

**Westinghouse**  
**Induction Type Relays**  
**Over-Current and**  
**Directional Over-Current**

**INSTRUCTION BOOK**



**Westinghouse Electric & Manufacturing Company**  
**Newark Works**

**Newark, N. J.**  
**I. B. 5319-A**

### CAUTION

Before cutting protective relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts are frictionless, and check the settings and electrical connections.

Table No. 1

BURDEN PLACED ON CURRENT TRANSFORMERS				
Relay Type	5 Amps. Flowing In Winding	Volt Amperes	Watts	P.F.
60 Cycles				
CO.....	5 Amp. Tap.....	17.....	8.0.....	47%
COA.....	5 Amp. Tap.....	17.....	8.0.....	47%
Low Energy CO.....	5 Amp. Tap.....	2.....	.8.....	40%
CR.....	5 Amp. Tap.....	18.....	8.5.....	47%
CRA.....	5 Amp. Tap.....	18.....	8.5.....	47%
Low Energy CR.....	5 Amp. Tap.....	3.....	1.2.....	40%
25 Cycles				
CO.....	5 Amp. Tap.....	16.....	10.....	62.5%
COA.....	5 Amp. Tap.....	16.....	10.....	62.5%
Low Energy CO.....	5 Amp. Tap.....	2.....	1.0.....	50%
CR.....	5 Amp. Tap.....	17.....	10.....	59%
CRA.....	5 Amp. Tap.....	17.....	10.....	59%
Low-Energy CR.....	5 Amp. Tap.....	3.....	1.5.....	50%

Table No. 2

BURDEN PLACED ON POTENTIAL TRANSFORMER				
Relay	Voltage	Volt Amperes	Watts	P.F.
60 Cycles				
CR.....	110.....	25.....	2.75.....	11%
CRA.....	110.....	25.....	2.75.....	11%
Low-Energy CR.....	110.....	25.....	2.75.....	11%
25 Cycles				
CR.....	110.....	11.....	1.6.....	14.5%
CRA.....	110.....	11.....	1.6.....	14.5%
Low-Energy CR.....	110.....	11.....	1.6.....	14.5%

# **Westinghouse**

## **Induction Type Relays**

### **Over-Current and Directional Over-Current**

Type CO Over-Current Relay  
Type CO (Low-Energy) Over-Current Relay  
Type COA Over-Current Relay  
Type CR Directional Over-Current Relay  
Type CR (Low-Energy) Directional Over-Current Relay  
Type CRA Directional Over-Current Relay

### **General Information**

The Westinghouse Type CO Over-Current Relay is an induction type instrument and the most reliable over-current relay on the market at the present time. It is essentially an induction meter with moving parts so arranged that it closes contacts on an excess amount of current. The Type COA Over-Current Relay is closely related to the Type CO inasmuch as the protective feature is exactly the same. The Type COA Relays are, in addition to the protective feature equipped with a self contained current indicating element so that they give, at all times, an indication of the current flowing in the line to which the relay is connected. The Low-Energy Type CO Relay is also a slight modification of the standard Type CO. Its operating characteristics and construction are practically the same, but due to some minor changes, it requires but a fractional part of the energy which

is needed by the standard CO Over-Current Relay to operate.

As in the case of the three types of related over-current relays there are also three parallel types of similarly related directional over-current relays. The Type CR Directional Over-Current Relay is the standard and consists of a Type CO over-current element and a directional element so constructed that its contacts close only with current flow in the direction for which the relay is connected. The Type CRA Relay as is the case with the Type COA is simply the standard directional over-current relay with a separate current indicating element added. In other words the Type CRA Relay consists of the directional element used in the Type CR and the over-current element used in the Type COA Relay. The Low-Energy Type CR Relay consists of the standard CR directional element with the over-current element of the Low-Energy Type CO Relay.

### **Type CO Over-Current Relay**

#### **APPLICATION**

The standard form of the Type CO Over-Current Relay is applicable wherever it is desired to have contacts closed after the lapse of a certain period of time when some predetermined amount of excess current is flowing. The following specific applications are in general the uses to which the CO Relay may be put.

(1) Over-current protection for automatic sectionalizing of transmission systems.

(2) Over-current protection of motors, transformers, etc.

(3) For use with the pilot wire systems of relay protection. Special relays are desirable for this purpose.

The standard Type CO Relay is also used for differential protection of transformers. However, the Type CA Ratio Differential Relay has been designed for this application, and is now recommended in place of the Type CO Relay.

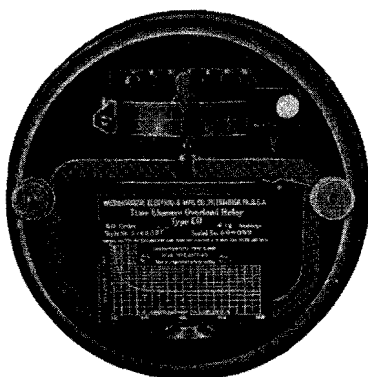


Fig. 1—Type CO Over-Current Relay

### CONSTRUCTION

The relay is similar in construction to the Westinghouse Type OA Watthour Meter and uses many of its parts. The important elements are:

- (1) The field producing element,
- (2) The moving element,
- (3) The timing or damping magnet,
- (4) The contact assembly,
- (5) The auxiliary contactor switch,
- (6) The mounting frame and bearings,
- (7) The torque compensator,
- (8) The time index lever and scale,
- (9) The base and cover.

**Field Producing Element**—The field producing element consists of a magnetic circuit and three driving coils. The magnetic circuit is made up of punchings of the type shown in figure 7. The main coil, figure 7, is wound to be connected in series with the main circuit to be protected. In most installations this is accomplished through the medium of a current transformer. The

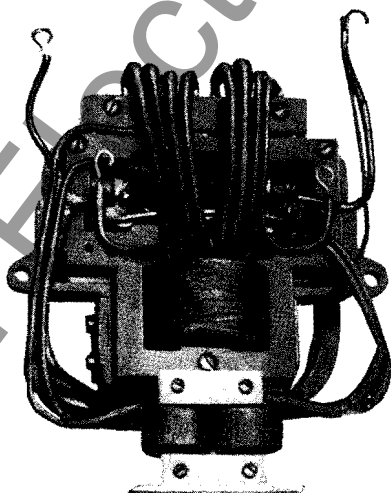


Fig. 2—Complete Electro-Magnet of Type CO Over-Current Relay (Rear View)

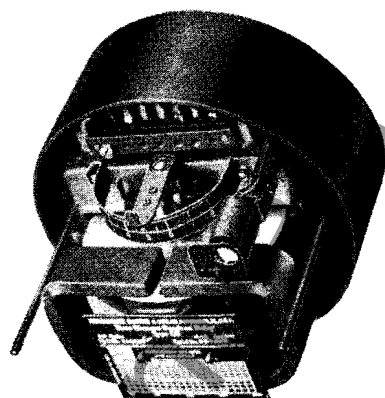


Fig. 3—Type CO Over-Current Relay (Cover Removed)

two auxiliary coils situated on the upper poles of the magnetic circuit are wound to be energized from the secondary of the torque compensator, a small transformer. The primary of the torque compensator is fed inductively from the main coil by means of a small winding located on the same pole with the main coil (figure 7).

The current terminal block is mounted above the windings and serves as a terminal for taps brought out of the main current winding at various points. By changing connections in the terminal block, the number of effective turns in the winding is changed and thus the minimum value of current at which the relay will operate is changed.

The various windings are so proportioned that a phase angle of approximately 90 degrees is produced between the current flowing in the main coil and the current flowing in the two upper coils.

**The Moving Element**—The moving element consists of a thin aluminum disc mounted on a small brass shaft. The upper portion of this shaft is covered by an insulating sleeve or hub, and the moving contact and one end of a spiral spring are attached to this sleeve. The other end of the spiral spring is permanently fixed to the relay frame. The ends of the disc shaft are supported in special bearings as shown in figure 8.

**Damping Magnet**—The damping or timing magnet is a permanent magnet mounted as shown in figure 5, in such a way that the disc when rotating passes between its poles.

**Contact Assembly**—The contacts are composed of chemically pure silver approximately  $\frac{1}{4}$ " in diameter. The stationary contact is spring mounted so that it is self-aligning with the moving one. An insulat-

# Westinghouse Induction Type Over-Current and Directional Over-Current Relays

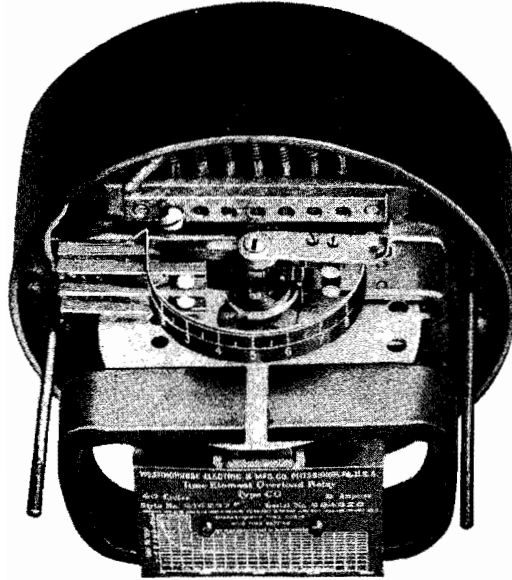


Fig. 4—Type CO Over-Current Relay with Double-Trip Circuit

ing shield is mounted between the contacts and the control spring to prevent them from touching when the relay is mounted in a place where the vibration is severe. The relay may be equipped with double contacts for installations where two circuit breakers are to be tripped by one relay.

**Auxiliary Contactor Switch**—The auxiliary contactor switch is a small solenoid operated switch which serves to shunt the main contacts of the relay. This switch relieves the main contacts of practically all duty after they have once closed and

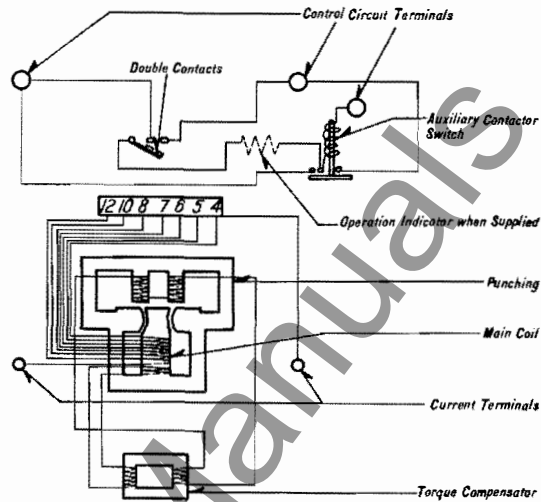


Fig. 6—Diagram of Internal Connections for Type CO Relay with Double-Trip Circuit (Rear View)

also insures a good contact in the tripping circuit regardless of the manner in which the main contact has been closed. The auxiliary switch also insures that the tripping circuit will remain closed until the circuit breaker opens, whether the main contacts remain closed or not. As shown in the wiring diagram, figure 7, when the switch operates it seals itself in, and the contacts will remain closed until the trip circuit is opened external to the relay.

**The Mounting Frame and Bearing**—The lower bearing of the Type CO Relay is an especially designed ball bearing as shown

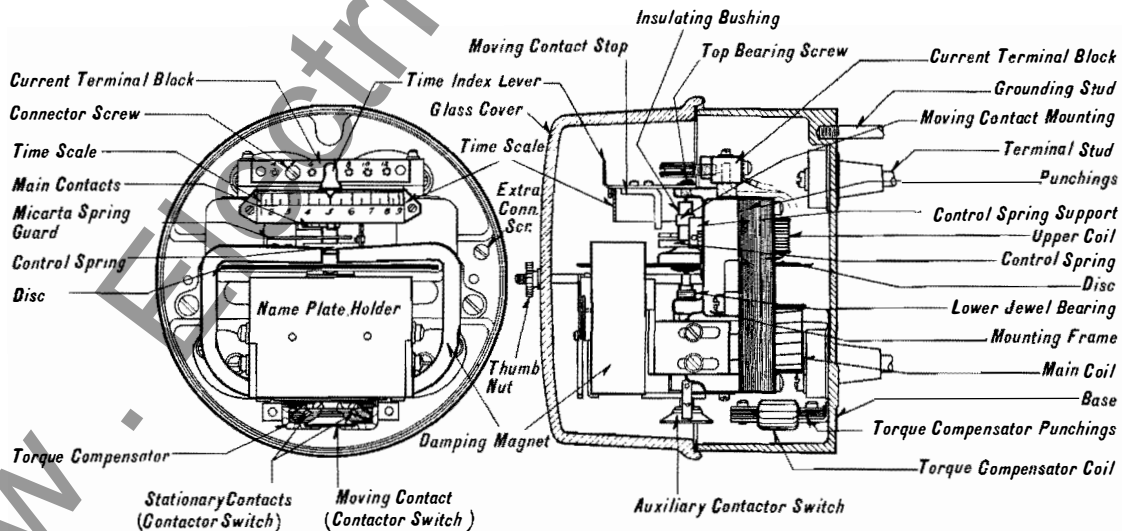


Fig. 5—Front and Side Sectional View of Type CO Over-Current Relay

## Westinghouse Induction Type Over-Current and Directional Over-Current Relays

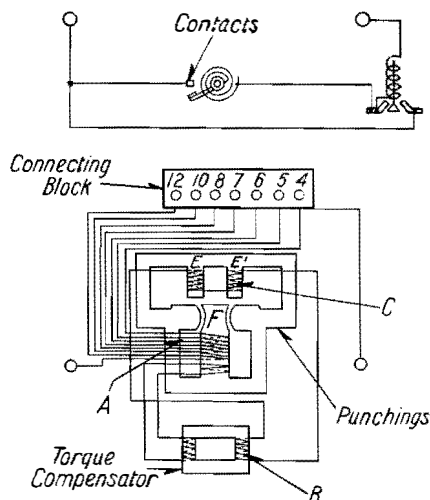


Fig. 7—Diagram of Internal Connections for Type CO Relay (Rear View)

in the cross section view, figure 8. It consists of a steel ball resting between two hemispherical cup jewels, one fixed in the end of the bearing screw and the other mounted in a removable sleeve on the end of the shaft. The bearing on the upper end of the shaft is only a guide bearing to keep the shaft in a vertical position and is subject to virtually no pressure. It consists of a steel pin fastened to a movable screw projecting down into a bushing in a recess drilled in the shaft. The bottom of this recess is filled with chamois discs saturated with watch oil. A film of oil is thus maintained around the pin at all times.

