INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

PILOT WIRE INSULATION AND PROTECTION FOR HCB AND HCB-1 RELAYING

APPLICATION

The insulation and protection equipment shown in Fig. 1. is used with the HCB or HCB-1 pilot wire relay. A complete installation for one terminal of a line consists of an insulating transformer, neutralizing reactor, capacitors, mutual drainage reactors and neutralizing reactor KX642 tube.

AC Bypass Capacitor (C)

The AC bypass capacitor (C) is required only when DC monitoring and/or remote trip relays are used. Otherwise connect H2 to H3 on the insulating transformer (refer to Fig. 1.). Use a 10 ufd capacitor for 50/60 cycle applications or a 25 ufd capacitor for 25 cycle applications.

Exciting Capacitors (Cg)

The exciting capacitors (Cg) and ground connection are omitted when the neutralizing reactor is not used. Use a 10 ufd capacitor for 50/60 cycle applications or a 2.5 ufd capacitor for 25 cycle applications.

Mutual Drainage Reactor

The mutual drainage reactor is applied to drain off longitudinally induced voltages which may occur by lightning surges (not a direct stroke) or the parallel association of the pilot wire with faulted power circuits.

The mutual drainage reactors must be applied at more than one terminal or location to provide a path for the drainage currents to flow.

With the mutual drainage reactor only (hence no rise-in-station ground hazzard), the remote and station ground are essentially equal, and the KX642 tube ground should be connected to the station ground.

Neutralizing Reactors

The neutralizing reactors are applied where the difference between station ground and remote ground can exceed 600 volts rms during power system faults. This rise in station ground potential appears across the neutralizing transformer inserted in the pilot wire. Thus all equipment and circuitry to the left of the neutralizing reactor terminals H2 and H4 (Fig. 1.) are essentially at station ground. All equipment, circuits, pilot wire, sheath, etc. to the right of H1 and H3 (Fig. 1.) are at remote ground and must be insulated from station ground and operating personnel in the station area. The shunt capacity to ground of the pilot wire pair should be on the order of 1 ufd or more. If not, capacitance (Cs) should be added as shown to provide equivalent of approx. 1 ufd. total on each wire to ground.

The neutralizing reactor and mutual drainage reactor may be used together as shown or either may be applied separately depending on the hazards encountered.

The neutralizing reactor may be applied at one terminal only if there is no rise in voltage at the other terminals.

Neutralizing Reactor Tube KX642

The neutralizing reactor tube KX642 is not necessary with modern shielded pilot wires, and is not required in addition to the mutual drainage reactor.

SUPERSEDES MIMEOGRAPHED
I. L. 41-971.4

EFFECTIVE SEPTEMBER 1966

TECHNICAL DATA

Insulating Transformer

Style	Rating	Frequency	Schematic	Reference	Outline Reference
1575394	4/1	50-60 Cycles	20D1472	Fig.2	Fig.3(a)
1629502	6/1	50-60 Cycles	16D9583	Fig.2	Fig.3(a)
248A692G06	4/1	25 Cycles	20D1472	Fig.2	Fig.3(b)
S.O. #HLR 2784	6/1	25 Cycles	16D9583	Fig.2	Fig.3(b)

General Specifications	Units	4/1	6/1	4/1	6/1	4/1	6/1
		60 Cycles		50 Cycles		25 Cycles	
Rated Voltage H1-H2 & H3-H4	Volts	60	90	60	90	60	90
Rated Voltage X1-X2	Volts	30	30	30	30	30	30
Continuous Rating H Windings	MA.	12	8	12	8	12	8
Resistance of each H Winding	Ohms	20.4	46.5	20.4	46.5	28.5	
Continuous Rating X Winding	MA.	48	48	48	48	48	48
Resistance of X Winding	Ohms	1.7	1.7	1.7	1.7	2.3	
Insulation H & L Windings to Ground	KV	5.0	5.0	5.0	5.0	5.0	5.0
Exciting Impedance X_1-X_2 at 30 V.	Ohms	850-1250	850-1250	850-1250	790-1030	1250-2000	1250-2000
Approx. Weight	Lbs.	25	25	25	25	40	40

KX-642 Gas Tube

A.C. rms voltage breakdown	300 - 500 Volts
Tube Voltage drop, average D.C.	20 - 30 Volts
1 Second current rating	90 Amps
2 Second current rating	40 Amps

Neutralizing Reactor

Style	Freq.	With KX6R Tube & Socket	Schematic	Reference	Outline Reference
1255186	60	Yes	6D1260	Fig.2	Fig.4 (b)
1255289	60	No	6D1260	Fig.2	Fig.4 (b)
S.O. #HLR 1931	50	Yes	6D1260	Fig.2	Fig.4 (b)
S.O. #17R8188	25	No	252A323	Fig.2	Fig.4 (a)

Auxiliaries

949122 1 mfd exciting capacitor - 2 required Res.
50-60 Cycles Neutralizing Reactor

2.5 mfd exciting capacitor - 2 required Res.
25 Cycles Neutralizing Reactor

General Specifications	Units	60 Cycles	50 Cycles	25 Cycles
Voltage Rating Between Windings	Volts	500	500	500
Voltage Rating Across Windings in parallel	Volts	4000	4000	4000
Exciting Impedance-both Windings in parallel at 4KV	Ohms	40,000-52,000	70,000-85,000	75,000-85,000
Leakage Reactance Each Winding	Ohms	75	87	95
Resistance of Each Winding	Ohms	88	104	224
Total Impedance One Reactor Adds to the Pilot Wire Loop	Volts	176 + j 150 = 231 $\angle$ 40.5°	272	448
Test Voltage Windings to Ground	Volts	10,000	10,000	10,000
Continuous Current Rating Each Winding	MA	10	10	10
One Second Current Rating Each Winding	MA	50	50	50
Approx. Weight	Lbs.	76	77	87

Mutual Drainage Reactors

Style	Freq.	Inc. Socket for Tube	Inc. KX642 Tube	Schematic	Reference	Outline Reference
248A691G02	60	Yes	Yes	253A180	Fig.2	Fig.5 (a)
1590629	60	Yes	No	247A775	Fig.2	Fig.5 (a)
S.O. KHU-0001	50	Yes	Yes	253A180	Fig.2	Fig.5 (a)
S.O. H6R 5481	25	Yes	No	258A504	Fig.2	Fig.5 (b)

General Specifications	Units	60 Cycles	50 Cycles	25 Cycles
Test Voltage Between Windings and Between Windings and Ground - for 1 Minute	Volts	4000	4000	4000
Excitation Impedance at 120 Volts from H1 to H4, H2 to H3 connected together	Ohms	30,000-36,000	22,000	30,000-36,000
D.C. Resistance - Each Winding	Ohms	7.6	9.5	10.3
Leakage Reactance Each Winding	Ohms	.28	.80	.45
One Second Rating - Each Winding	Amps	90	90	90
Two Second Rating - Each Winding	Amps	22	22	22
Approx. Weight	Lbs.	40	40	47

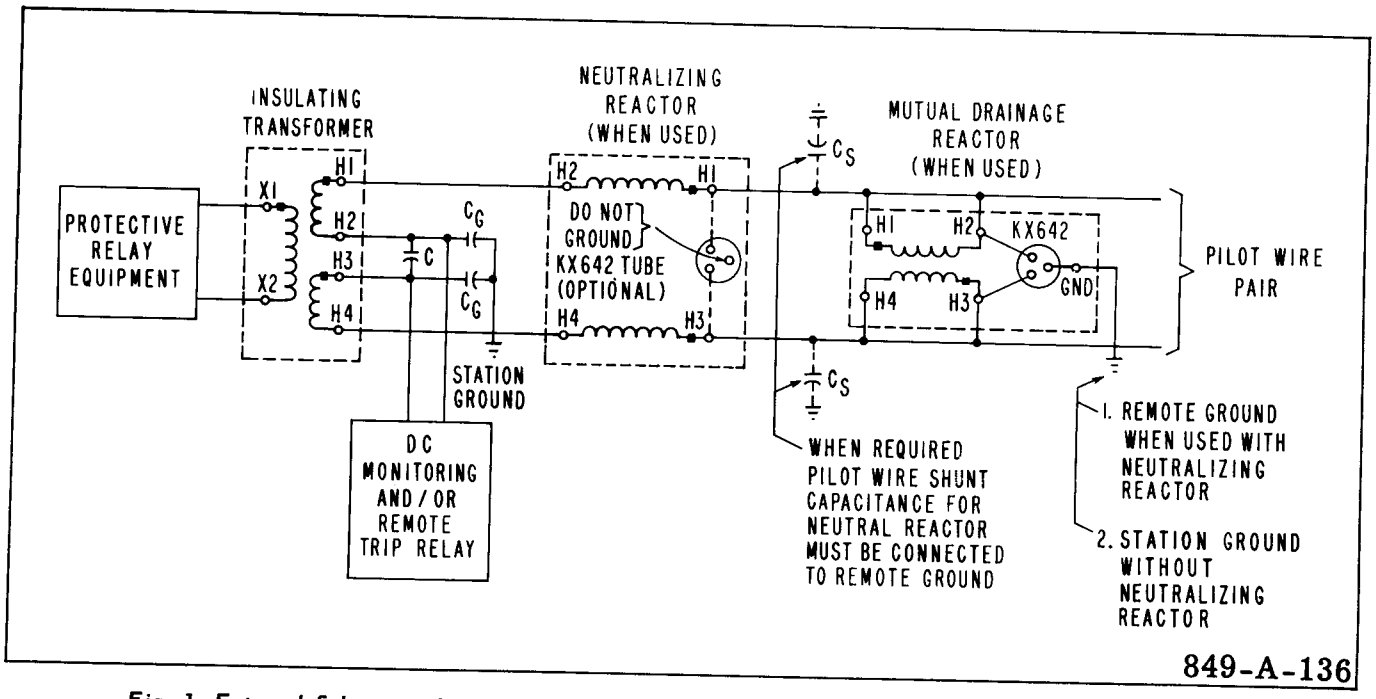


Fig. 1. External Schematic for Pilot Wire and Protective Equipment for HCB and HCB-1 Relaying.

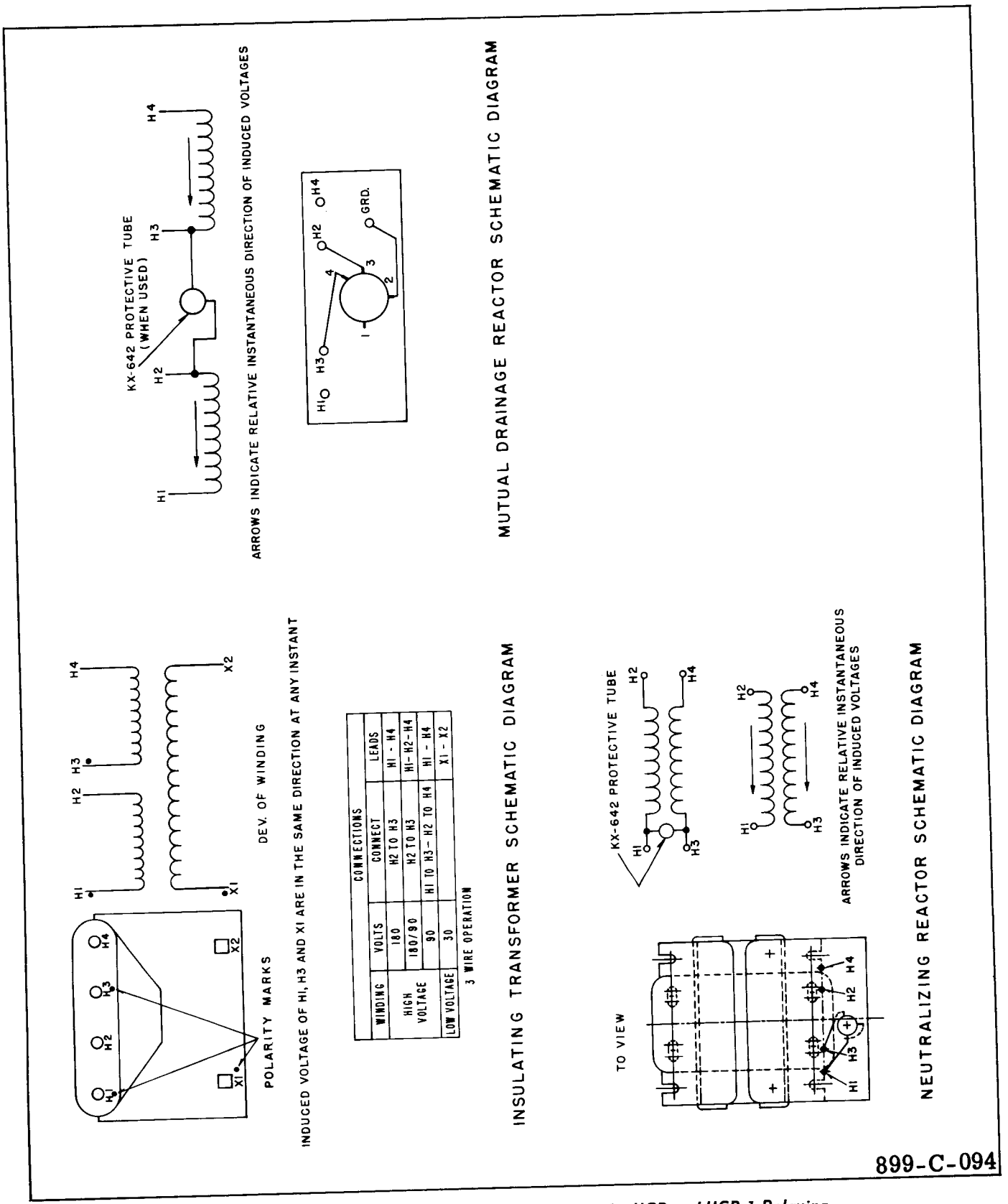
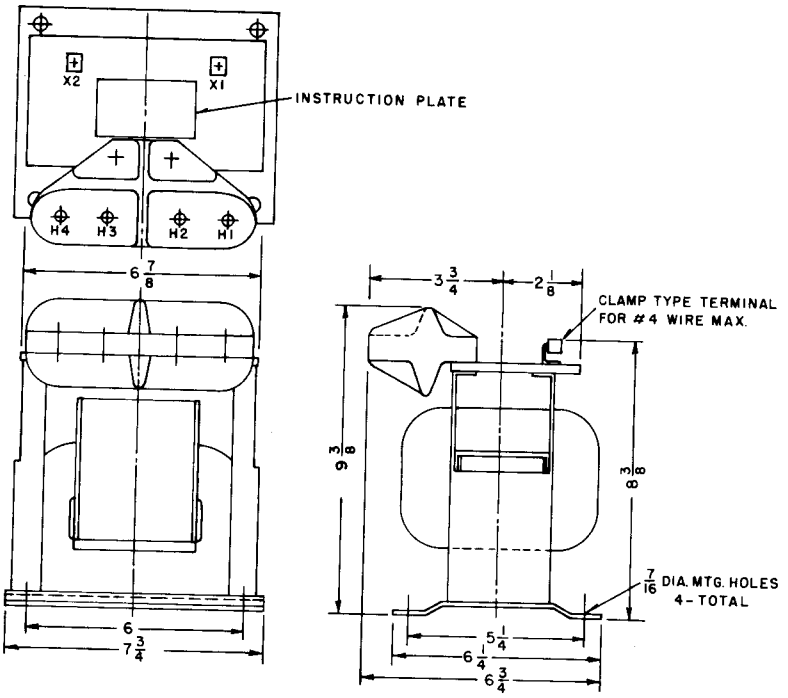
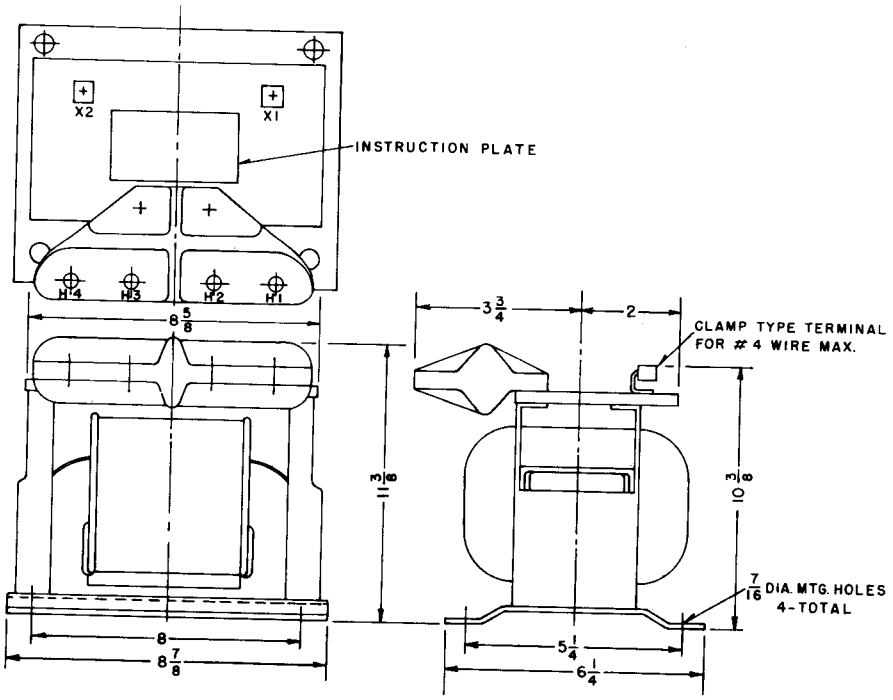


Fig. 2. Schematic Diagrams of Protective Equipment for HCB and HCB-1 Relaying.



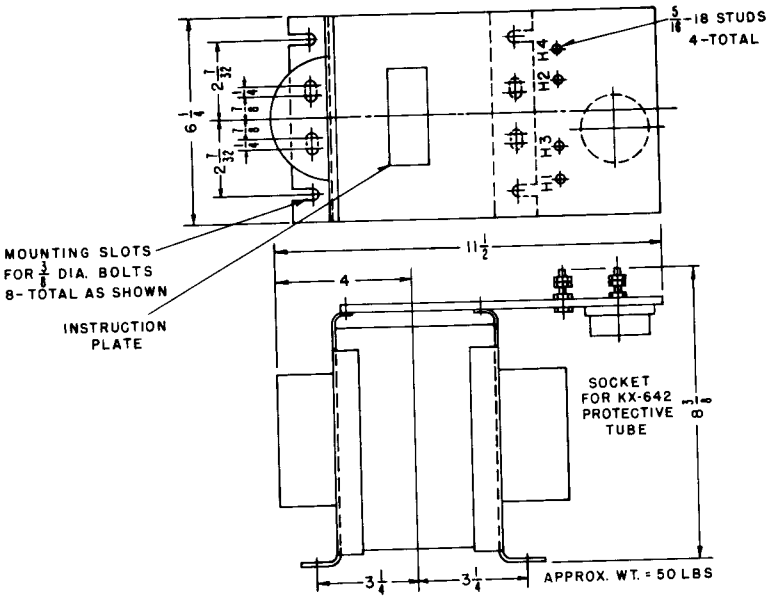
a) INSULATING TRANSFORMER OUTLINE FOR 50 AND 60 CYCLE OPERATION



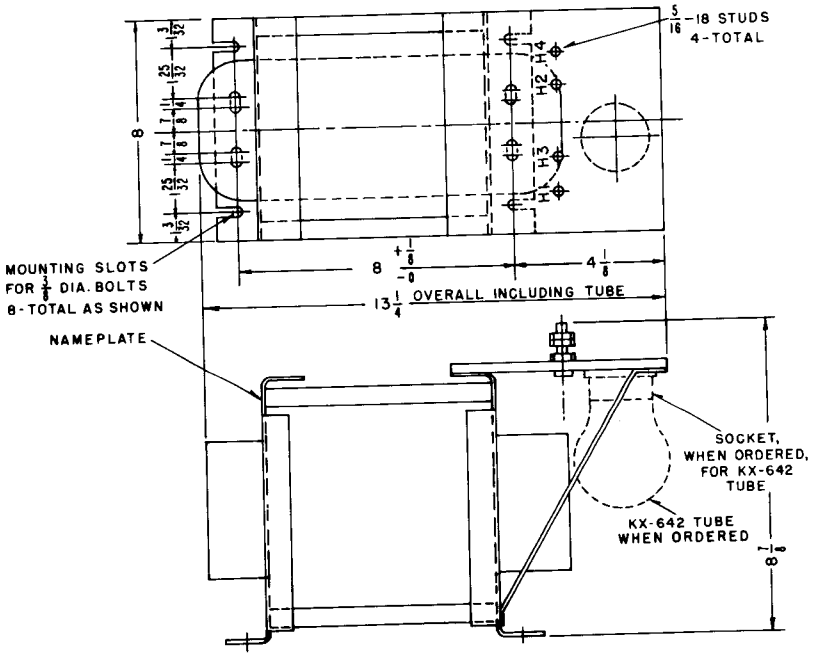
b) INSULATING TRANSFORMER OUTLINE FOR 25 CYCLE OPERATION

899-C-095

Fig. 3. Insulating Transformer Outlines for Protection Equipment for HCB and HCB-1 Relaying.



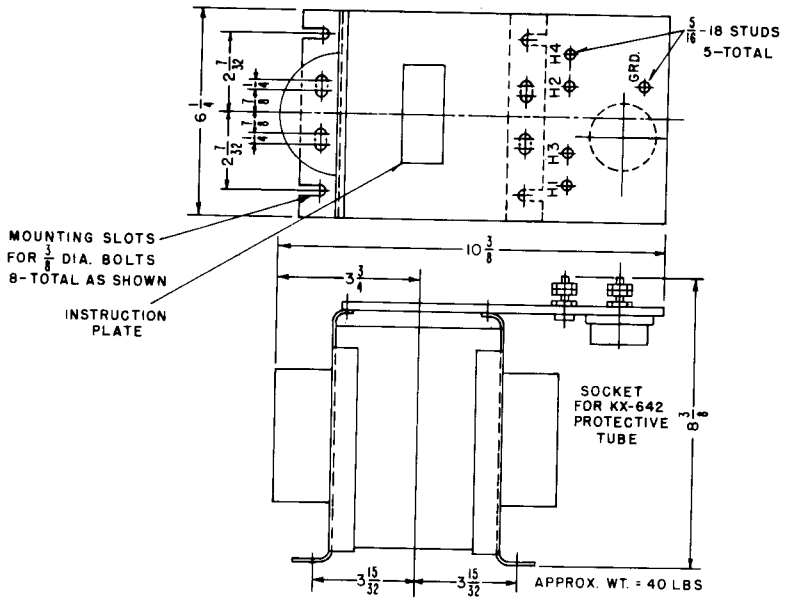
a) NEUTRALIZING REACTOR OUTLINE FOR 25 CYCLE OPERATION



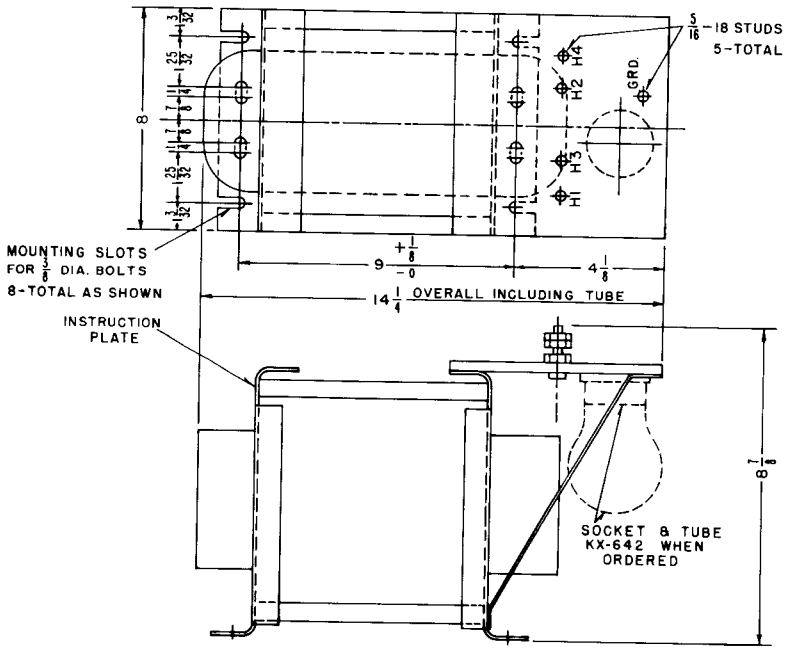
b) NEUTRALIZING REACTOR OUTLINE FOR 50 AND 60 CYCLE OPERATION

899-C-097

Fig. 4. Neutralizing Reactor Outlines for Protection Equipment for HCB and HCB-1 Relaying.



a) MUTUAL DRAINAGE REACTOR OUTLINE FOR 50 AND 60 CYCLE OPERATION



b) MUTUAL DRAINAGE REACTOR OUTLINE FOR 25 CYCLE OPERATION

899-C-096

Fig. 5. Mutual Drainage Reactor Outlines for Protective Equipment for HCB and HCB-1 Relaying.

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
Printed in U.S.A.

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AC Bypass Capacitor (C)

The AC bypass capacitor (C) is required only when DC monitoring and/or remote trip relays are used. Otherwise connect H2 to H3 on the insulating transformer (refer to Fig. 1.). Use a 10 ufd capacitor for 50/60 cycle applications or a 25 ufd capacitor for 25 cycle applications.

Exciting Capacitors (Cg)

The exciting capacitors (Cg) and ground connection are omitted when the neutralizing reactor is not used. Use a 1.0 ufd capacitor for 50/60 cycle applications or a 2.5 ufd capacitor for 25 cycle applications.

