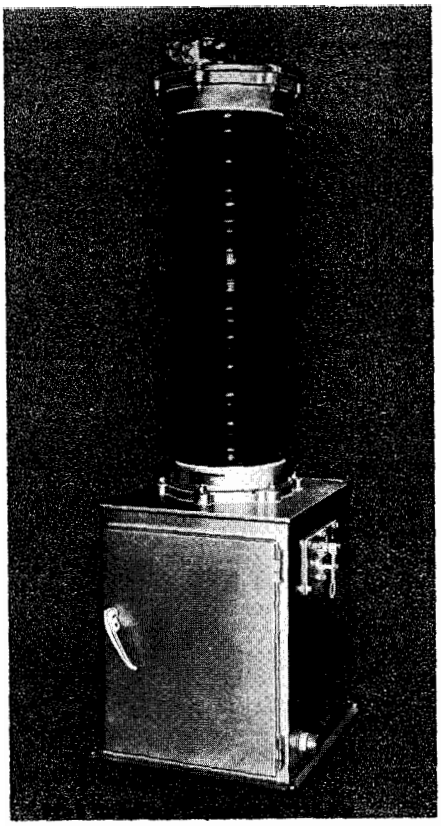
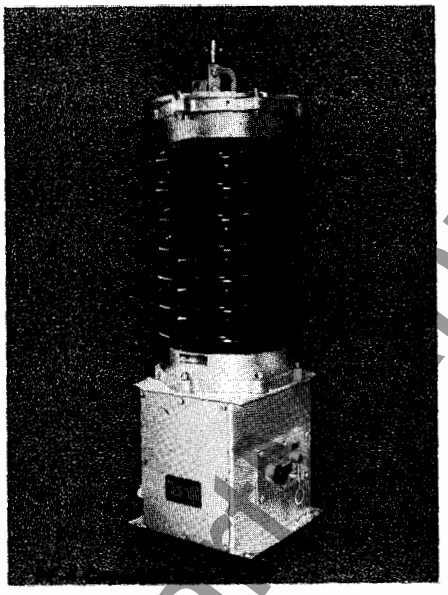
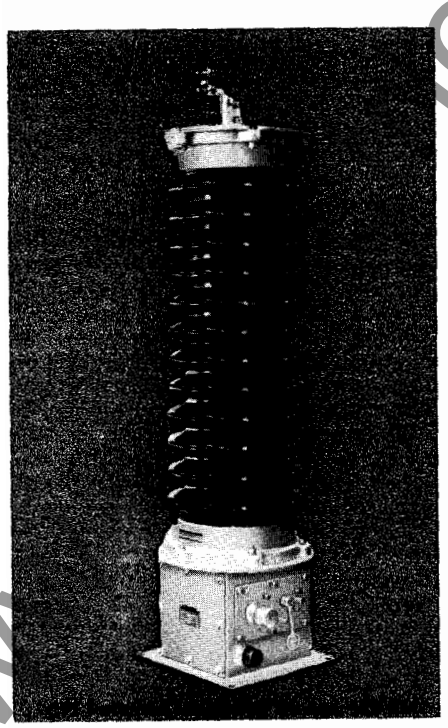
Westinghouse

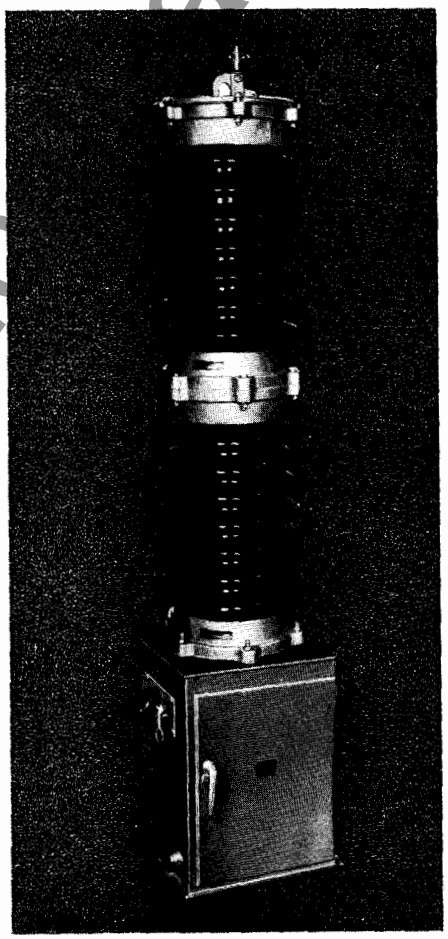
Coupling Capacitors Potential Devices

Low Capacitance
Field Adjusted









Application

The use of high-voltage power transmission lines for propagation of carrier signals requires efficient transfer of energy between the power line and the carrier system. Coupling capacitors have become the accepted standard for accomplishing this function. Coupling is obtained directly between carrier equipment and high voltage line without the use of auxiliaries, except for a coupling tuner.

The potential device provides low-voltage energy suitable for operation of relays, indicating instruments and lights. Its use with the coupling capacitor makes possible a wider field of application for power line carrier communications, relaying, telemetering, and supervisory control.

Types Available

Coupling Capacitors

PC-4: A low or "standard" capacitance coupling capacitor suitable for resonant coupling of one or two carrier channels to a power transmission line. If a type PC-5 high capacitance unit, or a type PC-6 extra-high capacitance unit is desired for broad band coupling of several carrier signals, refer to catalog section 39-621 and 39-631, respectively.

Any of the following types of potential devices may be used for carrier coupling if carrier accessories are specified.

Potential Devices

PCA-4: A voltage-transforming device employing a low-capacitance coupling capacitor, an intermediate potential transformer and a variable reactor in the secondary to obtain a 66.4/115 volt source which is in phase with the line voltage. A burden of 150 watts may be connected to this device.