**Torque Compensator**—The torque compensator is a small saturating transformer with a primary coil and a secondary coil as shown in figure 7.

**Time Index Lever**—The time index lever and scale consist of a lever carrying a micarta stop for the moving contact and a pointer which travels over the scale.

**Base and Cover**—The complete assembly of electro-magnet, damping magnet, moving element, auxiliary contactor switch and torque compensator is mounted on a cast frame which in turn is mounted on the cast iron base of the relay. A glass cover fits the base and makes a dust proof enclosure.

### OPERATING PRINCIPLE

The actual operation of the relay is simply that when a certain amount of current is flowing in the relay coil, sufficient torque is exerted on the disc to start it to rotate.

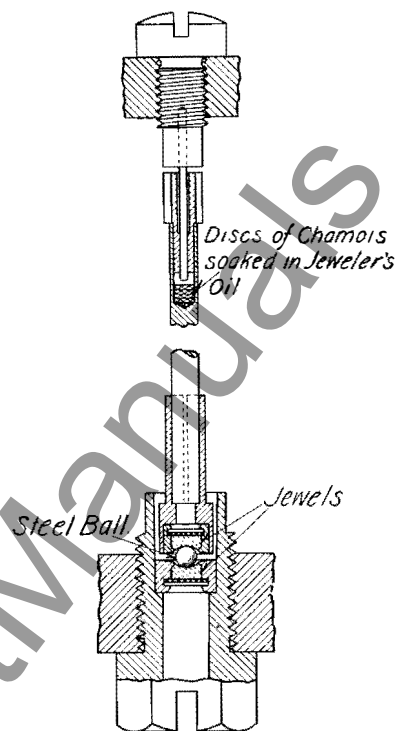


Fig. 8—Standard Bearing Used in the Westinghouse Induction Type Relays (Cross Section View)

The rotation of the disc is caused by the same action as that causing the rotation of the disc in any of the present day induction type instruments such as the Watt-hour Meter. A detailed explanation of this induction principle may be obtained by referring to any standard electrical hand book.

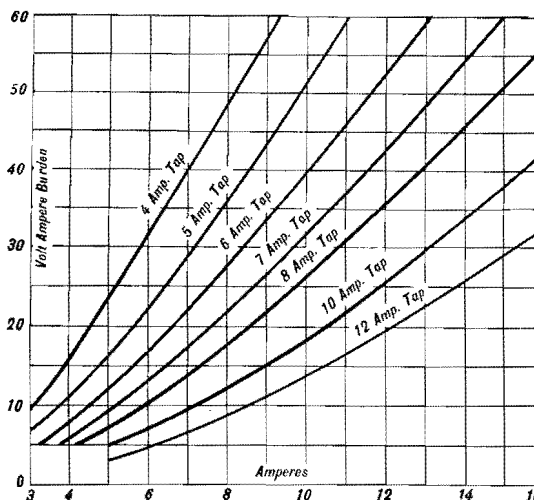


Fig. 9—Characteristic Curves of 4 to 12 Ampere, 60 Cycle, Type CO Over-Current Relay Showing Burden Placed on Current Transformer with Various Current Flowing in the Relay Windings

The construction of the disc and the contact arrangement is such that the disc must rotate through a given distance before the contacts are closed. Since the disc rotates between the poles of the damping magnet its speed is held constant at all times for any given current flowing in the winding. The damping magnet also serves to prevent the disc from over-traveling when the overload is suddenly removed after the disc has begun to rotate. The action of this magnet therefore makes the accurate time adjustment possible with the high torque obtained in the disc.

The relay disc has a number of holes punched in it so placed that they assume

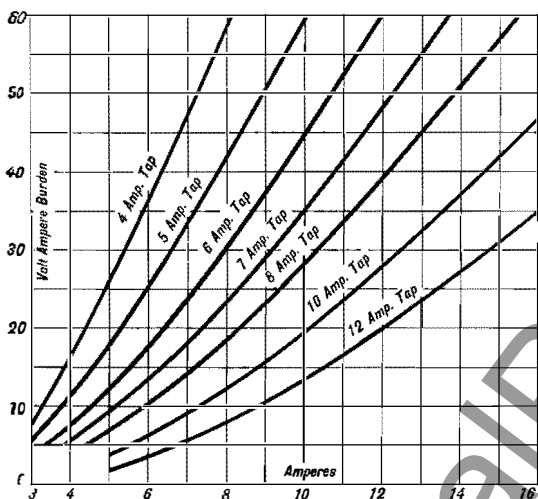


Fig. 10—Characteristic Curves of 4 to 12 Ampere, 25 Cycle, Type CO Over-Current Relay Showing Burden Placed on the Current Transformer with Various Currents Flowing in the Relay Windings

different relative positions beneath the poles of the electro magnet as the disc rotates from its initial position. As the disc rotates the spiral spring is wound up and thus the torque necessary to cause the disc to continue to rotate becomes somewhat greater. The action of the holes in the disc as they pass under the electro-magnet is such that the additional torque required as the spring winds up is provided, thus making the starting current uniform for all initial positions of the disc. In reality the relay requires slightly more current to close the contacts than is required to start the disc in motion from the initial extreme position. This serves to prevent the disc from creeping on fluctuating loads, where there are frequent peaks above the relay setting. This feature is a very important advantage of the present type of induction relay.

**Inverse Time Characteristic**—As is evident from the preceding description the speed with which the disc rotates depends upon the amount of current flowing in the winding. Thus, the greater the amount of current flowing in the relay winding, the more rapidly the disc will rotate and the shorter time will be required to close the contacts. This constitutes the inverse time characteristic of the relay.

**Definite Minimum Time Characteristic**—

Carrying the principle of the preceding paragraph still further it is evident that with an excessive amount of current flowing in the relay winding the speed of the relay will become very fast and the contacts will close almost instantly. The purpose of the torque compensator is to give a definite minimum time characteristic to the CO Relay when a predetermined overload condition is reached. At moderate overloads the current in the upper coil of the relay will increase in proportion to the current in the main coil but the iron in the coil of the torque compensator is of such cross section that after the current in the main coil passes a certain value it becomes saturated, and consequently the current in the upper coil of the relay cannot increase no matter what the overload may be. The torque on heavy overloads therefore becomes constant resulting in a definite minimum time required for the relay to trip regardless of the magnitude of the current. This is termed the definite minimum time characteristics of the relay. This definite minimum time as shown on the time current curves of the standard relay is two seconds when the time lever is set on the number 10 mark. Relays equipped with special electro-magnets which give a definite minimum time of four seconds instead of two can be supplied.

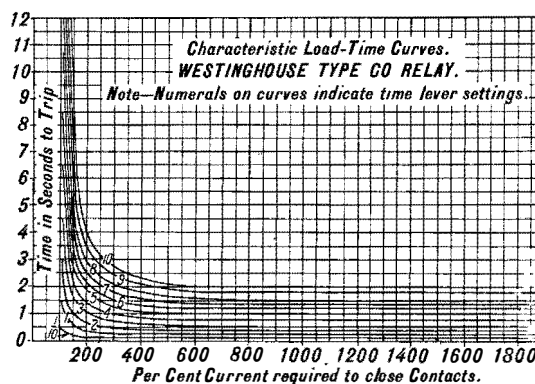


Fig. 11—Load-Time Curves of Type CO Relay Showing the Inverse and Definite Time Characteristics

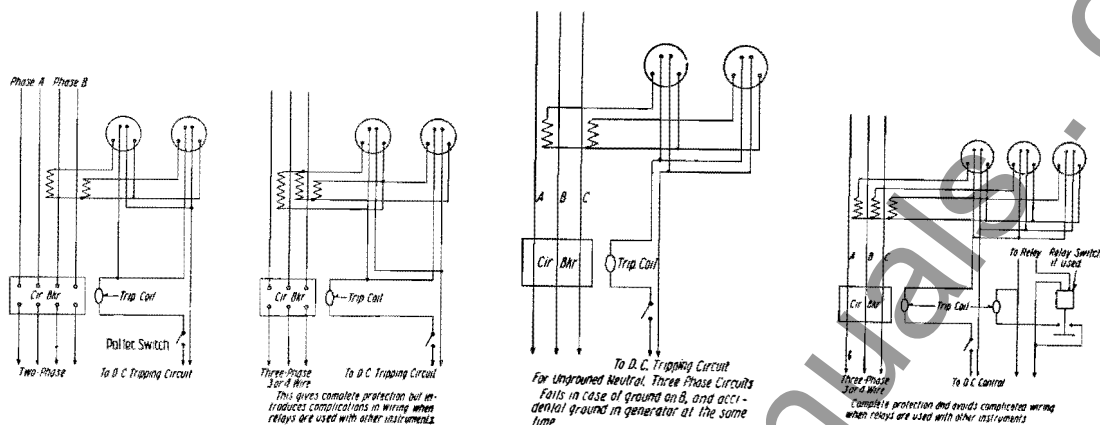


Fig. 12—Diagrams of Typical External Connections for Type CO Over-Current Relays

## INSTALLATION

Relays which are shipped unmounted should be carefully unpacked and inspected before they are mounted permanently on the switchboard panel. In unpacking and subsequent handling it should always be remembered that relays should never be subjected to any unnecessary or excessive knocks or severe usage. The relays are carefully packed for shipment, but when received should be carefully inspected for any damage such as broken terminals, misaligned parts, etc., due to rough handling in shipment. All dust and dirt accumulating in shipment should be removed from the relay.

The relays should be mounted vertically by means of the terminal studs. Plans for drilling and mounting panel are usually supplied with the relay or may be obtained upon request. After the relay has been properly mounted connections should be made to the terminals on the rear of the panel according to the diagram furnished with the relay, or in accord with some of the standard connections as shown in figures 12, 13, and 14.

In some cases relays are mounted on the switchboard panel before they are shipped from the factory. Relays received already mounted should be inspected carefully for damage done in shipment and any connections already on the rear of the panel should be carefully checked out to see that there are no loose joints or broken wires.

Owing to the extreme importance of proper functioning of relays too many precautions cannot be taken to have the installation in perfect condition before it is put into use. Before cutting a protective relay into service, remove all blocking

which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts are frictionless, and check the settings and electrical connections. It is very often convenient to make a preliminary test of the relay before final connections have been made. Such a test should include a checking of several points on the time current curve given on relay name plate and also a very careful check for any friction which may exist in the moving parts of the relay.

## ADJUSTMENTS

All adjustments of the permanent magnet, spiral springs, and other adjustable parts are made at the factory for the best possible operation and should not be disturbed unless found absolutely necessary. Any re-adjustment found necessary should be made in accordance with the instructions outlined in the paragraph under heading Factory Adjustment and Tests, see pages 10 and 11.

The Type CO Relay has two separate and independent adjustments: First, for the value of operating current and second, the time setting. In arriving at the proper settings required on any relay two things must be predetermined: (it should be remembered when making the settings of the Type CO Relay for use on a transmission or distribution system that it is intended for protection against extreme conditions such as short circuit or other faults causing excess current, and not to protect against ordinary overload conditions.)

First—The minimum amperes flowing in the line at which the relay is required to trip, is reduced to terms of the secondary



circuit of the current transformers used with the relay. This current must be higher than the maximum current due to service loads. Under short circuit conditions the maximum current which will flow to any fault will be determined by the equivalent impedance of the system at the point where the fault occurs and can only be determined exactly by a short circuit study of the system. However, when it is known that the short-circuit current is large compared to the load current and when it is not desired to set the relay to operate on the inverse part of the load-time curve, it is usually satisfactory to set the relay to operate on a current equal to 200 or 300 per cent of the full load current of the line which it is to protect. When the value of secondary current at which the relay is to trip has been determined, the relay may be set to operate at this value of current by placing the connector screw in the tap of the connector block with the number corresponding to the number of amperes. With the connector screw placed in any tap, the 8 ampere tap for instance, it means that the relay will just close its contacts with this amount of current flowing in the winding.

**Second**—The definite time for which the relay is to be set is determined by considering the sequence in which the breakers on the system should trip, sufficient time being allowed between successive relay settings to allow the breaker mechanism to open the switch and thus give the proper selective action throughout the system as a whole. In line with these considerations the relay is designed to have the current adjustment independent of the time adjustment. It should be remembered, however, in checking up the time settings of the relays of any system that advantages may be gained by making use of the inverse portion of the relay curve, thus taking into account the current flowing under any conditions when checking the time in which the relay will actually close its contact.

**Current Setting**—The small machine screw on the current terminal block located above the time scale makes connection so as to include various numbers of turns in the main winding, and by placing this screw in the different holes, the relay will close its contacts at the corresponding currents. The numbers above the different holes represent the current values in amperes. Four different current ranges can be supplied. These are as follows:

.5-7-9-12-15 amperes special range; sometimes used for pilot wire schemes.

2-2.5-3-3.5-4-5-6 special range.

4-5-6-7-8-10-12 amperes. Standard range ordinarily used.

4-6-8-10-12-14-16 amperes. Special range.

**Caution**—It should be remembered that some method must be used to short circuit the current transformer when any changes are being made in the current setting of the relay. This short-circuiting can be done either by connecting the current binding posts. (the two lower posts) together outside of the relay, or by making use of the extra connector screw supplied in the recent design of relay. This extra connector screw may be placed in the new or desired tap before the old connector screw is removed. The screw should be turned up tight so as to make good connection as the operating current passes through it.

**Time Setting**—The time index lever, as is seen by referring to figure 3, serves to determine the distance through which the disc must rotate before the contacts are closed. The load time curve given on the nameplate shows the time in which the contacts will close with various amounts of current flowing in the winding and with the time index lever at the number 10 setting. This curve shows a definite minimum time of two or four seconds, depending on whether the relay is equipped with a two-second or a four-second electro-magnet.

