Westinghouse Type "PCA" Capacitor Potential Devices

CONSTRUCTION—INSTALLATION—OPERATION AND MAINTENANCE

Description:

The type PCA Capacitor Potential Device provides an economical source of low voltage energy suitable for the operation of instruments and relays. The device consists of two main parts, e. g., the coupling unit and the potential network.

The coupling unit consists of a stack of coupling capacitors bolted together forming a series capacitance between line and ground. The lower capacitor is a multiple unit containing a tap for connection to the potential device network. This tapped portion is sometimes called the auxiliary capacitor. When there are several units in the stack, the upper coupling capacitors are identical. The multiple capacitor unit is bolted directly to the device housing in the factory and the leads from this unit are connected through two solder sealed porcelain terminals which extend into the device housing. These terminals are marked B and C, the "B" terminal is connected to the potential network and the "C" terminal is connected to ground. When used with carrier, the connections to the "B" and "C" terminals are made through radio frequency choke coils.

The potential network is contained within a weatherproof housing which supports the capacitor stack, and is bolted thereto. It contains a variable reactance transformer, voltage adjusting transformer, potential device spark gap and ground switch, power factor correction capacitor, and a 1200 ohm resistor. When equipped for use with carrier relaying, a carrier frequency choke coil, carrier frequency drain coil, carrier gap, and an externally operated ground switch are also installed within the housing. A carrier lead with entrance insulator is supplied for connection to the carrier transmitter.

The primary of the variable reactance transformer is connected to the tapped coupling capacitor (terminal B) and protected by the potential device gap which is mounted on the top plate of the transformer. This gap is totally enclosed and sealed within a porcelain shell, and set in the factory to break down at 15 kv. minimum. A carrier frequency choke coil is connected between the capacitor tap (terminal B) and the transformer primary when the coupling capacitor is used as a carrier coupling. The potential device ground switch for grounding the primary of this transformer is mounted on the underside of the bottom capacitor base. The operating handle is located near the upper left hand corner of the panel assembly. It is made easily accessible by opening the door of the housing. Turning of the handle to the left, grounds the transformer thus removing voltage from the secondary circuits.

A carrier frequency drain (or choke) coil is connected between the capacitor terminal "C" and ground when the capacitor stack is used as a carrier coupling. This permits grounding of the capacitor within the potential device housing. The drain coil as well as the choke coil has low impedance to power frequency and very high impedance to carrier frequencies; thus preventing dissipation of carrier energy and at the same time effectively grounding the capacitor stack at 60 cycles. The carrier lead from the transmitter is connected within the device housing to a supporting strap which is bolted on terminal "C." When the drain coil is omitted, terminal "C" is grounded directly to the capacitor base.

The secondary taps of the transformers are connected to a panel located within the device housing. These taps terminate in dials 1 to 6 which are used to adjust the secondary voltage and angle. The power factor correction capacitor is connected to single pole switches mounted thereon, for controlling the required amount of corrective capacitance. Terminals for connection to instrument and relay circuits are provided on the panel.

The potential device housing is provided with an entrance on each side for assembly of the carrier frequency lead exit to the transmitter. The carrier ground switch is mounted on a plate which can be fastened to either entrance. The carrier lead cable and insulator are fitted into this plate for support and connection to the capacitor. A blank plate is provided on the opening not used. When the potential device is used for residual voltage only, connections to the capacitor stacks on the outer phase legs are made through these openings, using a special plate having the correct fittings. This special plate is only provided with the required cables when a device is specifically ordered for residual voltage service.

The potential device housing is provided with an upper and lower vent to facilitate circulation of air within the housing when desired. The upper vent consists of a small screened opening in one of the side plates, and the lower vent is a similar type of opening in the base plate near the front right corner. These openings are sealed for shipping purposes.

Application:

The type PCA potential device is designed for operation between one line and ground, and may be connected directly to the line without fuses or other protective apparatus. It is rated at 150 watts at rated line voltage. The device may be used in single or polyphase combinations to obtain corresponding secondary voltage to operate synchronoscope, voltmeters, power indicating meters, and the usual types of relays. The device is not sufficiently accurate for metering involving the "billing of power".

The device is equipped with a multiple secondary to provide simultaneously nominal values of 115 and 66.4 volts and a 115 volts from a separate ungrounded winding all in phase with the line to ground voltage of the system. The first two values are obtained from secondary terminals S_1-S_3 and S_2-S_3 which may be connected in 'star' with devices in the other two phases to obtain voltages in phase with the line-to-line voltage of the system. A ground terminal (Gr) is provided on the panel of each device to facilitate making the star connection. The latter value (115-V.) is obtained from secondary terminals Z_1-Z_3 and may be connected in 'delta' with corresponding terminals in the other two phases to obtain residual voltage for the operation of directional ground relays. A tap Z_2-Z_3 is provided to deliver 66.4 volts, if the use of terminals Z_1-Z_3 results in excessive residual voltage for the individual application. All three sets of terminals S1-S3, S2-S3, Z1-Z3 can be loaded simultaneously and adjustment made for the combined total burden.

Although most relays and instruments generally constitute linear burdens (constant impedance) at variable voltages, care should be exercised in the kind of burdens used with potential devices, particularly where high speed relaying is involved. Since a device contains the essential parts of a resonant network, the characteristic of the circuit may be affected if saturating burdens are used. Burdens including the use of a closed magnetic circuit should be avoided unless the iron is worked at low flux density at normal rated voltage. In addition, the use of high power factor burdens will result in the minimum effect due to transients and circuit stability is unquestionable.

The power factor correction capacitor supplied with the device may be used to change the equivalent power factor of lagging burdens to unity power factor. This capacitor may be connected either across the 115 volt or 66.4 volt secondary terminals S1-S3 or S2-S3 respectively by operation of the single pole, double throw switch on the panel. The 1200 ohm resistor connected to terminals W1 and W2 may be used to improve the power factor of small burdens by energizing W1 and W2 from S1-S2, S1-S3, or Z1-Z3 150 VA burdens having less than 90% power factor should be corrected to unity power factor. The potential device is inherently stable throughout the operating range and up to twice normal voltage when operated with the usual burdens. At voltages above twice normal, the protective gap will function to prevent a higher voltage on the potential network.

Inspection:

Upon receipt of the Capacitor Potential Device, the first step is to make a thorough inspection to see that no parts have been broken or otherwise damaged during shipment. Particular attention should be paid to the coupling capacitor porcelains. Any damage which has occurred should be taken care of by restoring the parts to the original condition or by obtaining replacement parts from the manufacturer. Claims for damage during shipment should be taken up at once with the transportation company.

Installation:

The equipment is shipped with the multiple coupling capacitor (bottom unit) bolted to the potential device housing (See Fig. 1). The upper coupling capacitors and the carrier lead cable are shipped separately and are to be assembled in the field according to outline drawing 3-D-1650 or 3-D-1651 approved for the equipment. When ventilation is required, the small counter-sunk pipe plug should be removed from the under-side of the base plate before locating the device on the foundation.

After placing the device assembly on the foundation, inspect to insure cleanliness of the capacitor bolting surfaces. Place the upper coupling capacitor assembly on top of the bottom unit and bolt the flanges together using hardware furnished with the equipment. Lugs have been provided on the top cover for lifting purposes.

The equipment should be properly grounded through the clamp type terminal provided on the base plate for this purpose at the rear of the housing. The terminal (A) on the top capacitor cover is to be bolted to the high tension bus or line, taking care to prevent any undue strain due to expansion and contraction of the high voltage bus or line from being imposed on the capacitors.

Install conduit to the 1-1/2" conduit fitting at the front of the device housing and connect the leads from the station switchboard to the secondary terminals of the device as desired.