PCC-4: A voltage-transforming device employing a low capacitance coupling capacitor, an intermediate potential transformer, and auxiliary burden components to obtain a 66.4/115 volt source. This voltage is not in phase with the line voltage, but the phase angle may be adjusted between 30 degrees and 120 degrees leading. A burden of 75 watts may be connected to this device.

CPI: A potential indicating device with essentially zero burden capability. This device provides the most economical means of indicating whether a line is energized or not.

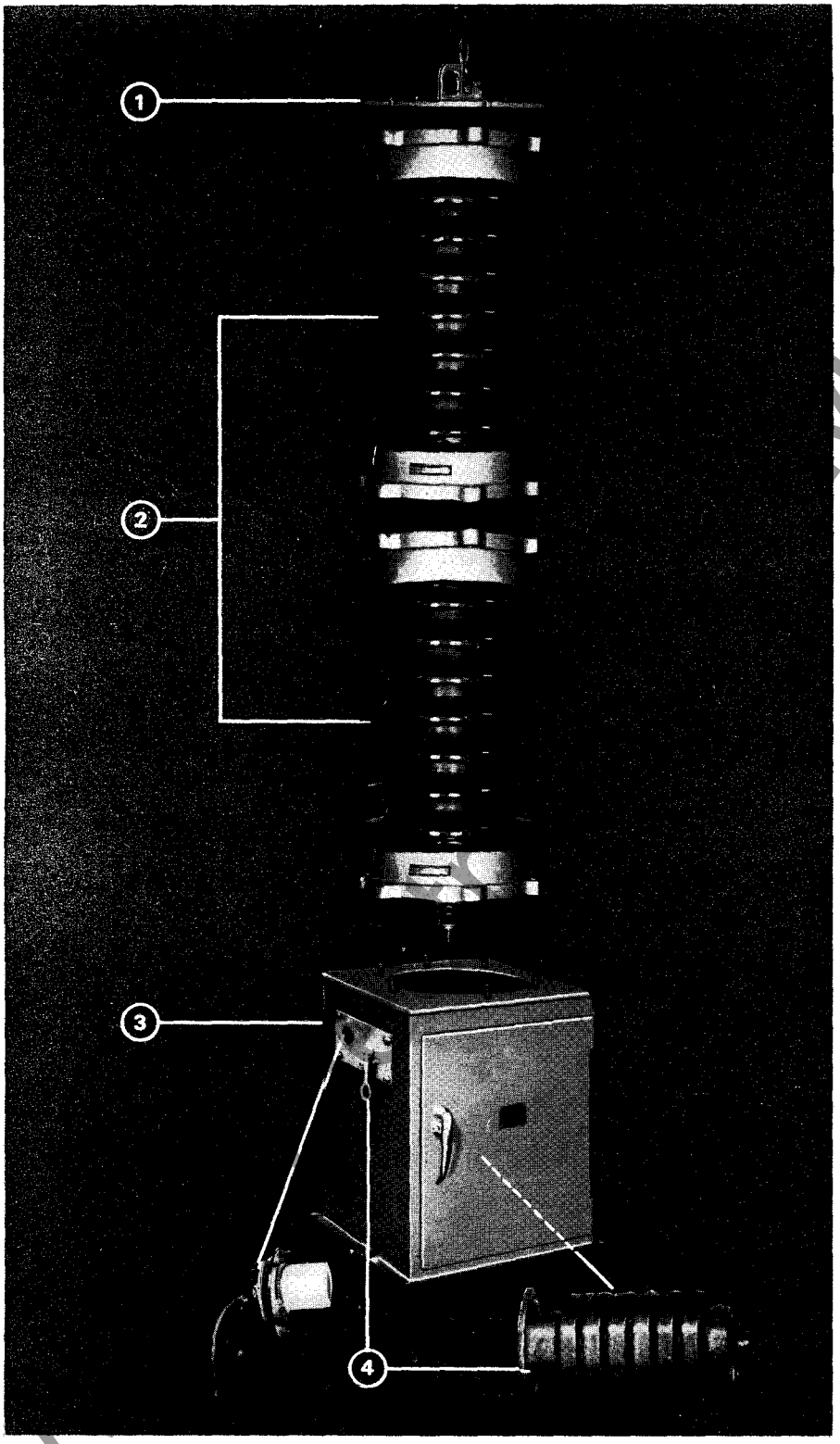
PF-4: A low burden (25 volt-amps), out-of-phase potential device used to operate a limited number of relays.

Standards

These devices meet all applicable requirements of NEMA standards SG11-1955 and IEEE Standards #31, or latest revision.

October, 1966
New Information
E, D, C/2003/DB

Westinghouse



Construction
Types PC-4, PCA-4, and PCC-4

1 Top Cover

Each coupling capacitor stack has a top cover with a clamp-type connector suitable for either vertical or horizontal connection of line cable. Terminals for aluminum or copper cable are available.

When one end of a line trap is to be mounted on the top of a coupling capacitor stack, a different top cover is supplied which has mounting holes on either a 3-inch or 5-inch bolt circle as specified by the purchaser.

2 Coupling Unit

Each individual coupling unit consists of a wet-process porcelain tube with fitted end castings designed to effectively seal the interior. This tube contains the capacitor element which consists of a large number of individual working sections connected in series.

The individual working sections are made up of an assembly of special Inertex paper and aluminum foil and connected in such a manner as to give negligible inductance. After assembly, the capacitor element is vacuum treated to remove all traces of moisture and then impregnated with degassed mineral oil. The characteristics of this insulating material are such as to insure minimum change in capacitance with variations in temperature.