The characteristic time curve given on the name plate is drawn for each individual relay when it is tested and so applies to the relay on which it appears. The time setting is proportional to the time lever position and by changing the position of the lever various times of operation can be secured for a given value of current through the relay. Example: Assuming the current connection screw is in the number 4 tap and assuming a short-circuit current such as will give 40 amperes in the transformer secondary or in the relay circuit, the relay will trip at ten times the tripping current or 1000 per cent on the curve. At this point the curve shows two seconds tripping time with the time index lever on the number 10 setting. If it is desired to obtain a one-second time setting under these conditions the time index lever should be set at number 5 on the scale. If 0.2 seconds time is desired the lever should be set on number one setting. To determine any time setting with current and

required time given, multiply the required time by 10 and divide by the time required for the relay to trip at the given current as read from the name plate curve (No. 10 setting). Stating this in mathematical form:

$$\frac{\text{Req. time}}{\text{Time read from curve or 10}} = \frac{\text{Req. time setting}}{10 \times \text{Req. time}} \times \text{Time read from curve}$$

### CARE AND MAINTENANCE

**Initial Tests**—On installations of any importance, as mentioned before, it is highly advisable, after the desired current and time settings of the relays have been determined, to make a final check on the operation of the relay to see that it operates on the desired current and in the desired time. This test may be made with the usual tester's outfit, the time being measured by the Westinghouse Cycle Counter as illustrated in figures 45 and 46.

The following paragraphs give an outline of the tests to which the relay is subject at the factory. This same outline may be adapted for use in inspections and initial or periodic testing.

### FACTORY ADJUSTMENTS AND TESTS

The following adjustments and tests are made on the Type CO Over-Current Relay at the factory. No adjustments other than those described above for making the current and time settings should be necessary on new relays, but if the factory adjustment has been disturbed for some cause or other, the following directions should be followed in making the re-adjustments.

**Insulation**—All relays are built to stand a 1500 volt insulation test between upper and lower terminals and between all terminals and the case.

**Spring Adjustment**—The spiral spring, one end of which is mounted on the shaft of the disc and the other end attached to a fixed support, should be so mounted that it tends to hold the contact open at all times. When the movable contact is turned back 180° away from the stationary contacts this spring should have approximately  $\frac{3}{4}$  of a turn tension. With this

condition when the relay closes its contacts the spring will be under approximately  $1\frac{1}{4}$  turns tension.

**Spring Setting to Give Proper Tripping Current**—With the time index lever on the No. 10 setting and the connector screw in the No. 4 tap, the contacts should close when 4 amperes is flowing in the winding. The same condition should be true with the connector screw in each of the other current taps, the contacts closing when the respective value of current is flowing in the winding. If such is not found to be the case, the outer end of the spiral spring may be adjusted slightly to obtain this condition. After any adjustments are made the screws should again be placed in the No. 4 tap and with the time index lever at No. 10, the disc should not start to rotate until 3.5 amperes or more are applied to the winding. If the disc starts at less current than this it is an indication that the disc is not in the correct position on the shaft or that the spring is not under sufficient tension at this point.

The allowable limits for minimum trip current values are + or - 5%.

**Timing Magnet Setting**—It will be noted that the timing magnet may be adjusted by loosening the two set screws at each side of the relay and shifting the magnet in or out. The magnet is selected at the factory with a strength such as will give the minimum time required when set in approximately the mid-position. If service tests on the relay show that the time of operation does not correspond with the calibration curve on the name plate, the timing magnet may be shifted slightly to remedy the difference.

Moving the timing magnet in towards the axis of the disc tends to decrease the delay effect on the motion of the disc and make the minimum time less. Moving the timing magnet outward or away from the axis of the disc tends to increase the delay action on the motion of the disc until the outer edge of the magnet is approximately  $\frac{1}{8}$  inch from the edge of the disc. Any movement past this point tends also to decrease the delay action of the magnet. If, when adjusting the magnet, a two-second time adjustment cannot be secured between the limits of movement of the magnet with the setting as mentioned above, it indicates that the magnet is not of the correct strength and a different magnet must be used.

After all adjustments have been made as above with the connector screws in the

four ampere tap and the time index lever on the number 10 setting and time of operation with 150, 200, 300, 500, 1000, 2000 per cent current in the relay winding is measured with a Cycle Counter and the curve is plotted on the name plate of the relay. The test should be made when the relays are in a cooled condition. [The time current curve for different relays may vary in time between the following limit, the time index lever being on the number 10 setting in all cases.

150 per cent load—5 to 6.8 seconds.  
200 per cent load—3.5 to 4.4 seconds.  
300 per cent load—2.6 to 3.2 seconds.  
500 per cent load—2.1 to 2.5 seconds.  
1000 per cent load—1.9 to 2.1 seconds.  
2000 per cent load—1.9 to 2.1 seconds.  
(2 seconds is desirable)

The above values are given for standard 60-cycle two-second relays. When the test applies to relays with four-second magnet, the above values are approximately doubled.]

Relays having current ranges other than 4 to 12 or 4 to 16 amperes are checked on the same time setting, the most convenient current taps being used. The outer end of the spiral spring is always soldered at the factory after the calibration is complete.

**Miscellaneous**—The following conditions should always be checked up before the relay is calibrated. These same conditions should be checked up in periodic inspections.

(1) The adjustment of the time index lever micarta bracket and the stationary contact should be such that when the pointer of the arm is on the zero position the contacts barely touch. If the adjustment is otherwise the time action of the relay will not be in exact proportion to the time divisions on the dial. Any defect in this respect may be remedied by shifting the position of the brackets on the time index lever so that the contacts will just barely touch when the time index lever is placed on the zero position.

(2) With the pointer on the number 10 setting there should be sufficient clearing between the moving contact and the spring support so that the contact will assume its proper position without danger of binding. (This refers particularly to double contact relays.)

(3) The moving contact should assume its proper position at all settings of the

time index lever. Sometimes the micarta angle on the time index lever is displaced, and at some points is liable to interfere with the screw on the back of the moving contact. Care should be taken to see that the moving contact cannot bind on the micarta angle.

(4) The stationary contact spring should be so adjusted that the free end barely touches the hooked end which serves as a stop. If this contact spring bears too strongly against the stop, a stiff contact results causing the Cycle Counter to jump when the relay is being checked for time. To check this adjustment a Cycle Counter may be used without any other load or signal lamp which would be likely to give the slightest arc. The spring should be so adjusted that a satisfactory contact results and the counter does not jump.

(5) The control spring should be so adjusted that none of the convolutions touch each other when the contacts are together, and the spring is wound up.

(6) For definite instructions for using the Westinghouse Cycle Counter in testing relays for time calibration see pages 26 and 27 of this book.

**Double-Trip Circuit Styles**—If this relay has a third terminal on the upper side (trip circuit) it is arranged for tripping two circuit-breakers simultaneously, operating a bell alarm, or for any purpose where it is desired to have two circuits closed at the same time by the relay and yet have them independent when the relay is not operated. A typical case would be for generator protection where armature and field would be opened together by the relay but would have to be entirely separate at all times. Another case is on double bus systems where each feeder has two circuit-breakers, one connecting it to each

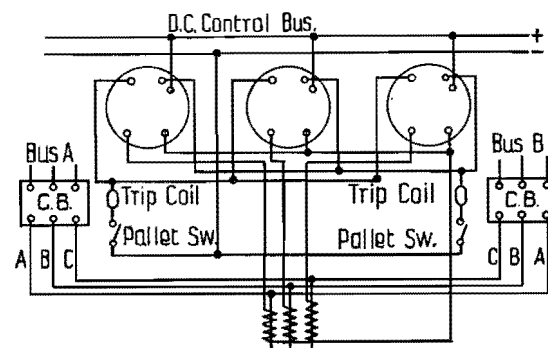


Fig. 13—Diagram of Connections for Double-Trip Type CO Relays Used on Trip Two Breakers Simultaneously

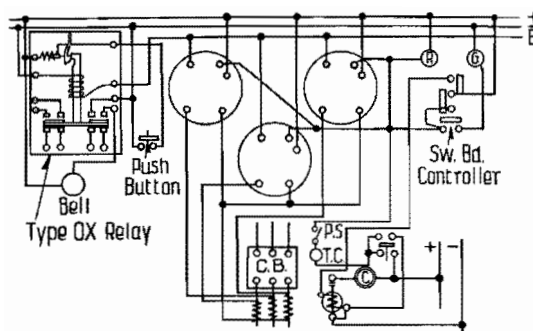


Fig. 14—Diagram of Connections for Double-Trip Type CO Relays Used to Trip One Circuit-Breaker and Energizing a Bell Alarm Circuit

bus. Double contacts on the relay are necessary so that either breaker may be opened independently of the other for

ordinary switching operations and allowing both to be tripped if both are closed when trouble occurs.

## Type COA Over-Current Relay

### APPLICATION

The Type COA Relay is a simple modification of the Type CO as already treated in this instruction book. It is simply the Type CO Relay with a current indicating element added. It is applicable wherever supervision of the current flowing in the circuit to which the relay is connected is desired, and where, either because of lack of switchboard room or for economic reasons, it is not desirable to have ammeters installed. The COA Relay was primarily designed for the purpose of showing the amount of current flowing in the circuit to which the relay is connected. The current indicating element, however, serves a double purpose. It not only shows the current flowing in the circuit but also furnishes a visible indication as to whether or not the relay circuit is in good condition.

### CONSTRUCTION

The current indicating element consists of a thin copper disc mounted on a separate shaft and having its own jewel bearing and control spring, but actuated by the same flux which passes through the main relay disc. Therefore, any action which occurs either inside or outside of the relay, to prevent the main electro-magnet from operating the main disc, will also keep the indicator disc from operating. The construction of the current indicating element and the method of adding it to the CO Relay is shown in figures 15, 16 and 17.

The indicating element instead of being equipped with a pointer as is the usual ammeter practice, is equipped with a moving scale. The entire moving element is quite rugged and well balanced and is fitted with a zero adjustment. The indicating disc occupies the same air gap as the main relay disc under the electro-magnet, but it does not use the same air gap in the timing magnet. For damping purposes a small vane of aluminum is placed above the permanent magnet and a small magnetic shunt draws enough flux from the permanent magnet to secure the necessary damping. This damping of the current indicating element is only sufficient to make it dead beat.

The current indicator is very rugged in its construction and cannot be injured by any excessive overloads to which the relay may be subjected.

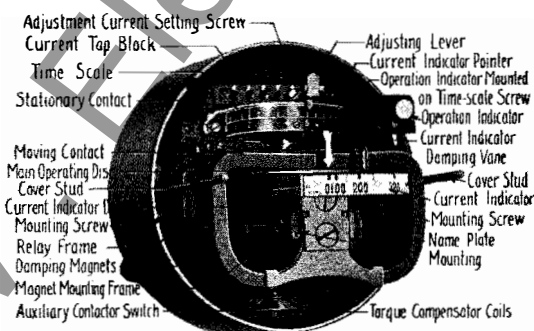


Fig. 15—Type COA Over-Current Relay with Operation Indicator, Single Phase (Cover Removed)

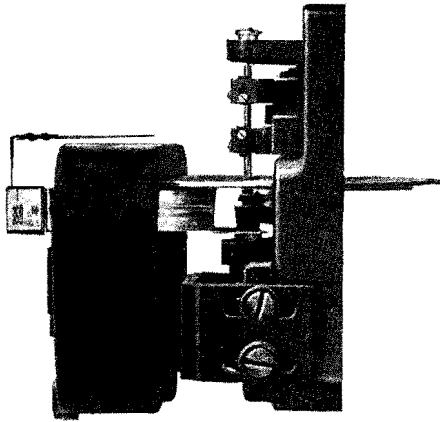


Fig. 16—Partial Assembly of Type COA Relay Showing Current Indicator Mounted Complete

### OPERATION AND CHARACTERISTICS

The operation and characteristics of the Type COA Relay as far as the protective element is concerned are exactly the same as the Type CO. The addition of the current indicating element makes no difference whatever in the calibration of the protective element. The same flux which serves to produce torque in the relay disc also produces torque in the ammeter disc, causing it to rotate against the torque exerted on it by the control spring. The distance through which the torque is able to rotate the ammeter disc is an indication of the amount of current which is flowing in the coils.

### ADJUSTMENT OF CURRENT INDICATING ELEMENT

All adjustments and tests for the Type COA Relay are just the same as those described for the Type CO. The adjustment of the current indicating element is the only different feature. The control spring used in the current indicator is of such strength that full scale deflection is secured when approximately 75 per cent of the tap value of current is flowing in the relay. For instance, if the relay current screw is set in the 8 ampere tap when approximately 6 amperes is flowing in the winding the current indicator will show full scale deflection. This is the standard spring used, but when desired or when more convenient for any given calibration, springs of different strengths may be supplied.

In calibrating the current indicator scale in amperes it is necessary to know the current tap at which the relay is to be operated and also the current transformer ratio. For example, supposing the relay is to be used operating on the 8 ampere current tap and with a 250 to 5 ratio current transformer. The current indicating scale will then be calibrated to full scale deflection as 300 amperes. This will mean that when the scale shows 300 amperes there will be 300 amperes flowing in the primary circuit and 6 amperes in the secondary circuit of the current transformer.