When using the device as a carrier coupling, the carrier lead cable should be installed at either of the side plate openings. Access to the inside of the device housing can be obtained by removing the 3 bolts holding the panel in place and allow it to lean forward at approximately 45 degrees. The housing right hand side plate will be equipped at the factory with a hook stick operative carrier ground switch, and will be connected internally to coupling capacitor terminal "C" See Figs. 1 or 3. The round blind flange on this plate is to be removed and the entrance porcelain on the carrier cable should be inserted using the gasket furnished. See Fig. 2. The porcelain is held in the housing by means of a flexible metallic ring which is tightened in place with 2 small bolts on the clamping ring. Care should be taken in installing the cable assembly to see that the gasketed joint is properly made, using the cement furnished, to effectively seal the joint. Connect the carrier frequency lead internally to the stud of the switch jaw as shown in Fig. 2 and replace the panel. The carrier gap is shown in detail in Fig. 3. It consists of a 1/4" ball gap, one end of which is connected to the capacitor terminal "C;" the other to the ground plate on the under side of the capacitor.

The carrier frequency lead can be connected to the left side of the housing by inter-changing the side plates and re-connecting to the horizontal internal connection strap which is attached to the drain coil and terminal "C".

In some installations, particularly where air circulation in the device is desired, the small 10-watt (1200 ohm) resistor can be used to heat damp air that may exist in some locations and prevent condensation. Air circulation is provided by removing the pipe cap from the inclined pipe on one of the side entrance plates and by removing the pipe plug in the base of the housing. The resistor can be energized from S1-S3 or Z1-Z3 on the device panel or from a separate 115-volt source.

Adjustment:

Before energizing the device, check to see that the transformer primary ground switch on each phase is closed, remove the knurled studs holding the dial arms in place and remove the blocking strap across the condenser switches. All adjustments of voltage and phase angle are made on the adjusting panel. Set dial 1 on the X1 position and dial 2 on the X3 position. Connect the actual burdens involved, if low burden adjusting instruments are used, or connect equivalent burdens to include the burden of the adjusting instruments. Adjustments should be made on a single phase basis individually. The method of determining adjusting burdens is given in Instruction Book 5441D.

To adjust the device, energize the capacitor stack at normal line voltage (to ground) and frequency. Set dials 3 and 4 on the R7 position and dials 5 and 6 on the V28 and V1 positions respectively. With the secondary terminals connected to a burden, including a voltmeter and phase-meter, open the transformer primary ground switch by turning approximately 120 degrees in a clockwise direction. (The ground switch should be closed when making or changing potential device adjustments). Note the reading of the phase meter as compared to a known voltage and also the secondary voltage as compared to the known voltage, and ratio. The correct line voltage should be ascertained to see if it corresponds to the rated voltage of the device, for instance 161-kv. If the line voltage is less than normal rating of the device, this fact should be taken into consideration in setting the secondary voltage so that all 3 devices in a 3 phase group will have the same secondary voltage when connected in 'star'.

Using these readings of voltage and angle as a starting basis, the device settings should be changed in accordance with the following information:

Phase angle adjustment: Taps R1 to R14 are provided on the variable reactance transformer for adjustment of phase angle. This winding is used to boost or buck the inherent reactance of the transformer and is controlled in this respect by the 2 pole double throw switch on the adjusting panel. Excessive inductive reactance will result in lagging phase angle and lack of reactance will result in leading phase angle. Large steps of reactance are obtained from dial number 4 and small steps from dial number 3.

If the original angular reading is lagging, set the double pole double throw switch in the "buck" position and move dial 4 clockwise to give a lagging angle closest to zero. Then move dial 3 counter clockwise to bring the angle to zero.

If the original angular reading is leading, set the double pole double throw switch in the "boost" position and move dial 4 clockwise to give a leading angle closest to zero; then move dial 3 counter clockwise to bring the angle to zero. Steps on dial 4 are in approximately 3 degree increments and steps on dial 3 are in approximately 1/4 to

1/2 degree increments at rated burden.These amounts are affected to some extend by the burden imposed on the device.

Voltage Adjustment: Taps V1 to V28 are provided on the voltage adjusting transformer for adjustment of secondary voltage. This transformer will increase or decrease the voltage obtained from terminals X1-X3 of the variable reactance transformer and is controlled by dials 5 and 6. Large steps of voltage are obtained from dial number 6 and small steps from dial number 5. Transformer ratios are indicated in figure 4.

The secondary voltage will, in most cases, be low with dials 5 and 6 set on the V28 and V1. Turn dial 6 clockwise until the voltage is increased to a value closest to but not exceeding the desired secondary voltage; then turn dial 5 counter-clockwise until the exact correct secondary voltage is obtained.

Under burden conditions, steps on dial 6 are in approximately 4 to 6 volt increments and steps on dial 5 are in approximately .3 to .5 volt increments. These amounts are affected to a small extent by the burden imposed on the device.

Approximate Adjustments: As a basis for adjusting devices in the field, several typical dial settings are given here for burdens as indicated:

Zero Phase Angle Displacement:

115 Kv.

(a) Burden: 150 watt - 66.4 volt - Terminals S2-S3.

Setting: X1-X3-R1-R10-V16-V9. D.P.D.T. switch in buck position.

(b) Burden: 25 watt - 66.4 volt - Terminals S2-S3.

Setting: X1-X3-R7-R10-V1-V8. D.P.D.T. switch in buck position.

161 Kv.

(a) Burden: 150 watt - 66.4 volt - Terminals S2-S3.

Setting: X1-X3-R7-R9-V26-V10. D.P.D.T. switch in buck position.

(b) Burden: 25 watt - 66.4 volt - Terminals S2-S3.

Settings: X1-X3-R2-R8-V28-V9. D.P.D.T. switch in buck position.

(c) Burden: 150 watt - 115 volt - Terminals S1-S3.

Settings: X1-X3-R7-R9-V16-V9. D.P.D.T. switch in buck position.

(d) Burden: 50 watt - 115 volt - Terminals S1-S3.

Settings: X1-X3-R1-R8-V26-V9. D.P.D.T. switch in buck position.

30 Degree Phase Angle Displacement:

The devices may also be adjusted for 30 degree lagging phase angle with respect to line-to-ground phase voltage. This is accomplished by loading the device with 150 VA leading power factor burden. A sufficient amount of resistance in parallel with the burden, and the required power factor correction capacity will provide the necessary adjustment. The combined burden should not exceed 150 VA.

A typical 161 kv. device adjustment at normal line voltage is as follows:

Total Burden 150 VA (117 ohms in parallel with 20 Mfds.)
Sec. Volts 115 - Phase Angle 30° lag - Terminals S1-S3.
Settings: -X1-X3-R5-R13-V6-V20-C5-C6-C7.
D.P.D.T. switch in "boost" position
S.P.D.T. switch in "115-V." position.

Similar adjustments are obtained with other voltage class units.

When the final setting has been obtained, it is desirable to check the capacitor tap or transformer primary voltage. This is done by measuring the voltage between H2 terminal and Gr terminal on the panel, using a high resistance voltmeter. The measurement should be made at normal line voltage with the maximum service burden connected. This reading will usually be less than 140 volts and in no case should it exceed 150 volts. The ratio of the H2 tap is 50 to 1.

Lagging burden power factor correction is obtained by adjustment of the single pole switches on the main panel. Operation of the single pole double throw (S.P.D.T.) switch will connect one side of the capacitor to either the 115-V. or 66.4 volt secondary. Closing of switches C2 to C7 will energize the capacitor, thus inserting the capacity correction.

Power Factor Adjustment: Based on the known volt ampere and power factor of the burden at the voltage involved, determine the reactive volt ampere component as follows:-

$$\text{Reactive Factor (RF)} = \sqrt{1 - (\text{Power Factor})^2}$$

Reactive Volt amps. = Burden Volt amps. X.R.F.

Using curves of Fig. 5, determine the required correction in microfarads. By proper selection of switch combinations, the desired value of capacitance may be obtained in steps of 3.5 volt amperes. Over-correction is recommended. The nominal capacitance values available are as follows:-

Switch	Capacitance (MF)	Volt Amps. (115 V.)
C2	.70	3.50
C3	1.45	7.25
C4	1.60	8
C5	3.00	15
C6	6.00	30
C7	12.00	60

After adjustments have been completed, the dial arms should be locked in place with the knurled set screws shipped with the equipment and the switches locked in position by use of the insulating strap. Care should be taken to see that all power factor correction capacitor switches not used are in the full open position. The potential device ground switch should be left in the open position. The door of the housing should be closed tightly by complete ninety degree turn of the handle. See that the hook stick operated carrier ground switch is placed in the "grounded" position until after connection has been properly made to the carrier.