Coupling capacitor assemblies are designed with insulation levels equivalent to similar apparatus such as circuit breaker or transformer bushings and are connected directly to the line without the use of auxiliaries such as disconnects or fuses.

The individual capacitor sections within the coupling unit are designed to withstand momentary voltages far in excess of the normal operating voltages. The outside creepage path and striking distance of the porcelain tube are so coordinated with the internal insulation that the individual capacitor sections are not damaged when the coupling unit is subjected to voltages sufficient to cause external flashover. The internal capacitance of the complete coupling stack dominates the capacitance to surrounding objects and forces a uniform voltage distribution along the coupling units. The flashover rating of the stack is, therefore, approximately the sum of the flashover ratings of the individual coupling units making up the stack. The capacitors are so designed that the application of impulse voltage will not damage the internal working elements or

Coupling Capacitors Potential Devices

Low Capacitance
Field Adjusted

cause a change in their electrostatic capacitance.

Above 115 kv, the coupling capacitor consists of 2 or more coupling units bolted together to form the series capacitance between line and ground.

Upper coupling units have internal connections terminating in the end castings and external connections are made merely by bolting one unit to the bottom coupling unit and additional units to each other.

The lower coupling unit in each stack is bolted directly to the base housing and is supplied with a porcelain bushing (not to be confused with the carrier lead-in bushing) complete with terminal for connection to the drain coil when used with carrier coupling or, to the auxiliary capacitor when a potential device is used.

3 Base Housing

The base housing is a weatherproof, welded steel enclosure. It serves as a mounting base for the coupling capacitor stack and a housing for the carrier accessories and/or potential device. A potential device may be added to this cabinet at any time after a coupling capacitor is installed.

Each base housing is supplied with a clamp type ground terminal suitable for #2 solid to 800 mcm copper cable and has provision for entrance of the carrier lead from either side. One side is provided with a removable plate with the carrier grounding switch and either a 1¼" threaded nipple for conduit connection when coaxial cable is used for the carrier lead, or provision for mounting a lead-in bushing when single-conductor high impedance cable is used. A blank plate containing a breather port is mounted on the opposite side.

4 Carrier Accessories (see Fig. 1)

Unless otherwise specified, all coupling capacitors intended for carrier coupling only are supplied with the following items mounted in the base housing:

Carrier Drain Coil: The drain coil is connected between the coupling capacitor and ground to provide a low-impedance path for power frequency current, and at the same time prevent dissipation of the carrier frequency energy to ground. This coil is designed to have a minimum impedance of not less than 20,000 ohms over the carrier frequency range from 30 to 200 kc and not over 300 ohms at power frequency.

Carrier Grounding Switch: Normally open, this switch is closed to remove voltage from the drain coil during inspection and adjustments. The operating handle for the switch is on the outside of the base housing.

Carrier Gap: This gap is connected in parallel with the drain coil and its sparkover value is coordinated with the dielectric strength of the drain coil to prevent excessive voltage being impressed on the drain coil such as may be caused by the surges on the high voltage line. Gap sparkover does not interfere with operation of the potential device when used.

Mounting

Coupling capacitors are normally supplied suitable for base mounting by means of six mounting holes located on the bottom flange of the base housing. A design suitable for rigid suspension mounting is also available.

Corona Ring

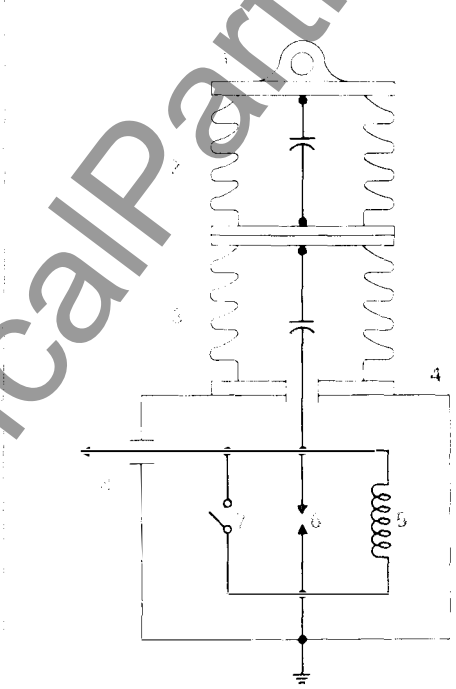
A corona ring is supplied with each type PC-4 and PCA-4 capacitor rated 230 kv and above.

Line Coupling Tuners

Resonant type JZ line tuners are used when standard capacitance coupling capacitors are employed. The line tuners are contained in a weatherproof cabinet suitable for mounting on the outside of a large base housing or, for separate mounting.

For further information on JZ line tuners, Hi-Couplers or impedance matching transformer, refer to Section 41-900.

Impedance-Matching Transformer: Where applicable, an impedance-matching transformer can be mounted in the base housing if desired and so specified on the order.



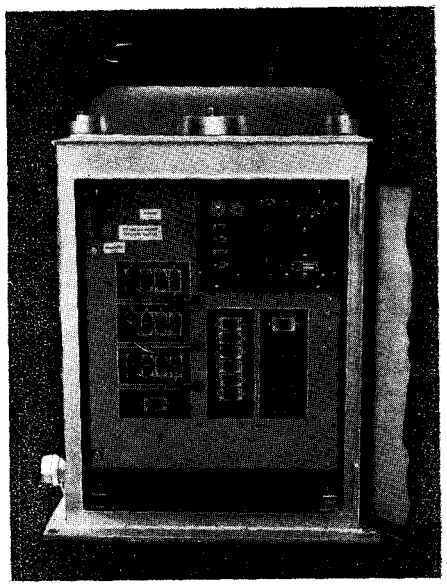
1 Top cover.
2 Coupling capacitor – upper unit.
3 Coupling capacitor – lower unit.
4 Base housing.
5 Carrier drain coil.
6 Carrier gap.
7 Carrier grounding switch.
8 Carrier lead-in.