The current indicating scale may be given a universal calibration by marking it in per cent. Thus with the 75 per cent spring the full scale deflection is marked 75 per cent and the scale is divided into suitable divisions and marked accordingly. In order to read the current value with such a calibration it is necessary to take the

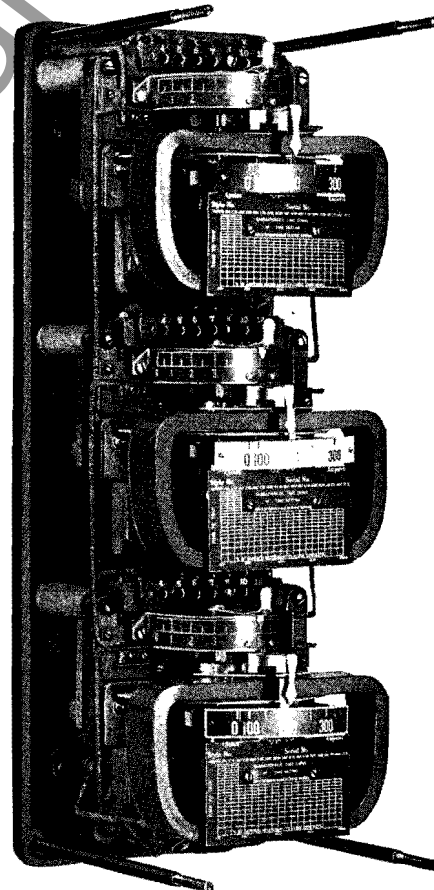


Fig. 17—Type COA Over-Current Relay, Three-Phase (Cover Removed)

percentage reading of the indicator scale, multiply it by the current tap setting of the relay and again by the ratio of the current transformer.

The scale is made of bristol board and may easily be removed and a new cali-

brated scale added. This feature is valuable where the relay is liable to be changed from one installation to another or where the current capacity of its circuit is changed or the current tap setting changed.

## Low-Energy Type CO Over-Current Relay

### APPLICATION

This relay is listed separately because its application is somewhat different from the standard type. It is made with two standard ranges of current adjustments, each of which has its own particular application. The main uses to which the Low-Energy Type CO Relays are applied are as follows:

(1) The 4 to 12 ampere range is to be used where low ratio bushing type transformers are the only convenient means for supplying the energy to relays. The burden placed upon the transformer by this type of relay is approximately two volt amperes at the tripping point. This relay should be used for line sectionalizing and the overload protection of power transformers where the low energy consumption is necessary, but should not be used for the differential protection of power transformers because it is too sensitive. Relays for the above applications can also be supplied with a special current range of 2 to 6 amperes.

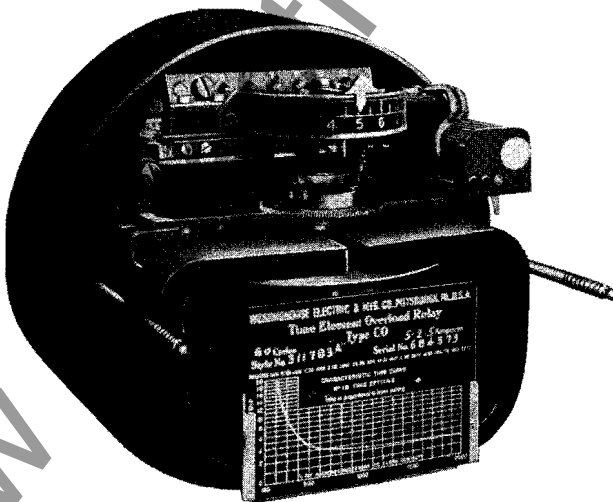


Fig. 18—Low-Energy Type CO Relay (Cover Removed)

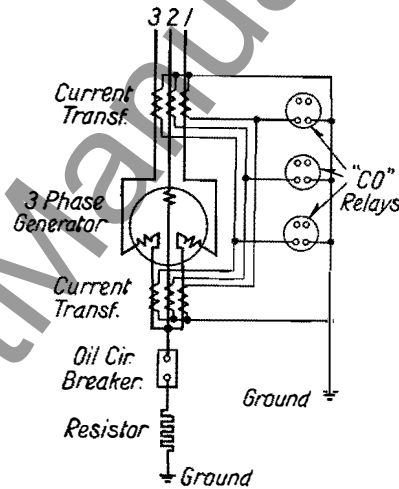


Fig. 19—Diagram of Connections for Low-Energy Type CO Relays Used for Differential Protection of a Three-Phase Generator

(2) The .5 to 2.5 ampere relay is suitable for use as a ground relay for the automatic sectionalizing of a system with its neutral grounded through a resistance which limits the ground current to a low value.

Although the Low-Energy Type CO Relay having an 0.5 to 2.5 ampere current range is sometimes used for differential protection of generators and large motors, the Type CA Ratio Differential Relay is more suitable for this purpose.

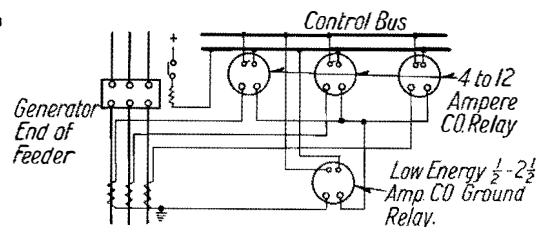


Fig. 20—Diagram of Connections Showing Application of Low-Energy Type CO Relays for Ground Protection

## Westinghouse Induction Type Over-Current and Directional Over-Current Relays

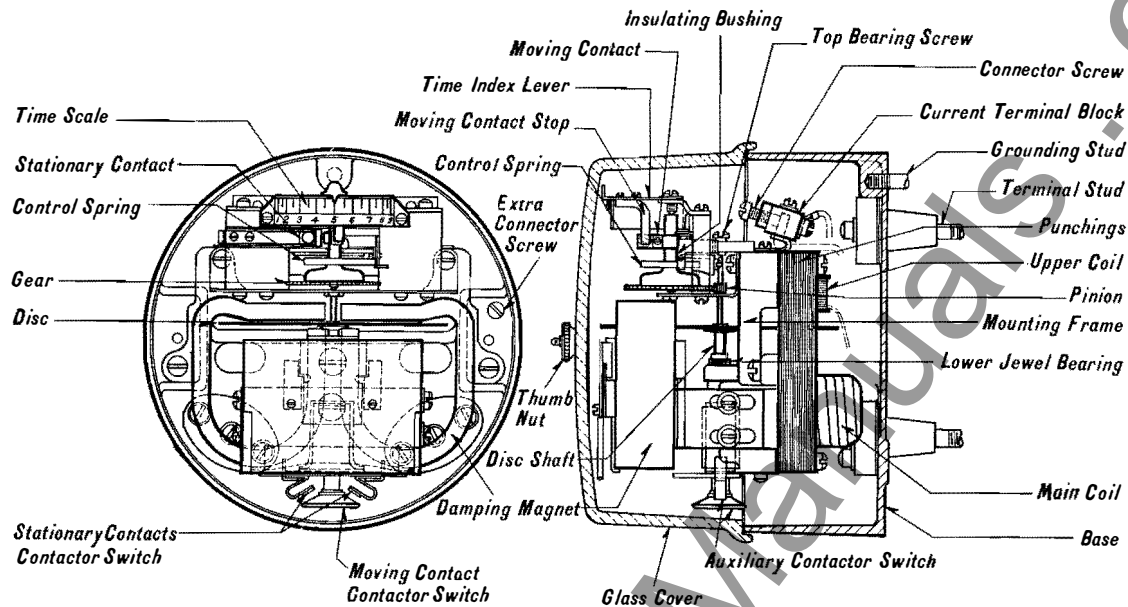


Fig. 21—Front and Side Sectional View of Low-Energy Type CO Over-Current Relay

### CONSTRUCTION

Figure 18 shows the Low-Energy Type CO Relay with cover removed while figure 21 shows a cross section view. The construction of the magnetic element, the disc, the case and the cover are exactly the same as the Type CO Relay. The method of mounting the contacts is different, however, inasmuch as they are mounted on a separate shaft which is geared to the main disc shaft. With this arrangement a very small amount of energy is all that is necessary to cause the disc to rotate. The number of turns in the winding of both the main and the auxiliary coils is different from that on the standard energy Type CO Relay. The torque compensator is also omitted and the definite minimum time characteristic is obtained by having the disc run at synchronous speed with excessive overload. This is possible inasmuch as the gearing makes it necessary for the disc to make a number of revolutions before the contacts are closed.

### OPERATION AND CHARACTERISTICS

The operation of the Low-Energy Type CO Relay is the same as that already described for the high energy type. Inasmuch as it requires such a low amount of energy for operation it is consequently much more sensitive than the standard type. The gearing makes it somewhat

slower in resetting than the standard type of relay.

The inverse time characteristic and the definite minimum time are similar to those of the standard CO Relay. As will be noted by figure 22 showing the time current curves of the low energy relay, the curves are somewhat more inverse and do not flatten out as quickly as those of the standard Type CO.

The relay is also equipped with an internal contactor switch and it may be supplied with either single or double tripping circuits and with either two or four-second minimum time characteristics.

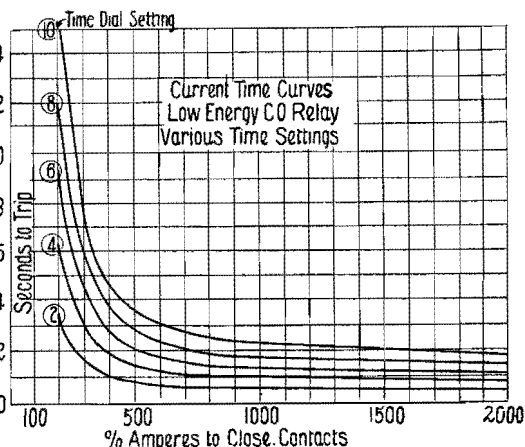


Fig. 22—Current-Time Curves of Low-Energy Type CO Over-Current Relays

## Westinghouse Induction Type Over-Current and Directional Over-Current Relays

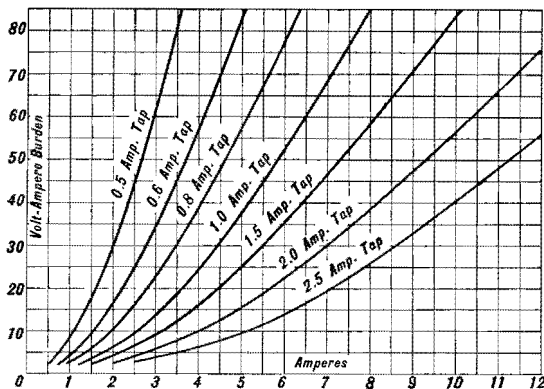


Fig. 23—Characteristic Curves of Low-Energy Type CO Over-Current Relay, Showing the Burden Placed on the Current Transformer with Various Currents in the Relay Windings

### INSTALLATION, ADJUSTMENT AND TESTING

The instructions for installing, adjusting and for the care and maintenance of the Low-Energy Type CO Relay are the same as those already given for the standard Type CO. Also the same general test information is applicable.

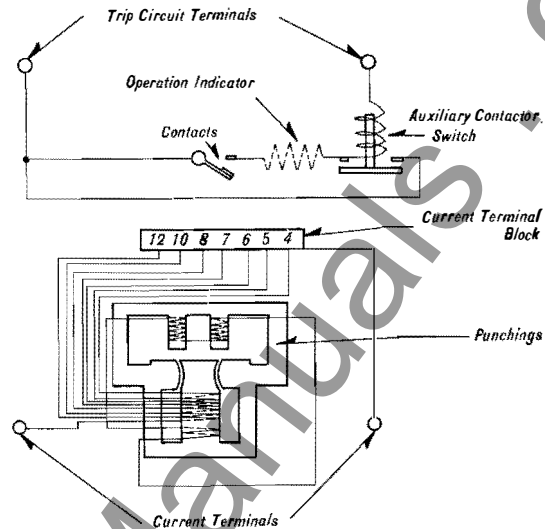


Fig. 24—Diagram of Internal Connections for Low-Energy Type CO Over-Current Relay

The current tap values of the 4 to 12 ampere range are the same as the standard relay, namely, 4-5-6-7-8-10-12 amperes. The tap values of the .5 to 2.5 amperes range are .5-.6-.8-1.0-1.5-2.0-2.5.

## Type CR Directional Over-Current Relay

### APPLICATION

The line of Type CR Directional Over-Current Relays is designed to protect or disconnect transmission lines when there is a short circuit or other fault on the system of such a nature that the current flow is excessive in the direction for which the relays are connected to operate. In general practice the direction in which the current flows in order to have the directional relay trip is away from the station bus bars inasmuch as in most applications the relays are connected so as to hold their contacts open as long as the flow is toward the substation. The Type CR Relay may be depended upon to discriminate as to the direction of current flow under all conditions of low voltage which are likely to occur in cases of severe short circuits.

**Parallel Transmission Lines**—The Type CR Relays are suitable for use at the receiving end of lines where a fault on any line will cause the power to reverse and flow back to the point of the trouble on the defective line. Figure 25 shows a typical application of the directional over-current relay for the protection of parallel feeders.

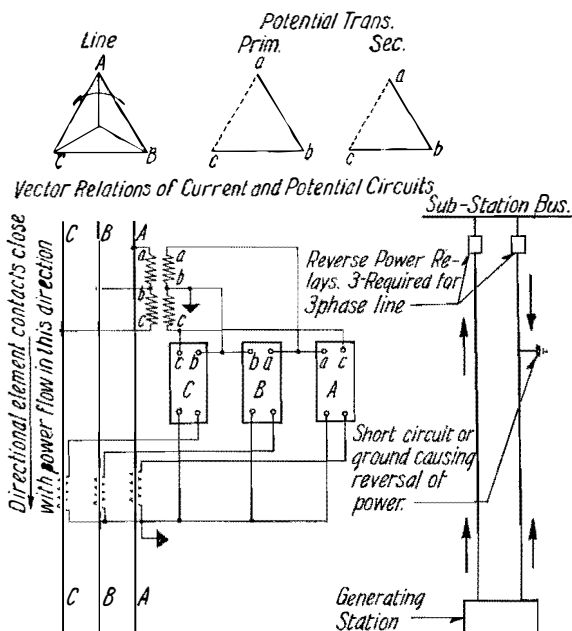


Fig. 25—Ordinary Method of Connecting Type CR Directional Over-Current Relays on Three-Phase System. Voltage Vectors Shown. Connections give Current  $30^\circ$  Lead at 100% P.F.