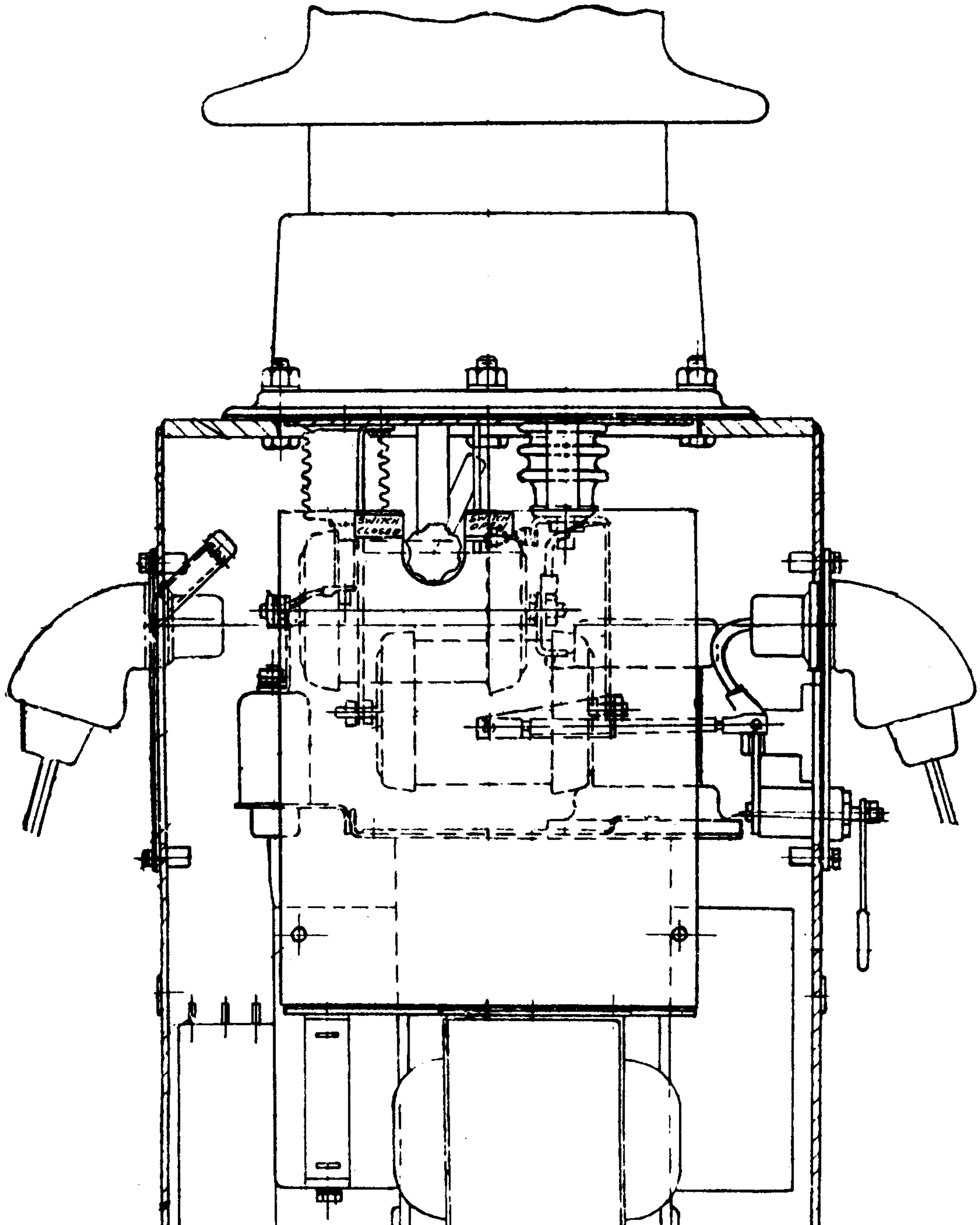


Figure 1

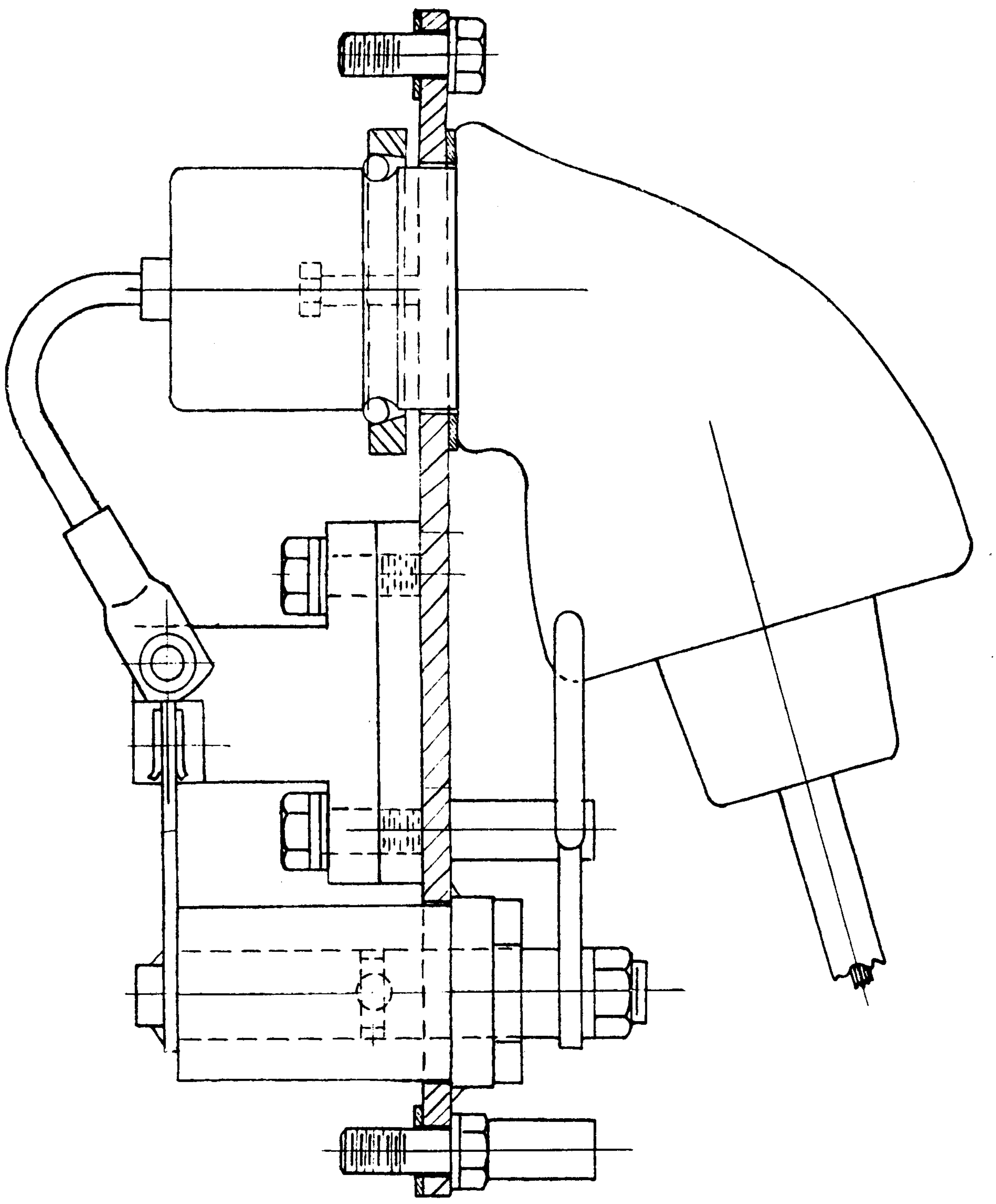


Figure 2

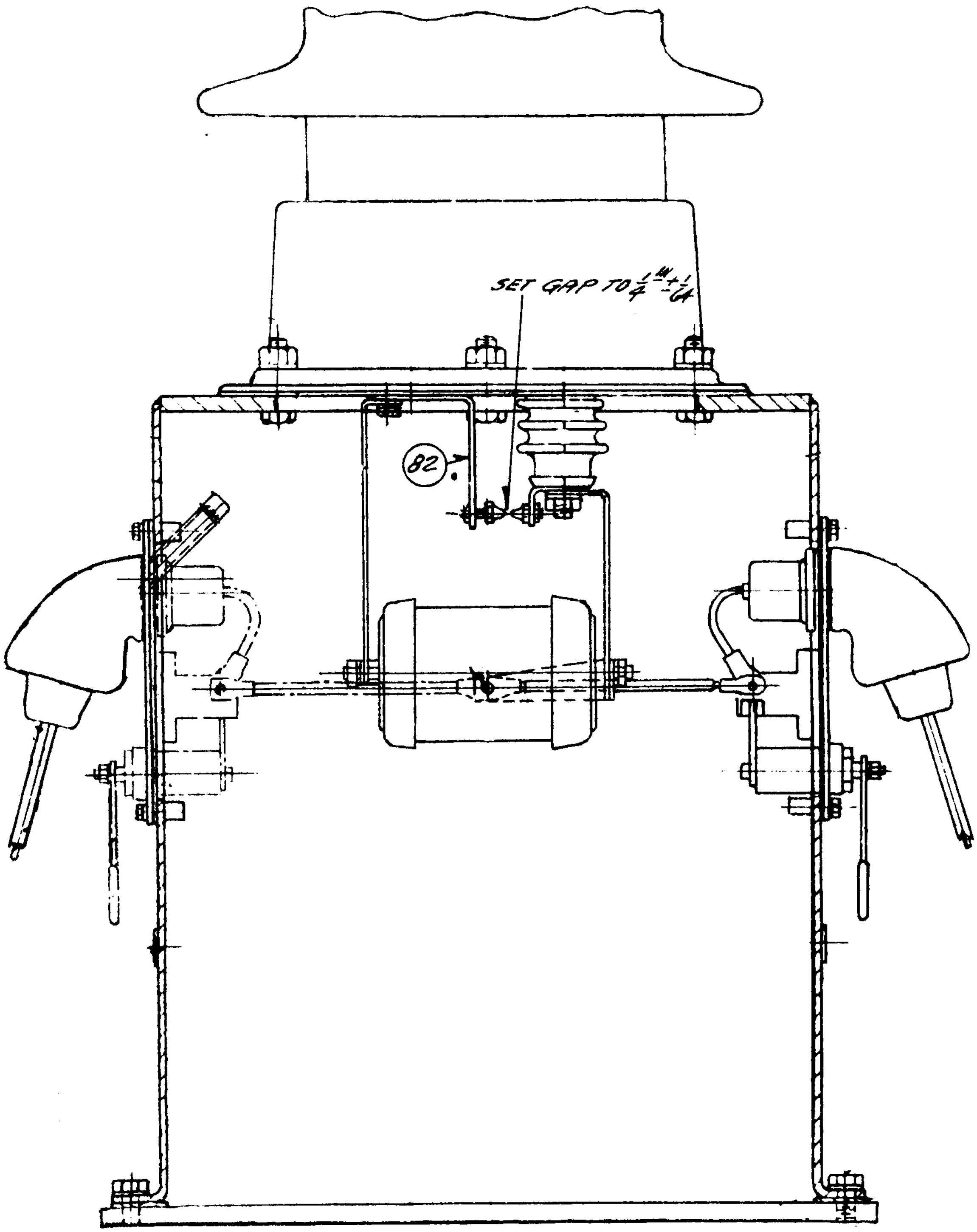
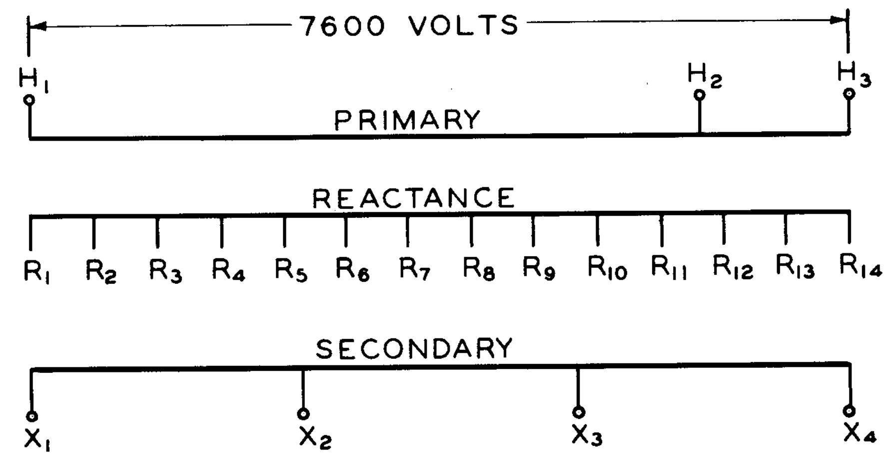