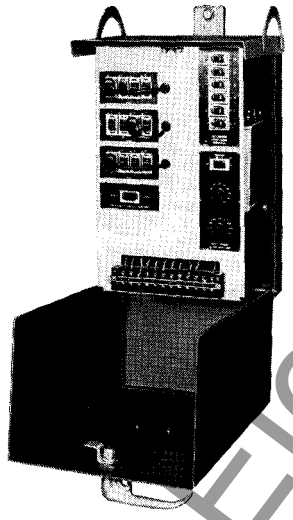
Fig. 1: PC-4 Coupling Capacitor with Carrier Accessories, Without Potential Device

Westinghouse

Construction Cont'd.

Coupling Capacitor Potential Devices Types PCA-4 and PCC-4





Remote Adjusting Unit PCA-4 Coupling Capacitor Potential Devices

Class A coupling capacitor potential devices consist of two main parts: 1. The coupling capacitor unit or units already described plus: 2. A potential network contained in a weatherproof housing which forms the base for the coupling capacitor stack.

The type PCA-4 potential devices have a total output of 150 watts at 60 cycles (with the capacitor connected line-to-ground) when energized from a system having nominal rated line-to-line voltage as listed on page 7.

The potential device supplies four secondary voltages simultaneously from the secondary terminals. A 115-volt secondary with a 66.4 volt tap is available for operation of relays and indicating instruments. A separate 115-volt auxiliary winding with a 66.4 tap is available for broken delta connection for operation of ground relays. Burden rating of this auxiliary winding is 75 watts. Suitable terminals are provided for making connections to these voltages.

The devices are designed to provide correction of lagging burden to unity power factor and sufficient corrective capacity is available to provide correction from 3¾ to 115 reactive volt-amperes based on 115 volt secondary in steps not greater than 3¾ volt-amperes.

Design Features

Numbers given in the following description refer to the schematic diagrams on page 5.

Top cover (1) and coupling capacitor units (2) (3) are identical to those described on pages 2 and 3. The type PCA-4 coupling capacitor potential device uses type PC-4 coupling capacitor units.

Auxiliary capacitor (9) connected between the main capacitance and ground provides the voltage tap for the potential device. It is filled with the same fluid insulating material as the coupling capacitor units.

Transformer gap (11) prevents excessive voltage from being impressed on the auxiliary capacitor and variable reactance transformer. These overvoltages may be caused by impulse surges on the high voltage line or by overloads or short circuits on the potential device. Gap sparkover does not interfere with carrier signals.

Transformer grounding switch (12), normally in the open position, is closed to remove voltage from the potential device during adjustment or inspection. Operation of the transformer gap or grounding switch does not interfere with normal carrier coupling. When the adjusting panel is contained within the large base housing, the transformer grounding switch operating handle is located inside the base housing and is mechanically interlocked with the low-voltage adjusting panel so that high voltage parts are not accessible until the low-voltage adjusting panel is swung open. The low-voltage panel cannot be opened until the transformer grounding switch operating handle has been rotated to the "grounded" position. An external transformer grounding switch operating handle is, therefore, not necessary but can be supplied if desired.

When the adjusting panel is remote (see 17) from the base housing, an external transformer grounding switch handle is supplied on the base housing.

Variable reactance transformer (10) steps down the voltage and tunes the potential device circuit impedance so that the secondary voltages are in phase with the line-to-ground voltage of the circuit to which the coupling capacitor potential device is connected.

Voltage-adjusting transformer (13) is used to adjust the secondary voltage to 115/66.4 volts.

Power factor correction capacitor (14) adjusts the burden power factor to unity thus reducing the volt ampere requirements on the potential device to a minimum.

Base housing (4) is shown at left.

Remote adjusting unit (17) is an alternate arrangement, utilizing the voltage adjusting transformer and power factor correction capacitor along with the reactance-adjusting transformer in a weatherproof metal enclosure suitable for indoor or outdoor mounting remote from the coupling capacitor potential device base housing. All electrical adjustments may be made at the remote adjusting unit. Connecting leads from the remote adjusting unit to the coupling capacitor potential device must be supplied by the purchaser.

Carrier accessories (5) (6) (7) are required only when power line carrier coupling is employed simultaneously with the potential device. These accessories consist of a carrier drain coil; carrier grounding switch; carrier gap as previously described on page 3, and, in addition, a carrier choke coil. This latter coil is identical to the carrier drain coil; however, it is connected between the auxiliary capacitor and the variable reactance transformer primary to prevent dissipation of the carrier energy thru the potential device.

Heaters are provided in large base housings containing potential devices, and in remote adjusting units to keep them dry and free from corrosion and mildew in damp, cool locations. Heaters should be energized from a separate 115 or 230 volt source.

Type CPI Potential Indicating Device

For such applications as potential indication in an unattended substation, automatic throwover initiation, potential indication during maintenance periods and as an activating source for a recording oscillograph, only voltage indication is required. The type CPI potential indicating device serves the need for a low cost equipment to perform such functions without requiring the utility to provide for a power source that is not utilized.

Coupling Capacitors Potential Devices

Low Capacitance
Field Adjusted

The unit consists of a high voltage capacitor rated line-to-line and connected line-to-ground. In series with the ground connection is an enclosed double pole, double throw, current relay. This relay responds to the capacitor current which is a function of the line-to-ground voltage. Also, the relay closes its contacts whenever the line is energized. These contacts can then be used to sound alarms or initiate any applicable function.