Mutual Drainage Reactor

The mutual drainage reactor is applied to drain off longitudinally induced voltages which may occur by lightning surges (not a direct stroke) or the parallel association of the pilot wire with faulted power circuits.

The mutual drainage reactors must be applied at more than one terminal or location to provide a path for the drainage currents to flow.

With the mutual drainage reactor only (hence no rise-in-station ground hazzard), the remote and station ground are essentially equal, and the KX642 tube ground should be connected to the station ground.

Neutralizing Reactors

The neutralizing reactors are applied where the difference between station ground and remote ground can exceed 600 volts rms during power system faults. This rise in station ground potential appears across the neutralizing transformer inserted in the pilot wire. Thus all equipment and circuitry to the left of the neutralizing reactor terminals H2 and H4 (Fig. 1.) are essentially at station ground. All equipment, circuits, pilot wire, sheath, etc. to the right of H1 and H3 (Fig. 1.) are at remote ground and must be insulated from station ground and operating personnel in the station area. The shunt capacity to ground of the pilot wire pair should be on the order of 1 ufd or more. If not, capacitance (Cs) should be added as shown to provide equivalent of approx. 1 ufd. total on each wire to ground.

The neutralizing reactor and mutual drainage reactor may be used together as shown or either may be applied separately depending on the hazards encountered.

The neutralizing reactor may be applied at one terminal only if there is no rise in voltage at the other terminals.

Neutralizing Reactor Tube KX642

The neutralizing reactor tube KX642 is not necessary with modern shielded pilot wires, and is not required in addition to the mutual drainage reactor.

SUPERSEDES I.L. 41-971.4A
*Denotes change from superseded issue.

EFFECTIVE MAY 1967

TECHNICAL DATA

Insulating Transformer

Style	Rating	Frequency	Schematic	Reference	Outline Reference
1575394	4/1	50-60 Cycles	20D1472	Fig.2	Fig.3(a)
1629502	6/1	50-60 Cycles	16D9583	Fig.2	Fig.3(a)
248A692G06	4/1	25 Cycles	20D1472	Fig.2	Fig.3(b)
S.O. #HLR 2784	6/1	25 Cycles	16D9583	Fig.2	Fig.3(b)

General Specifications	Units	4/1	6/1	4/1	6/1	4/1	6/1
		60 Cycles		50 Cycles		25 Cycles	
Rated Voltage H1-H2 & H3-H4	Volts	60	90	60	90	60	90
Rated Voltage X1-X2	Volts	30	30	30	30	30	30
Continuous Rating H Windings	MA.	12	8	12	8	12	8
Resistance of each H Winding	Ohms	20.4	46.5	20.4	46.5	28.5	
Continuous Rating X Winding	MA.	48	48	48	48	48	48
Resistance of X Winding	Ohms	1.7	1.7	1.7	1.7	2.3	
Insulation H & L Windings to Ground	KV	5.0	5.0	5.0	5.0	5.0	5.0
Exciting Impedance X_1-X_2 at 30 V.	Ohms	850-1250	850-1250	850-1250	790-1030	1250-2000	1250-2000
Approx. Weight	Lbs.	25	25	25	25	40	40

KX-642 Gas Tube

A.C. rms voltage breakdown	300 - 500 Volts
Tube Voltage drop, average D.C.	20 - 30 Volts
1 Second current rating	90 Amps
2 Second current rating	40 Amps

Neutralizing Reactor

Style	Freq.	* With KX642 Tube & Socket	Schematic	Reference	Outline Reference
1255186	60	Yes	6D1260	Fig.2	Fig.4 (b)
1255289	60	No	6D1260	Fig.2	Fig.4 (b)
S.O. #HLR 1931	50	Yes	6D1260	Fig.2	Fig.4 (b)
S.O. #17R8188	25	No	252A323	Fig.2	Fig.4 (a)

Auxiliaries

949122 1 mfd exciting capacitor - 2 required Res. 50-60 Cycles Neutralizing Reactor

2.5 mfd exciting capacitor - 2 required Res. 25 Cycles Neutralizing Reactor

* Neutralizing Reactor, Cont.

General Specifications	Units	60 Cycles	50 Cycles	25 Cycles
Voltage Rating Between Windings	Volts	500	500	500
Voltage Rating Across Windings in parallel	Volts	4000	4000	4000
Exciting Impedance-both Windings in parallel at 4KV	Ohms	40,000-52,000	70,000-85,000	75,000-85,000
Leakage Reactance Each Winding	Ohms	75	87	95
Resistance of Each Winding	Ohms	88	104	224
Total Impedance One Reactor Adds to the Pilot Wire Loop	* Ohms	176 + j 150 = 231 $\angle$ 40.5°	272	448
Test Voltage Windings to Ground	Volts	10,000	10,000	10,000
Continuous Current Rating Each Winding	MA	10	10	10
One Second Current Rating Each Winding	MA	50	50	50
Approx. Weight	Lbs.	76	77	87

Mutual Drainage Reactors

Style	Freq.	Inc. Socket for Tube	Inc. KX642 Tube	Schematic	Reference	Outline Reference
248A691G02	60	Yes	Yes	253A180	Fig.2	Fig.5 (a)
1590629	60	Yes	No	247A775	Fig.2	Fig.5 (a)
S.O. KHU-0001	50	Yes	Yes	253A180	Fig.2	Fig.5 (a)
S.O. H6R 5481	25	Yes	No	258A504	Fig.2	Fig.5 (b)

General Specifications	Units	60 Cycles	50 Cycles	25 Cycles
Test Voltage Between Windings and Between Windings and Ground - for 1 Minute	Volts	4000	4000	4000
Excitation Impedance at 120 Volts from H1 to H4, H2 to H3 connected together	Ohms	30,000-36,000	22,000	30,000-36,000
D.C. Resistance - Each Winding	Ohms	7.6	9.5	10.3
Leakage Reactance Each Winding	Ohms	.28	.80	.45
One Second Rating - Each Winding	Amps	90	90	90
Two Second Rating - Each Winding	Amps	22	22	22
Approx. Weight	Lbs.	40	40	47

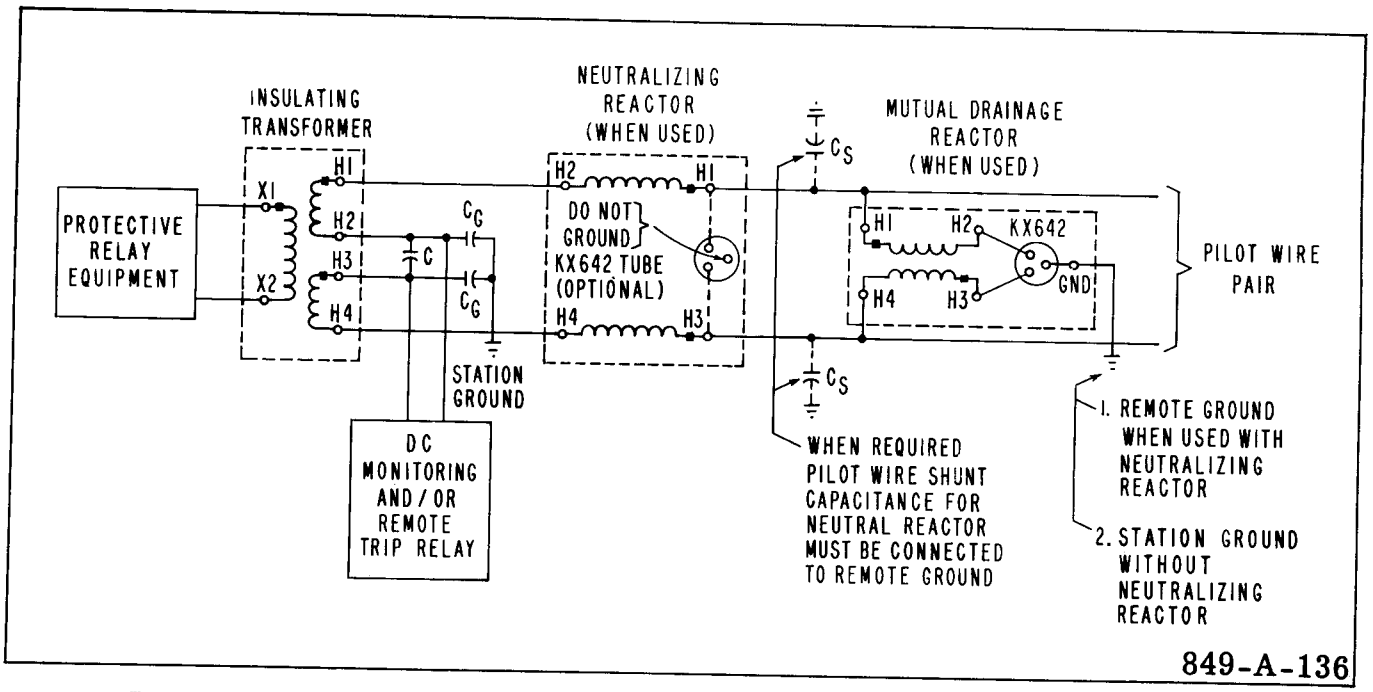


Fig. 1. External Schematic for Pilot Wire and Protective Equipment for HCB and HCB-1 Relaying.

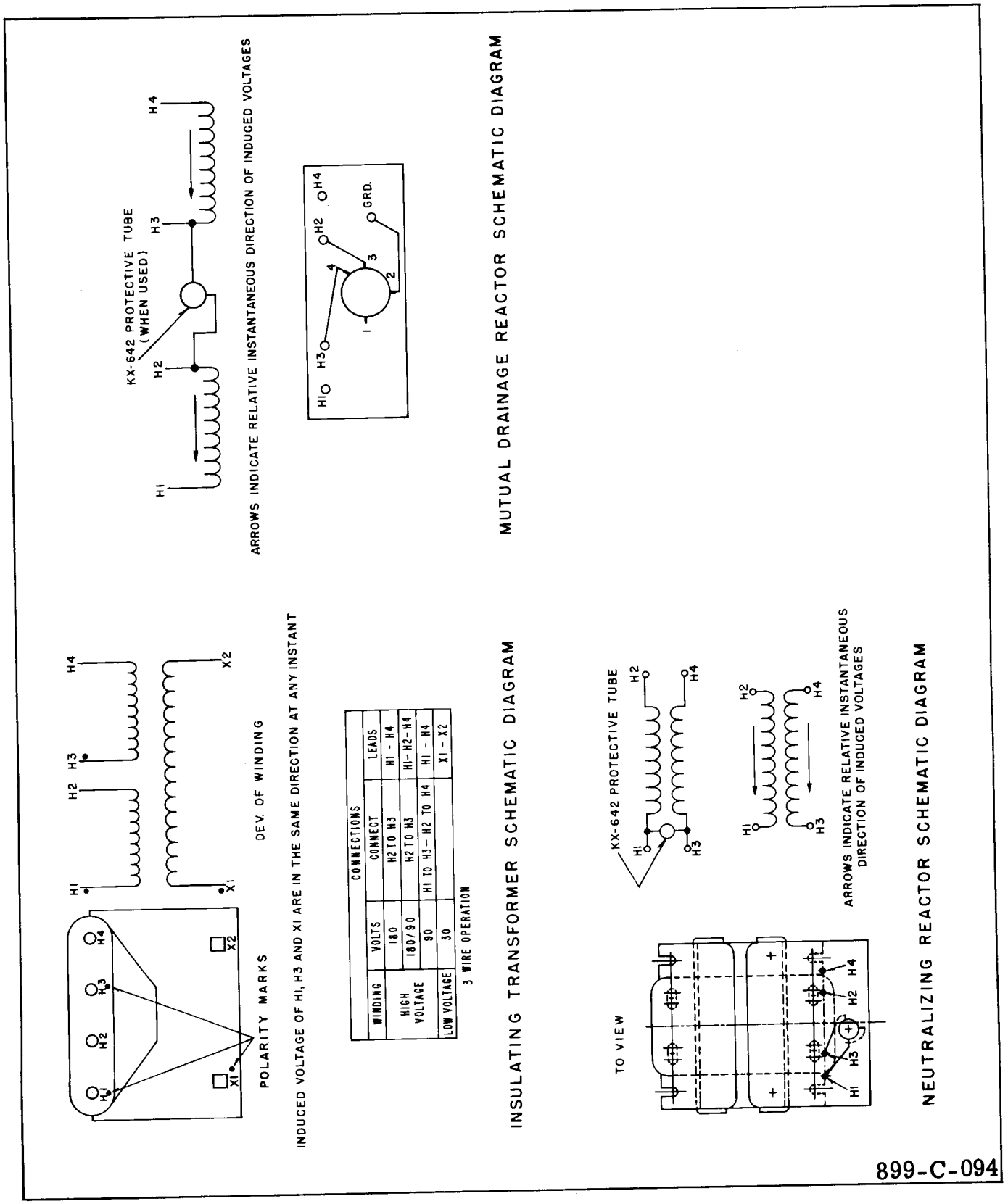
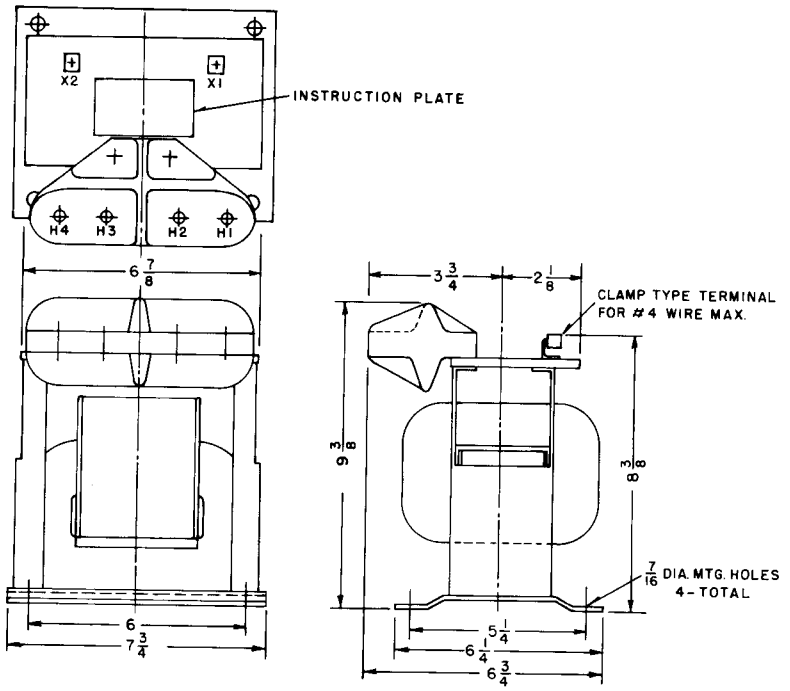
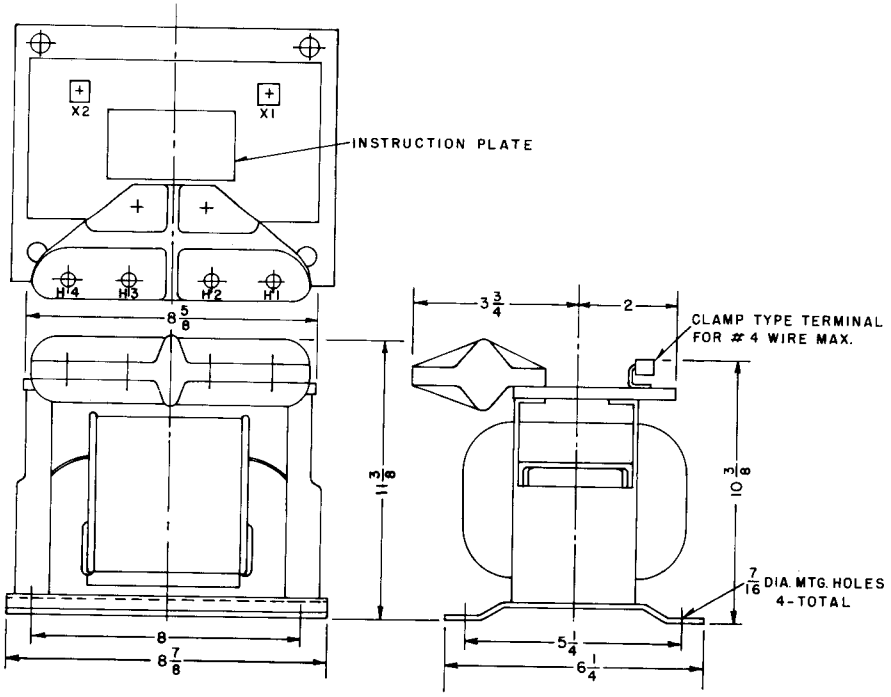


Fig. 2. Schematic Diagrams of Protective Equipment for HCB and HCB-1 Relaying.



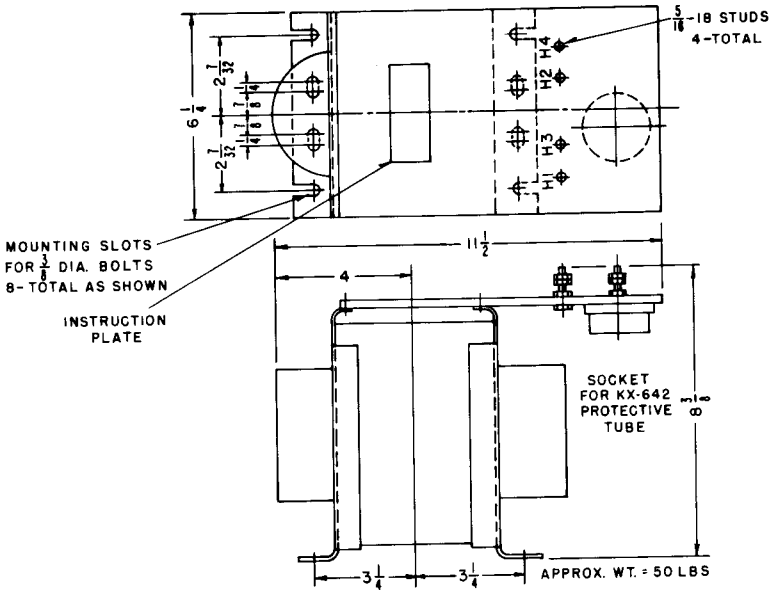
a) INSULATING TRANSFORMER OUTLINE FOR 50 AND 60 CYCLE OPERATION



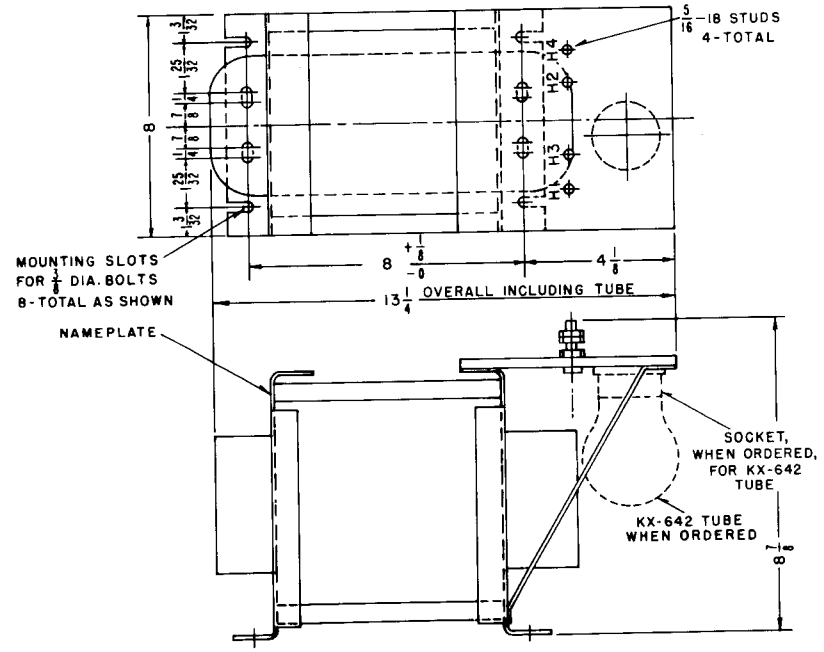
b) INSULATING TRANSFORMER OUTLINE FOR 25 CYCLE OPERATION

899-C-095

Fig. 3. Insulating Transformer Outlines for Protection Equipment for HCB and HCB-1 Relaying.



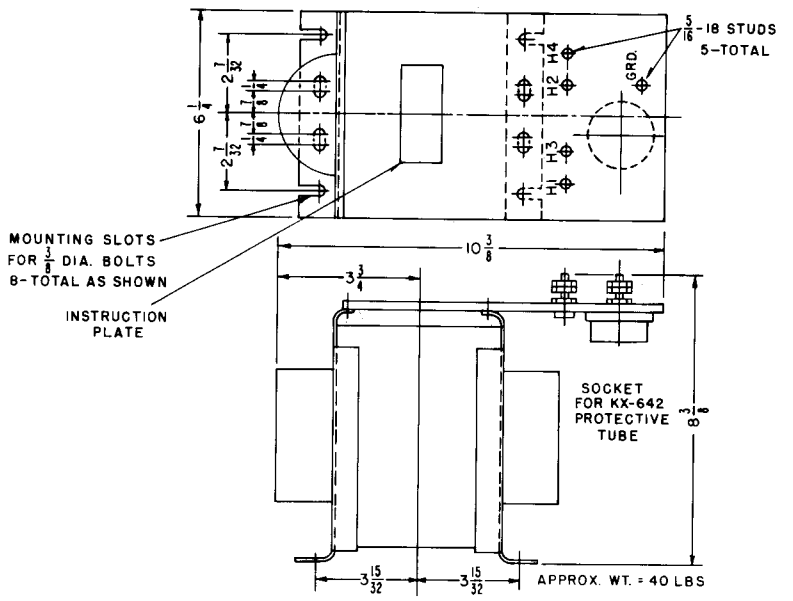
a) NEUTRALIZING REACTOR OUTLINE FOR 25 CYCLE OPERATION



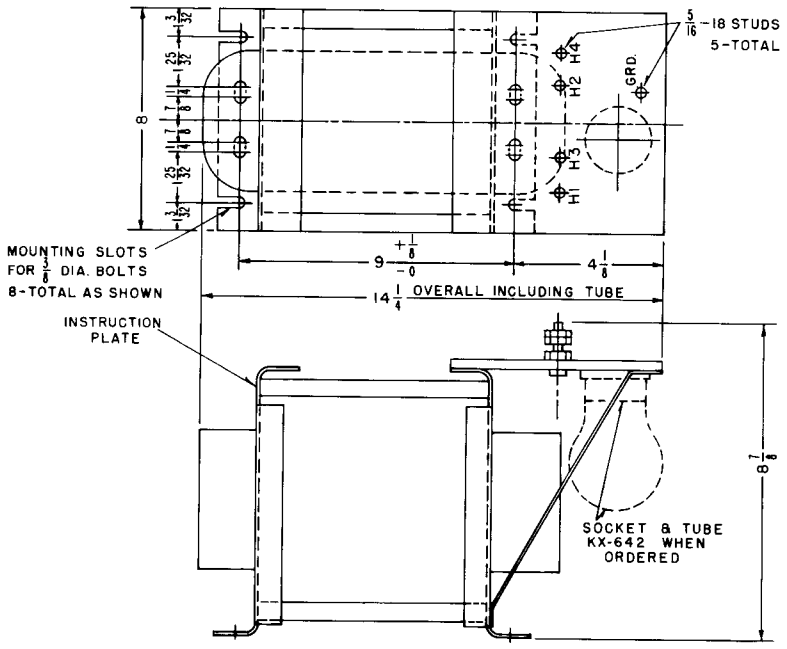
b) NEUTRALIZING REACTOR OUTLINE FOR 50 AND 60 CYCLE OPERATION

899-C-097

Fig. 4. Neutralizing Reactor Outlines for Protection Equipment for HCB and HCB-1 Relaying.



a) MUTUAL DRAINAGE REACTOR OUTLINE FOR 50 AND 60 CYCLE OPERATION



b) MUTUAL DRAINAGE REACTOR OUTLINE FOR 25 CYCLE OPERATION

899-C-096

Fig. 5. Mutual Drainage Reactor Outlines for Protective Equipment for HCB and HCB-1 Relaying.

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
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Exciting Capacitors (Cg)

The exciting capacitors (Cg) and ground connection are omitted when the neutralizing reactor is not used. Use a 1.0 ufd capacitor for 50/60 HZ applications * or a 2.5 ufd capacitor for 25 HZ applications.

Mutual Drainage Reactor

The mutual drainage reactor is applied to drain off longitudinally induced voltages which may occur by lightning surges (not a direct stroke) or the parallel association of the pilot wire with faulted power circuits.

The mutual drainage reactors must be applied at more than one terminal or location to provide a path for the drainage currents to flow.

With the mutual drainage reactor only (hence no rise-in-station ground hazzard), the remote and station ground are essentially equal, and the KX642 tube ground should be connected to the station ground.

Neutralizing Reactors

The neutralizing reactors are applied where the difference between station ground and remote ground can exceed 600 volts rms during power system faults. This rise in station ground potential appears across the neutralizing transformer inserted in the pilot wire. Thus all equipment and circuitry to the left of the neutralizing reactor terminals H2 and H4 (Fig. 1.) are essentially at station ground. All equipment, circuits, pilot wire, sheath, etc. to the right of H1 and H3 (Fig. 1.) are at remote ground and must be insulated from station ground and operating personnel in the station area. The shunt capacity to ground of the pilot wire pair should be on the order of 1 ufd or more. If not, capacitance (Cs) should be added as shown to provide equivalent of approx. 1 ufd. total on each wire to ground.