Figure 3

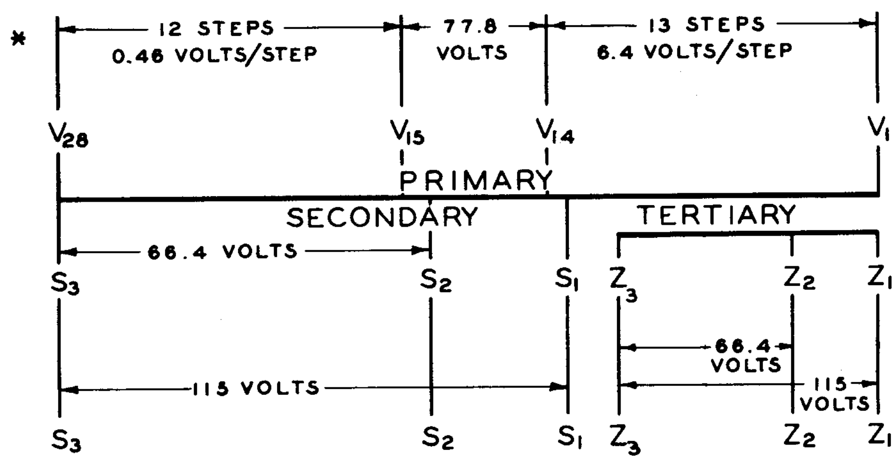
TRANSFORMER RATIO CHART

VARIABLE REACTANCE TRANSFORMER



TAP	RATIO TO PRIMARY
$H_2 - H_3$	50/1
$X_2 - X_3$	50/1
$X_1 - X_3$	40/1
$X_2 - X_4$	35.2/1
$X_1 - X_4$	30/1

VOLTAGE ADJUSTING TRANSFORMER



* BASED ON NO LOAD VOLTAGE

Figure 4

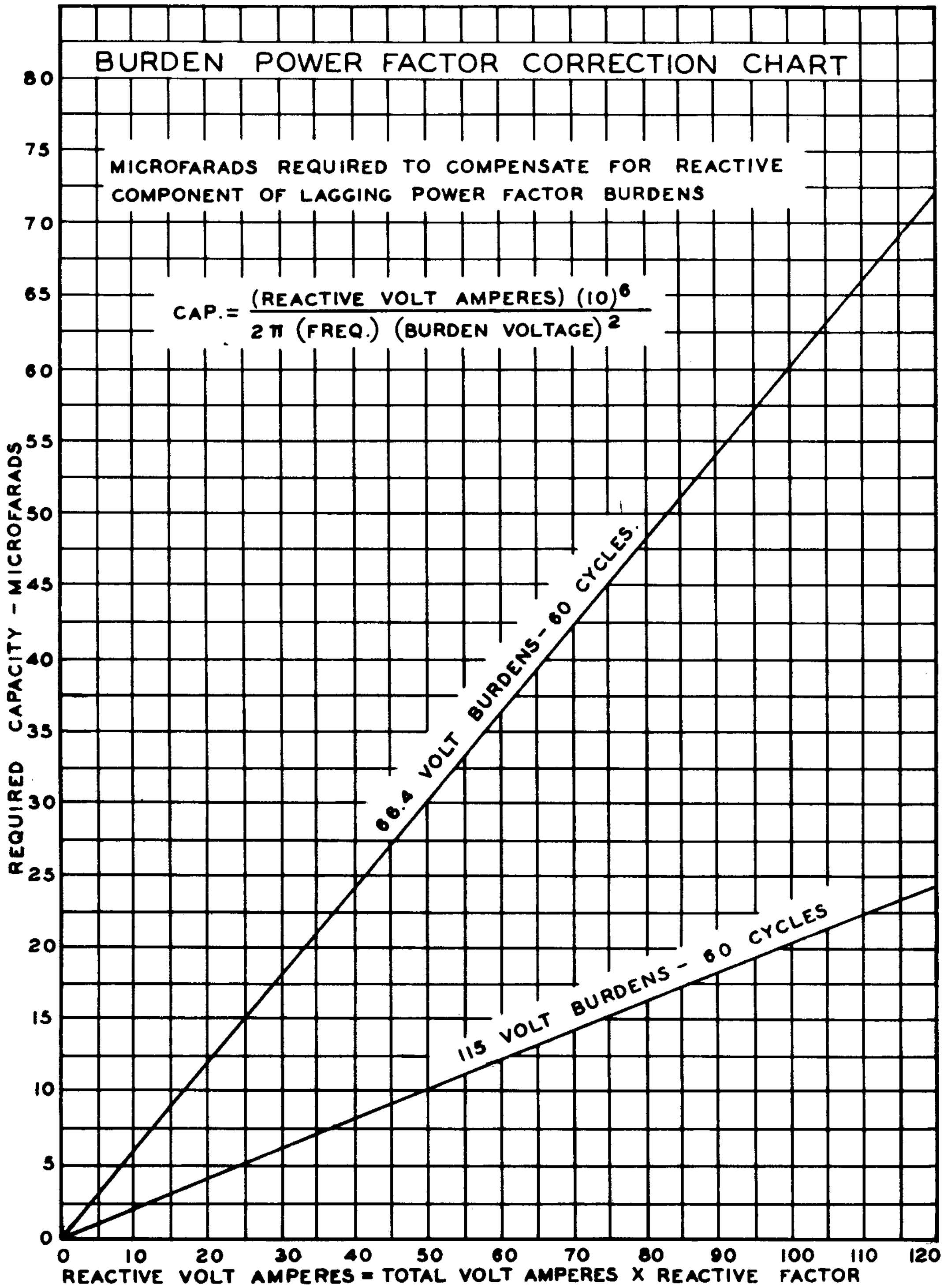

BURDEN POWER FACTOR CORRECTION CHART
MICROFARADS REQUIRED TO COMPENSATE FOR REACTIVE COMPONENT OF LAGGING POWER FACTOR BURDENS