A slight modification allows the new device to be used as a coupling capacitor for carrier current application concurrent with potential indication.

A schematic diagram of the CPI device is given in Figure 4.

Type PF-4 Capaciformer (25 Va Burden)

The Capaciformer is a simplified coupling capacitor potential device that can be supplied for application on circuit voltages of 34.5 through 345 kv and can supply a burden up to 25 volt-amperes at either 66.4 or 115 volts. These ratings fill the needs of many applications now being supplied by the more expensive potential transformers and coupling capacitor potential devices with 150 watts burden capability.

The Capaciformer is designed to serve only as a source of potential and has no adjustment of phase angle or regulation; however, the secondary voltage can be manually adjusted by changing the taps of the potential transformer. The phase angle is determined by the characteristics of the burden.

The potential transformer is equipped with 10 secondary taps giving the following ratios:

Taps	Ratio	Taps	Ratio
X1-X10	8.61/1	X3-X7	13.63/1
X1-X9	8.85/1	X3-X6	14.25/1
X1-X8	9.1/1	X4-X10	14.9/1
X1-X7	9.38/1	X3-X9	15.65/1
X1-X6	9.68/1	X4-X8	16.5/1
X2-X10	10.13/1	X4-X7	17.4/1
X2-X9	10.5/1	X4-X6	18.4/1
X2-X8	10.82/1	X5-X10	19.5/1
X2-X7	11.1/1	X5-X9	20.8/1
X2-X6	11.62/1	X5-X8	22.5/1
X3-X10	12.1/1	X5-X7	23.2/1
X3-X9	12.55/1	X5-X6	25.1/1
X3-X8	13.08/1		

The network capacitor is equipped with three sections: C1 capacitor unit – 1 mf capacity; C2 and C3 units – 2 mf capacity each.

Schematic Diagrams

1 Top cover.
2 Coupling capacitor – upper unit.
3 Coupling capacitor – lower unit.
4 Base housing.
5 Carrier drain coil.
6 Carrier gap.
7 Carrier grounding switch.
8 Carrier lead-in.
9 Auxiliary capacitor.
10 Variable reactance transformer.
11 Transformer gap.
12 Transformer grounding switch.
13 Voltage adjusting transformer.
14 Power factor correction capacitor.
15 Carrier choke coil.
16 Remote reactance adjusting transformer.
17 Enclosure for remote adjusting unit.

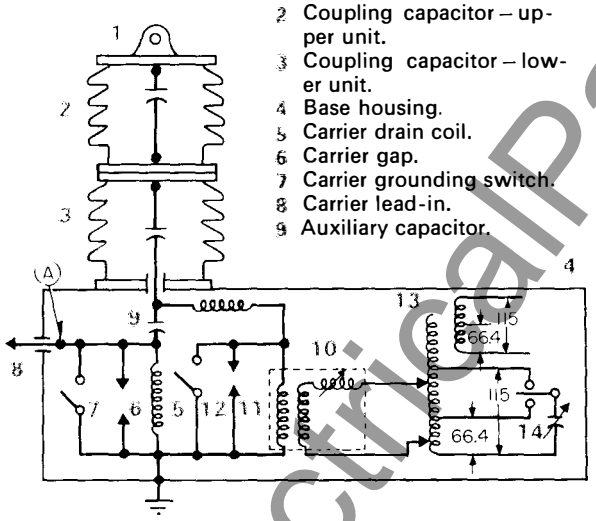


Figure 2: PCA-4 Coupling Capacitor Potential Device with Carrier Accessories and Internal Adjusting Unit

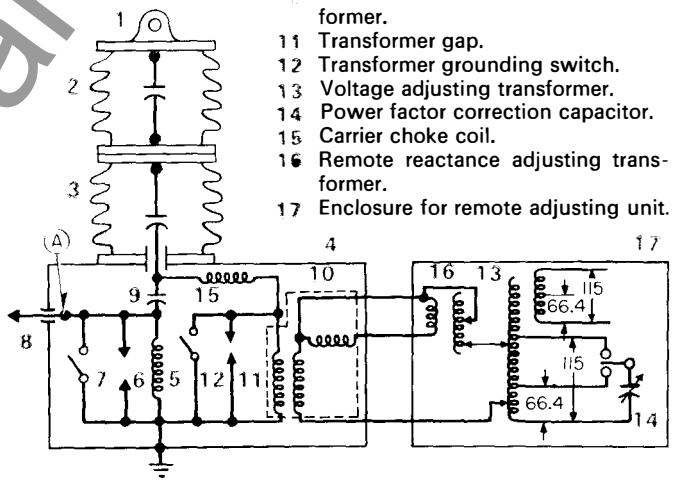


Figure 3: PCA-4 Coupling Capacitor Potential Device with Carrier Accessories and Remote Adjusting Unit