The neutralizing reactor and mutual drainage reactor may be used together as shown or either may be applied separately depending on the hazards encountered.

The neutralizing reactor may be applied at one terminal only if there is no rise in voltage at the other terminals.

Neutralizing Reactor Tube KX642

* The neutralizing reactor tube KX642 is recommended to minimize wire to wire voltage during a disturbance with one wire accidentally grounded.

TECHNICAL DATA

Insulating Transformer

Style	Rating	Frequency	Schematic	Reference	Outline Reference
1575394	4/1	50-60 HZ	20D1472	Fig.2	Fig.3(a)
1629502	6/1	50-60 HZ	16D9583	Fig.2	Fig.3(a)
248A692G06	4/1	25 HZ	20D1472	Fig.2	Fig.3(b)
Sim. to 1629502 Except 25HZ	6/1	25 HZ	16D9583	Fig.2	Fig.3(b)

General Specifications	Units	4/1	6/1	4/1	6/1	4/1	6/1
		60 HZ		50 HZ		25 HZ	
Rated Voltage H1-H2 & H3-H4	Volts	60	90	60	90	60	90
Rated Voltage X1-X2	Volts	30	30	30	30	30	30
Continuous Rating H Windings	MA.	12	8	12	8	12	8
Resistance of each H Winding	Ohms	20.4	46.5	20.4	46.5	28.5	
Continuous Rating X Winding	MA.	48	48	48	48	48	48
Resistance of X Winding	Ohms	1.7	1.7	1.7	1.7	2.3	
Insulation H & L Windings to Ground	KV	5.0	5.0	5.0	5.0	5.0	5.0
Exciting Impedance X_1-X_2 at 30 V.	Ohms	850-1250	850-1250	850-1250	790-1030	1250-2000	1250-2000
Approx. Weight	Lbs.	25	25	25	25	40	40

KX-642 Gas Tube

A.C. rms voltage breakdown	300 - 500 Volts
Tube Voltage drop, average D.C.	20 - 30 Volts
1 Second current rating	90 Amps
2 Second current rating	40 Amps

Neutralizing Reactor

Style	Freq.	* With KX642 Tube & Socket	Schematic	Reference	Outline Reference
815A629G03	60	Yes	6D1260	Fig.2	Fig.4 (b)
815A629G01	60	No	6D1260	Fig.2	Fig.4 (b)
815A629G03	50	Yes	6D1260	Fig.2	Fig.4 (b)
Sim. to 815A629G01 Except 25HZ	25	No	252A323	Fig.2	Fig.4 (a)

Auxiliaries

949122 1 mfd exciting capacitor - 2 required Res.
50-60 HZ Neutralizing Reactor

2.5 mfd exciting capacitor - 2 required Res.
25 HZ Neutralizing Reactor

* Neutralizing Reactor, Cont.

General Specifications	Units	60 HZ	50 HZ
Voltage Rating Between Windings	Volts	500	500
Voltage Rating Across Winding in Parallel	Volts	4000	4000
Exciting Impedance-both Windings in Parallel at 4KV	Ohms	134,000-267,000	56,750-113,500
Leakage Reactance Each Winding	Ohms	65	54
Resistance of Each Winding	Ohms	88	88
Total Impedance One Reactor Adds to the Pilot Wire Loop	* Ohms	219	207
Test Voltage Windings to Ground	Volts	10,000	10,000
Continuous Current Rating Each Winding	MA	10	10
One Second Current Rating Each Winding	MA	50	50
Approx. Weight	Lbs.	76	76

Mutual Drainage Reactors

Style	Freq.	Inc. Socket for Tube	Inc. KX642 Tube	Schematic	Reference	Outline Reference
815A566G03	60	Yes	Yes	253A180	Fig.2	Fig.5 (a)
815A566G02	60	Yes	No	247A775	Fig.2	Fig.5 (a)
815A566G03	50	Yes	Yes	253A180	Fig.2	Fig.5 (a)
Sim. to 815A566G02 Except 25HZ	25	Yes	No	258A504	Fig.2	

General Specifications	Units	60 HZ	50 HZ
Test Voltage Between Windings and Between Windings and Ground-for 1 Minute	Volts	4000	4000
Excitation Impedance at 120 Volts from H1 to H4, H2 to H3 connected together	Ohms	24,000-48,000	24,000-48,000
D.C. Resistance — Each Winding	Ohms	7.7	7.7
Leakage Reactance Each Winding	Ohms	.28	2.8
One Second Rating — Each Winding	Amps	90	90
Two Second Rating — Each Winding	Amps	22	22
Approx. Weight	Lbs.	40	40

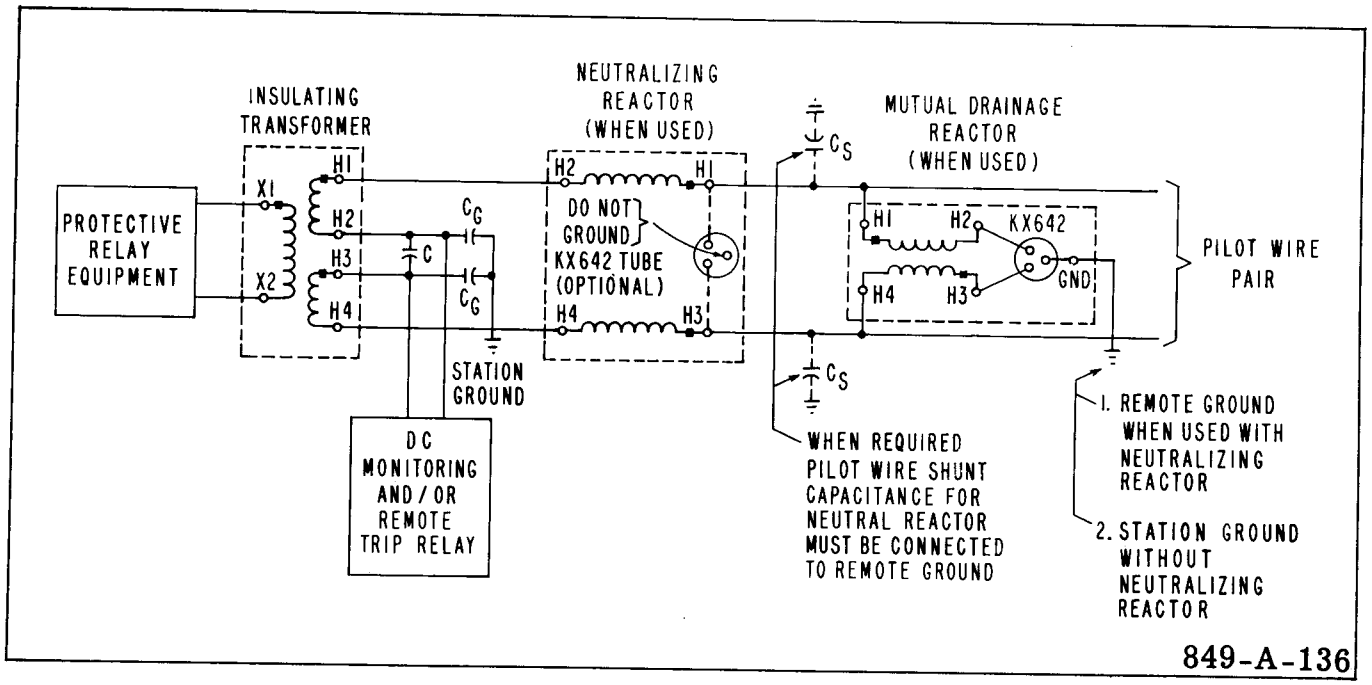


Fig. 1. External Schematic for Pilot Wire and Protective Equipment for HCB and HCB-1 Relaying.

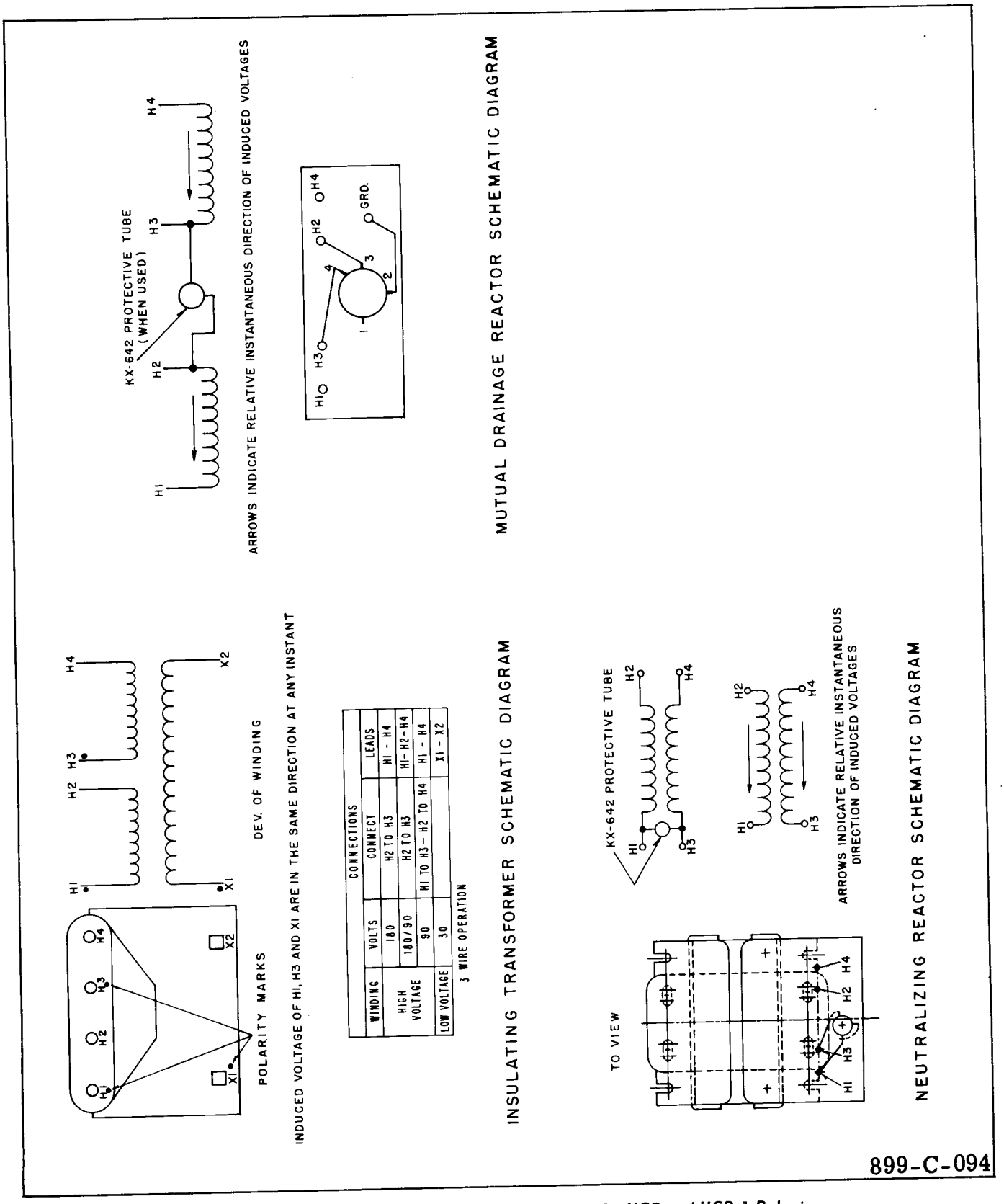
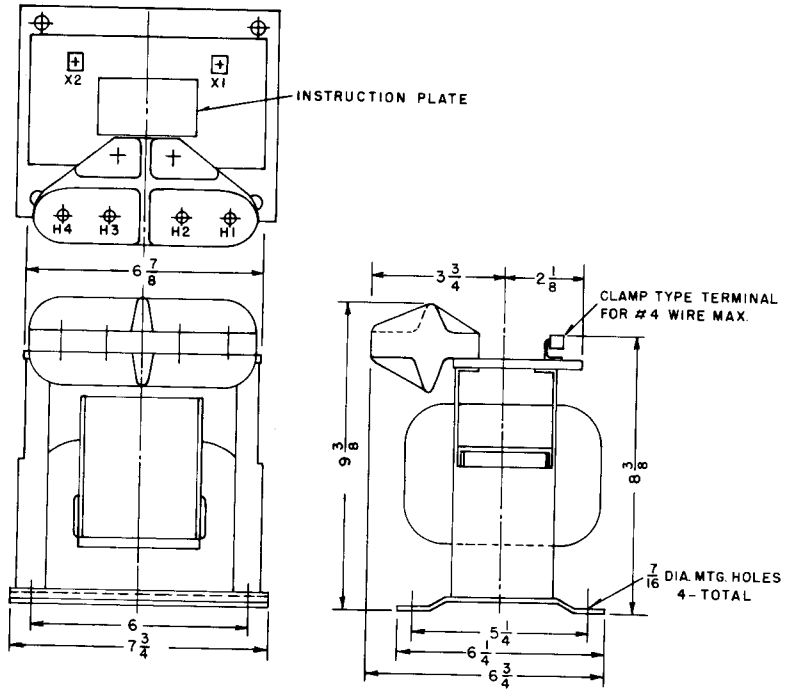
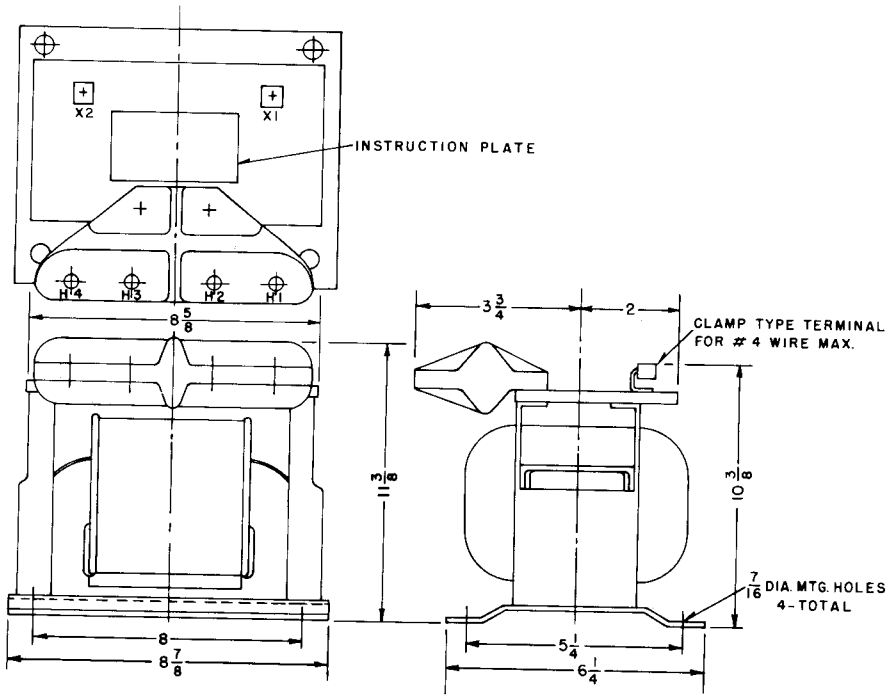


Fig. 2. Schematic Diagrams of Protective Equipment for HCB and HCB-1 Relaying.



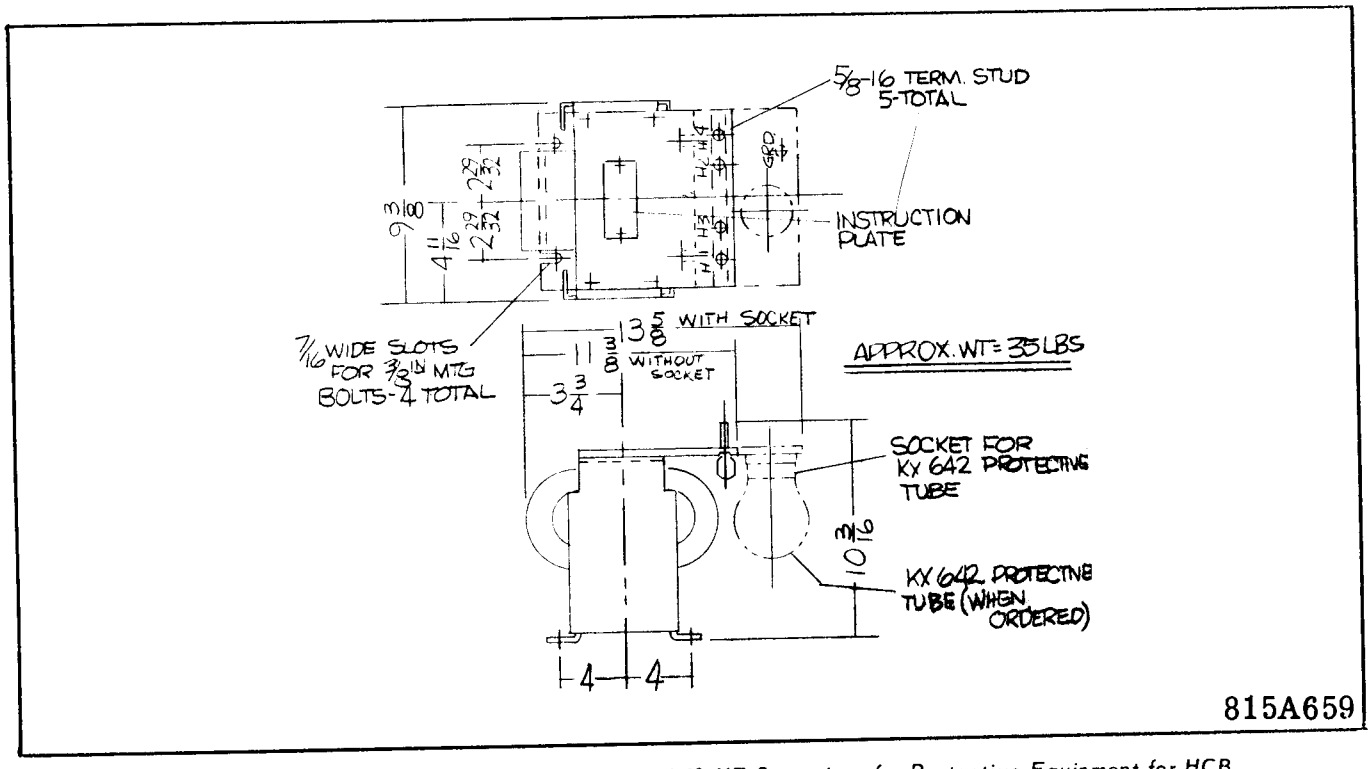
a) INSULATING TRANSFORMER OUTLINE FOR 50 AND 60 CYCLE OPERATION



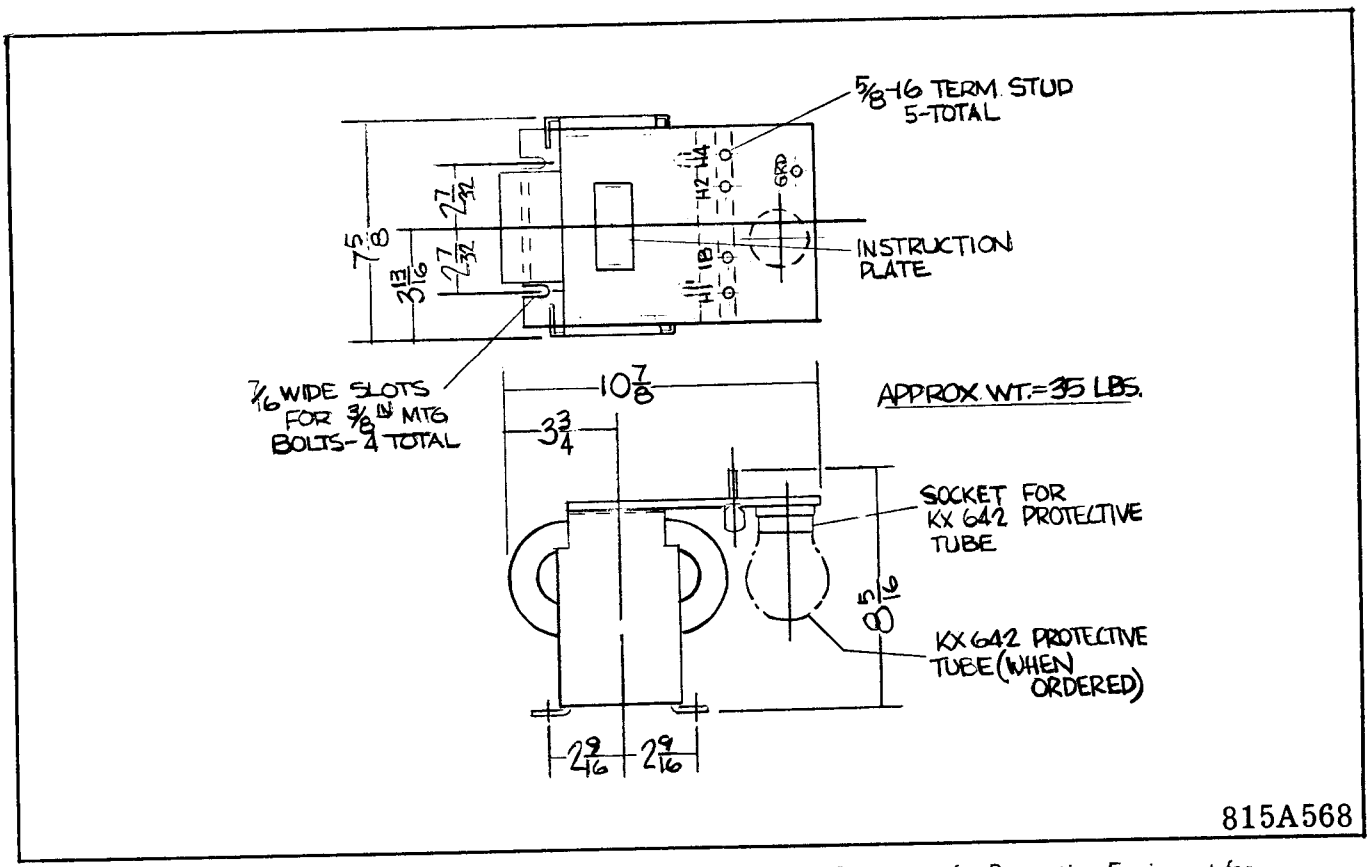
b) INSULATING TRANSFORMER OUTLINE FOR 25 CYCLE OPERATION

899-C-095

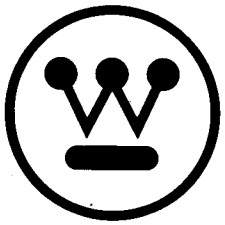
Fig. 3. Insulating Transformer Outlines for Protection Equipment for HCB and HCB-1 Relaying.



* *Fig. 4. Neutralizing Reactor outlines 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.*



* *Fig. 5. Mutual Drainage Reactor Outline, 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.*



WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION
NEWARK, N. J.
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

PILOT WIRE INSULATION AND PROTECTION FOR HCB AND HCB-1 RELAYING

APPLICATION

The insulation and protection equipment shown in Fig. 1. is used with the HCB or HCB-1 pilot wire relay. A complete installation for one terminal of a line consists of an insulating transformer, neutralizing reactor, capacitors, mutual drainage reactors and neutralizing reactor KX642 tube.

AC Bypass Capacitor (C)

The AC bypass capacitor (C) is required only when DC monitoring and/or remote trip relays are used. Otherwise connect H2 to H3 on the insulating transformer (refer to Fig. 1.). Use a 10 ufd capacitor for 50/60 HZ applications or a 25 ufd capacitor for 25 HZ applications.

Exciting Capacitors (Cg)

The exciting capacitors (Cg) and ground connection are omitted when the neutralizing reactor is not used. Use a 1.0 ufd capacitor for 50/60 HZ applications or a 2.5 ufd capacitor for 25 HZ applications.

* For an application using dc monitoring remote-trip relays without the insulating transformer for HCB/HCB.1 relaying, capacitor C should be connected across the wires to minimize the metallic voltage (wire-wire voltage) generated by the ununbalanced impedance of capacitors C_g.

Mutual Drainage Reactor

The mutual drainage reactor is applied to drain off longitudinally induced voltages which may occur by lightning surges (not a direct stroke) or the parallel association of the pilot wire with faulted power circuits.

The mutual drainage reactors must be applied at more than one terminal or location to provide a path for the drainage currents to flow.

With the mutual drainage reactor only (hence no rise-in-station ground hazard), the remote and station ground are essentially equal, and the KX642 tube ground should be connected to the station ground.

* By forcing equal current flow from the two wires into ground, the reactor minimizes metallic voltage (wire-to-wire voltage). The reactor cannot, however, eliminate all metallic voltage even though the longitudinally induced voltages (common mode) are equal and the currents are equal on the two wires unless the wire resistances are identical.

* Since it is not practical to make the wire resistances equal, there is a limit to the amount of induced voltage which can be handled without introducing the possibility of relay misoperation due to the generation of spurious metallic voltage. Therefore, it is recommended that these reactors not be applied for cases where the induced voltage from the power system could exceed 1500 volts, rms. Where the induced voltage could exceed 1500 volts, use a cable with sufficient insulation to withstand the induced voltage stress or improve the shielding to reduce this voltage.

