RY3}=I_{S3}=$ (A)
	RELAY CURRENT VALUE — △ CONNECTION	$I_{RY1}=\sqrt{3}I_{S1}=$ (A)	$I_{RY2}=\sqrt{3}I_{S2}=$ (A)	$I_{RY3}=\sqrt{3}I_{S3}=$ (A)
8	LINE CURRENT WHEN THE TRANSFORMER OPERATING. (ACTUALLY-MEASURED CURRENT BY AMP-METER)	I'_{P1} = (A)	I'_{P2} = (A)	I'_{P3} = (A)
9	LOAD FACTOR	$X1=\frac{I'_{P1}}{I_{P1}}$	$X2=\frac{I'_{P2}}{I_{P2}}$	$X3=\frac{I'_{P3}}{I_{P3}}$
10	RELAY TAP VALUE	T_1 = (A)	T_2 = (A)	T_3 = (A)
11	$\frac{\text{RELAY CURRENT WHEN THE TRANSFORMER OPERATING}}{\text{RELAY TAP VALUE}}$	$\frac{I_{RY1} \times X1}{T_1}=$	$\frac{I_{RY2} \times X2}{T_2}=$	$\frac{I_{RY3} \times X_3}{T_3}=$
12	DIFFERENTIAL CURRENT	INCOMING PRIMARY, OUTGOING SECONDARY AND TERTIARY $I_D = \frac{I_{RY1} \times X1}{T_1} - (\frac{I_{RY2} \times X2}{T_2} + \frac{I_{RY3} \times X3}{T3}) =$ OUTGOING PRIMARY, INCOMING SECONDARY AND TERTIARY $I_D = (\frac{I_{RY2} \times X2}{T_2} + \frac{I_{RY3} \times X3}{T3}) - \frac{I_{RY1} \times X1}{T_1} =$		
13	BASIC VOLTAGE	LEAD THE INDUCED VOLTAGE CORRESPONDING TO THE DIFFERENTIAL CURRENT ON THE GRAPH GIVEN IN FIG.12 V=		
14	ACTUALLY-MEASURED VOLTAGE AT THE CHECK TERMINAL	MEASURING BY TESTER V_{ACT} = (V)		
15	JUDGEMENT	IF $V>V_{ACT}$, RELAYS CONDITION IS GOOD. IF $V<V_{ACT}$, RELAYS CONDITION IS NO GOOD. CHECK THE FOLLOWING ; 1. CHECKING THE TAP VALUE 2. CHECKING THE CONNECTIONS OF THE RELAY AND CURRENT TRANSFORMER (INCLUDING CHECKING THE CONNECTION TERMINAL OF THE CURRENT TRANSFORMER) 3. CHECKING THE RELAY CHARACTERISTICS 4. OTHERS (EX.; CURRENT TRANSFORMER CHARACTERISTICS, PRESENCE/ABSENCE OF FAILURES)		



Front view



Side view



Panel cut-out dimensions (Front view)

Fig. 14 Outline and Panel drilling

④ 5 Apr-3-'81 P22,34,35,36 CHG DESCR AND ERSD P37 S. Nakajima 1981 4 27
③ 5 Jan-28-'81 P1.20.34 ADD DESCR AND ADD P35.36.37 S. Nakajima
② 2 Sep-11-'80 P2, P3 CHG DESCR Y. Moriyama 1980 9.16
① 1 Jun-23-'80 P3 ADD DESCR S. Nakajima 1980 6.25

APPROVED BY	CHECKED BY	DRAWN BY
S. Suzuki	T. Takizawa	T. Chiba
Jan. 22. '78	Jan. 17. '78	Jan. 13. '78
REGISTERED	'78. 3. 2	