CAP. = (REACTIVE VOLT AMPERES) (10)6 / 2π (FREQ.) (BURDEN VOLTAGE)2
66.4 VOLT BURDENS - 60 CYCLES.
115 VOLT BURDENS - 60 CYCLES
REQUIRED CAPACITY - MICROFARADS
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
0 10 20 30 40 50 60 70 80 90 100 110 120
REACTIVE VOLT AMPERES = TOTAL VOLT AMPERES X REACTIVE FACTOR

Figure 5

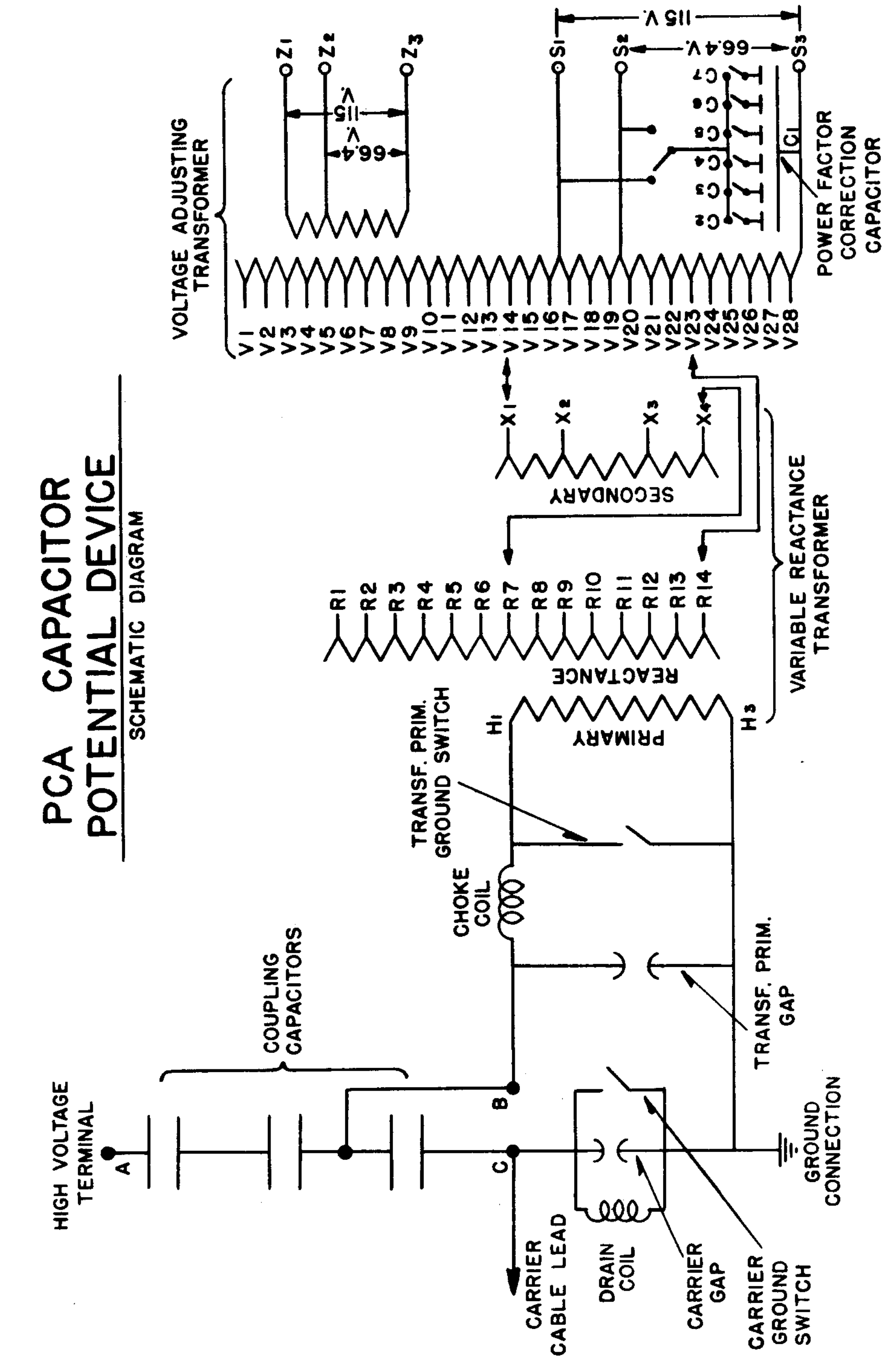
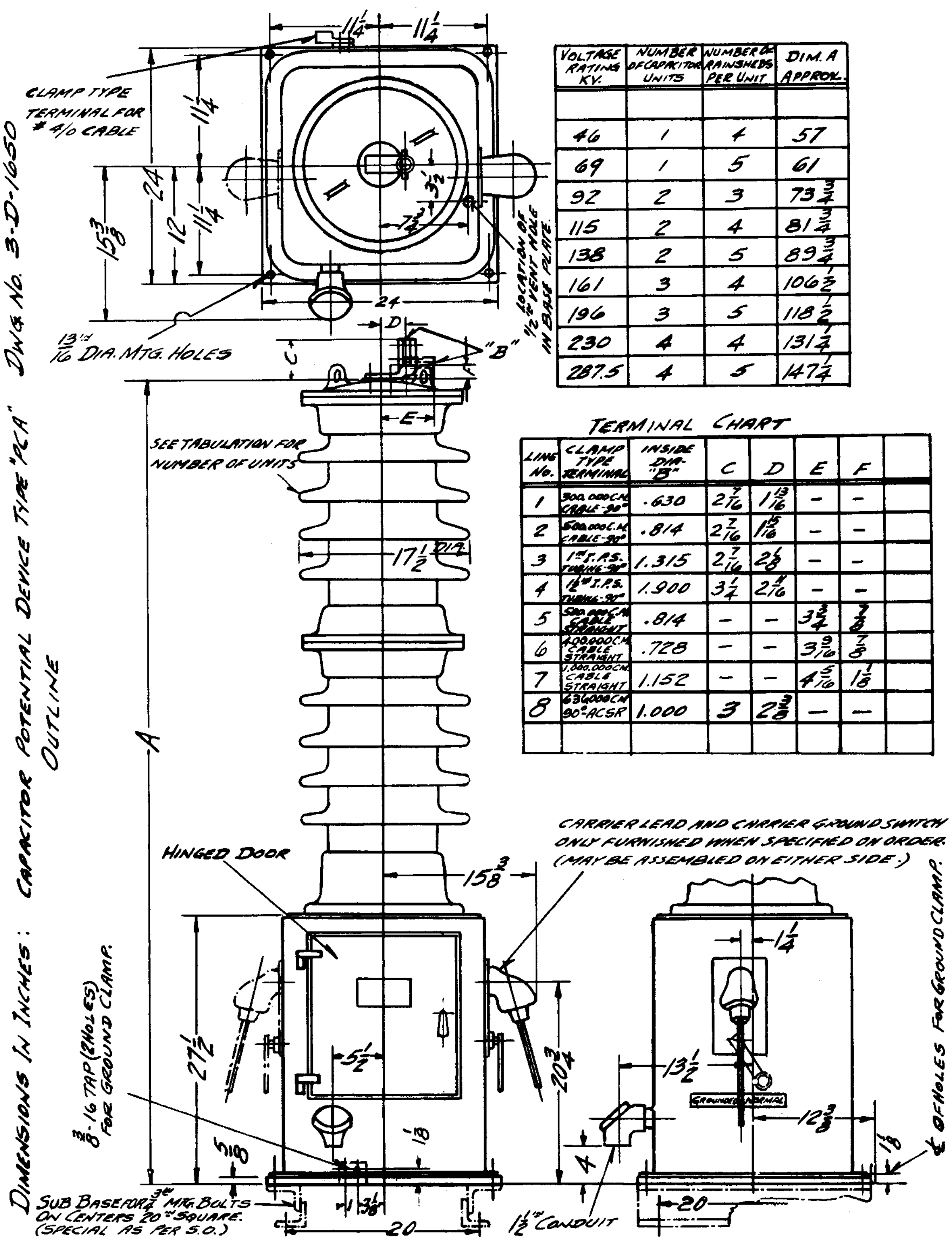