Neutralizing Reactors

The neutralizing reactors are applied where the difference between station ground and remote ground can exceed 600 volts rms during power system faults. This rise in station ground potential appears across the neutralizing transformer inserted in the pilot wire. Thus all equipment and circuitry to the left of the neutralizing reactor terminals H2 and H4 (Fig. 1.) are essentially at station ground. All equipment, circuits, pilot wire, sheath, etc. to the right of H1 and H3 (Fig. 1.) are at remote ground and must be insulated from station ground and operating personnel in the station area. The shunt capacity to ground of the pilot wire pair should be on the order of 1 ufd or more. If not, capacitance (Cs) should be added as shown to provide equivalent of approx. 1 ufd. total on each wire to ground.

TECHNICAL DATA

Insulating Transformer

Style	Rating	Frequency	Schematic	Reference	Outline Reference
1575394	4/1	50-60 HZ	20D1472	Fig.2	Fig.3(a)
1629502	6/1	50-60 HZ	16D9583	Fig.2	Fig.3(a)
248A692G06	4/1	25 HZ	20D1472	Fig.2	Fig.3(b)
Sim. to 1629502 Except 25HZ	6/1	25 HZ	16D9583	Fig.2	Fig.3(b)

General Specifications	Units	4/1	6/1	4/1	6/1	4/1	6/1
		60 HZ		50 HZ		25 HZ	
Rated Voltage H1-H2 & H3-H4	Volts	60	90	60	90	60	90
Rated Voltage X1-X2	Volts	30	30	30	30	30	30
Continuous Rating H Windings	MA.	12	8	12	8	12	8
Resistance of each H Winding	Ohms	20.4	46.5	20.4	46.5	28.5	
Continuous Rating X Winding	MA.	48	48	48	48	48	48
Resistance of X Winding	Ohms	1.7	1.7	1.7	1.7	2.3	
Insulation H & L Windings to Ground	KV	5.0	5.0	5.0	5.0	5.0	5.0
Exciting Impedance X_1-X_2 at 30 V.	Ohms	850-1250	850-1250	850-1250	790-1030	1250-2000	1250-2000
Approx. Weight	Lbs.	25	25	25	25	40	40

KX-642 Gas Tube

A.C. rms voltage breakdown	300 - 500 Volts
Tube Voltage drop, average D.C.	20 - 30 Volts
1 Second current rating	90 Amps
2 Second current rating	40 Amps

Neutralizing Reactor

Style	Freq.	* With KX642 Tube & Socket	Schematic	Reference	Outline Reference
815A629G03	60	Yes	6D1260	Fig.2	Fig.4 (b)
815A629G01	60	No	6D1260	Fig.2	Fig.4 (b)
815A629G03	50	Yes	6D1260	Fig.2	Fig.4 (b)
Sim. to 815A629G01 Except 25HZ	25	No	252A323	Fig.2	Fig.4 (a)

Auxiliaries

949122 1 mfd exciting capacitor - 2 required Res. 50-60 HZ Neutralizing Reactor

2.5 mfd exciting capacitor - 2 required Res. 25 HZ Neutralizing Reactor

The neutralizing reactor and mutual drainage reactor may be used together as shown or either may be applied separately depending on the hazards encountered.

The neutralizing reactor may be applied at one terminal only if there is no rise in voltage at the other terminals.

Neutralizing Reactor Tube KX642

The neutralizing reactor tube KX642 is recommended to minimize wire to wire voltage during a disturbance with one wire accidentally grounded.

* Shield Grounding

In order to be electromagnetically effective the shield must be grounded at least twice to provide a path for the flow of demagnetizing current—the question, though, is where? Should the shield be grounded or insulated from the station mat?

Neutralizing Reactor, Cont.

General Specifications	Units	60 HZ	50 HZ
Voltage Rating Between Windings	Volts	500	500
Voltage Rating Across Winding in Parallel	Volts	4000	4000
Exciting Impedance-both Windings in Parallel at 4KV	Ohms	134,000-267,000	56,750-113,500
Leakage Reactance Each Winding	Ohms	65	54
Resistance of Each Winding	Ohms	88	88
Total Impedance One Reactor Adds to the Pilot Wire Loop	* Ohms	219	207
Test Voltage Windings to Ground	Volts	10,000	10,000
Continuous Current Rating Each Winding	MA	10	10
One Second Current Rating Each Winding	MA	50	50
Approx. Weight	Lbs.	76	76

*** Mutual Drainage Reactors**

Style	Freq.	Inc. Socket for Tube	Inc. KX642 Tube	Schematic	Reference	Outline Refer-
881A868G03	60/50	Yes	Yes	253A180	Fig.2	Fig.5 (a)
881A868G02	60/50	Yes	No	247A775	Fig.2	Fig.5 (a)
Sim. to 881A868G02 Except 25 HZ	25	Yes	No	258A504	Fig.2	

General Specifications	Units	60 HZ	50 HZ
Test Voltage Between Windings and Between Windings and Ground-for 1 Minute	Volts	4000	4000
Excitation Impedance at 120 Volts from H1 to H4 H2 to H3 connected together	Ohms	24,000-48,000	17,000-33,000
D.C. Resistance— Each Winding	Ohms	8.	8.
Leakage Reactance Each Winding	Ohms	1.5	1.2
One Second Rating— Each Winding	Amps	90	90
Two Second Rating — Each Winding	Amps	22	22
Approx. Weight	Lbs.	40	40
Saturation Point H1 & H3, to (Winding in Parallel)	Volts, Rms.	500	400

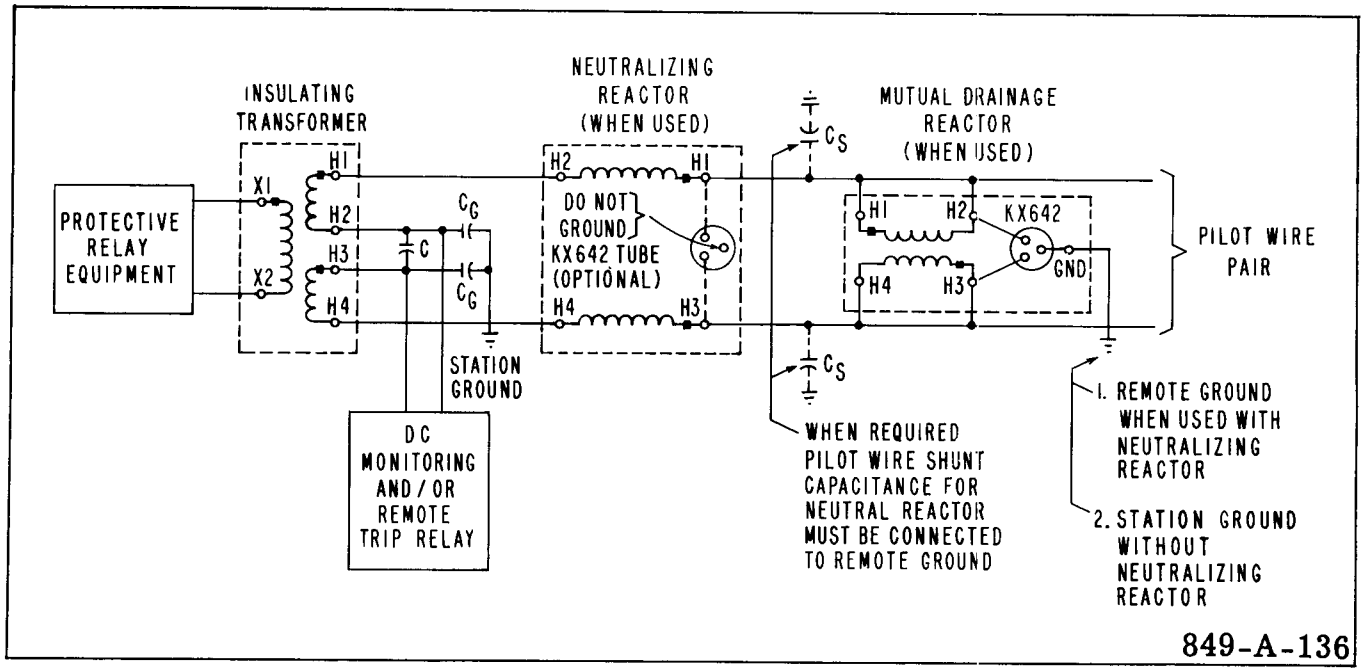


Fig. 1. External Schematic for Pilot Wire and Protective Equipment for HCB and HCB-1 Relaying.

If the shield is grounded to the power-station mat the shield may be damaged by current generated by a rise in station-ground potential during a power-system fault. Unless, the shield has sufficient conductivity to withstand the thermal stress, it should be insulated from station ground. Note that an increase in shield conductivity does not cause a proportional increase in shield current due to the inductance in the loop. If the shield is insulated from station ground (i.e., within 500 ft. of station) it is not effective in reducing induced voltage in the insulated section; if this voltage is large a high-conductivity shield which can thermally withstand the stress of a mat ground is indicated. The "insulated shield" section must be remote grounded to minimize electric-field pickup.

Where the two stations are within about 1500 ft. or less of each other either a single shield ground should be used or the shield should be tied to both mats. In such an application it is common to interconnect the two mats via large power cables (in addition to the overhead shield wires); these reduce the 60 Hz mat voltage difference. However, they have a limited effectiveness due to the cable inductance.

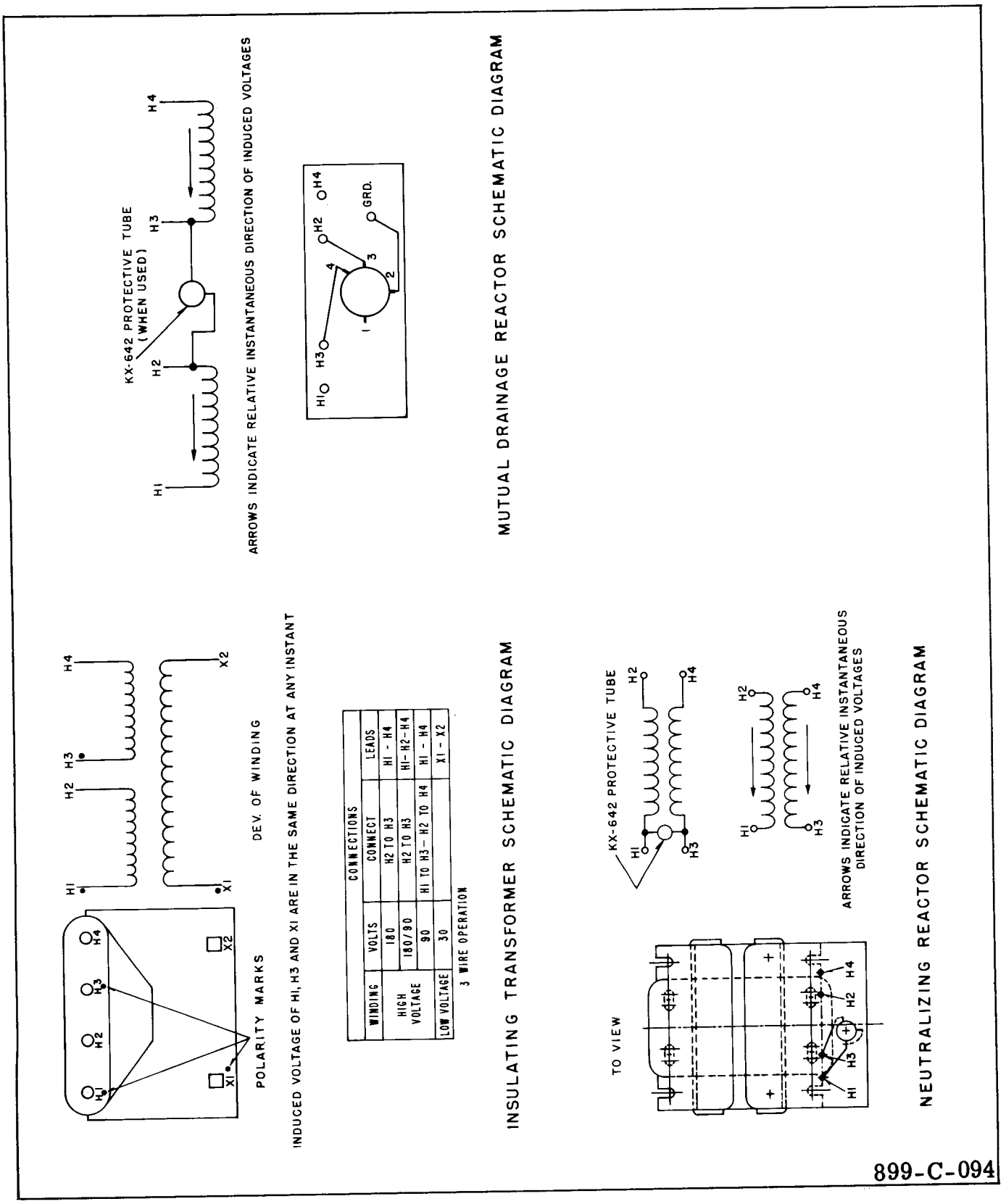
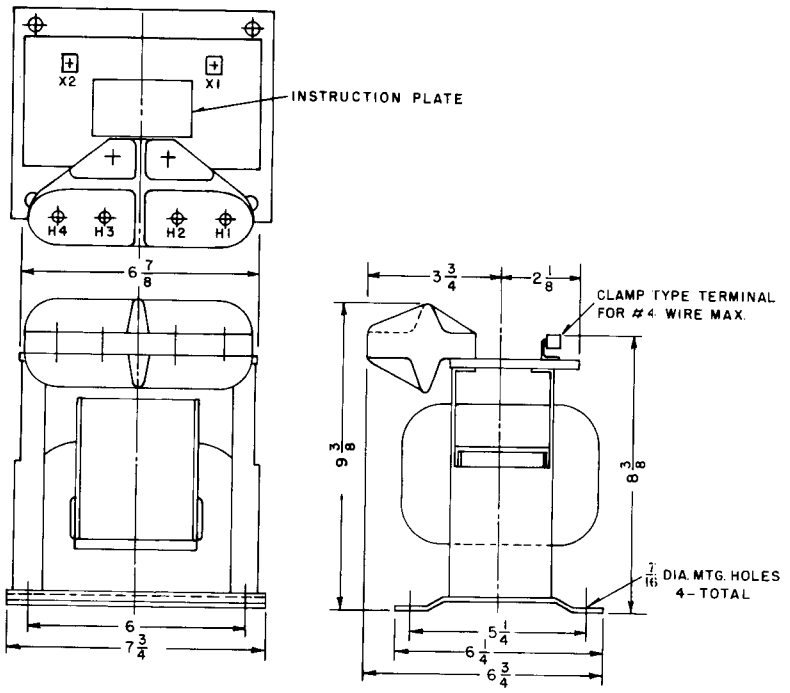
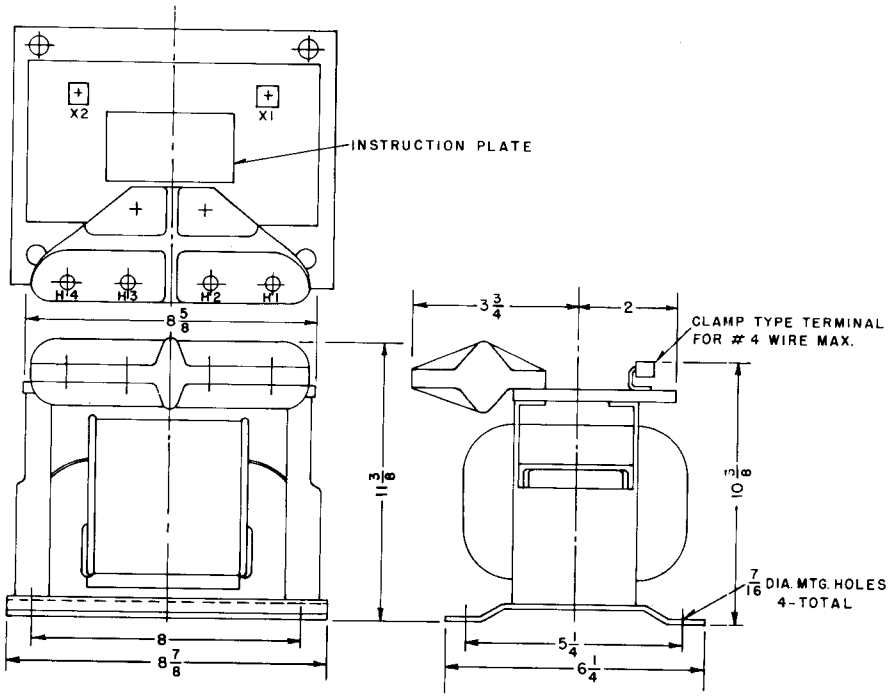


Fig. 2. Schematic Diagrams of Protective Equipment for HCB and HCB-1 Relaying.



a) INSULATING TRANSFORMER OUTLINE FOR 50 AND 60 CYCLE OPERATION



b) INSULATING TRANSFORMER OUTLINE FOR 25 CYCLE OPERATION

899-C-095

Fig. 3. Insulating Transformer Outlines for Protection Equipment for HCB and HCB-1 Relaying.

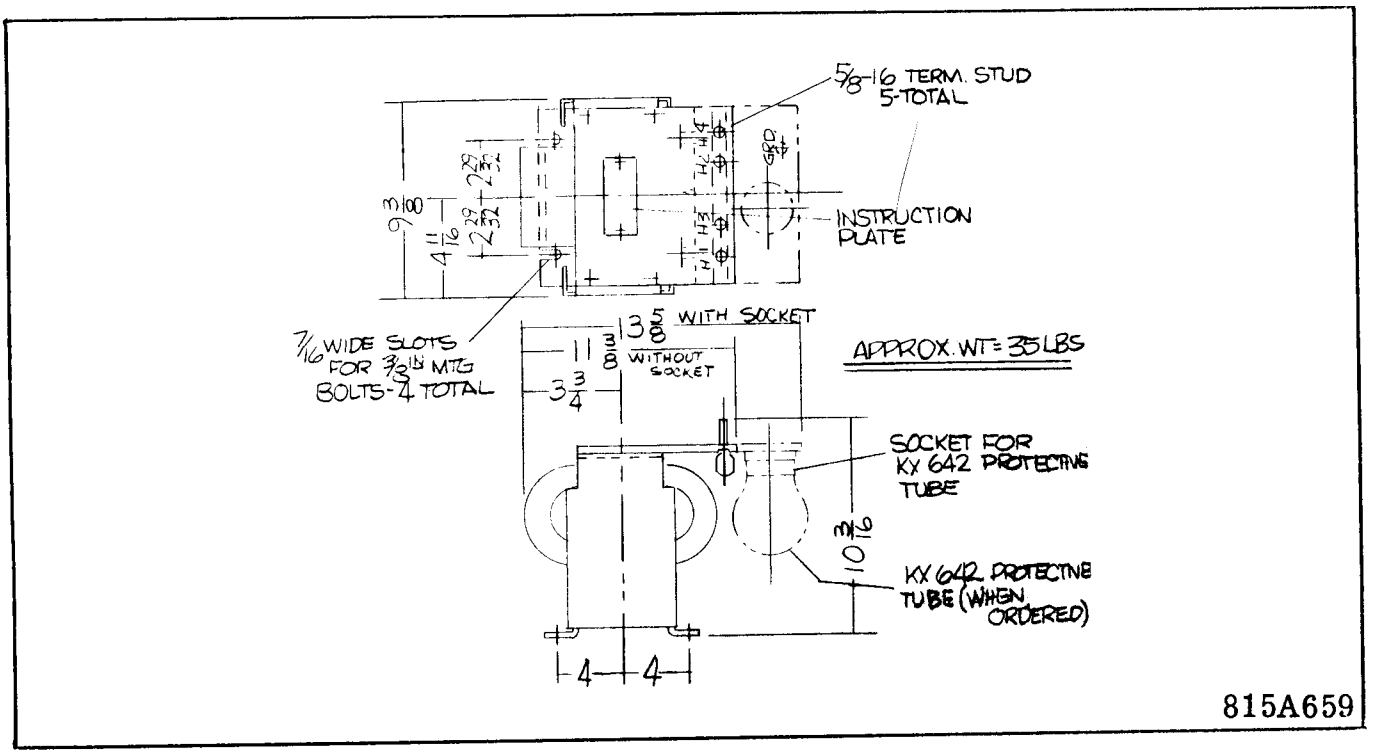


Fig. 4. Neutralizing Reactor outlines 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.

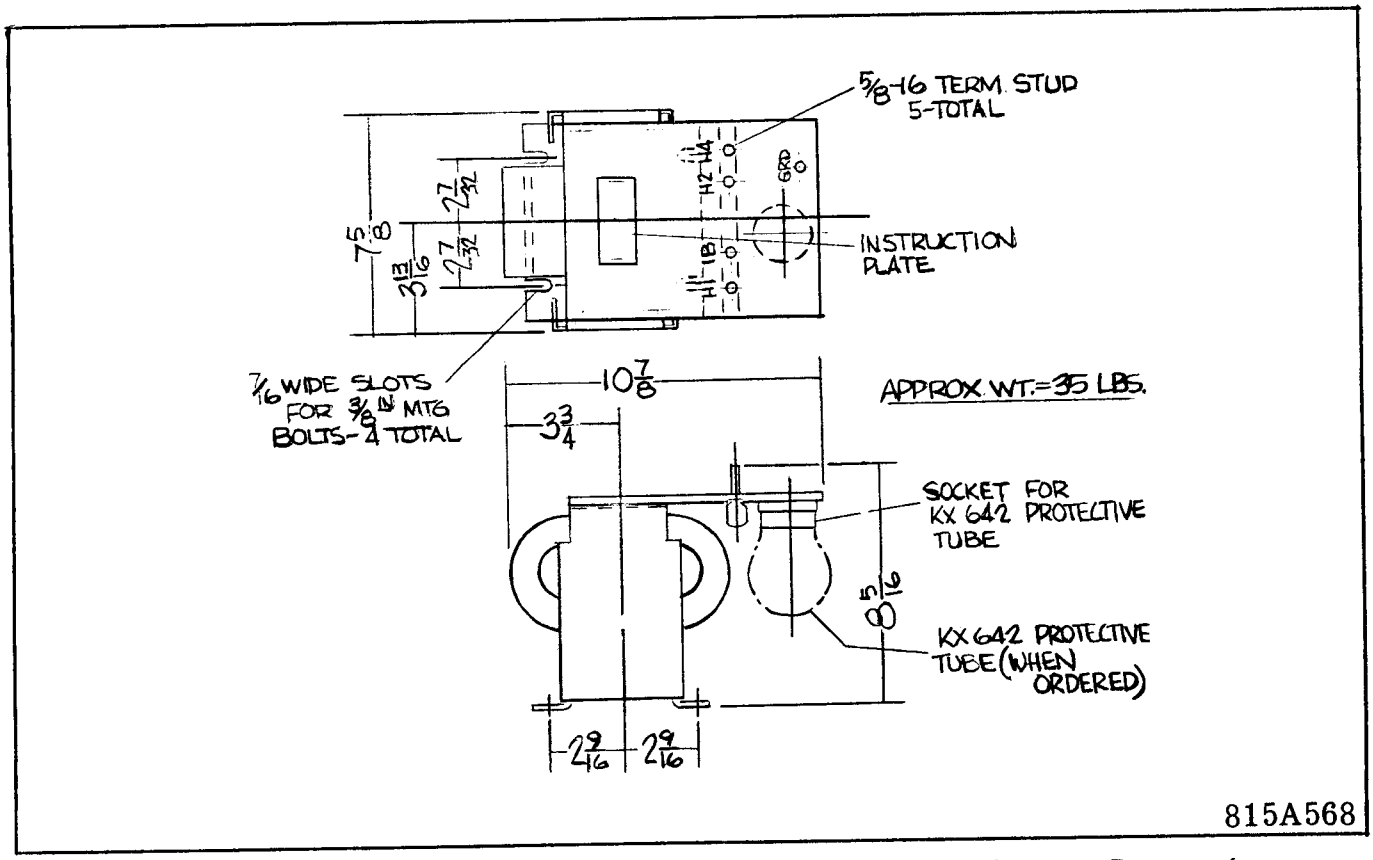
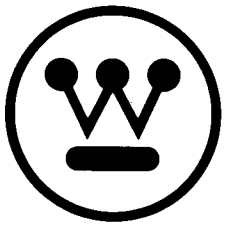


Fig. 5. Mutual Drainage Reactor Outline, 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.



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AC Bypass Capacitor (C)

The AC bypass capacitor (C) is required only when DC monitoring and/or remote trip relays are used. Otherwise connect H2 to H3 on the insulating transformer (refer to Fig. 1.). Use a 10 ufd capacitor for 50/60 HZ applications or a 25 ufd capacitor for 25 HZ applications.

Exciting Capacitors (Cg)

The exciting capacitors (Cg) and ground connection are omitted when the neutralizing reactor is not used. Use a 1.0 ufd capacitor for 50/60 HZ applications or a 2.5 ufd capacitor for 25 HZ applications.

For an application using dc monitoring remote-trip relays without the insulating transformer for HCB/HCB.1 relaying, capacitor C should be connected across the wires to minimize the metallic voltage (wire-wire voltage) generated by the ununbalanced impedance of capacitors C_g.

Mutual Drainage Reactor

The mutual drainage reactor is applied to drain off longitudinally induced voltages which may occur by lightning surges (not a direct stroke) or the parallel association of the pilot wire with faulted power circuits.

The mutual drainage reactors must be applied at more than one terminal or location to provide a path for the drainage currents to flow.

With the mutual drainage reactor only (hence no rise-in-station ground hazard), the remote and station ground are essentially equal, and the KX642 tube ground should be connected to the station ground.

By forcing equal current flow from the two wires into ground, the reactor minimizes metallic voltage (wire-to-wire voltage). The reactor cannot, however, eliminate all metallic voltage even though the longitudinally induced voltages (common mode) are equal and the currents are equal on the two wires unless the wire resistances are identical.