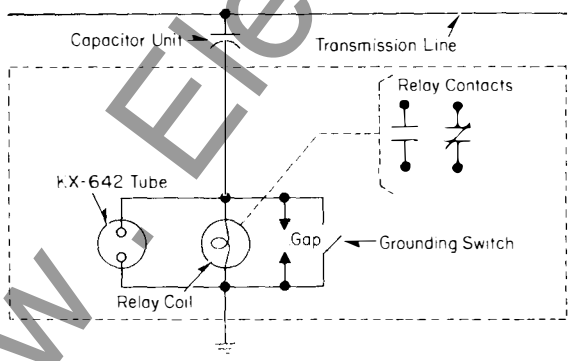


Figure 4: CPI Potential Indicating Device without Carrier Accessories

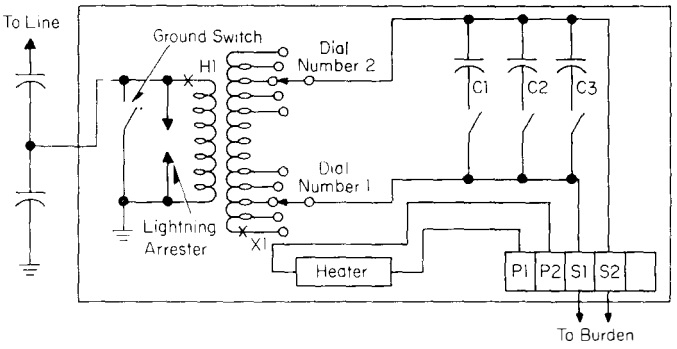
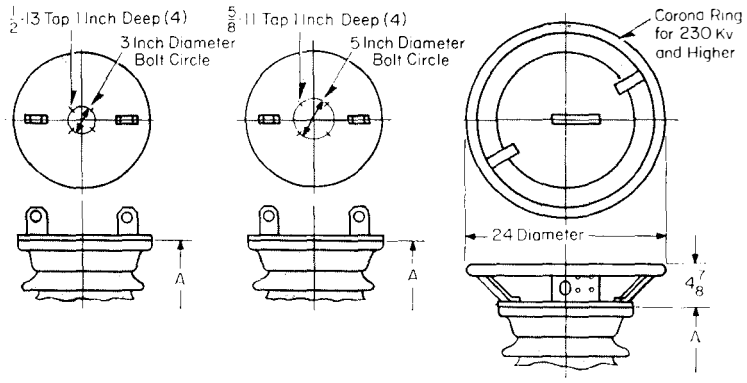


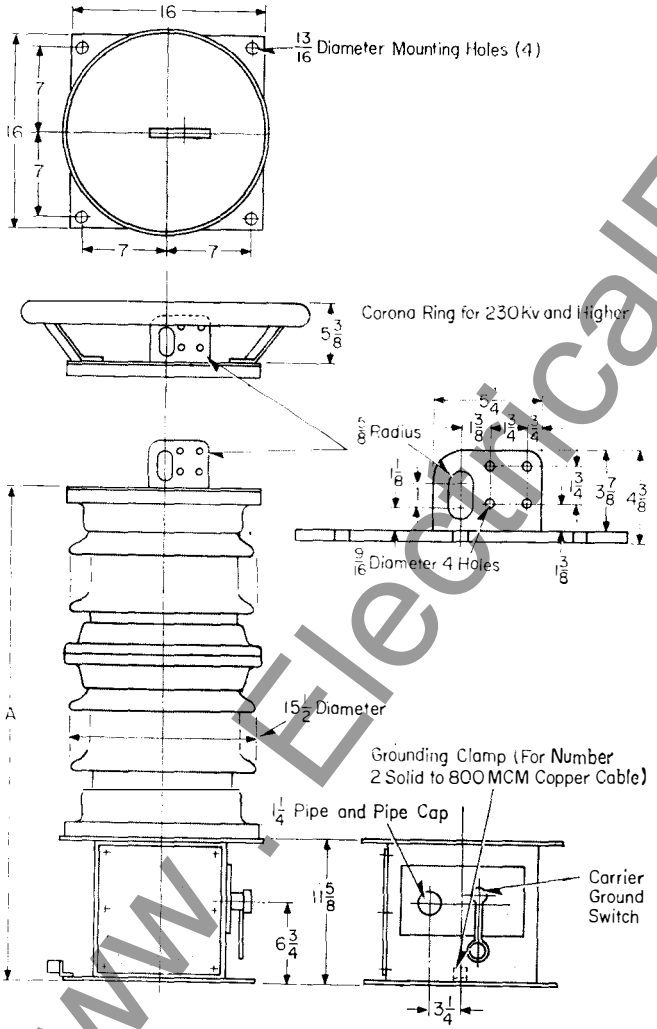
Figure 5: Type PF-4 Capaciformer

Westinghouse

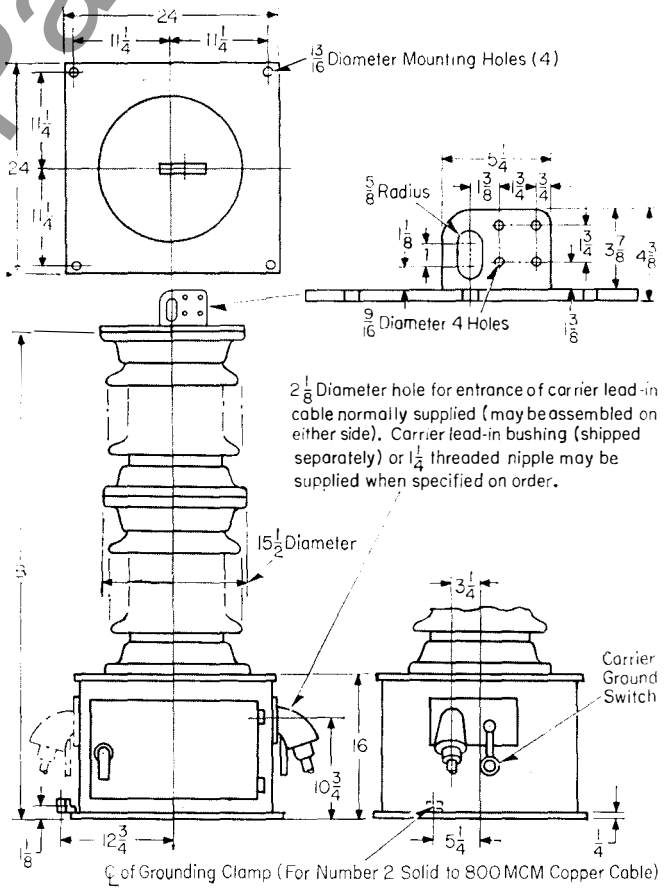
Dimensions in Inches Not to be used for construction purposes unless approved.