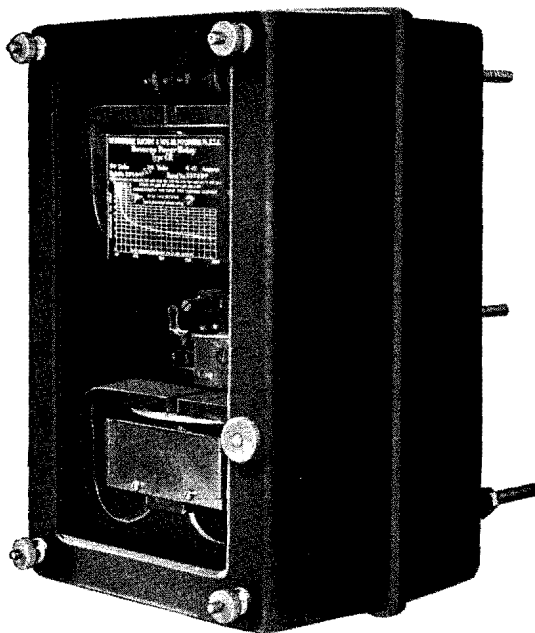


Fig. 26—Type CR Directional Over-Current Relay

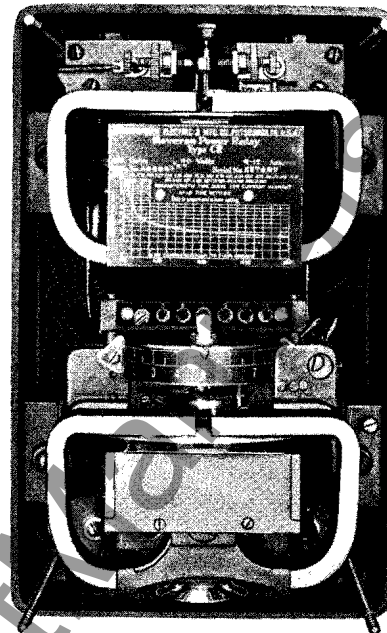


Fig. 27—Type CR Directional Over-Current Relay  
(Cover Removed)

**Ring Systems**—A ring system such as shown in figure 28 is similar to the case of two parallel feeders supplying a substation except that each feeder is made to loop through a number of substations. On such a system definite time limit directional over-current relays such as the Type CR must be used. The time limit of each successive relay is increased by a sufficient amount to allow time for the circuit breaker in the preceding substation to open. Relays applied on such a system are usually installed in such a way that at each substation the normal direction of power is assumed to be into the substation. The relays will trip only when the current is flowing out of a given substation and exceeds the amount for which the over-current element of the Type CR Relay is set to close its contact.

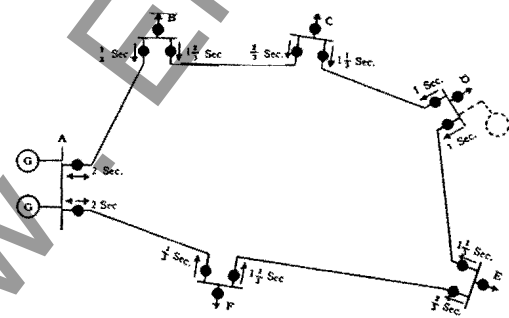


Fig. 28—Typical Ring System Protected by Means of Type CO and Type CR Relays

**Special Application**—There are many special applications in which the Type CR Relay is used. Among these might be mentioned the cross connection system of protection as used on parallel feeders shown in figure 29. Another application is the use of the Type CR Duo-Directional Relay for the protection of two parallel feeders. A schematic diagram of this is shown in figure 30.

### CONSTRUCTION

Figures 26 and 27 show the general appearance and arrangement of the parts of the Type CR Directional Relays. Each relay consists of two separate and distinct parts, excess current element and

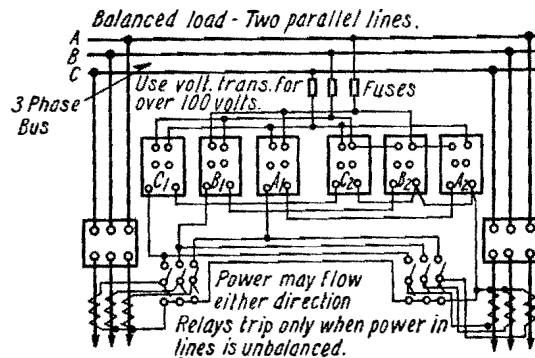


Fig. 29—Diagram of Cross-Connected Type CR Relays for Parallel Line Protection

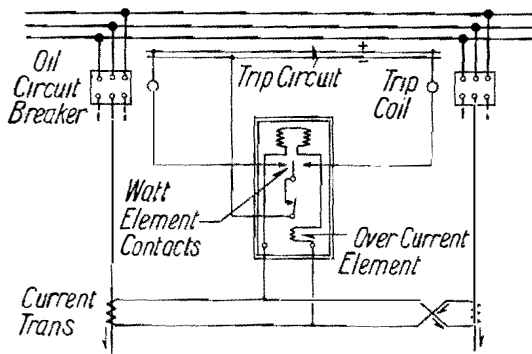


Fig. 30—Diagram of Connections for Type CR Duo-Directional Relays for the Protection of Two Parallel Lines

the directional or wattmeter element. The over-current element is identical with the Type CO Overload Relay as already described, and is mounted on the lower part of the base with the wattmeter element mounted directly above it.

**Directional Element**—The wattmeter or directional element is composed of an electro-magnet, the moving element, contact assembly, and mounting frame and bearings, mounted in the upper half of the relay base. The electro-magnet resembles that of the standard Westinghouse Watthour Meter and operates in exactly the same way as the Watthour Meter element. The current coils are wound on the two upper

poles and the potential coil on the main lower pole.

**Moving Parts**—The moving parts of the directional element are practically the same as those already described under the Type CO Relay. The disc differs from that of the Type CO inasmuch as it is copper and there are no holes punched in it. The special type of ball bearings as used in the over-current element is not used in the directional element but instead a rigid steel shaft with a hemispherical bottom rests on a sapphire cup jewel. At the top of the shaft is an adjustable pivot bearing. This construction gives a means of adjustment for end play and allows very little so that heavy short circuits will not cause undue vibration.

The moving element is carefully balanced and is controlled by a light spring so that its action in closing the directional contacts will be as nearly simultaneous with the reversal of current as possible. With the standard adjustment there should be practically no torque placed on the disc by the spring. The spring is used mainly for a current conductor for the moving contact.

**Contact Assembly**—The contact assembly consists of a stationary contact screw mounted and a moving contact spring mounted on an insulating sleeve on the disc shaft. The moving contact closes a

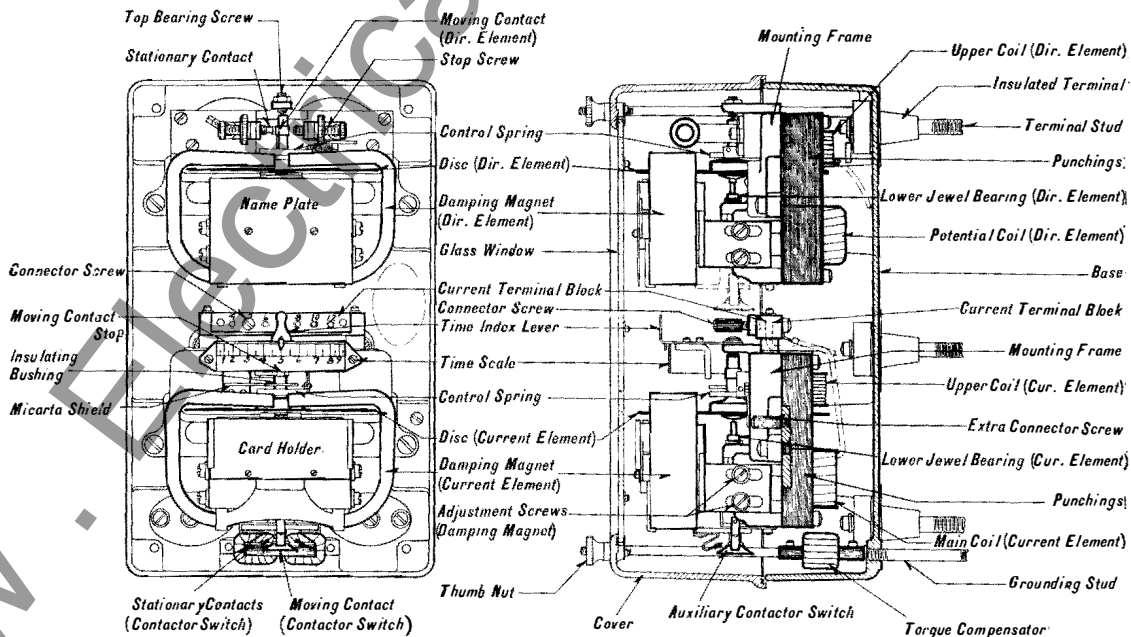


Fig. 31—Front and Side Sectional View of Type CR Directional Over-Current Relay

# Westinghouse Induction Type Over-Current and Directional Over-Current Relays

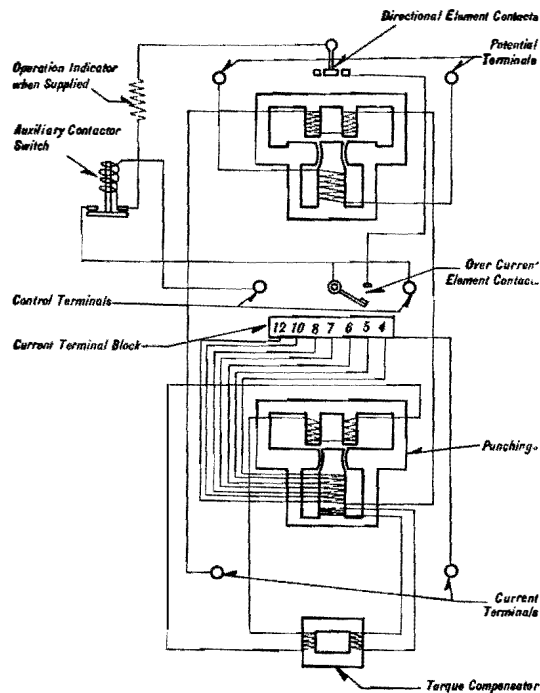


Fig. 32—Internal Wiring Diagram of Type CR Relay Showing Standard Connections With Six Terminals (Rear View)

circuit in one direction or both directions of travel according to whether it is a uni-directional or a duo-directional relay. Its motion is small, being only about 3/16 of an inch either way. As shown by the wiring diagram in figures 32, 33, 34, and 39, the contacts of the directional element are connected in series with those of the over-current element and the contactor switch as used in the Type CO Current Relay is so connected in the tripping circuit that the contacts are relieved of practically all duty.

**Latest Design**—In the latest design of the CR Directional Relay as shown in figure 26, the stationary contact, or contacts, as the case may be are made screw mounted and located in the front of the case instead of at one side as in the former design. The moving contact is spring mounted. In this design the contactor switch is located at the bottom of the base to the rear of the overload element thus insuring it against accidental tripping when the cover is being removed.

It is sometimes desirable to install standard CR Directional Relays inasmuch as future additions to the system will make

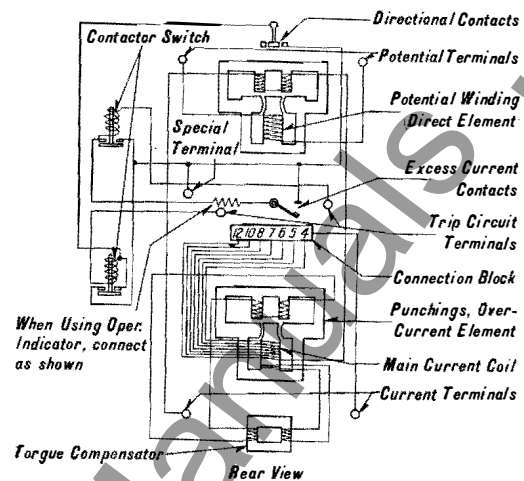


Fig. 33—Internal Wiring Diagram of Type CR Relay with Special Terminal in Trip Circuit between Elements (7 Terminals, 2 Contactor Switches)

them necessary, but at the time of installation it is desirable to have them operate as straight overload relays. With the new design of the Type CR this is easily accomplished inasmuch as the directional element contacts may be locked shut by closing the screw mounted stationary contact firmly against the moving contact. This eliminates the action of the directional element from the action of the relay as a whole.

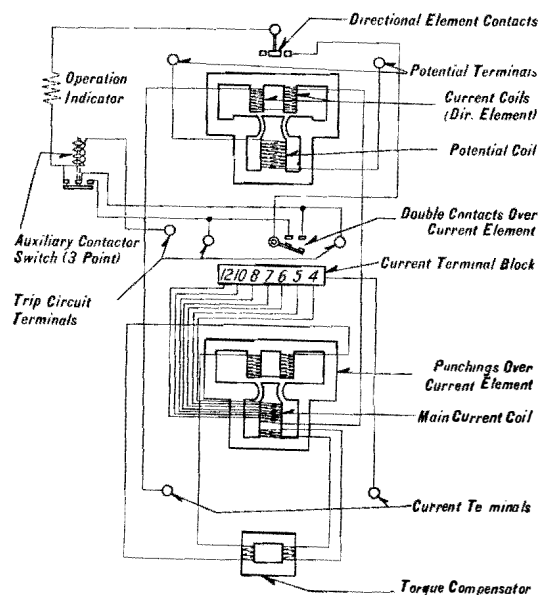


Fig. 34—Internal Wiring Diagram of Type CR Relay with Double-Trip Circuit (7 Terminals)

## OPERATION AND CHARACTERISTICS

The directional element of the Type CR Relay is so constructed that it is extremely sensitive and quick acting. It will close its contacts with a reasonable excess current flowing and a voltage as low as one per cent of normal. The contacts of the directional element will only close, however, with the current flow in the direction for which the relay is connected to act. No amount of excess current flowing in the other direction will operate this element. As stated in the preceding paragraph the spiral spring on the directional element exerts practically no torque on the disc shaft, its main purpose being to conduct the current of the tripping circuit. In the uni-directional relays as soon as there is any current flowing in the proper direction there will be a torque exerted on the disc tending to hold the contacts open. With no current flowing in the line the directional element contact may close, but this is of no consequence, as the overload element contacts will remain open.