Since it is not practical to make the wire resistances equal, there is a limit to the amount of induced voltage which can be handled without introducing the possibility of relay misoperation due to the generation of spurious metallic voltage. Therefore, it is recommended that these reactors not be applied for cases where the induced voltage from the power system could exceed 1500 volts, rms. Where the induced voltage could exceed 1500 volts, use a cable with sufficient insulation to withstand the induced voltage stress or improve the shielding to reduce this voltage.

Neutralizing Reactors

The neutralizing reactors are applied where the difference between station ground and remote ground can exceed 600 volts rms during power system faults. This rise in station ground potential appears across the neutralizing transformer inserted in the pilot wire. Thus all equipment and circuitry to the left of the neutralizing reactor terminals H2 and H4 (Fig. 1.) are essentially at station ground. All equipment, circuits, pilot wire, sheath, etc. to the right of H1 and H3 (Fig. 1.) are at remote ground and must be insulated from station ground and operating personnel in the station area. The shunt capacity to ground of the pilot wire pair should be on the order of 1 ufd or more. If not, capacitance (Cs) should be added as shown to provide equivalent of approx. 1 ufd. total on each wire to ground.

SUPERSEDES I.L. 41-971.4D
*Denotes change from superseded issue.

EFFECTIVE JUNE 1969

TECHNICAL DATA

Insulating Transformer

Style	Rating	Frequency	Schematic	Reference	Outline Reference
1575394	4/1	50-60 HZ	20D1472	Fig.2	Fig.3(a)
1629502	6/1	50-60 HZ	16D9583	Fig.2	Fig.3(a)
248A692G06	4/1	25 HZ	20D1472	Fig.2	Fig.3(b)
Sim. to 1629502 Except 25HZ	6/1	25 HZ	16D9583	Fig.2	Fig.3(b)

General Specifications	Units	4/1	6/1	4/1	6/1	4/1	6/1
		60 HZ		50 HZ		25 HZ	
Rated Voltage H1-H2 & H3-H4	Volts	60	90	60	90	60	90
Rated Voltage X1-X2	Volts	30	30	30	30	30	30
Continuous Rating H Windings	MA.	12	8	12	8	12	8
Resistance of each H Winding	Ohms	20.4	46.5	20.4	46.5	28.5	
Continuous Rating X Winding	MA.	48	48	48	48	48	48
Resistance of X Winding	Ohms	1.7	1.7	1.7	1.7	2.3	
Insulation H & L Windings to Ground	KV	5.0	5.0	5.0	5.0	5.0	5.0
Exciting Impedance X_1-X_2 at 30 V.	Ohms	850-1250	850-1250	850-1250	790-1030	1250-2000	1250-2000
Approx. Weight	Lbs.	25	25	25	25	40	40

KX-642 Gas Tube

A.C. rms voltage breakdown	300 - 500 Volts
Tube Voltage drop, average D.C.	20 - 30 Volts
1 Second current rating	90 Amps
2 Second current rating	40 Amps

Neutralizing Reactor

Style	Freq.	With KX642 Tube & Socket	Schematic	Reference	Outline Reference
815A629G03	60	Yes	6D1260	Fig.2	Fig.4 (b)
815A629G01	60	No	6D1260	Fig.2	Fig.4 (b)
815A629G03	50	Yes	6D1260	Fig.2	Fig.4 (b)
Sim. to 815A629G01 Except 25HZ	25	No	252A323	Fig.2	Fig.4 (a)

Auxiliaries

949122 1 mfd exciting capacitor - 2 required Res. 50-60 HZ Neutralizing Reactor

2.5 mfd exciting capacitor - 2 required Res. 25 HZ Neutralizing Reactor

The neutralizing reactor and mutual drainage reactor may be used together as shown or either may be applied separately depending on the hazards encountered.

The neutralizing reactor may be applied at one terminal only if there is no rise in voltage at the other terminals.

Neutralizing Reactor Tube KX642

The neutralizing reactor tube KX642 is recommended to minimize wire to wire voltage during a disturbance with one wire accidentally grounded.

Shield Grounding

In order to be electromagnetically effective the shield must be grounded at least twice to provide a path for the flow of demagnetizing current—the question, though, is where? Should the shield be grounded or insulated from the station mat?

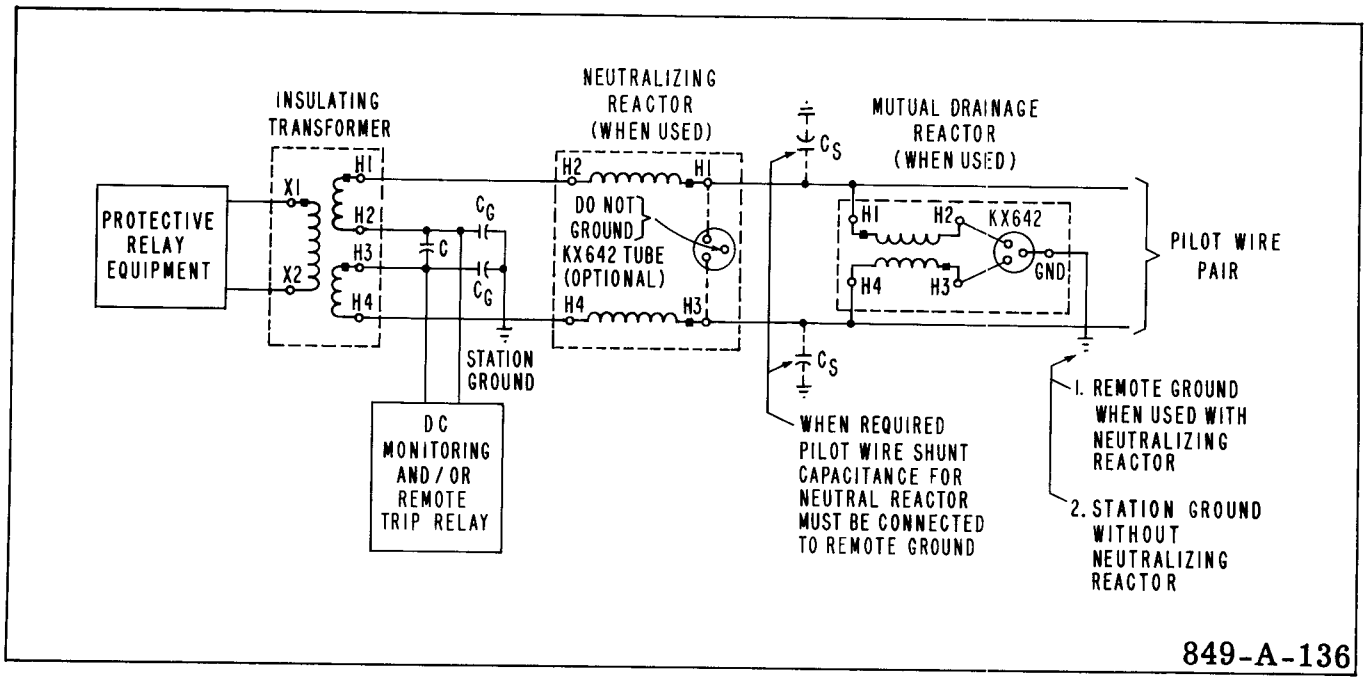
Neutralizing Reactor, Cont.

General Specifications	Units	60 HZ	50 HZ
Voltage Rating Between Windings	Volts	500	500
Voltage Rating Across Winding in Parallel	Volts	4000	4000
Exciting Impedance-both Windings in Parallel at 4KV	Ohms	134,000-267,000	56,750-113,500
Leakage Reactance Each Winding	Ohms	65	54
Resistance of Each Winding	Ohms	88	88
Total Impedance One Reactor Adds to the Pilot Wire Loop	Ohms	219	207
Test Voltage Windings to Ground	Volts	10,000	10,000
Continuous Current Rating Each Winding	MA	10	10
One Second Current Rating Each Winding	MA	50	50
Approx. Weight	Lbs.	76	76

Mutual Drainage Reactors

Style	Freq.	Inc. Socket for Tube	Inc. KX642 Tube	Schematic	Reference	Outline Refer-
881A868G03	60/50	Yes	Yes	253A180	Fig.2	Fig.5 (a)
881A868G02	60/50	Yes	No	247A775	Fig.2	Fig.5 (a)
Sim. to 881A868G02 Except 25 HZ	25	Yes	No	258A504	Fig.2	

General Specifications	Units	60 HZ	50 HZ
Test Voltage Between Windings and Between Windings and Ground-for 1 Minute	Volts	4000	4000
Excitation Impedance at 120 Volts from H1 to H4 H2 to H3 connected together	Ohms	24,000-48,000	17,000-33,000
D.C. Resistance—Each Winding	Ohms	8.	8.
Leakage Reactance Each Winding	Ohms	1.5	1.2
One Second Rating—Each Winding	Amps	90	90
Two Second Rating — Each Winding	Amps	22	22
Approx. Weight	Lbs.	40	40
Saturation Point H1 & H3, to (Winding in Parallel)	Volts, Rms.	500	400



* *Fig. 1. External Schematic for Pilot Wire and Protective Equipment for HCB and HCB-1 Relaying.*

If the shield is grounded to the power-station mat the shield may be damaged by current generated by a rise in station-ground potential during a power-system fault. Unless, the shield has sufficient conductivity to withstand the thermal stress, it should be insulated from station ground. Note that an increase in shield conductivity does not cause a proportional increase in shield current due to the inductance in the loop. If the shield is insulated from station ground (i.e., within 500 ft. of station) it is not effective in reducing induced voltage in the insulated section; if this voltage is large a high-conductivity shield which can thermally withstand the stress of a mat ground is indicated. The "insulated shield" section must be remote grounded to minimize electric-field pickup.

Where the two stations are within about 1500 ft. or less of each other either a single shield ground should be used or the shield should be tied to both mats. In such an application it is common to interconnect the two mats via large power cables (in addition to the overhead shield wires); these reduce the 60 Hz mat voltage difference. However, they have a limited effectiveness due to the cable inductance.

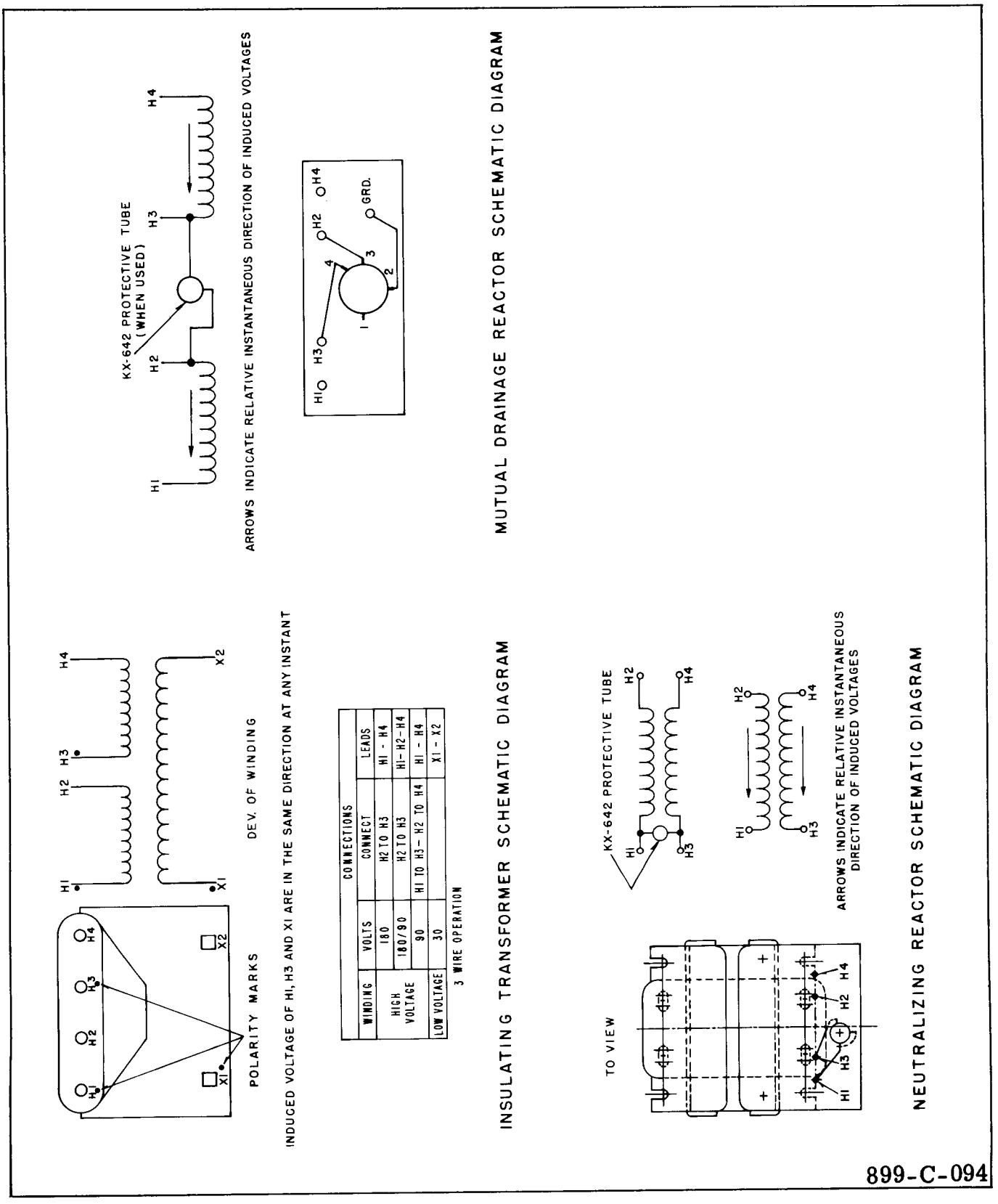
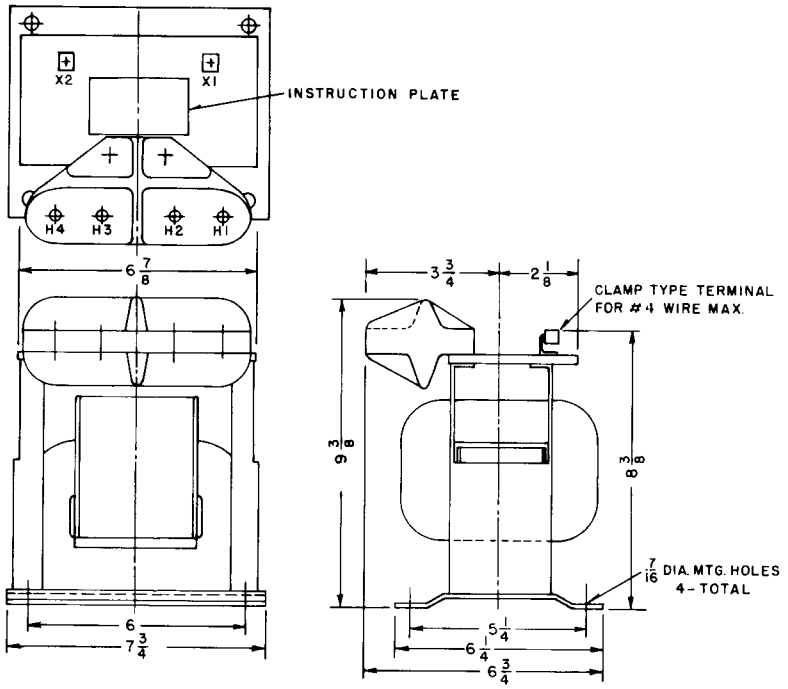
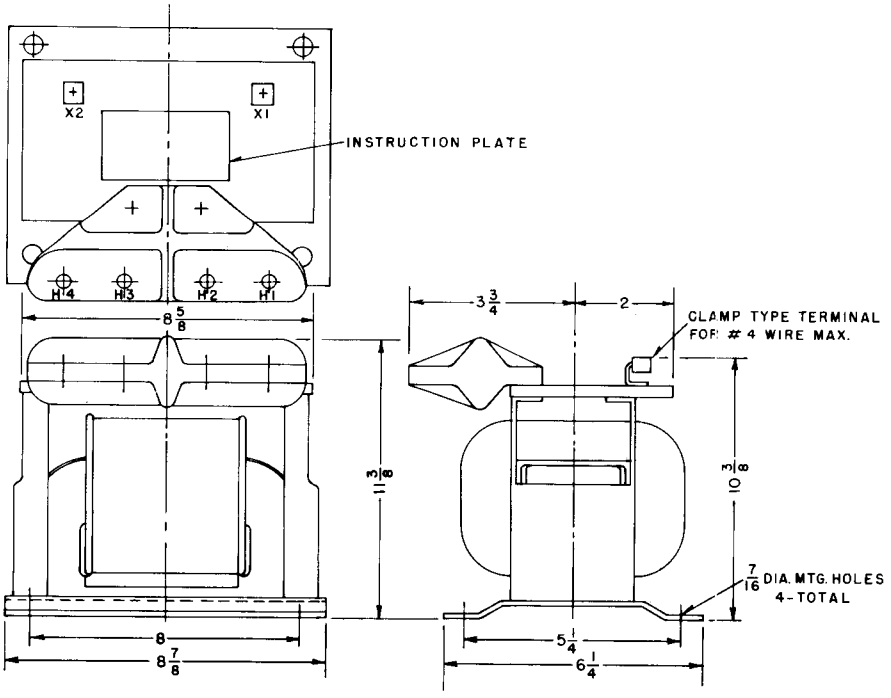


Fig. 2. Schematic Diagrams of Protective Equipment for HCB and HCB-1 Relaying.



a) INSULATING TRANSFORMER OUTLINE FOR 50 AND 60 CYCLE OPERATION



b) INSULATING TRANSFORMER OUTLINE FOR 25 CYCLE OPERATION

899-C-095

Fig. 3. Insulating Transformer Outlines for Protection Equipment for HCB and HCB-1 Relaying.

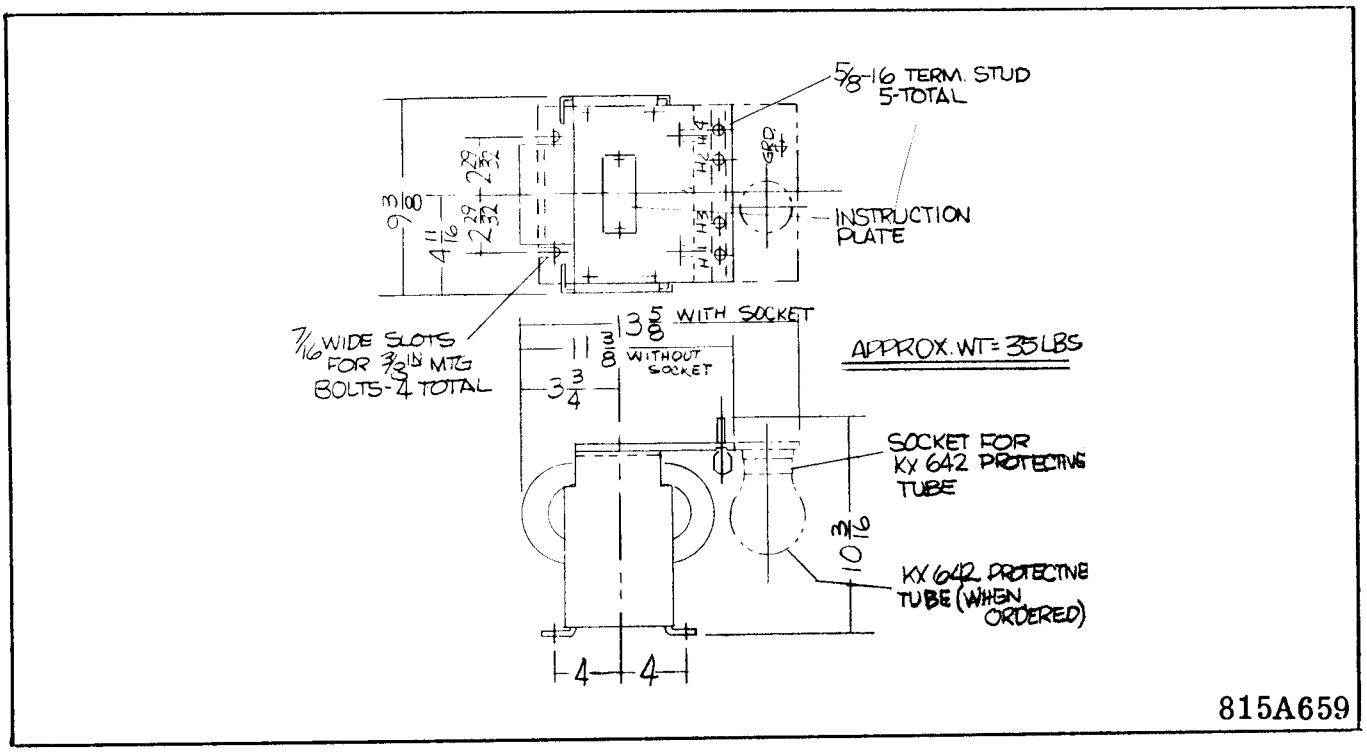


Fig. 4. Neutralizing Reactor outlines 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.

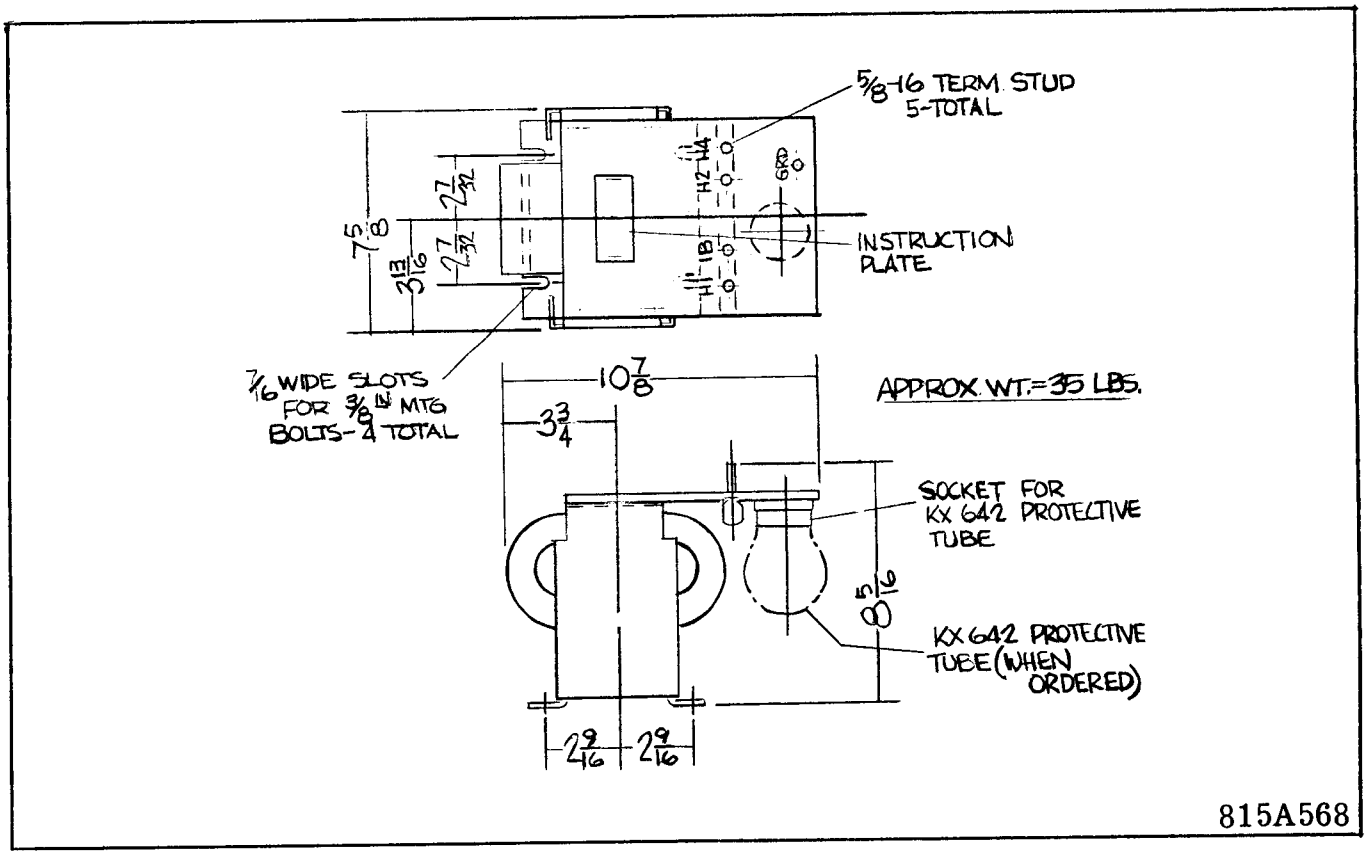


Fig. 5. Mutual Drainage Reactor Outline, 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.

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PILOT WIRE INSULATION AND PROTECTION FOR HCB AND HCB-1 RELAYING

APPLICATION

The insulation and protection equipment shown in Fig. 1. is used with the HCB or HCB-1 pilot wire relay. A complete installation for one terminal of a line consists of an insulating transformer, neutralizing reactor, capacitors, mutual drainage reactors and neutralizing reactor KX642 tube.

AC Bypass Capacitor (C)

The AC bypass capacitor (C) is required only when DC monitoring and/or remote trip relays are used. Otherwise connect H2 to H3 on the insulating transformer (refer to Fig. 1.). Use a 10 ufd capacitor * for 50/60 HZ applications.