PCA CAPACITOR
POTENTIAL DEVICE
SCHEMATIC DIAGRAM
HIGH VOLTAGE TERMINAL
A
B
C
COUPLING CAPACITORS
CARRIER CABLE LEAD
DRAIN COIL
CARRIER GAP
CARRIER GROUND SWITCH
GROUND CONNECTION
CHOKE COIL
TRANSF. PRIM. GROUND SWITCH
TRANSF. PRIM. GAP
H1
H3
PRIMARY
REACTANCE
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14
SECONDARY
X1 X2 X3 X4
VARIABLE REACTANCE TRANSFORMER
V1 V2 V3 V4 V5 V6 V7 V8 V9 V10 V11 V12 V13 V14 V15 V16 V17 V18 V19 V20 V21 V22 V23 V24 V25 V26 V27 V28
VOLTAGE ADJUSTING TRANSFORMER
Z1 Z2 Z3
66.4 V.
115 V.
S1 S2 S3
66.4 V.
115 V.
C1 C2 C3 C4 C5 C6 C7
POWER FACTOR CORRECTION CAPACITOR

Figure 6

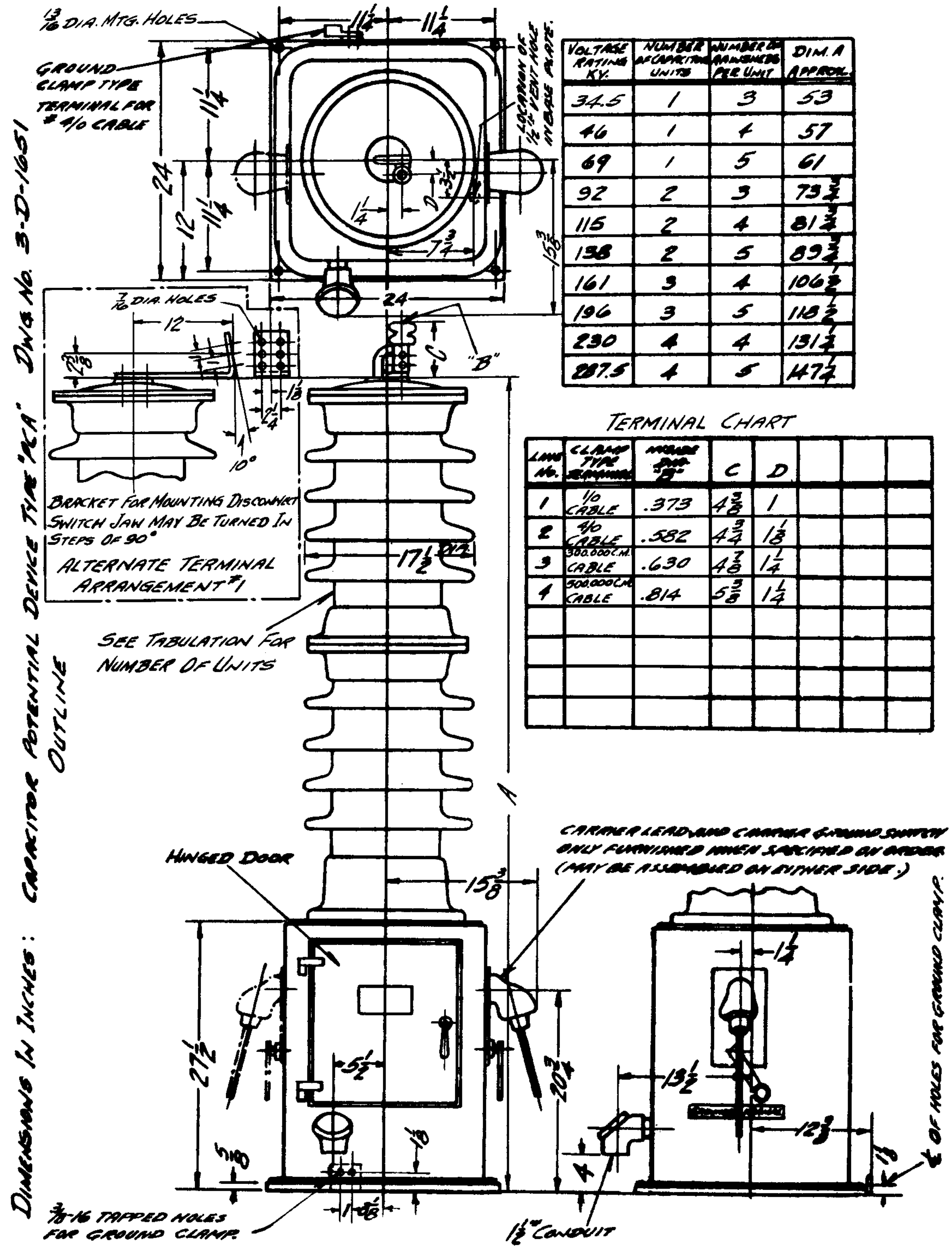


VOLTAGE RATING KV.	NUMBER OF CAPACITOR UNITS	NUMBER OF RAINSHEDS PER UNIT	DIM. A APPROX.
46	1	4	57
69	1	5	61
92	2	3	$73\frac{3}{4}$
115	2	4	$81\frac{3}{4}$
138	2	5	$89\frac{3}{4}$
161	3	4	$106\frac{1}{2}$
196	3	5	$118\frac{1}{2}$
230	4	4	$131\frac{1}{4}$
287.5	4	5	$147\frac{1}{4}$