◀**Bolt Circles and Corona Ring**



Type CPI Potential Device



Type PF-4 Potential Device

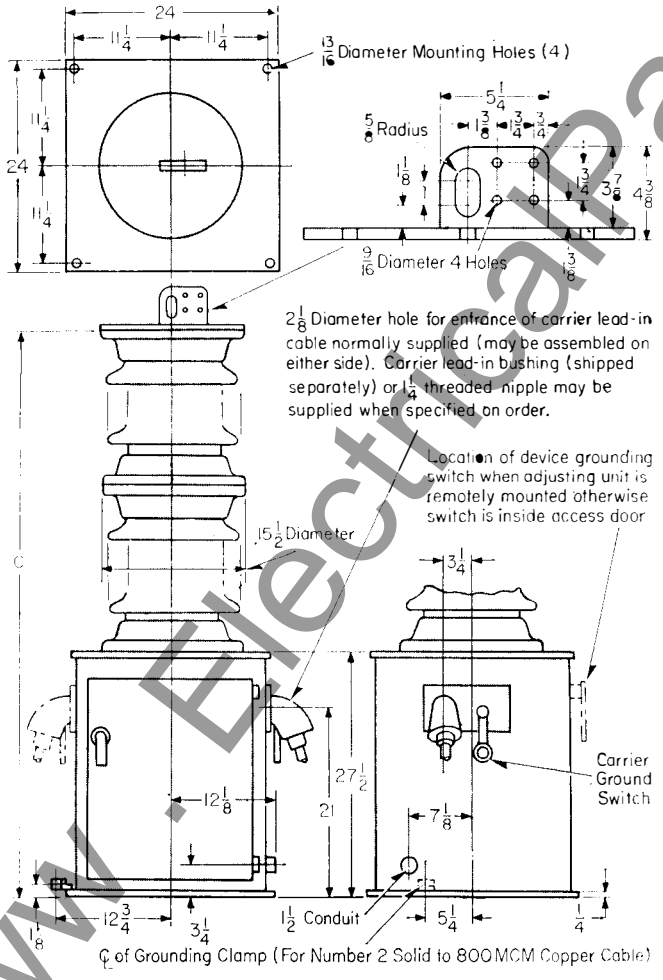
Coupling Capacitors Potential Devices

Low Capacitance
Field Adjusted

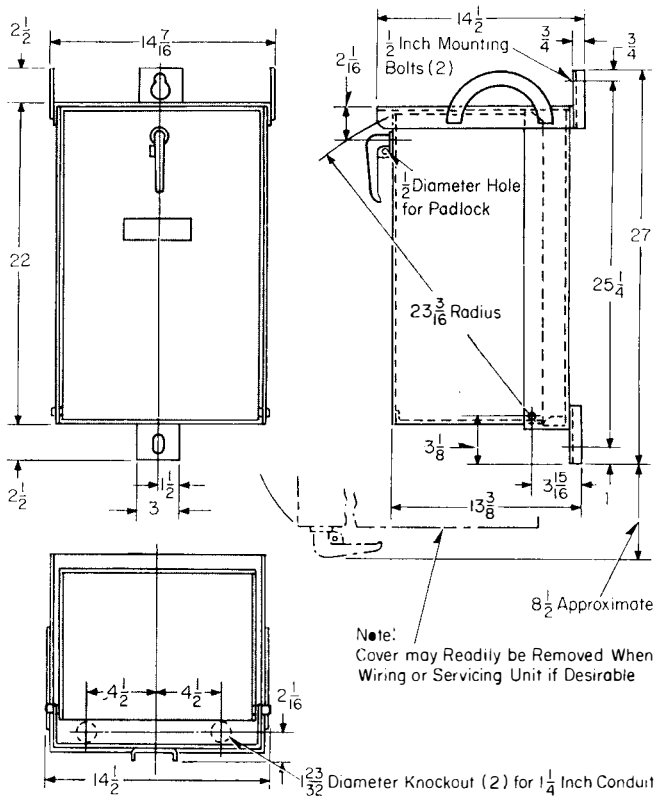
Ratings, Dimensions① and Weights

Parameter	Device Rating (Nominal System Kv)									
	34.5	46	69	92	115	138	161	230	287	345
Number and Rating of Coupling Units	1-34.5	1-46	1-69	1-92	1-115	2-69	1-46 1-115	2-115	1-46 2-115	3-115
Average Capacitance, Mfd.	.007	.0052	.0035	.0026	.0021	.00175	.0015	.0010	.00088	.00070
Low Frequency Test, Rms-Kv, 1 Minute Dry	85	110	165	215	265	320	370	525	655	785
10-Second Wet	80	100	145	190	230	275	315	445	555	665
Impulse Test, Crest Kv (+) or (−), 1.5/40 s, Full Wave	200	250	350	450	550	650	750	1050	1300	1550
Dimension A, Approximate Inches CPI	31¾	35¾	39¾	55¼	55¼	68½	80	99½	124¼	143¾
Dimension B, Approximate, Inches PF-4	36¾	40¾	44¾	60¼	60¼	73½	85	104½	129¼	148¾
Dimension C, Approximate, Inches PC-4, PCA-4, PCC-4	48¼	52¼	56¼	71¾	71¾	85	96½	116	140¾	160¼
Weight, Type PC-4	435	480	515	655	655	795	900	1075	1320	1495
Weight, Type PCA-4	745	790	825	965	965	1105	1210	1385	1630	1805
Weight, Type PF-4	465	510	545	685	685	825	930	1105	1350	1525
Weight, Type PCC-4	615	660	695	835	835	975	1080	1255	1500	1675
Weight, Type CPI	257	302	337	547	477	617	722	897	1142	1317

① Dimensions are approximate and should not be used for construction.