## INSTALLATION

**Caution**—As already mentioned, too much care cannot be exercised in the handling of the relays, as, although they are of sufficiently rugged construction to stand all ordinary handling, they are sensitive instruments and will not stand the excessive bumps and knocks to which other apparatus is sometimes subjected.

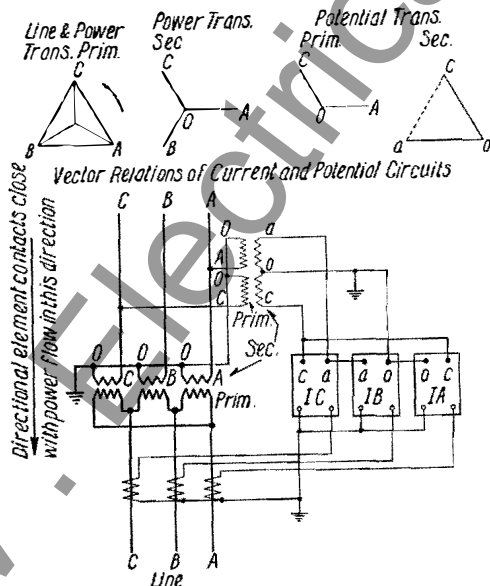
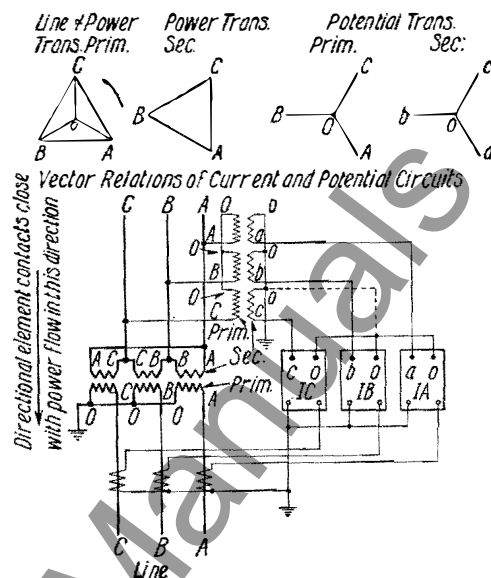


Fig. 35—Type CR Directional Over-Current Relay Connections with Y-Δ Power Transformer between Line and Station. Connections as Shown Give Current 30° Lead at 100% P. F.



This scheme of connections requires three voltage transformers, but enables the standard 125-volt relays to be used.

Fig. 36—Proper Connections for Type CR Directions over-Current Relay used on Three-Phase System with Δ-Y Power Transformers between Line and Substation

If the relay is not already mounted on a slate panel when received it should be mounted by means of the terminal studs. Drilling plans for preparing the panel for mounting the relay are either supplied with the relay or may be obtained from the nearest district office.

After the relay has been permanently mounted it should be thoroughly cleaned by means of a small brush and cloth. The cover should be removed and the interior part of the relay carefully inspected for any damage which might have been done in shipment. This inspection should especially include a test of the moving parts to see that they have not become misaligned and that there is no friction existing. The presence of friction can usually be determined by moving the disc with the hand and allowing it to return to the normal position. The auxiliary contactor switch plunger should also be moved up and down with the finger in order to insure against any sticking or friction.

## CONNECTIONS

After the relay has been properly mounted as described above, connections should be made to terminals on the rear

of the panel either according to the diagrams of connections accompanying the relay or according to standard diagrams as shown in figures 25, 29, 35, 36, and 37. All connections made to the terminals should be well tightened and where it is necessary to make connections where there is no connecting stud, all joints should be well soldered. Poor or loose connections are very often the cause of a great amount of trouble.

In applying the Type CR Directional Relays to polyphase systems consideration must be given to the varying effects of short circuits involving two, three or four conductors or to ground on the phase relation of the current and the voltage applied to the relay. The characteristics of the ordinary wattmeter element are such that the disc will reverse its direction or rotation when the phase relation between the voltage and current becomes 90 degrees or greater. As many faults very greatly disturb the relation of the voltage and current, care must be taken to connect the directional relay in such a way that the voltage and current phase relation may never become more than 90 degrees apart.

Connections must therefore be made so that with unity power factor on the line

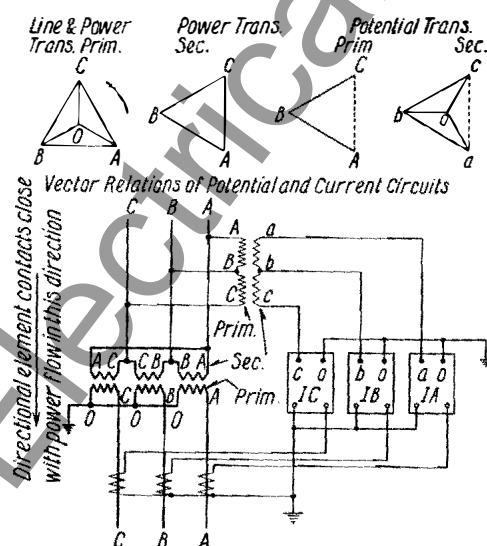
the current in the relay directional element will be 30 degrees ahead of the potential supplying the directional element. This will allow the current to lag a considerable amount during time of short circuit without placing a 90 degree angle between the voltage and current. This will enable the relay to operate properly upon the occurrence of unbalanced short circuits such as result where only two wires of a three phase system are short circuited and also on other faults of a similar nature.

The following methods should be used in checking up the correct connections to the directional element of the relay.

**Wattmeter Method**—With the power flowing in either direction, if the current is lagging, so that power factor is between 50 and 100 per cent, connect the current coils of a single phase wattmeter in series with the current winding of the relay. Then select a pair of voltage leads which give the highest reading on the wattmeter. The two leads should be connected to the relay potential terminal. Inspect the contact of the directional element, which should be open when the power is flowing towards the bus-bars. If the contacts are closed when the current flows towards the bus-bars, then the potential leads of the relay should be reversed.

**Power Factor Meter Method**—A second method is to connect the current coils of a single phase power factor meter in series with the current coils of the relay. A pair of potential leads are then selected which will give 86.6 per cent power factor leading on the power factor meter when the line power factor is 100 per cent. These two leads should be connected to the relay potential terminals. The upper contact should be inspected, as before mentioned in the preceding paragraph and checked for proper operation.

**Phase Meter Method**—A third method of checking the proper connections of the relay is by means of the Westinghouse Phase Meter. It is a portable instrument



**NOTE**—These connections require voltage transformers with 200 volt secondary, the star voltage on the relay in such case being 116-volts. If standard 110-volt secondary transformers are used, special 58-volt relays or extra 58-116-volt step up transformers are necessary.

**Fig. 37**—Proper Connections for Type CR Directional Over-Current Relay When Used on Three-Phase System with  $\Delta$ -Y Power Transformers between Line and Substation Connections. Use only Two Voltage Transformers and as Shown Give Current 30° Lead at 100% P.F.

## Westinghouse Induction Type Over-Current and Directional Over-Current Relays

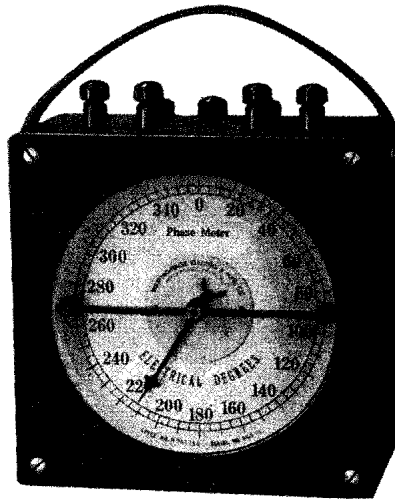


Fig. 38—Portable Phase Indicator for Use in Making Connections

built on very much the same principle as a power factor meter but calibrated to read in degrees and show precisely the phase relation between any current and voltage sources to which it may be connected. Full directions for the use of the portable phase meter are supplied with the instrument, which is shown in figure 38.

**Characteristics**—The operating characteristics of the over-current element are the same as those of the Type CO Relay. The same time current curves therefore apply as shown in figure 11.

With the contacts of the directional element and those of the overload element connected in series several conditions are necessary before the relay will completely close the tripping circuit:

- A—Excess current must be flowing
  - (1) In the direction for which the relay is connected to operate.
  - (2) For a length of time sufficient to close the excess current element contacts.

The sensitivity of the directional element is such that it may close its contacts on momentary surges of current in the reverse direction, but unless the excess current is maintained a sufficient length of time to operate the over-current element the tripping circuit is not completed. Conversely, the contacts of the overload element may be closed by excess current flowing in the normal direction but the directional element contact will remain open.

**Type CR Duo-Directional Relays**—The Type CR Duo-Directional Relays as already mentioned under special applications are

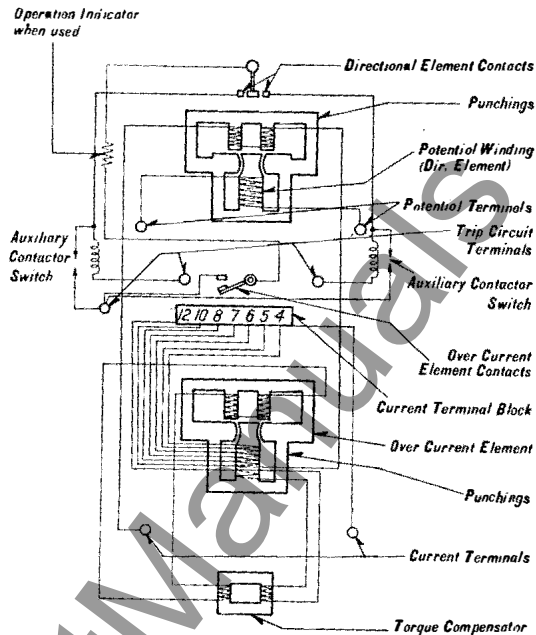


Fig. 39—Internal Wiring Diagram Type CR Duo-Directional Relay. (7 Terminals, 2 Contactor Switches)

used in cross connected relay schemes where practically no current flows in the windings unless trouble exists. This relay is exactly the same as the standard single contact relay except that there is a stationary contact on each side of the moving contact, thus allowing the tripping circuit to be made in either direction. The contact arrangement, spiral spring, and all mountings are exactly the same as in the standard relay. Under ordinary conditions either contact may be closed by the floating of the disc in either direction, but under such conditions the over-current element contact will remain open. During any faulty condition, however, the flow of current will be such that torque will be produced in the directional disc to close the contact in the proper direction and thus have the tripping circuit completed as soon as the over-current element contacts are closed.

### CURRENTS AND TIME SETTINGS

**Current Setting**—These settings of the Type CR Directional Over-Current Relay are practically the same as those already described for the Type CO Over-Current Relay. The only possible current adjustment of the CR Relay is that of the over-current element which is obtained by changing the current screw in the contact block located above the element proper. Full directions for the proper setting of

the over-current elements have been given. See pages 8 and 9.

**Caution**—Care should be taken whenever the current adjustment is being changed that the secondary circuit of the current transformer is not opened. When changing the current screw from one current tapped hole to another the transformer secondary circuit may be closed either by shorting the current terminals on the rear of the relay, (the two lower current terminals) or by inserting the extra screw in the tapped hole desired before removing the screw from the existing setting. One extra screw for this purpose is supplied in a hole in one of the bosses on which the mounting frame is fastened.

**Time Setting**—The time setting of the over-current element of the Type CR Relay is exactly the same as that already described for the Type CO. The directional element contacts are so arranged that they close almost instantly when there is a reversal in the flow of current so that all time adjustments for the complete operation of the relay are taken care of by the time adjustment of the overload element.

#### CARE AND MAINTENANCE

**Initial Test**—After the relays have been properly installed, they should be given an initial inspection and test to insure that the operation of the relay is going to be as desired. Inspect the moving parts of both the over-current and the directional element and also the plunger of the auxiliary contactor switch to see that no sticking or unnecessary friction exists. The discs of both elements should be turned through their complete travel and it should be noted that they run true, or, in other words, remain at all points in their travel approximately in the center of the air gap through which they pass. The discs are carefully adjusted at the factory so that they rotate exactly in the center of the air gap and such a condition is necessary for the proper operation of the relay.

The plunger of the auxiliary contactor switch should be moved up and down with the finger in order to insure it against sticking. It should be observed that the Type CR Duo-Directional Relay contains two auxiliary contactor switches, one being connected to shunt each of the directional element contacts and the over-current contacts.

**Electrical Test**—The initial electrical test of the relay varies somewhat with different operating companies. The opera-

tion of the directional element, however, should be checked out to insure that it closes the contacts when the current is flowing in the desired direction. This check, of course, can be made by observing the action of the directional element when there is power flowing in the line. For instance, if the directional element is connected to close its contact whenever the current is flowing away from the substation bus-bars, then with the current flow towards the substation bus-bars the directional element contacts should remain open. When the current flow is in the opposite direction, the contact should close immediately even upon a very small voltage. The over-current element may be tested as already described under testing in the Type CO Relay. See pages 10 and 11.

**Routine Test**—In installations of any importance, it is the common practice to subject all relays to periodic test. These tests are usually much the same as the initial test and it is recommended that each test be made to include all the features as described in the initial test. As noted under the testing of the Type CO Relay, it is also recommended that record cards be kept whereon all information gained at each test can be recorded and thus a life record of the relay kept readily accessible.

**Inspections and Care**—Inasmuch as the working part of all relays are inclosed in a practically dust-proof case, few inspections are necessary other than those which may be made at the time of the routine testing. As the operation of the ordinary protective relay is rather infrequent, and the construction is relatively rugged, little care is necessary after the initial installation is properly made.

#### ADJUSTMENTS

The following adjustments are those made in the factory when the relay is assembled and the same instructions should be followed out in case occasion arises where any adjustments of the mechanical features of the relay are necessary.