TERMINAL CHART

LINE No.	CLAMP TYPE TERMINAL	INSIDE DIA. "B"	C	D	E	F	
1	300,000 C.M. CABLE-90°	.630	$2\frac{7}{16}$	$1\frac{13}{16}$	–	–	
2	500,000 C.M. CABLE-90°	.814	$2\frac{7}{16}$	$1\frac{15}{16}$	–	–	
3	1" I.P.S. TUBING-90°	1.315	$2\frac{7}{16}$	$2\frac{1}{8}$	–	–	
4	$1\frac{1}{2}$" I.P.S. TUBING-90°	1.900	$3\frac{1}{4}$	$2\frac{11}{16}$	–	–	
5	500,000 C.M. CABLE STRAIGHT	.814	–	–	$3\frac{3}{4}$	$\frac{7}{8}$	
6	400,000 C.M. CABLE STRAIGHT	.728	–	–	$3\frac{9}{16}$	$\frac{7}{8}$	
7	1,000,000 C.M. CABLE STRAIGHT	1.152	–	–	$4\frac{5}{16}$	$1\frac{1}{8}$	
8	636,000 C.M. 90°-ACSR	1.000	3	$2\frac{3}{8}$	—	—	

Figure 7



VOLTAGE RATING KV.	NUMBER OF CAPACITOR UNITS	NUMBER OF [illegible] PER UNIT	DIM. A APPROX.
34.5	1	3	53
46	1	4	57
69	1	5	61
92	2	3	73¾
115	2	4	81¾
138	2	5	89¾
161	3	4	106¾
196	3	5	118½
230	4	4	131¼
287.5	4	5	147¼

TERMINAL CHART

LINE No.	CLAMP TYPE TERMINAL	[illegible] "B"	C	D
1	1/0 CABLE	.373	4⅜	1
2	4/0 CABLE	.582	4¾	1⅛
3	300,000 C.M. CABLE	.630	4⅞	1¼
4	500,000 C.M. CABLE	.814	5⅜	1¼

Figure 8

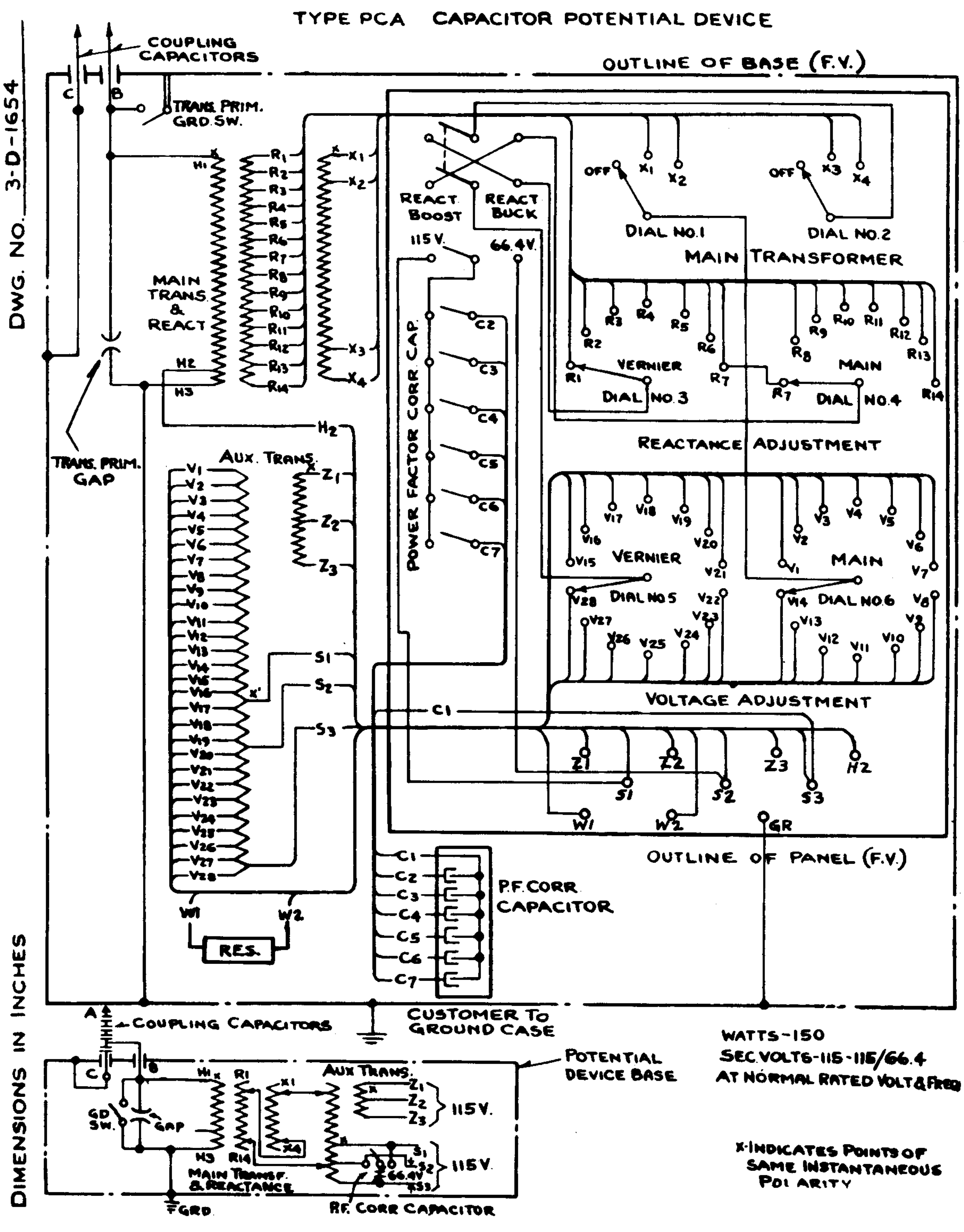

TYPE PCA CAPACITOR POTENTIAL DEVICE
DWG. NO. 3-D-1654
COUPLING CAPACITORS
OUTLINE OF BASE (F.V.)
TRANS. PRIM. GRD. SW.
MAIN TRANS. & REACT.
TRANS. PRIM. GAP
REACT BOOST
REACT BUCK
115 V.
66.4 V.
DIAL NO. 1
DIAL NO. 2
MAIN TRANSFORMER
VERNIER
DIAL NO. 3
MAIN
DIAL NO. 4
REACTANCE ADJUSTMENT
POWER FACTOR CORR. CAP.
AUX. TRANS.
VERNIER
MAIN
DIAL NO 5
DIAL NO 6
VOLTAGE ADJUSTMENT
OUTLINE OF PANEL (F.V.)
P.F. CORR. CAPACITOR
RES.
DIMENSIONS IN INCHES
COUPLING CAPACITORS
CUSTOMER TO GROUND CASE
POTENTIAL DEVICE BASE
GD SW.
GAP
MAIN TRANSF. & REACTANCE
AUX TRANS.
115 V.
115 V.
66.4 V.
GRD
P.F. CORR CAPACITOR
WATTS-150
SEC. VOLTS-115-115/66.4
AT NORMAL RATED VOLT & FREQ
X-INDICATES POINTS OF SAME INSTANTANEOUS POLARITY