Exciting Capacitors (Cg)

The exciting capacitors (Cg) and ground connection are omitted when the neutralizing reactor is not used. Use a 1.0 ufd capacitor for 50/60 HZ applica- * tions.

For an application using dc monitoring remote-trip relays without the insulating transformer for HCB/HCB.1 relaying, capacitor C should be connected across the wires to minimize the metallic voltage (wire-wire voltage) generated by the ununbalanced impedance of capacitors C_g.

Mutual Drainage Reactor

The mutual drainage reactor is applied to drain off longitudinally induced voltages which may occur by lightning surges (not a direct stroke) or the parallel association of the pilot wire with faulted power circuits.

The mutual drainage reactors must be applied at more than one terminal or location to provide a path for the drainage currents to flow.

With the mutual drainage reactor only (hence no rise-in-station ground hazard), the remote and station ground are essentially equal, and the KX642 tube ground should be connected to the station ground.

By forcing equal current flow from the two wires into ground, the reactor minimizes metallic voltage (wire-to-wire voltage). The reactor cannot, however, eliminate all metallic voltage even though the longitudinally induced voltages (common mode) are equal and the currents are equal on the two wires unless the wire resistances are identical.

Since it is not practical to make the wire resistances equal, there is a limit to the amount of induced voltage which can be handled without introducing the possibility of relay misoperation due to the generation of spurious metallic voltage. Therefore, it is recommended that these reactors not be applied for cases where the induced voltage from the power system could exceed 1500 volts, rms. Where the induced voltage could exceed 1500 volts, use a cable with sufficient insulation to withstand the induced voltage stress or improve the shielding to reduce this voltage.

Neutralizing Reactors

The neutralizing reactors are applied where the difference between station ground and remote ground can exceed 600 volts rms during power system faults. This rise in station ground potential appears across the neutralizing transformer inserted in the pilot wire. Thus all equipment and circuitry to the left of the neutralizing reactor terminals H2 and H4 (Fig. 1.) are essentially at station ground. All equipment, circuits, pilot wire, sheath, etc. to the right of H1 and H3 (Fig. 1.) are at remote ground and must be insulated from station ground and operating personnel in the station area. The shunt capacity to ground of the pilot wire pair should be on the order of 1 ufd or more. If not, capacitance (Cs) should be added as shown to provide equivalent of approx. 1 ufd. total on each wire to ground.

TECHNICAL DATA

Insulating Transformer

Style	Rating	Frequency	Schematic	Reference	Outline Reference
1575394	4/1	50-60 HZ	20D1472	Fig.2	Fig.3(a)
1629502	6/1	50-60 HZ	16D9583	Fig.2	Fig.3(a)

*

General Specifications	Units	4/1	6/1	4/1	6/1
		60 HZ		50 HZ	
Rated Voltage H1-H2 and H3-H4	Volts	60	90	60	90
Rated Voltage X1-X2	Volts	30	30	30	30
Continuous Rating H Windings	MA.	12	8	12	8
Resistance of each H Winding	Ohms	20.4	46.5	20.4	46.5
Continuous Rating X Winding	MA.	48	48	48	48
Resistance of X WINDING	Ohms	1.7	1.7	1.7	1.7
Exciting Impedance X_1-X_2 at 30 V.	Ohms	850-1250	850-1250	850-1250	790-1030
Approx. Weight	Lbs.	25	25	25	25

KX-642 Gas Tube

A.C. rms voltage breakdown	300 - 500 Volts
Tube Voltage drop, average D.C.	20 - 30 Volts
1 Second current rating	90 Amps
2 Second current rating	40 Amps

Neutralizing Reactor

Style	Freq.	With KX642 Tube & Socket	Schematic	Reference	Outline Reference
815A629G03	60	Yes	6D1260	Fig.2	Fig.4 (b)
815A629G01	60	No	6D1260	Fig.2	Fig.4 (b)
815A629G03	50	Yes	6D1260	Fig.2	Fig.4 (b)

Auxiliaries

949122 1 mfd exciting capacitor - 2 required Res. 50-60 HZ Neutralizing Reactor

The neutralizing reactor and mutual drainage reactor may be used together as shown or either may be applied separately depending on the hazards encountered.

The neutralizing reactor may be applied at one terminal only if there is no rise in voltage at the other terminals.

Neutralizing Reactor Tube KX642

The neutralizing reactor tube KX642 is recommended to minimize wire to wire voltage during a disturbance with one wire accidentally grounded.

Shield Grounding

In order to be electromagnetically effective the shield must be grounded at least twice to provide a path for the flow of demagnetizing current—the question, though, is where? Should the shield be grounded or insulated from the station mat?

* Neutralizing Reactor, Cont.

General Specifications	Units	60 HZ	50 HZ
Voltage Rating Between Windings	Volts	500	500
Voltage Rating Across Winding in Parallel	Volts	4000	4000
Exciting Impedance-both Windings in Parallel at 4KV	Ohms	134,000-267,000	56,750-113,500
Leakage Reactance Each Winding	Ohms	65	54
Resistance of Each Winding	Ohms	88	88
Total Impedance One Reactor Adds to the Pilot Wire Loop	Ohms	219	207
Test Voltage Windings to Ground	Volts	10,000	10,000
Continuous Current Rating Each Winding	MA	10	10
One Second Current Rating Each Winding	MA	50	50
Approx. Weight	Lbs.	76	76

Insulation	Units	4/1	6/1	4/1	6/1
		60 HZ		50 HZ	
H to L	KV	12	12	12	12
H to GND	KV	12	12	12	12
L to GND	KV	4	4	4	4

Mutual Drainage Reactors

Style	Freq.	Inc. Socket for Tube	Inc. KX642 Tube	Schematic	Reference	Outline Refer-
881A868G03	60/50	Yes	Yes	253A180	Fig. 2	Fig. 5 (a)
881A868G02	60/50	Yes	No	247A775	Fig. 2	Fig. 5 (a)

General Specifications	Units	60 HZ	50 HZ
Test Voltage Between Windings and Between Windings and Ground-for 1 Minute	Volts	4000	4000
Excitation Impedance at 120 Volts from H1 to H4 H2 to H3 connected together	Ohms	24,000-48,000	17,000-33,000
D.C. Resistance— Each Winding	Ohms	8.	8.
Leakage Reactance Each Winding	Ohms	1.5	1.2
One Second Rating— Each Winding	Amps	90	90
Two Second Rating — Each Winding	Amps	22	22
Approx. Weight	Lbs.	40	40
Saturation Point H1 & H3, to (Winding in Parallel)	Volts, Rms.	500	400

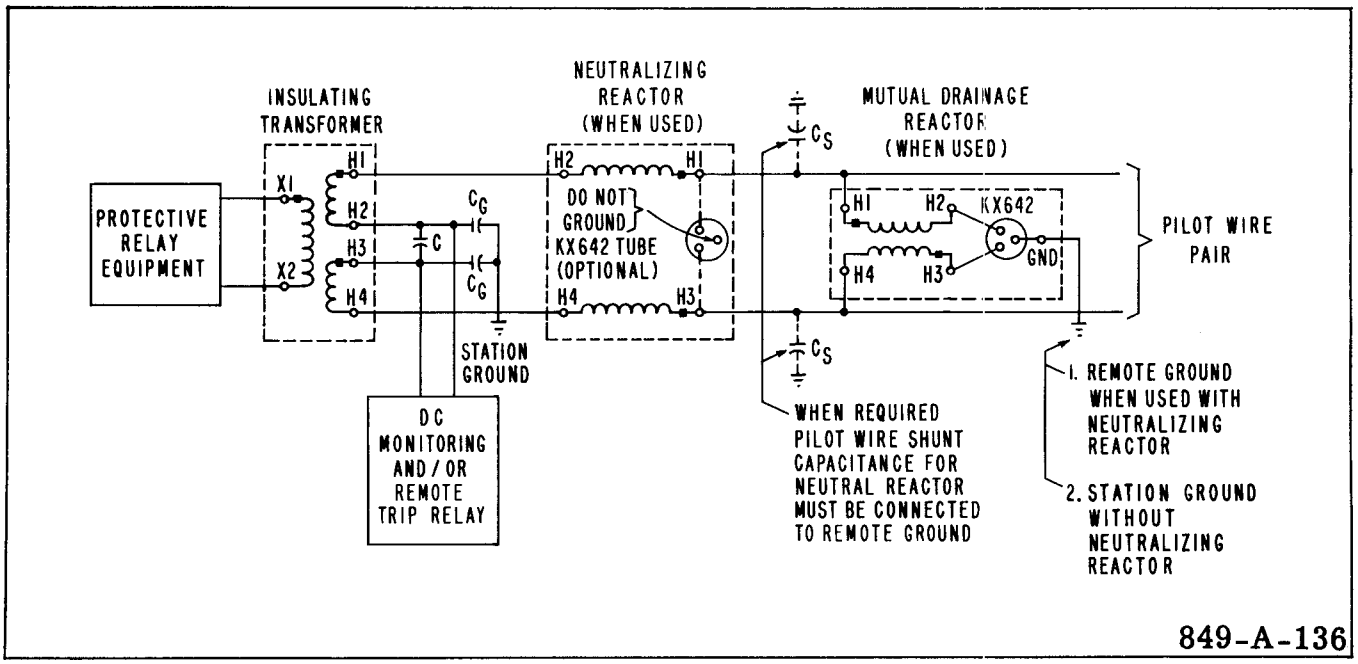


Fig. 1. External Schematic for Pilot Wire and Protective Equipment for HCB and HCB-1 Relaying.

If the shield is grounded to the power-station mat the shield may be damaged by current generated by a rise in station-ground potential during a power-system fault. Unless, the shield has sufficient conductivity to withstand the thermal stress, it should be insulated from station ground. Note that an increase in shield conductivity does not cause a proportional increase in shield current due to the inductance in the loop. If the shield is insulated from station ground (i.e., within 500 ft. of station) it is not effective in reducing induced voltage in the insulated section; if this voltage is large a high-conductivity shield which can thermally withstand the stress of a mat ground is indicated. The "insulated shield" section must be remote grounded to minimize electric-field pickup.

Where the two stations are within about 1500 ft. or less of each other either a single shield ground should be used or the shield should be tied to both mats. In such an application it is common to interconnect the two mats via large power cables (in addition to the overhead shield wires); these reduce the 60 Hz mat voltage difference. However, they have a limited effectiveness due to the cable inductance.

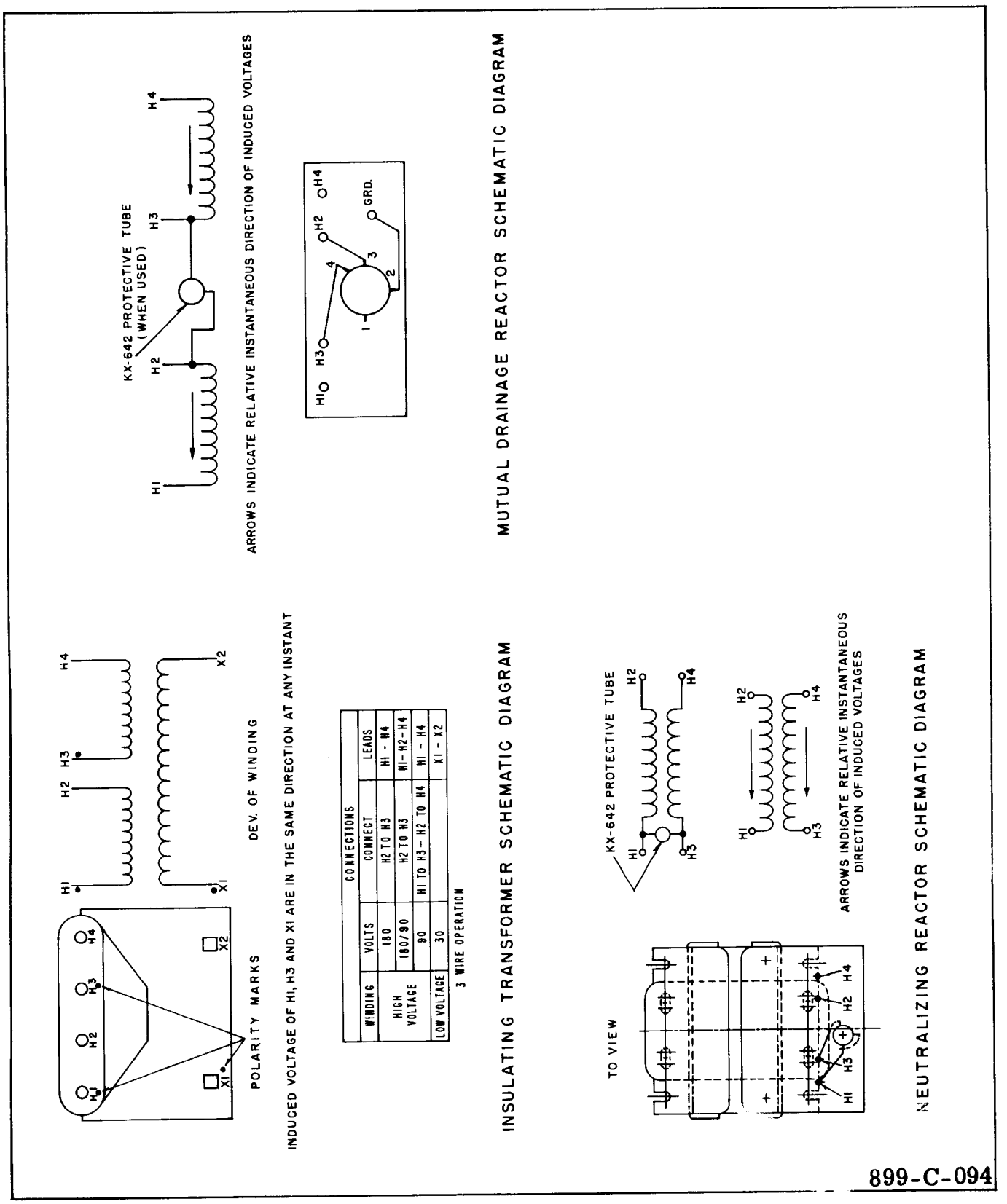
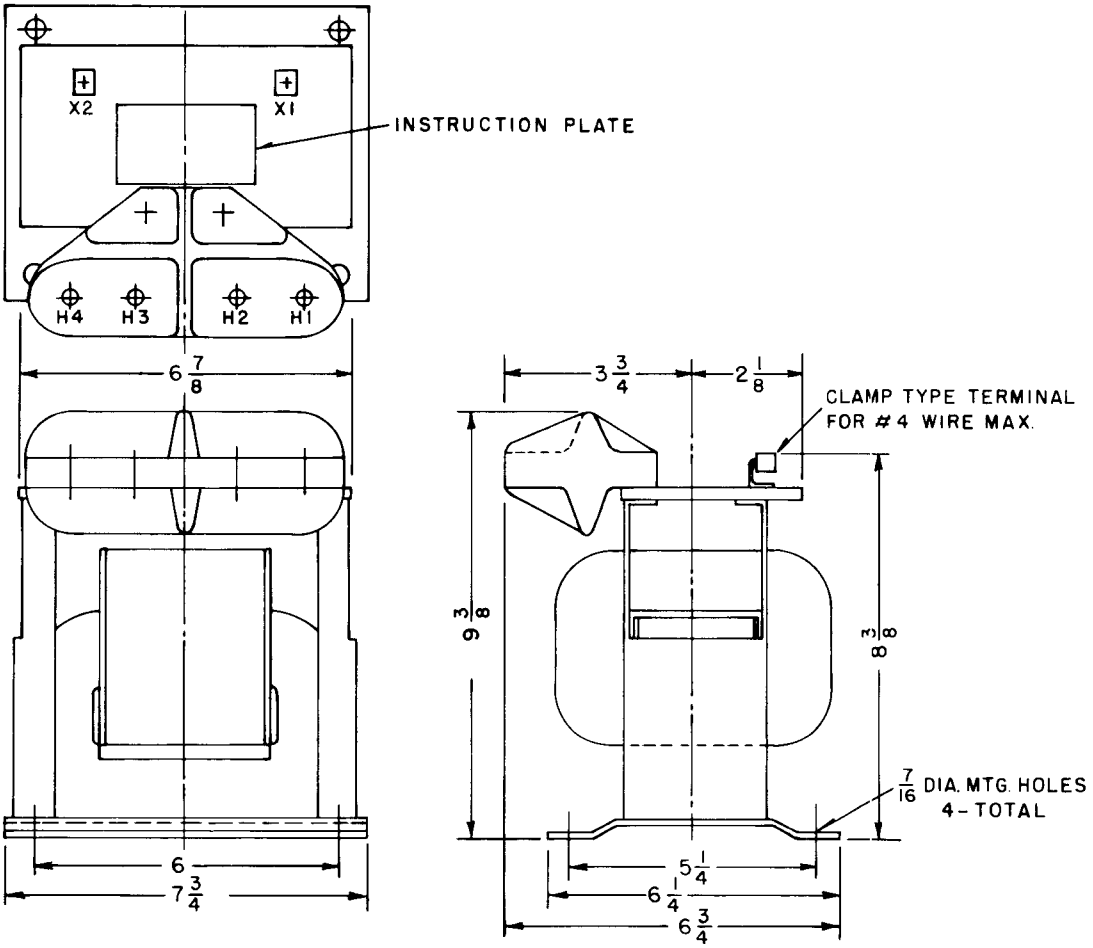


Fig. 2. Schematic Diagrams of Protective Equipment for HCB and HCB-1 Relaying.



INSULATING TRANSFORMER OUTLINE FOR 50 AND 60 CYCLE OPERATION

899-C-095

* *Fig. 3. Insulating Transformer Outlines for Protection Equipment for HCB and HCB-1 Relaying.*

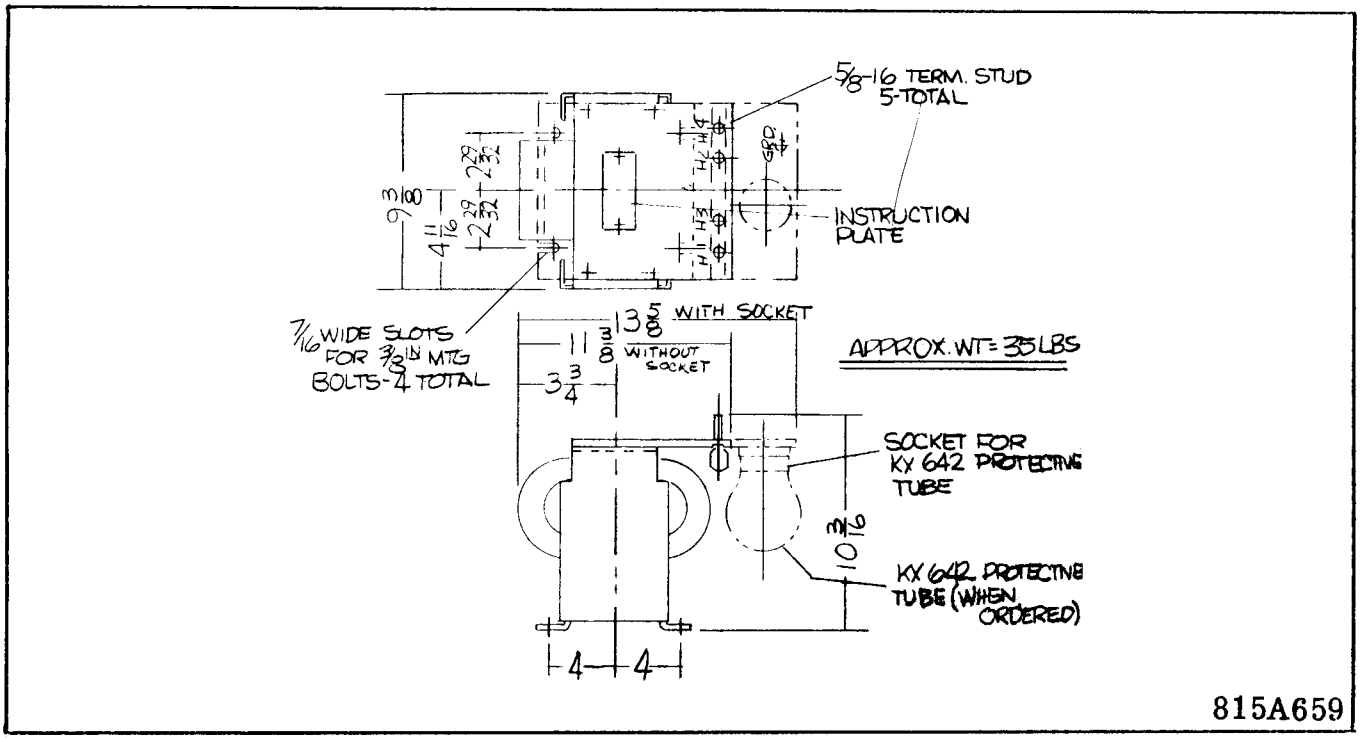


Fig. 4. Neutralizing Reactor outlines 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.

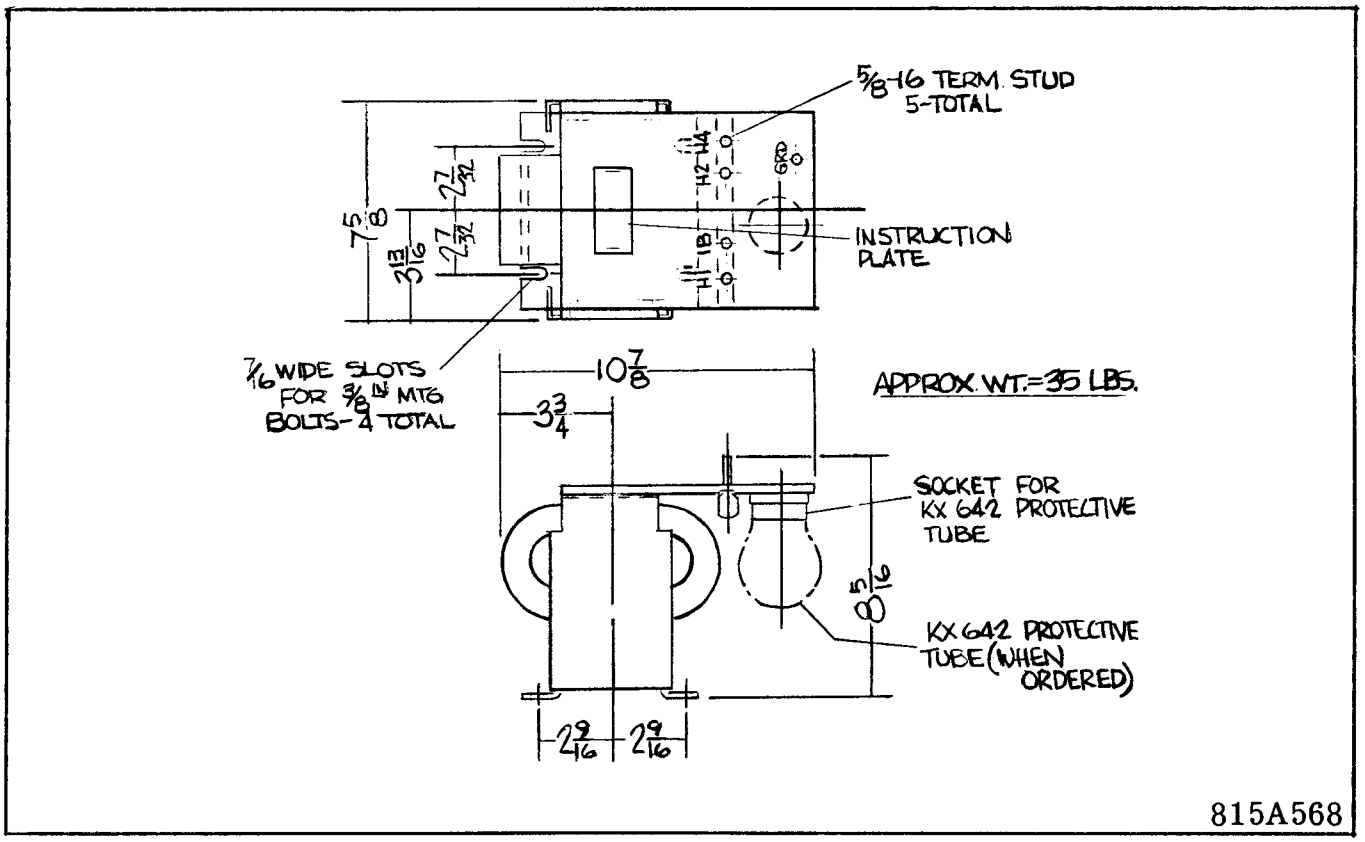
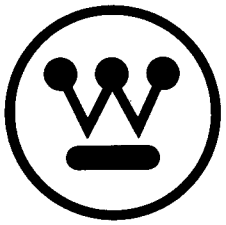


Fig. 5. Mutual Drainage Reactor Outline, 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.



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PILOT WIRE INSULATION AND PROTECTION FOR HCB AND HCB-1 RELAYING

APPLICATION

The insulation and protection equipment shown in Fig. 1. is used with the HCB or HCB-1 pilot wire relay. A complete installation for one terminal of a line consists of an insulating transformer, neutralizing reactor, capacitors, mutual drainage reactors and neutralizing reactor KX642 tube.

AC Bypass Capacitor (C)

The AC bypass capacitor (C) is required only when DC monitoring and/or remote trip relays are used. Otherwise connect H2 to H3 on the insulating transformer (refer to Fig. 1.). Use a 10 ufd capacitor for 50/60 HZ applications.

Exciting Capacitors (Cg)

The exciting capacitors (Cg) and ground connection are omitted when the neutralizing reactor is not used. Use a 1.0 ufd capacitor for 50/60 HZ applications.