**Over-Current Element**—The over-current element of the Type CR Directional Over-Current Relay is tested and calibrated in the same way as the Type CO Over-Current Relay. All mechanical adjustments and current time settings are therefore the same for the Type CR over-current element as for the Type CO Over-Current Relay. See pages 8, 9 and 10.

### **DIRECTIONAL ELEMENT**

**Adjustment of Jewel Screws**—The top jewel screws should be turned down far enough to reduce the play of the disc shaft to a minimum. These screws should not, however, be tightened so much that friction is introduced. With some care the jewel screw may easily be adjusted so that no appreciable end play can be detected by pushing up and down on the edge of the disc and at the same time no friction will be present. The lock nut on the jewel screw should be well tightened after any adjustment has been made.

The proper adjustment of the jewel screw is very important and great care should be taken to insure that the disc will vibrate the minimum amount on high current.

**Contact Adjustment**—In the latest design of directional element contacts, the contact stop should be so adjusted that the moving contact arm when against the stop is approximately 90° from the movement frame, and then the fixed contact should be adjusted so that there is a 3/16" gap between the contacts. For the duo-directional type relay, the spring should be so adjusted that the movable contact arm is at right angles to the plane of the movement frame and then the fixed contacts

should be adjusted to give approximately a 3/16" gap between the moving contact and each stationary contact.

**Spiral Spring Adjustment**—The spiral spring should be so adjusted that the contacts are just barely held open with zero current and voltage.

**Electrical Test**—The directional element disc should not tend to creep in either direction when 30 amperes is passed through the winding with zero voltage on the potential coil, and the spring disconnected. If the disc creeps in either direction on current alone the position of the magnetic shunts situated above the disc on either side of the main pole should be changed until the disc stops creeping. This adjustment is manipulated with a screw driver in the same manner as the light load adjuster on the Type OA Watt-hour Meter. Turning either one of the adjusters in toward the main pole causes the movable contact to move in the direction that the adjuster is being turned.

With one volt impressed on the voltage coil of the directional element, and 40 amperes or less flowing in the series coil, the contact should close on a reversal of direction of the current flow, and remain open on the normal direction of current flow.

## **Type CRA Directional Over-Current Relay**

The type CRA Relay consists of the standard Type CR directional element with the Type COA over-current element instead of the standard Type CO over-current element. Its characteristics and operation are therefore exactly the same as the Type COA Relay. Its application is also the same as the standard Type CR Relay where it is desired to have supervision of the current flowing in the relay circuit without going to the extent of supplying separate ammeters for the circuit.

For the calibration of the current indicating elements see description under Type COA Relay. See pages 13 and 14.

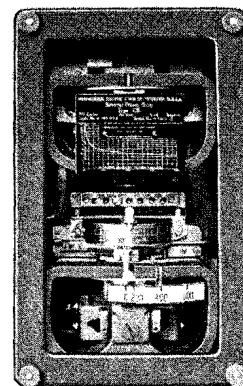


Fig. 40—Type CRA Directional Over-Current Relay

## **Low-Energy Type CR Directional Over-Current Relay**

### **APPLICATION**

The Low-Energy Type CR Directional Over-Current Relay consists of the standard directional element and the low-energy Type CO over-current element mounted in the same case. The relays are made in

two standard ranges, each being suitable for a different application as follows:

The relay having a current range of 4 to 12 amperes is used for line sectionalizing to protect against short circuits in exactly the same way as standard Type CR Relay



## Westinghouse Induction Type Over-Current and Directional Over-Current Relays

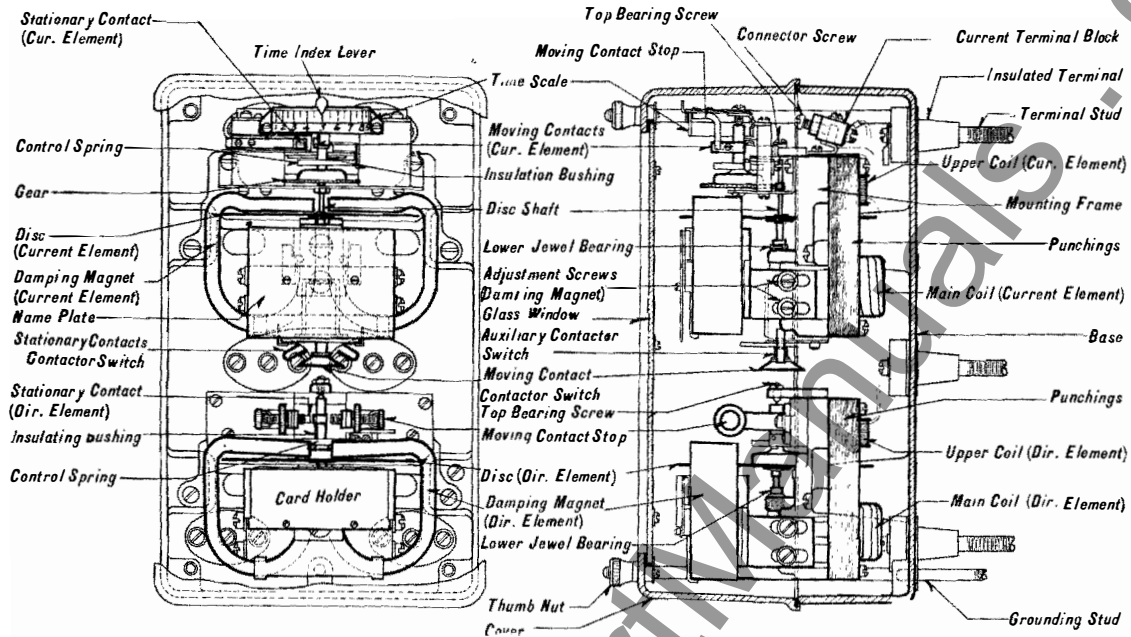


Fig. 41—Front and Side Sectional View of Low-Energy Type CR Relay

except that the low energy type is necessary where the current transformers are of the bushing type or of such other types that they can carry only a small secondary burden. The relay can also be supplied with

a special current range of 2 to 6 amperes. The relay having a range of .5 to 2.5 amperes is intended for the automatic sectionalizing of transmission lines when used as a ground relay.

### CONSTRUCTION

The construction of the Low-Energy Type CR Relay differs from that of the standard CR only inasmuch as the low-energy CO over-current element is used in place of the standard CO over-current ele-

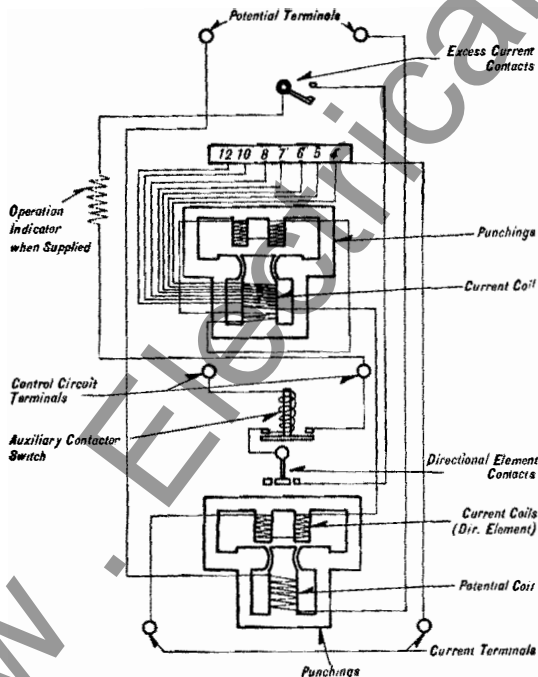


Fig. 42—Internal Wiring Diagram of Low-Energy Type CR Relay.  
(6 Terminals—Rear View)

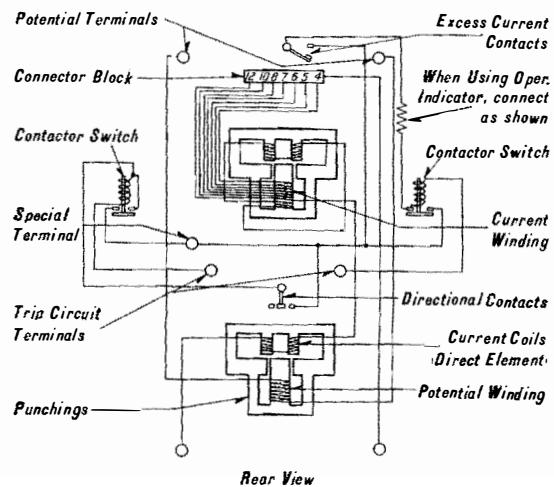


Fig. 43—Internal Wiring Diagram of Low-Energy Type CR Relay with Extra Terminal in Trip Circuit Between Elements. (7 Terminals, 2 Contactor Switches)

ment, and that the over-current element is mounted in the top of the case instead of in the lower part of the case as in the standard Type CR Relay.

### OPERATION AND CHARACTERISTICS

As the directional element is practically instantaneous in its operation and operates on a very small amount of current and voltage, the characteristics of the entire relay depend upon those of the over-current element. The characteristics and operation of the Low-Energy Type CR Relay are therefore exactly the same as those of the Low-Energy Type CO Relay. Fig. 22 gives the current time characteristics at various settings of the time index lever.

All instructions as already stated for the standard Types CO and CR Relays for installation, adjustment, care and maintenance apply to the Low-Energy Type CR.

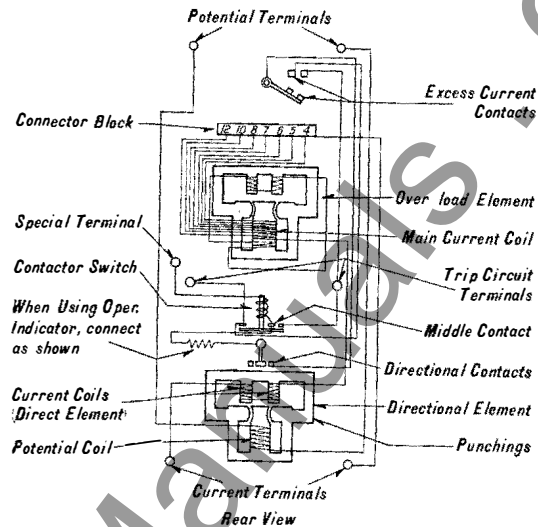


Fig. 44—Internal Wiring Diagram of Low-Energy Type CR Relay With Double-Trip Circuit

## Repairing

Repairing can be done most satisfactorily at our Works. Interchangeable renewal parts can be furnished, however, and cus-

tomers equipped for doing repair work will find that the construction of the relays facilitates this.

## Testing

### TESTING WITH CYCLE COUNTER

The calibration of the CO Relay and of the over-current element of the CR Relay is remarkably constant, but, because of the importance of accurate operation, it is advisable to test the relays on the system at frequent intervals. If possible, this test should be made on the complete relay installation, thus testing the operation of the tripping circuit of the circuit-breaker, and the condition of the control wiring.

The method of testing relays by means of a stop-watch is not sufficiently accurate when short time intervals are used, and it is, therefore, recommended that the Cycle Counter be used. This is a device for indicating definitely the number of cycles which have elapsed, between the time that current is sent through the relay and the time when relay contacts are closed.

**Operation**—The Cycle Counter (figure 45) is connected in circuit with the relay as shown on the diagram (figure 46), when

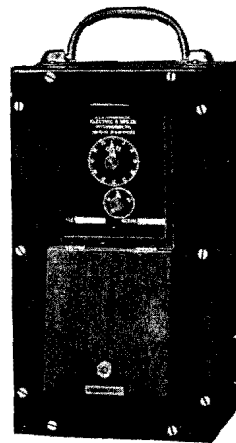


Fig. 45—Cycle Counter

the load is adjusted to give the desired current through the relay and the testing switch is closed, the "cycle" pointer begins to revolve one step per cycle, and continues to do so until the relay contacts are closed. The instrument acts as though it had no inertia; that is, it starts the instant power is applied and stops the instant power disappears.

**Construction**—The mechanism is virtually an electric self-winding clock with the escapement operated by an alternating-current oscillating magnet instead of a pendulum or balance wheel. At each cycle, one tooth of the escapement is released.

The self-winding clock periodically rewinds from power supplied from a shunt connection to the circuit when the cycle pointer has made 60 revolutions (3600 cycles). This arrangement keeps an even tension on the escapement. Thus the escapement magnet is not depended on to drive the indicator, but simply to regulate its speed; power for driving is furnished by the clock mechanism.

**Other Applications**—Although primarily designed for use in testing or adjusting time-element relays, this instrument is obviously suitable for a great variety of testing and should have a broad field of application. Its particular field of usefulness is for measuring elapsed intervals of time too short to be satisfactorily observed with a stop-watch and where readings in steps of one alternation are sufficiently accurate, thus obviating the use of complicated and expensive apparatus such as chronographs or oscillographs. Given a known frequency, the readings can, of course, be reduced to seconds if desired. Conversely, by connecting the instrument to a circuit for a definite period of time the frequency can be determined. By adding contacts to machine tools, elevator machinery, etc., the time required for various functions can be determined. It will be found to be useful in many laboratories and test rooms for timing purposes.

### DIRECTIONS FOR TESTING RELAYS

Connect as shown in Fig. 46, unless a different diagram is furnished with the Cycle Counter. Adjust the pointer on the Cycle Counter by hand to zero before each test. Adjust the artificial load on the relay

to the desired amount. Close the testing switch which will start the relay and keep the circuit closed until the contacts on the relay have come together which will stop the Cycle Counter. Then open the switch and read the number of cycles which have been recorded by the counter. When testing the relays for heavy overloads, keep the switch closed as little as possible and do not repeat often enough to overheat the relay. It should be borne in mind that the relay is intended to carry only 5 amperes normally, and the passage of a current of 100 or 200 amperes through the winding should not be continued for more than a few seconds.

### GENERAL TESTING INFORMATION

Relays testing as referring to operating companies may be divided into two divisions:

- (1) Initial tests including all tests and inspections made before the relay is first placed in control of the tripping circuit.
- (2) Periodic tests which include all tests and inspections made at stated intervals after the relay has been placed in service.