Figure 9

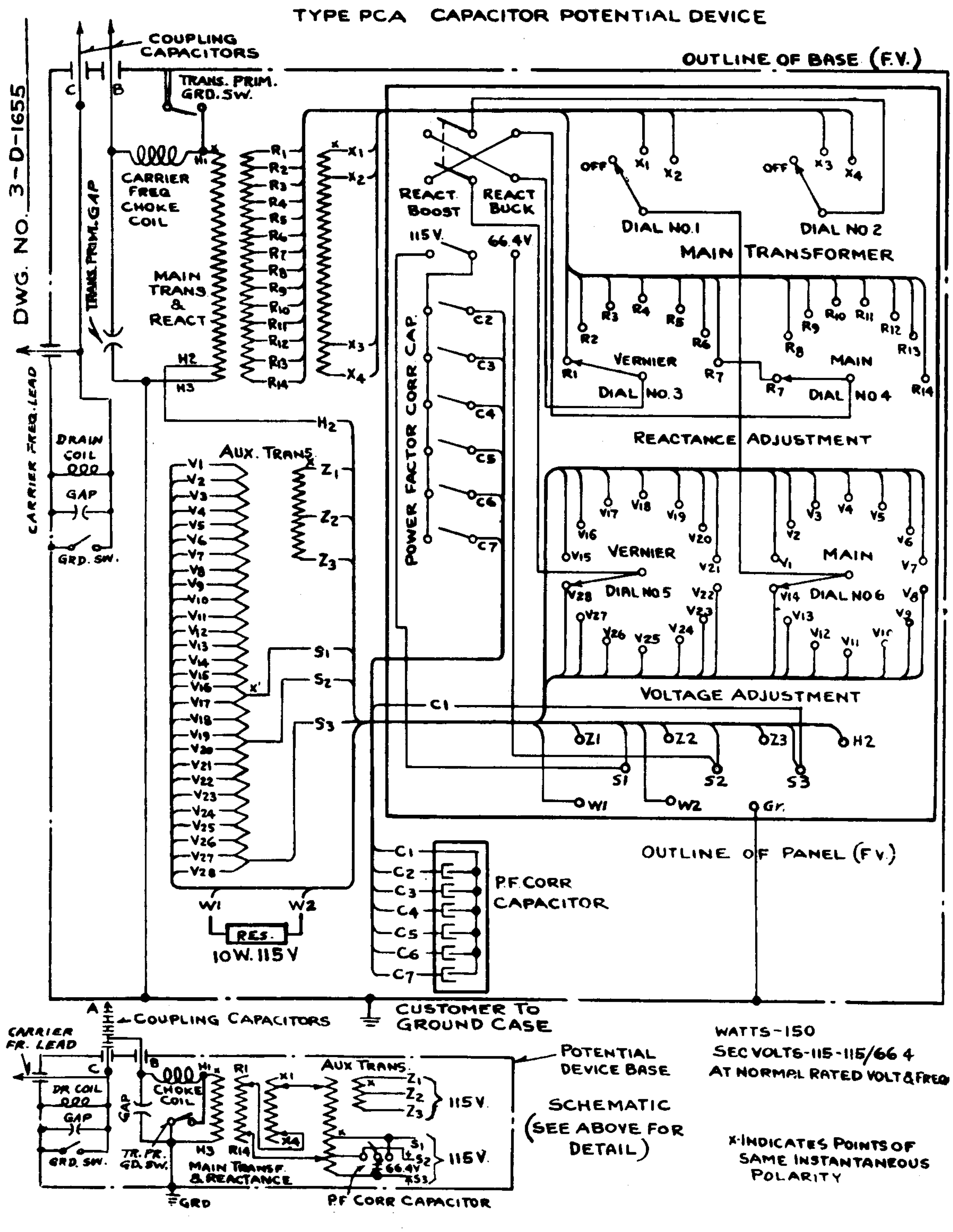
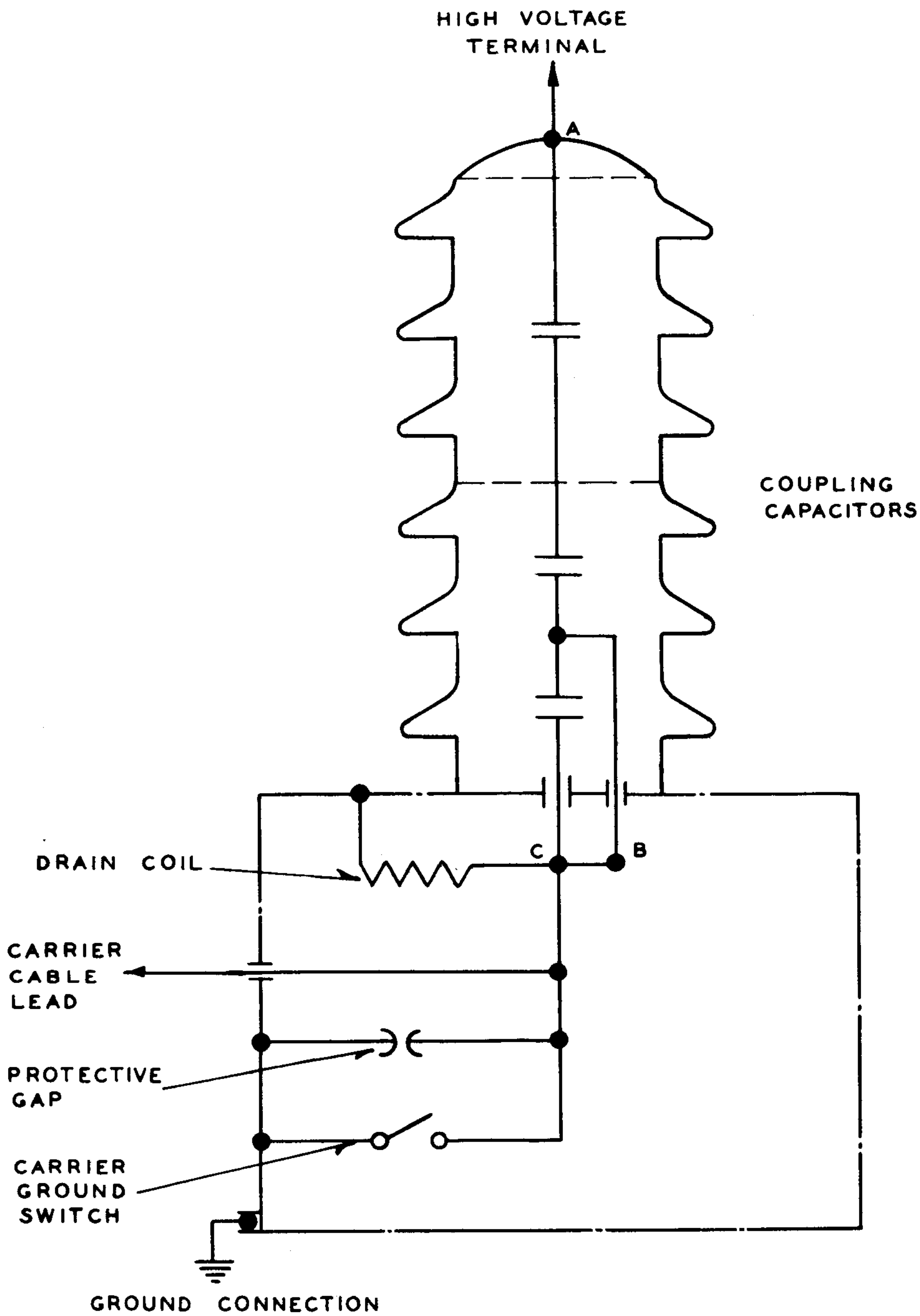

TYPE PCA CAPACITOR POTENTIAL DEVICE
DWG. NO. 3-D-1655
COUPLING CAPACITORS
OUTLINE OF BASE (F.V.)
TRANS. PRIM. GRD. SW.
CARRIER FREQ CHOKE COIL
MAIN TRANS & REACT
TRANS. PRIM. GAP
CARRIER FREQ. LEAD
DRAIN COIL
GAP
GRD. SW.
REACT BOOST
REACT BUCK
115 V.
66.4V
DIAL NO. 1
DIAL NO 2
MAIN TRANSFORMER
VERNIER
MAIN
DIAL NO. 3
DIAL NO 4
REACTANCE ADJUSTMENT
POWER FACTOR CORR CAP.
AUX. TRANS.
VERNIER
MAIN
DIAL NO 5
DIAL NO 6
VOLTAGE ADJUSTMENT
OUTLINE OF PANEL (F.V.)
P.F. CORR CAPACITOR
RES.
10W. 115V
CUSTOMER TO GROUND CASE
COUPLING CAPACITORS
CARRIER FR. LEAD
DR COIL
CHOKE COIL
TR. PR. GD. SW.
MAIN TRANSF. & REACTANCE
GRD
P.F. CORR CAPACITOR
115V.
POTENTIAL DEVICE BASE
SCHEMATIC (SEE ABOVE FOR DETAIL)
WATTS-150
SEC VOLTS-115-115/66.4
AT NORMAL RATED VOLT & FREQ
X-INDICATES POINTS OF SAME INSTANTANEOUS POLARITY

Figure 10



CARRIER CURRENT COUPLING
DEVICE

Figure 11

MEMORANDUM