For an application using dc monitoring remote-trip relays without the insulating transformer for HCB/HCB.1 relaying, capacitor C should be connected across the wires to minimize the metallic voltage (wire-wire voltage) generated by the ununbalanced impedance of capacitors C_g.

Mutual Drainage Reactor

The mutual drainage reactor is applied to drain off longitudinally induced voltages which may occur by lightning surges (not a direct stroke) or the parallel association of the pilot wire with faulted power circuits.

The mutual drainage reactors must be applied at more than one terminal or location to provide a path for the drainage currents to flow.

With the mutual drainage reactor only (hence no rise-in-station ground hazard), the remote and station ground are essentially equal, and the KX642 tube ground should be connected to the station ground.

By forcing equal current flow from the two wires into ground, the reactor minimizes metallic voltage (wire-to-wire voltage). The reactor cannot, however, eliminate all metallic voltage even though the longitudinally induced voltages (common mode) are equal and the currents are equal on the two wires unless the wire resistances are identical.

Since it is not practical to make the wire resistances equal, there is a limit to the amount of induced voltage which can be handled without introducing the possibility of relay misoperation due to
* the generation of spurious metallic voltage. Care must be taken to assure that the resistance unbalance does not generate a metallic voltage greater than 7 volts when the induced voltage is drained. If this value cannot be obtained then use a cable with sufficient insulation to withstand the induced voltage stress or improve the shielding to reduce this voltage.

Neutralizing Reactors

The neutralizing reactors are applied where the difference between station ground and remote ground can exceed 600 volts rms during power system faults. This rise in station ground potential appears across the neutralizing transformer inserted in the pilot wire. Thus all equipment and circuitry to the left of the neutralizing reactor terminals H2 and H4 (Fig. 1.) are essentially at station ground. All equipment, circuits, pilot wire, sheath, etc. to the right of H1 and H3 (Fig. 1.) are at remote ground and must be insulated from station ground and operating personnel in the station area. The shunt capacity to ground of the pilot wire pair should be on the order of 1 ufd or more. If not, capacitance (Cs) should be added as shown to provide equivalent of approx. 1 ufd. total on each wire to ground.

SUPERSEDES I.L. 41-971.4F
*Denotes changes from superseded issue.

EFFECTIVE OCTOBER 1974

TECHNICAL DATA

Insulating Transformer

Style	Rating	Frequency	Schematic	Reference	Outline Reference
1575394	4/1	50-60 HZ	20D1472	Fig.2	Fig.3(a)
1629502	6/1	50-60 HZ	16D9583	Fig.2	Fig.3(a)

Insulation 60 Sec. Rating	Units	4/1	6/1	4/1	6/1
		60 HZ		50 HZ	
H to L	KV	12	12	12	12
H to GND	KV	12	12	12	12
L to GND	KV	4	4	4	4

General Specifications	Units	4/1	6/1	4/1	6/1
		60 HZ		50 HZ	
Rated Voltage H1-H2 and H3-H4	Volts	60	90	60	90
Rated Voltage X1-X2	Volts	30	30	30	30
Continuous Rating H Windings	MA.	12	8	12	8
Resistance of each H Winding	Ohms	20.4	46.5	20.4	46.5
Continuous Rating X Winding	MA.	48	48	48	48
Resistance of X WINDING	Ohms	1.7	1.7	1.7	1.7

General Specifications	Units	4/1	6/1	4/1	6/1
		60 HZ		50 HZ	
Exciting Impedance X_1-X_2 at 30 V.	Ohms	850-1250	850-1250	850-1250	790-1030
Approx. Weight	Lbs.	25	25	25	25

KX-642 Gas Tube

A.C. rms voltage breakdown	300 - 500 Volts
Tube Voltage drop, average D.C.	20 - 30 Volts
1 Second current rating	90 Amps
2 Second current rating	40 Amps

Neutralizing Reactor

Style	Freq.	With KX642 Tube & Socket	Schematic	Reference	Outline Reference
815A629G03	60	Yes	6D1260	Fig.2	Fig.4 (b)
815A629G01	60	No	6D1260	Fig.2	Fig.4 (b)
815A629G03	50	Yes	6D1260	Fig.2	Fig.4 (b)

Auxiliaries

949122 1 mfd exciting capacitor - 2 required Res. 50-60 HZ Neutralizing Reactor

The neutralizing reactor and mutual drainage reactor may be used together as shown or either may be applied separately depending on the hazards encountered.

The neutralizing reactor may be applied at one terminal only if there is no rise in voltage at the other terminals.

Neutralizing Reactor Tube KX642

The neutralizing reactor tube KX642 is recommended to minimize wire to wire voltage during a disturbance with one wire accidentally grounded.

Shield Grounding

In order to be electromagnetically effective the shield must be grounded at least twice to provide a path for the flow of demagnetizing current—the question, though, is where? Should the shield be grounded or insulated from the station mat?

Neutralizing Reactor, Cont.

General Specifications	Units	60 HZ	50 HZ
Voltage Rating Between Windings	Volts	500	500
Voltage Rating Across Winding in Parallel	Volts	4000	4000
Exciting Impedance-both Windings in Parallel at 4KV	Ohms	134,000-267,000	56,750-113,500
Leakage Reactance Each Winding	Ohms	65	54
Resistance of Each Winding	Ohms	88	88
Total Impedance One Reactor Adds to the Pilot Wire Loop	Ohms	219	207
Test Voltage Windings to Ground	Volts	10,000	10,000
Continuous Current Rating Each Winding	MA	10	10
One Second Current Rating Each Winding	MA	50	50
Approx. Weight	Lbs.	76	76

Mutual Drainage Reactors

Style	Freq.	Inc. Socket for Tube	Inc. KX642 Tube	Schematic	Reference	Outline Refer-
881A868G03	60/50	Yes	Yes	253A180	Fig.2	Fig.5 (a)
881A868G02	60/50	Yes	No	247A775	Fig.2	Fig.5 (a)

General Specifications	Units	60 HZ	50 HZ
Test Voltage Between Windings and Between Windings and Ground-for 1 Minute	Volts	4000	4000
Excitation Impedance at 120 Volts from H1 to H4 H2 to H3 connected together	Ohms	24,000-48,000	17,000-33,000
D.C. Resistance—Each Winding	Ohms	8.	8.
Leakage Reactance Each Winding	Ohms	1.5	1.2
One Second Rating—Each Winding	Amps	90	90
Two Second Rating — Each Winding	Amps	22	22
Approx. Weight	Lbs.	40	40
Saturation Point H1 & H3, to (Winding in Parallel)	Volts, Rms.	500	400

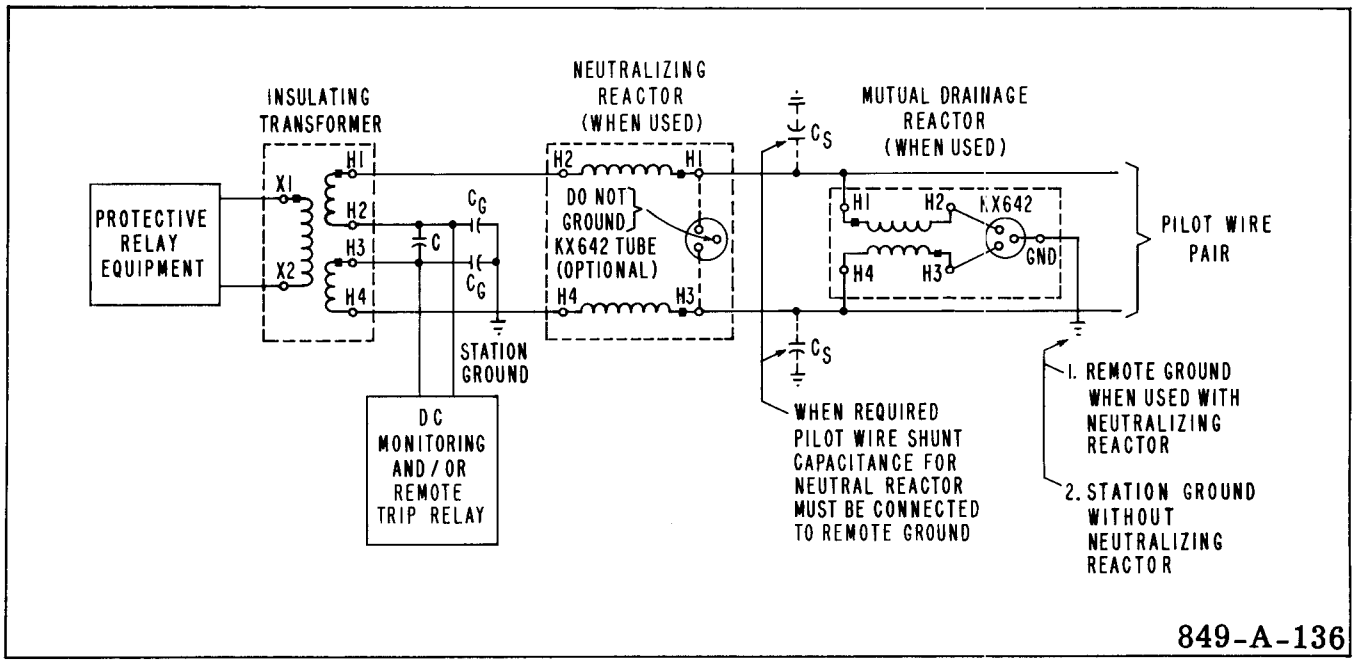


Fig. 1. External Schematic for Pilot Wire and Protective Equipment for HCB and HCB-1 Relaying.

If the shield is grounded to the power-station mat the shield may be damaged by current generated by a rise in station-ground potential during a power-system fault. Unless, the shield has sufficient conductivity to withstand the thermal stress, it should be insulated from station ground. Note that an increase in shield conductivity does not cause a proportional increase in shield current due to the inductance in the loop. If the shield is insulated from station ground (i.e., within 500 ft. of station) it is not effective in reducing induced voltage in the insulated section; if this voltage is large a high-conductivity shield which can thermally withstand the stress of a mat ground is indicated. The "insulated shield" section must be remote grounded to minimize electric-field pickup.

Where the two stations are within about 1500 ft. or less of each other either a single shield ground should be used or the shield should be tied to both mats. In such an application it is common to interconnect the two mats via large power cables (in addition to the overhead shield wires); these reduce the 60 Hz mat voltage difference. However, they have a limited effectiveness due to the cable inductance.

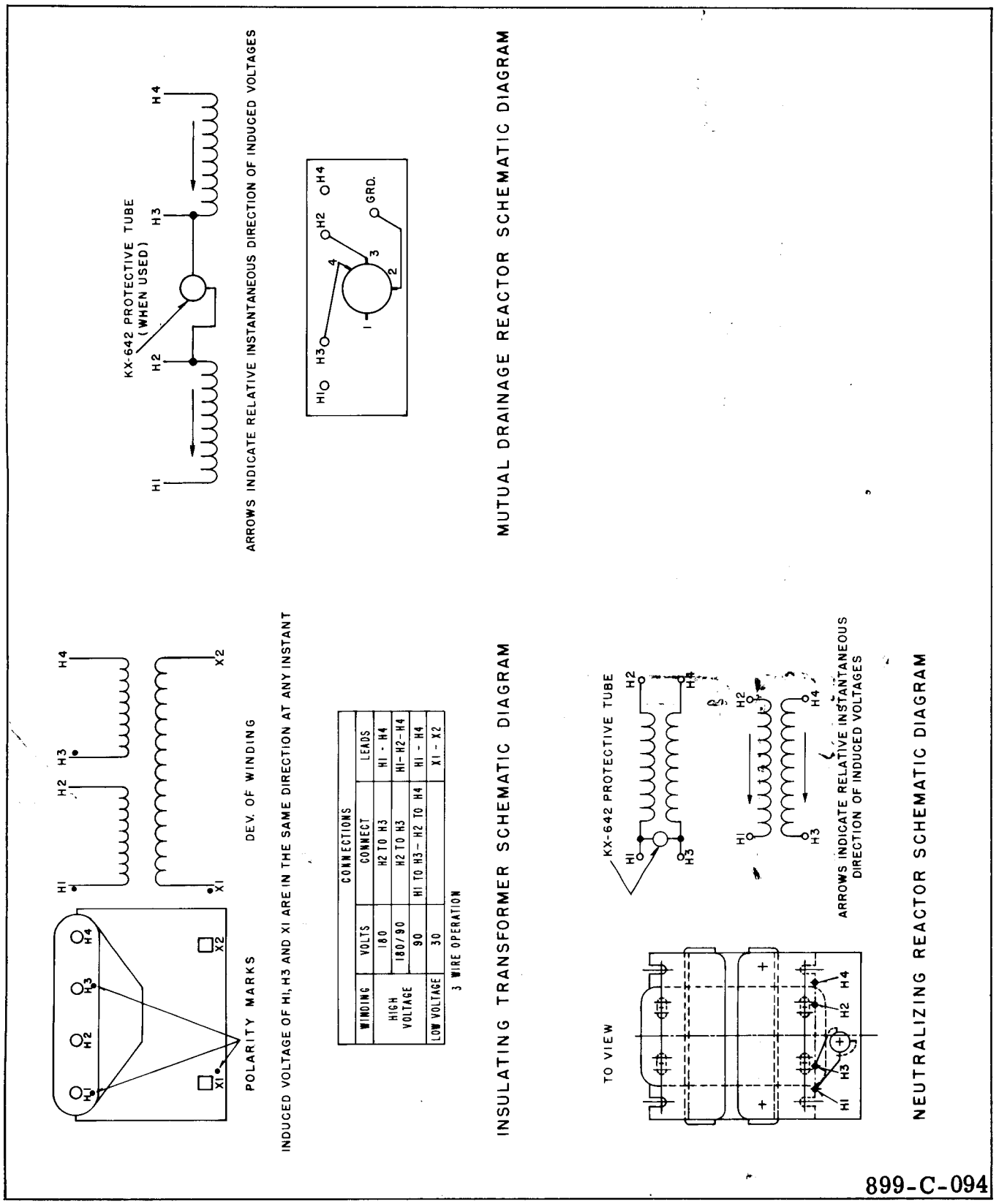
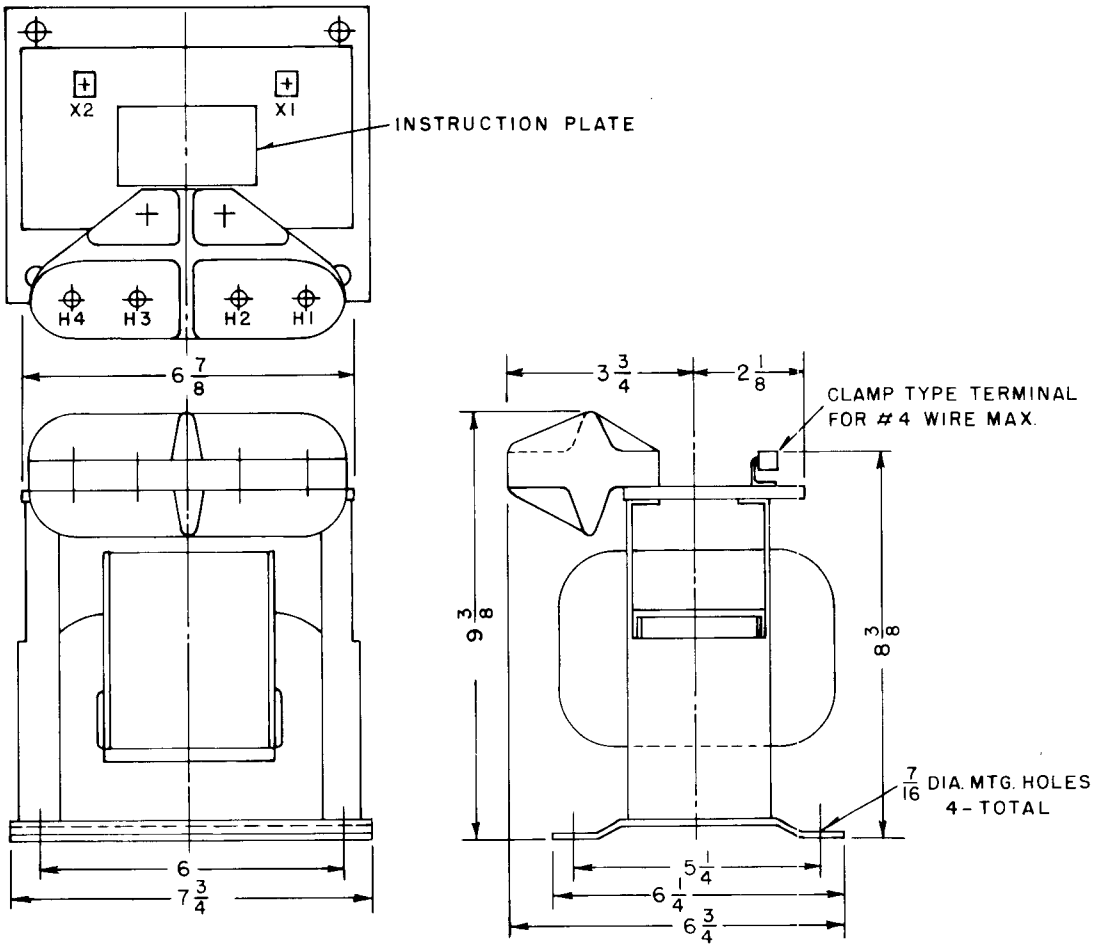


Fig. 2. Schematic Diagrams of Protective Equipment for HCB and HCB-1 Relaying.



INSULATING TRANSFORMER OUTLINE FOR 50 AND 60 CYCLE OPERATION

899-C-095

Fig. 3. Insulating Transformer Outlines for Protection Equipment for HCB and HCB-1 Relaying.

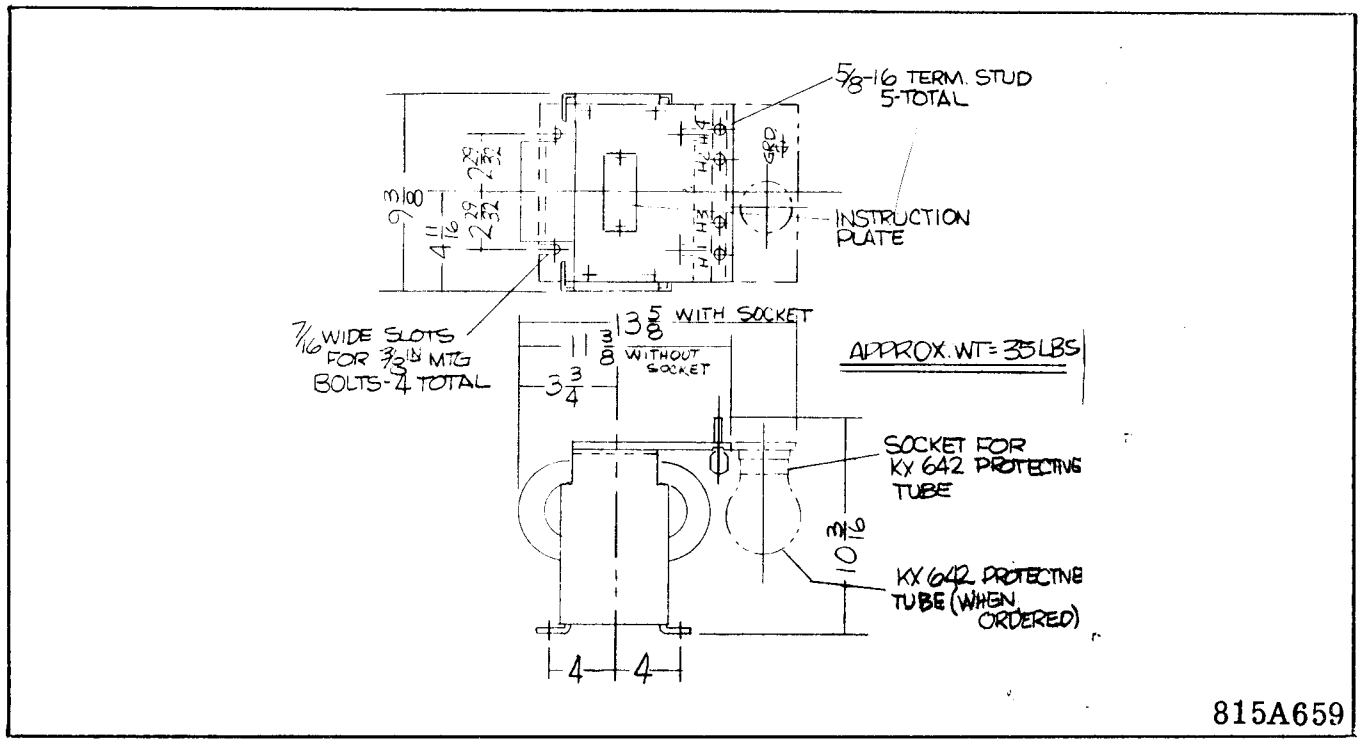


Fig. 4. Neutralizing Reactor outlines 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.

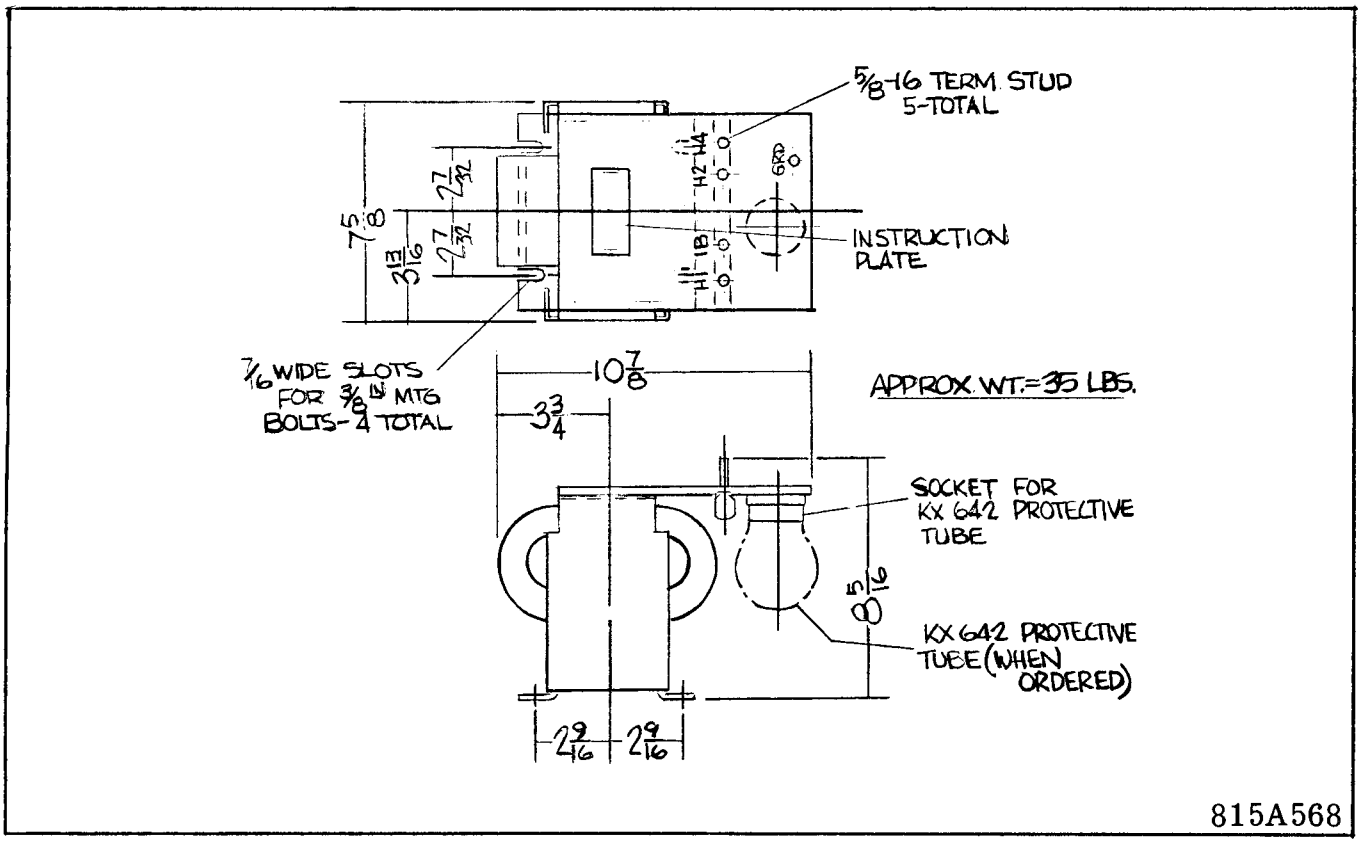
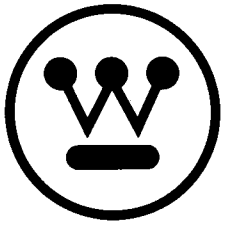


Fig. 5. Mutual Drainage Reactor Outline, 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.



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PILOT WIRE INSULATION AND PROTECTION FOR HCB AND HCB-1 RELAYING

APPLICATION

The insulation and protection equipment shown in Fig. 1. is used with the HCB or HCB-1 pilot wire relay. A complete installation for one terminal of a line consists of an insulating transformer, neutralizing reactor, capacitors, mutual drainage reactors and neutralizing reactor KX642 tube.

AC Bypass Capacitor (C)

The AC bypass capacitor (C) is required only when DC monitoring and/or remote trip relays are used. Otherwise connect H2 to H3 on the insulating transformer (refer to Fig. 1.). Use a 10 ufd capacitor for 50/60 HZ applications.