Type PC-4 Coupling Capacitor; Types PCA-4 and PCC-4 Coupling Capacitor Potential Devices



Remote Adjusting Unit for PCA-4

Coupling Capacitors Potential Devices

Low Capacitance
Field Adjusted

Specifications

Mechanical Strength

Standard base-mounted coupling capacitors and coupling capacitor potential devices of all voltage ratings have sufficient cantilever and tensile strength to withstand normal handling and winds up to 100 mph. The working cantilever strength is 9600 foot-pounds. Where other apparatus is supported on top of a coupling capacitor stack, the user should advise Westinghouse of all conditions such as weight, dimensions, method of mounting, expected wind velocity, expected earth shocks, and transverse cable loads.

Voltage Rating

Coupling capacitors and coupling capacitor potential devices are applied from one conductor of a transmission line to ground. Their voltage rating, however, is the system line-to-line voltage regardless of grounding practices on the system. The ground terminal of all coupling capacitors and coupling capacitor potential devices must be solidly grounded.

Reduced Voltage or 50-Cycle Operation

When the operating voltage of the circuit on which the coupling capacitor potential device is used is one rated circuit voltage lower than the rating of the device, or when operated on a 50-cycle system, the output rating of the device is 80% of the standard values and the design is such that standard accuracy is maintained at rated secondary voltage or voltages.

Overvoltage Operation

Emergency operation at 1.73 times normal voltage is permissible for extended periods of time.

Carrier Frequency

All coupling capacitors are suitable for use with carrier frequencies from 30 to 300 kc.

Carrier Accessories

Coupling capacitors are always supplied with carrier accessories unless otherwise specified. Coupling capacitor potential devices are not supplied with carrier accessories unless specified by the purchaser since they are required only when the application involves simultaneous use of the potential device and power line carrier coupling.

Further Information

Prices: PL 39-610

NEMA Classification of Potential Devices

Capacitor potential devices are divided into two general classifications based on AIEE Standards No. 31 and NEMA publication SG11-1955. One classification is the "in-phase" device with Class A accuracy and the other the "out-of-phase" device with Class C accuracy. Their characteristics are briefly:

Class A accuracy; in-phase type; adjustment to zero phase angle; maximum rated output 150 watts 60 cycle (Westinghouse types PCA-4 and PCA-5 – see Selector Guide 39-600 for PCA-5 literature). In this class, the secondary voltages are adjustable to be closely in-phase and to have correct ratio with respect to the line-to-ground voltage of the phase to which the device is connected, and remain so for all values of applied primary voltage and secondary burden within the rating of the device.

Class C accuracy; out-of-phase type; adjustment to 30° to 120° leading phase angle, maximum rated output 75 watts 60 cycles at 90° phase angle (Westinghouse type PCC-4 consisting of standard type PC-4 coupling capacitor units mounted on a base housing containing a Class C potential device). This class contains auxiliary burden components of resistance, inductance, and capacitance which are adjusted to control voltage, and to some extent the phase angle. This device has maximum output when the phase angle with respect to line-to-gorund voltage with which the device is connected is approximately 90° leading. Phase angle cannot be adjusted to zero but may be varied from 30° to 120° leading by proper adjustment of the secondary burden.

PCC-4 is available with integral adjusting unit or remote adjusting nut.

Burden

Types PCA-4 and PCC-4 potential devices should have a connected burden of at least 25% of rating in order to obtain satisfactory adjustment. It is desirable that the full burden rating of 150 watts be applied.

It is recommended that the output of PCA-4 potential devices not be fused. In a Class A device, the voltage across the auxiliary capacitor rises with increasing burden. The gap connected across the auxiliary capacitor will flash over and reduce the output voltage before the output current can increase enough to allow the fuse to operate. This is not true of PCA-5 devices (see Selector Guide 39-600).

Guaranteed Performance Under Rated Load PCA-4

Rated Output
- main winding – 150 watts.
- auxiliary winding – 75 watts.
- total simultaneous – 150 watts.

Secondary Voltages
- main winding – 115 and 66.4 volts.
- auxiliary winding – 115 and 66.4 volts.

Minimum Range of Ratio Adjustment – ±5%
Smallest Ratio Adjustment Steps – less than 1%.
Minimum Range of Phase Angle Adjustment – ±5°.
Smallest Phase Angle Adjustment Steps – less than 1°.
Maximum Ratio and Phase Angle Deviation with variation of applied voltage where device is initially adjusted within the limits shown at 100% voltage, with rated burden:

% Primary Voltage	% Ratio	Angle, Degrees
100	±1	±1
25	±3	±3
5	±5	±5

Maximum Ratio and Phase Angle Deviation with variation in burden when device is initially adjusted within the limits shown at 100% burden:

% Burden	% Ratio	Angle, Degrees
100	± 1	±1
50	± 6	±4
0	±12	±8

Metering and Relaying

PCA-4 coupling capacitor potential devices do not have sufficiently good phase angle and ratio regulation to permit their use for revenue metering. Refer to Type PCM potential devices in Selector Guide 39-600 for metering applications.

When PCA-4 Class A devices are used to energize high speed directional relays, it is recommended that such devices be loaded to their full watt rating with resistive load and that the power factor be corrected to slightly leading. Under these conditions, there is least possibility of incorrect relay operation resulting from a severe fault close to the device, this being the most critical condition.

Westinghouse Electric Corporation
Distribution Apparatus Division: Bloomington, Ind., 47401
Printed in USA