**Initial Tests**—The initial tests should include a close inspection of all mechanical features of the relay as outlined on pages 10 and 11. The electrical or operating tests should include the checking of several points on the calibration curve given on the nameplate of the relay as to time and tripping current and if possible the circuit-breakers should be tripped out by the relay, thus insuring the proper connections of the control circuit. In many cases it is also highly desirable to time the combined

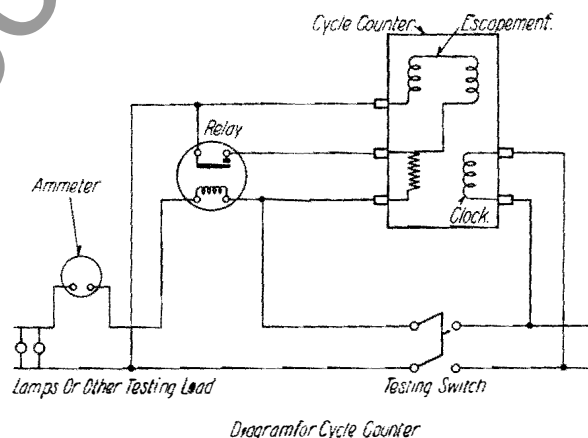


Fig. 46—Diagram of Connections for Using the Cycle Counter In Testing the Types CO and CR Relays

operation of the relay and circuit-breaker and thus check the time intervals between successive relays as allowed in the application.

Some operating companies use low voltage high current testing transformers for the initial tests and energize the current transformers from the primary side. This tests out all relay and transformer connections.

The initial tests of directional over-current relays should include a careful check of the potential connections as to whether or not the proper phase relation between the current and voltage exists. This is outlined fully on pages 21 and 22.

**Periodic Tests**—All primary relays on a system should be tested at least once every six months. In addition to this a thorough inspection should be made once every three months or oftener. These tests and inspections should be similar to the initial tests and inspections and should be carried on by a competent man.

Circuits should be taken out of service wherever possible when the relays are being tested and the entire relay wiring should be included in the test. In cases where the circuits cannot be taken out of service it should be remembered that the circuits are without protection during the test.

Another feature carried out by some operating companies in their relay testing schedule is to have the oil circuit-breakers tripped by their respective relays at least once every month. Such procedure is not possible in all cases but is highly desirable inasmuch as it insures the proper functioning of the circuit-breaker in connection with the relay and serves to prevent any sluggishness in the action of the breaker due to gummed oil or dirt in the mechanism.

**A stitch in time saves nine**, and so serious and expensive service interruptions may be averted by the proper skillful attention being given to keeping the relays and circuit-breakers in the very best operating condition. This can only be done by frequent tests and inspections.

Systematic records of all tests and inspections should be kept for each relay and breaker.

### **TESTING RELAYS WITH RESISTANCE OR WITH PHANTOM LOADING**

It is often found that an induction type over-current relay which functions satisfactorily while being calibrated does not give the same performance when in actual service. This is particularly true of timing calibration when phantom loading has been used in calibrating. Actual tests have shown that as high as .15 seconds more time is required for the relay to trip at a given amount of over-current (300% and upwards) when tested with a phantom load than when tested with a resistance load. The resistance loading represents actual conditions very closely and is therefore recommended for use in all checking, testing and calibrating. This is the method used at the factory.

Errors in the time of operation of the Types CO and CR Relays in practice may be due to this cause. If tested with a phantom load, the relay may be expected to trip from .1 to .2 seconds quicker in actual service than it did on test. This applies to overloads, the error decreasing as the current decreases.

The reason for this difference in operation, as shown by oscillographic studies, is that the saturation of the iron in the torque compensator causes a variation in the impedance of the relay. This variation in impedance may cause voltage distortion, current distortion or both. With the actual operating conditions or resistance loading, the current in the relay maintains the sinusoidal wave form while the voltage across the terminals is somewhat distorted from this wave form. With phantom loading, both the current and voltage wave forms are somewhat distorted and thus the effective flux is less, decreasing the torque on the disc slightly, and thus requiring a longer time for operation.

The diagram of connections as shown in Fig. 46 illustrates the recommended method of testing with a resistance load.

## RENEWAL PARTS

Parts of a relay seldom wear out but are subject to loss or damage during repair or test work. Due to the number and types of relays covered in the text it is difficult to recommend the exact number of parts to be carried.

Recommended List of Renewal Parts that should be carried in Stock.

### Common Parts

Ref. No.	Name of Part	Style Number
4	Large Terminal and Stud .....	183038
17	Lower Jewel Bearing—Lower Half .....	289762
15	Damping Magnet .....	300342
21	Contact Switch .....	285398
22	Coil Complete .....	289765
23	Moving Contact Complete .....	285196
24	Contact Base and Contacts .....	289767
25	Operation Indicator—1.0 Ampere .....	376251
26	Operation Indicator—0.1 Ampere .....	376252

### Overload Elements

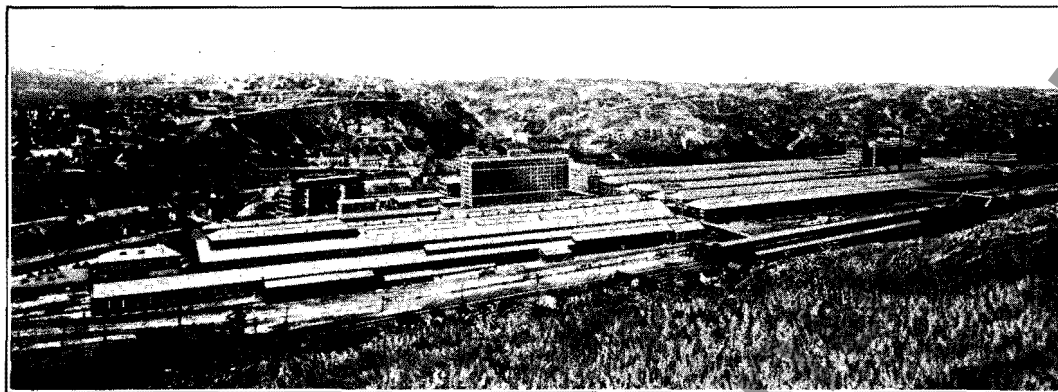
1	Moulded Connector Block .....	375566
2	Brass Connector Block .....	.....
3	Connector Screw .....	375323
19	Stationary Contact Spring and Contact .....	.....
20	Stationary Contact Spring Stop .....	.....
10	Moving Contact, Support and Spring .....	.....
11	Contact and Support .....	.....
12	Control Spring .....	.....
7	Moving Element Complete—Standard Energy .....	274812
8	Moving Element Complete—Low Energy .....	321018
9	Lower Jewel Bearing—Upper Half .....	214870
5	Index Lever and Stop—Standard Energy .....	214554
6	Index Lever and Stop—Low Energy .....	333697
13	Micarta Spring Guard .....	242590
16	Top Bearing Screw .....	214429
14	Coils and Iron Complete .....	.....
27	Glass Cover .....	152389
18	Steel Ball .....	25463
28	Thumb Nut (Relays without Operation Indicator) .....	289840
29	Thumb Nut (Relays with Operation Indicator) .....	376333

### Directional Elements

35	Coils and Iron Complete .....	.....
36	Stationary Contact and Block Complete .....	393483
37	Contact Screw and Contact .....	376531
38	Stationary Stop and Block Complete .....	393484
39	Torque Adjuster Bracket—Right Hand .....	438569
40	Torque Adjuster Bracket—Left Hand .....	438570
30	Moving Element Complete .....	477343
31	Moving Contact Complete .....	393477
32	Control Spring .....	273012
41	Glass Cover (Without Operation Indicator) .....	376019
42	Glass Cover (With Operation Indicator) .....	376020
43	Thumb Nuts (Glass Cover) .....	289840
44	Thumb Nuts (Metal Cover) .....	226261
33	Top Bearing Screw .....	253322
34	Adjusting Nut .....	203056
45	Glass Front for Metal Cover Relays .....	222178

Parts indented are included in part under which they are indented.

Style Numbers not given are dependent on the frequency, range or type of relay and can be furnished by stating the style number of the relay.



The Company's Works at East Pittsburgh, Pa.

## Westinghouse Products

A few of the Westinghouse Products are listed below and will furnish some idea of the great variety of electrical apparatus manufactured by the Company and the many extensive fields for their use.

### For Industrial Use

Instruments  
Motors and controllers for every application, the more important of which are: Machine shops, wood-working plants, textile mills, steel mills, flour mills, cement mills, brick and clay plants, printing plants, bakeries, laundries, irrigation, elevators and pumps.

Welding outfits  
Gears  
Industrial heating devices, such as: Glue pots, immersion heaters, solder pots, hat-making machinery and electric ovens.  
Lighting systems  
Safety switches

### For Power Plants and Transmission Lines

Carrier current equipment  
Circuit-breakers and switches  
Condensers  
Controllers  
Control switches  
Frequency changers  
Fuses and fuse blocks  
Generators  
Insulating material  
Instruments  
Lamps, incandescent and arc  
Lightning arresters  
Line material  
Locomotives  
Meters  
Motors  
Motor-generators  
Portable Power Stands, 110 volts  
Rectifiers  
Regulators

Relays  
Solder and soldering fluids  
Stokers  
Substations, portable and automatic  
Switchboards  
Synchronous converters  
Transformers  
Turbine-generators

### For Transportation

Locomotives  
Railway equipment  
Marine equipment

### For Mines

Automatic substations  
Lamps  
Locomotives  
Motor for hoists and pumps  
Motor-generators  
Portable substations  
Switchboards  
Line material  
Ventilating outfits

### For Farms

Fans  
Household appliances  
Motors for driving churns, cream separators, corn shellers, feed grinders, pumps, air compressors, grindstones, fruit cleaning machines and sorting machines.  
Generators for light, power and heating apparatus.  
Portable Power Stands, 32 Volts  
Radio Apparatus  
Transformers

### For Office and Store

Electric radiators  
Fans

Arc lamps  
Incandescent lamps  
Sol-Lux lighting fixtures  
Small motors for driving addressing machines, dictaphones, adding machines, cash carriers, moving window displays, signs, flashers, envelope sealers, duplicators, etc.  
Ventilating outfits

### For Electric and Gasoline Automobiles and the Garage

Battery charging outfits  
Charging plugs and receptacles  
Lamps  
Instruments  
Motors and controllers  
Small motors for driving lathes, tire pumps, machine tools, polishing and grinding lathes.  
Solder and soldering fluids  
Tire vulcanizers

### For the Home

Electric ware, including: Table stoves, toasters, irons, warming pads, curling irons, coffee percolators, chafing dishes, disc stoves, radiators and sterilizers.  
Automatic electric ranges  
Fans  
Incandescent lamps  
Radio apparatus  
Sol-Lux lighting fixtures  
Small motors for driving coffee grinders, ice cream freezers, ironing machines, washing machines, vacuum cleaners, sewing machines, small lathes, polishing and grinding wheels, pumps and piano players.  
Sew-motors.

# Westinghouse Electric & Manufacturing Company East Pittsburgh, Pa.

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\*BUFFALO, N. Y., Ellicott Square Bldg., Ellicott Square  
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CHARLESTON, W. VA., Capitol & Virginia Sts.  
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\*CHICAGO, ILL., Conway Bldg., 111 W. Washington St.  
\*CINCINNATI, OHIO, Westinghouse Elec. Bldg., Third and Elm Sts.  
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\*DENVER, COLO., Gas & Electric Bldg., 910 Fifteenth St.  
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JACKSON, MISS., 820 Carlisle St., P. O. Box 141  
\*JACKSONVILLE, FLA., 1223 Barnett National Bank Bldg.  
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SPRINGFIELD, MASS., 395 Liberty St.  
\*ST. LOUIS, MO., Ambassador Bldg., 411 N. 7th St.  
STOCKTON, CALIF., 22 S. Sutter St.  
SYRACUSE, N. Y., University Bldg., S. Warren and E. Wash. Sts.  
TACOMA, WASH., 1117 W. R. Rust Bldg., 954 Pacific Ave.  
\*TAMPA, FLA., Westinghouse Elec. Bldg., 417 Ellamae Ave.  
TERRE HAUTE, IND., 309 Terre Haute Trust Bldg., Seventh & Wash Sts.  
TOLEDO, OHIO, Ohio Bldg., Madison Ave and Superior St.  
TULSA, OKLA., Mid Continent Bldg., Fifth St. & Boston Ave.  
\*UTICA, N. Y., 408 Pine St., Utica Gas and Electric Bldg.  
WASHINGTON, D. C., Hibbs Bldg., 723 Fifteenth St., N. W.  
WATERLOO, IOWA, P. O. Box 585  
WATERTOWN, N. Y., 254 Woolworth Bldg., Public Square  
WICHITA, KAN., P. O. Box 1226  
WILKES BARRE, PA., 267 N. Pennsylvania Ave., West. Elec. Bldg.  
WORCESTER, MASS., Park Bldg., 507 Main St.  
YOUNGSTOWN, OHIO, 810 First National Bank Bldg., Federal and Chestnut Sts.  
The HAWAIIAN ELECTRIC CO., Ltd., Honolulu, T. H.—Agent  
\*Warehouse located in this city.

## BROADCASTING STATIONS

KDKA, EAST PITTSBURGH, PA.  
WBZA, SPRINGFIELD, MASS.

KYW. CHICAGO, ILL.  
KFKX, HASTINGS, NEB.

(KDKA—The Pioneer Radio Broadcasting Station of the World)  
(KFKX—The Pioneer Radio Repeating Station)

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CHARLOTTE, N. C., 210 E. 6th St.  
CHICAGO, ILL., 2201 W. Pershing Road  
CINCINNATI, OHIO, Third and Elm Sts.  
CLEVELAND, OHIO, 2209 Ashland Rd., S. E.  
DENVER, COLO., 1909-11-13-15 Blake St.

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## WESTINGHOUSE MARINE SERVICE PORT ENGINEERS

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PHILADELPHIA, 30th and Walnut Sts.  
SAN FRANCISCO (Emeryville), 1466 Powell St.

SEATTLE, 3451 E. Marginal Way

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