Exciting Capacitors (Cg)

The exciting capacitors (Cg) and ground connection are omitted when the neutralizing reactor is not used. Use a 1.0 ufd capacitor for 50/60 HZ applications.

For an application using dc monitoring remote-trip relays without the insulating transformer for HCB/HCB.1 relaying, capacitor C should be connected across the wires to minimize the metallic voltage (wire-wire voltage) generated by the ununbalanced impedance of capacitors C_g.

Mutual Drainage Reactor

The mutual drainage reactor is applied to drain off longitudinally induced voltages which may occur by lightning surges (not a direct stroke) or the parallel association of the pilot wire with faulted power circuits.

The mutual drainage reactors must be applied at more than one terminal or location to provide a path for the drainage currents to flow.

With the mutual drainage reactor only (hence no rise-in-station ground hazard), the remote and station ground are essentially equal, and the KX642 tube ground should be connected to the station ground.

By forcing equal current flow from the two wires into ground, the reactor minimizes metallic voltage (wire-to-wire voltage). The reactor cannot, however, eliminate all metallic voltage even though the longitudinally induced voltages (common mode) are equal and the currents are equal on the two wires unless the wire resistances are identical.

Since it is not practical to make the wire resistances equal, there is a limit to the amount of induced voltage which can be handled without introducing the possibility of relay misoperation due to * the generation of spurious metallic voltage. Care must be taken to assure that the resistance unbalance does not generate a metallic voltage greater than 7 volts when the induced voltage is drained. If this value cannot be obtained then use a cable with sufficient insulation to withstand the induced voltage stress or improve the shielding to reduce this voltage.

Neutralizing Reactors

The neutralizing reactors are applied where the difference between station ground and remote ground can exceed 600 volts rms during power system faults. This rise in station ground potential appears across the neutralizing transformer inserted in the pilot wire. Thus all equipment and circuitry to the left of the neutralizing reactor terminals H2 and H4 (Fig. 1.) are essentially at station ground. All equipment, circuits, pilot wire, sheath, etc. to the right of H1 and H3 (Fig. 1.) are at remote ground and must be insulated from station ground and operating personnel in the station area. The shunt capacity to ground of the pilot wire pair should be on the order of 1 ufd or more. If not, capacitance (Cs) should be added as shown to provide equivalent of approx. 1 ufd. total on each wire to ground.

SUPERSEDES I.L. 41-971.4F
*Denotes changes from superseded issue.

EFFECTIVE OCTOBER 1974

TECHNICAL DATA

Insulating Transformer

Style	Rating	Frequency	Schematic	Reference	Outline Reference
1575394	4/1	50-60 HZ	20D1472	Fig.2	Fig.3(a)
1629502	6/1	50-60 HZ	16D9583	Fig.2	Fig.3(a)

*

Insulation 60 Sec. Rating	Units	4/1	6/1	4/1	6/1
		60 HZ		50 HZ	
H to L	KV	12	12	12	12
H to GND		12	12	12	12
L to GND		4	4	4	4

General Specifications	Units	4/1	6/1	4/1	6/1
		60 HZ		50 HZ	
Rated Voltage H1-H2 and H3-H4	Volts	60	90	60	90
Rated Voltage X1-X2	Volts	30	30	30	30
Continuous Rating H Windings	MA.	12	8	12	8
Resistance of each H Winding	Ohms	20.4	46.5	20.4	46.5
Continuous Rating X Winding	MA.	48	48	48	48
Resistance of X WINDING	Ohms	1.7	1.7	1.7	1.7

General Specifications	Units	4/1	6/1	4/1	6/1
		60 HZ		50 HZ	
Exciting Impedance X_1-X_2 at 30 V.	Ohms	850-1250	850-1250	850-1250	790-1030
Approx. Weight	Lbs.	25	25	25	25

KX-642 Gas Tube

A.C. rms voltage breakdown	300 - 500 Volts
Tube Voltage drop, average D.C.	20 - 30 Volts
1 Second current rating	90 Amps
2 Second current rating	40 Amps

Neutralizing Reactor

Style	Freq.	With KX642 Tube & Socket	Schematic	Reference	Outline Reference
815A629G03	60	Yes	6D1260	Fig.2	Fig.4 (b)
815A629G01	60	No	6D1260	Fig.2	Fig.4 (b)
815A629G03	50	Yes	6D1260	Fig.2	Fig.4 (b)

Auxiliaries

949122 1 mfd exciting capacitor - 2 required Res. 50-60 HZ Neutralizing Reactor

The neutralizing reactor and mutual drainage reactor may be used together as shown or either may be applied separately depending on the hazards encountered.

The neutralizing reactor may be applied at one terminal only if there is no rise in voltage at the other terminals.

Neutralizing Reactor Tube KX642

The neutralizing reactor tube KX642 is recommended to minimize wire to wire voltage during a disturbance with one wire accidentally grounded.

Shield Grounding

In order to be electromagnetically effective the shield must be grounded at least twice to provide a path for the flow of demagnetizing current—the question, though, is where? Should the shield be grounded or insulated from the station mat?

Neutralizing Reactor, Cont.

General Specifications	Units	60 HZ	50 HZ
Voltage Rating Between Windings	Volts	500	500
Voltage Rating Across Winding in Parallel	Volts	4000	4000
Exciting Impedance-both Windings in Parallel at 4KV	Ohms	134,000-267,000	56,750-113,500
Leakage Reactance Each Winding	Ohms	65	54
Resistance of Each Winding	Ohms	88	88
Total Impedance One Reactor Adds to the Pilot Wire Loop	Ohms	219	207
Test Voltage Windings to Ground	Volts	10,000	10,000
Continuous Current Rating Each Winding	MA	10	10
One Second Current Rating Each Winding	MA	50	50
Approx. Weight	Lbs.	76	76

Mutual Drainage Reactors

Style	Freq.	Inc. Socket for Tube	Inc. KX642 Tube	Schematic	Reference	Outline Refer-
881A868G03	60/50	Yes	Yes	253A180	Fig.2	Fig.5 (a)
881A868G02	60/50	Yes	No	247A775	Fig.2	Fig.5 (a)

General Specifications	Units	60 HZ	50 HZ
Test Voltage Between Windings and Between Windings and Ground-for 1 Minute	Volts	4000	4000
Excitation Impedance at 120 Volts from H1 to H4 H2 to H3 connected together	Ohms	24,000-48,000	17,000-33,000
D.C. Resistance—Each Winding	Ohms	8.	8.
Leakage Reactance Each Winding	Ohms	1.5	1.2
One Second Rating—Each Winding	Amps	90	90
Two Second Rating — Each Winding	Amps	22	22
Approx. Weight	Lbs.	40	40
Saturation Point H1 & H3, to (Winding in Parallel)	Volts, Rms.	500	400

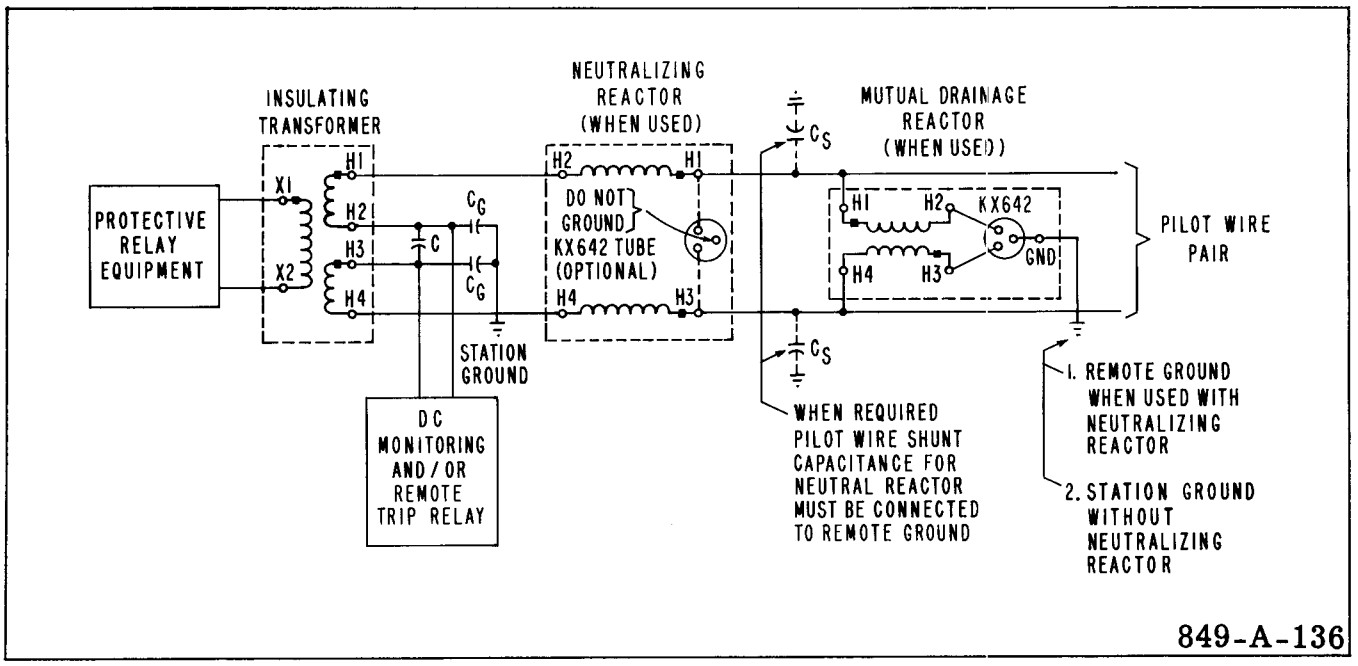


Fig. 1. External Schematic for Pilot Wire and Protective Equipment for HCB and HCB-1 Relaying.

If the shield is grounded to the power-station mat the shield may be damaged by current generated by a rise in station-ground potential during a power-system fault. Unless, the shield has sufficient conductivity to withstand the thermal stress, it should be insulated from station ground. Note that an increase in shield conductivity does not cause a proportional increase in shield current due to the inductance in the loop. If the shield is insulated from station ground (i.e., within 500 ft. of station) it is not effective in reducing induced voltage in the insulated section; if this voltage is large a high-conductivity shield which can thermally withstand the stress of a mat ground is indicated. The "insulated shield" section must be remote grounded to minimize electric-field pickup.

Where the two stations are within about 1500 ft. or less of each other either a single shield ground should be used or the shield should be tied to both mats. In such an application it is common to interconnect the two mats via large power cables (in addition to the overhead shield wires); these reduce the 60 Hz mat voltage difference. However, they have a limited effectiveness due to the cable inductance.

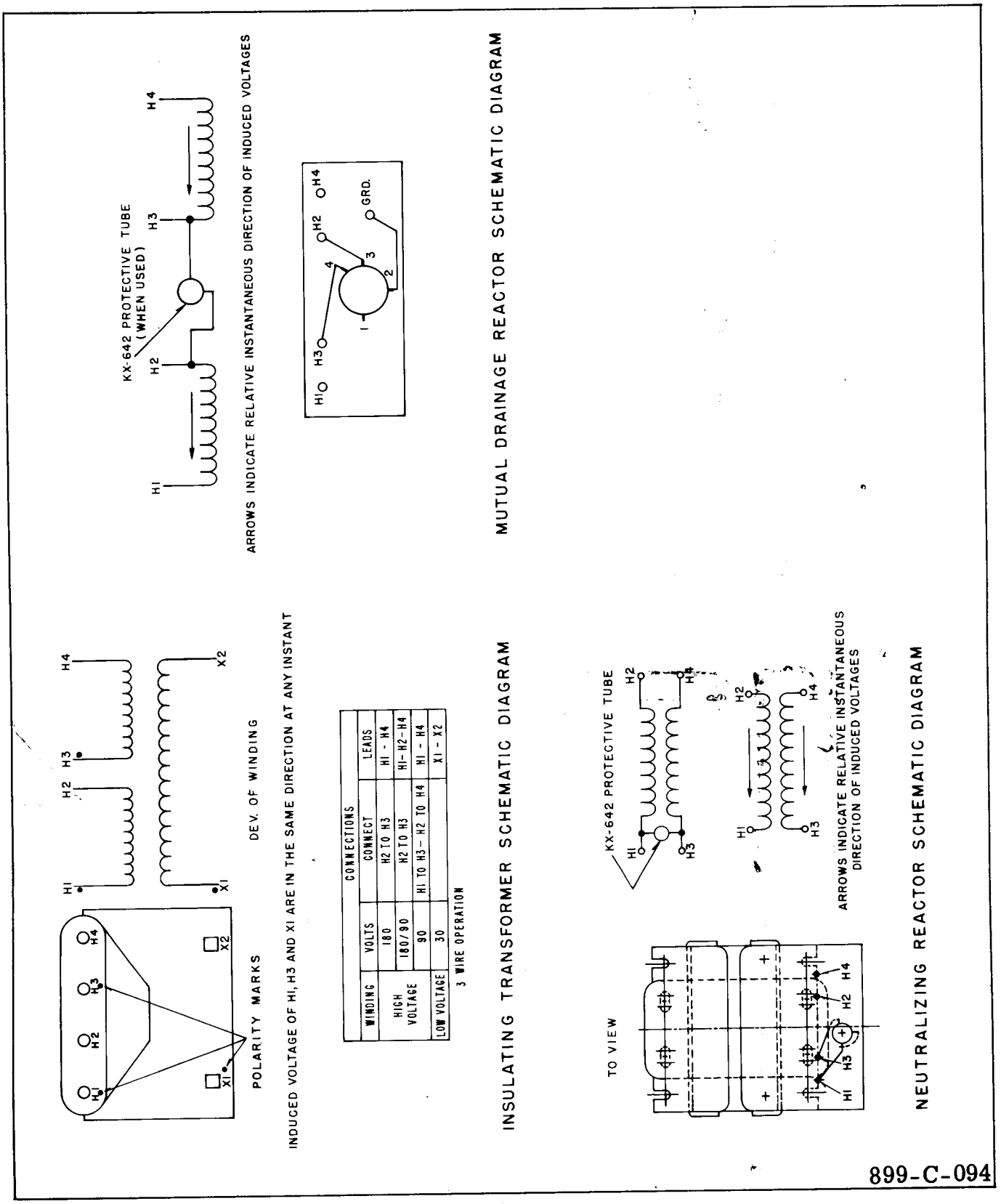
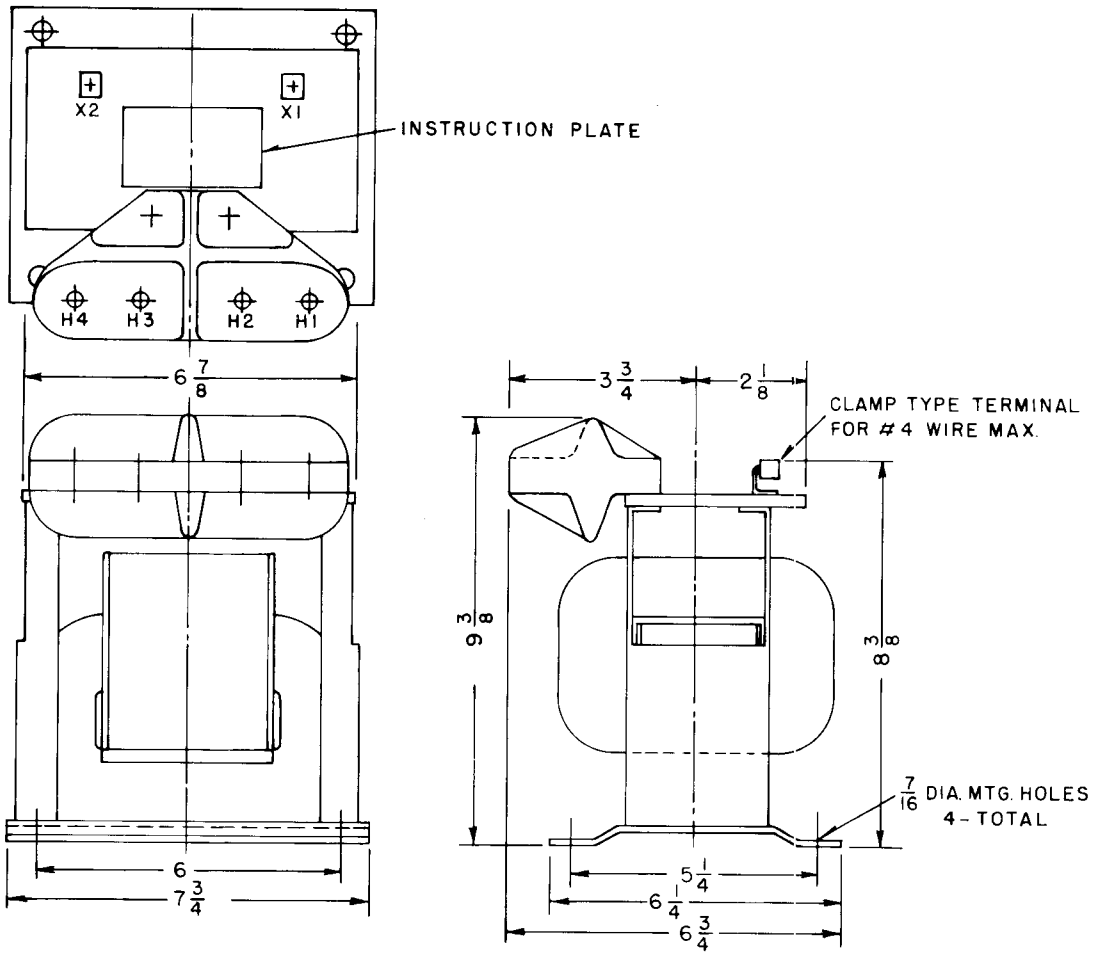


Fig. 2. Schematic Diagrams of Protective Equipment for HCB and HCB-1 Relaying.



INSULATING TRANSFORMER OUTLINE FOR 50 AND 60 CYCLE OPERATION

899-C-095

Fig. 3. Insulating Transformer Outlines for Protection Equipment for HCB and HCB-1 Relaying.

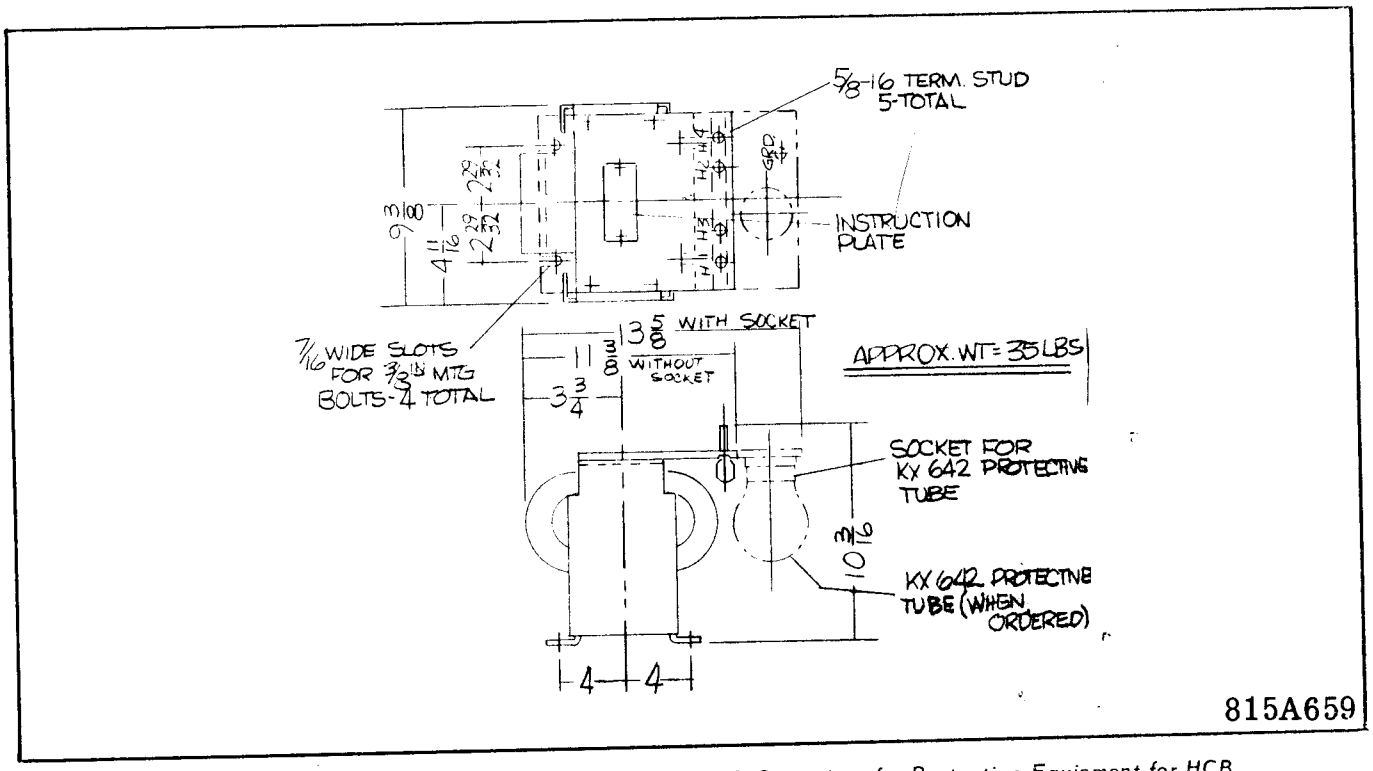


Fig. 4. Neutralizing Reactor outlines 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.

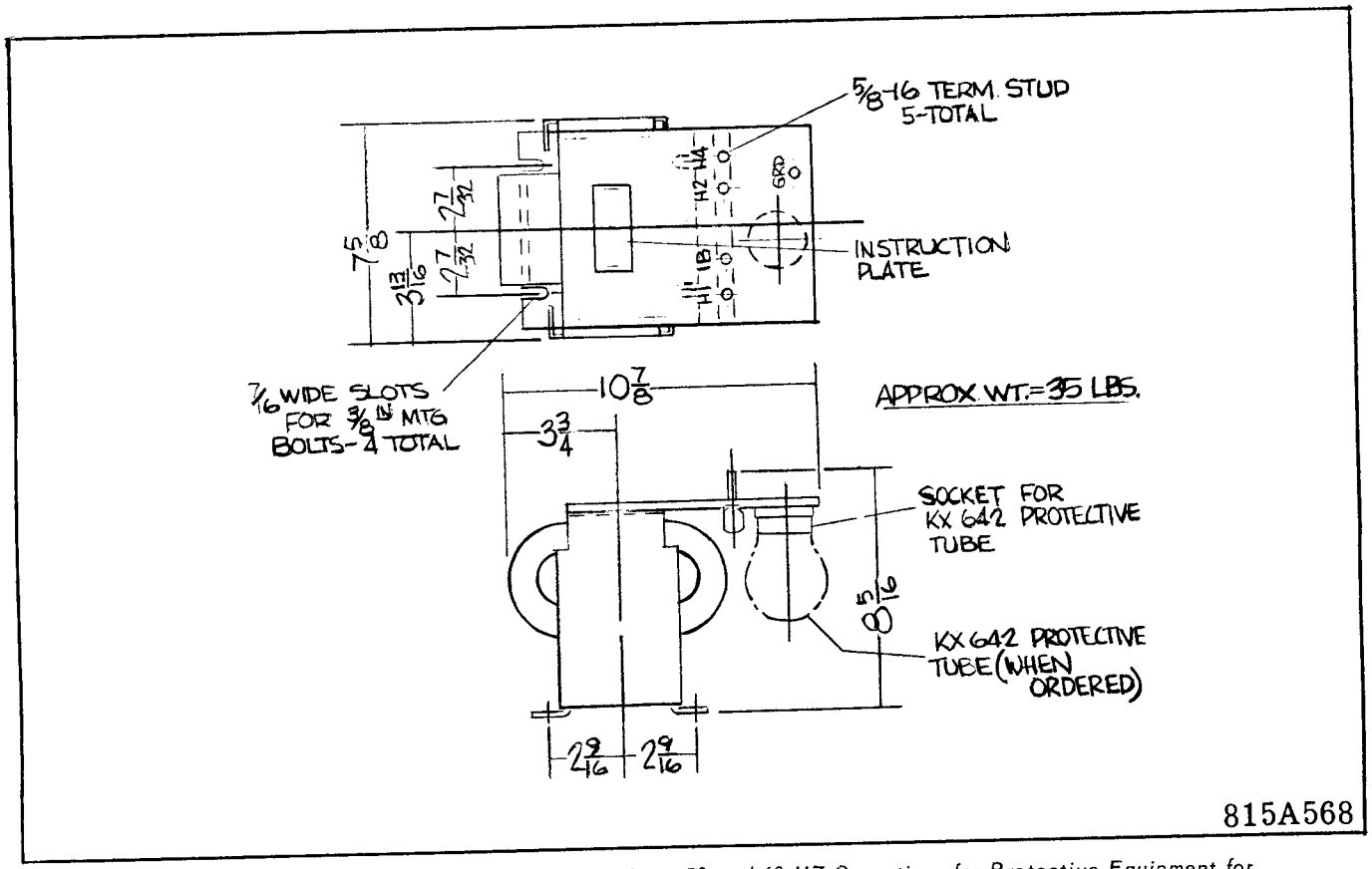
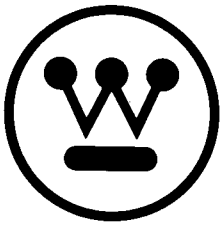


Fig. 5. Mutual Drainage Reactor Outline, 50 and 60 HZ Operation, for Protective Equipment for HCB and HCB-1 Relaying.



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