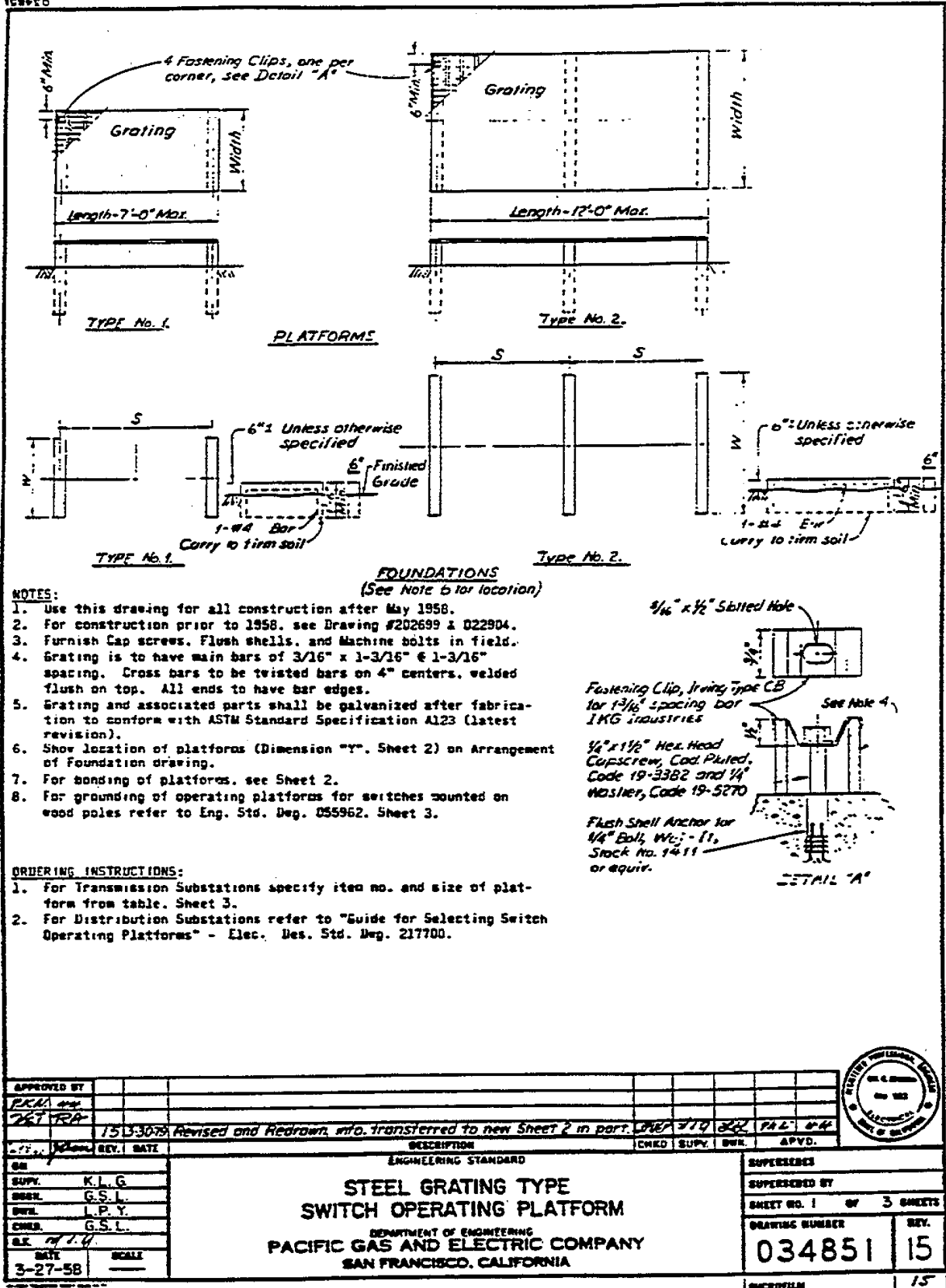


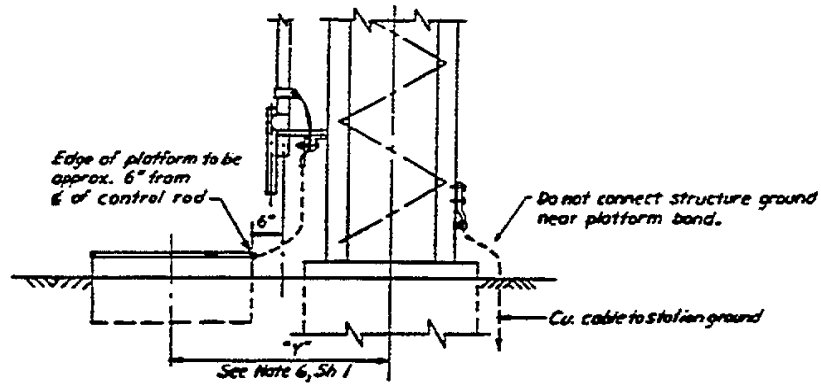


APPENDIX E

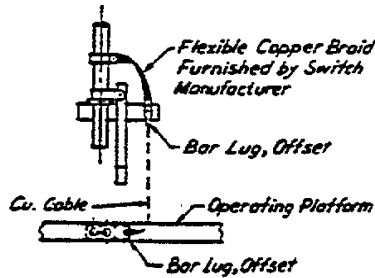
SUBSTATION GROUNDING REQUIREMENTS

PG&E INTERCONNECTION HANDBOOK

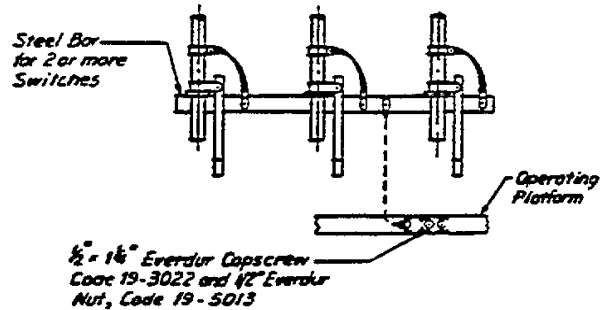




TYPICAL STEEL STRUCTURE INSTALLATION



BONDING ARRANGEMENT FOR 1 SWITCH



BONDING ARRANGEMENT FOR 2 OR MORE SWITCHES

NOTES:

- (a) Provide continuous visible bonding connection from operating rod(s) to operating platform.
- (b) Use 250 Kcail copper cable for bonding. For code numbers for bar lugs and copper cable see Eng. Std. 055962.

APPROVED BY										
CHKD	REV	DATE	DESCRIPTION	CHKD	SUPV	ENGR	APVD.			
JKP	TRP	5-21-79	Rev. Note for Bonding Arrang. 2 or More Switches.	JKP	TRP	TRP				
		4-3-79	New Sheet, former Sheet 2 made Sheet 3							
ENGR	SUPV	CHKD	DESCRIPTION	CHKD	SUPV	ENGR	APVD.			
			ENGINEERING STANDARD							
SUPV.	K. L. G.		STEEL GRATING TYPE SWITCH OPERATING PLATFORM DEPARTMENT OF ENGINEERING PACIFIC GAS AND ELECTRIC COMPANY SAN FRANCISCO, CALIFORNIA	SUPERSEDED BY						
ENGR.	G. S. L.			SHEET NO. 2 OF SHEETS						
ENGR.	L. P. Y.			DRAWING NUMBER						
ENGR.	G. S. L.			034851						
S.E.	7/1/79			REV.						
DATE	SCALE									
6-24-63										





10000

ITEM	TYPE	SIZE OF PLATFORM	FOUNDATION		TYPICAL APPLICATIONS FOR TRANSMISSION SUBSTATIONS Arrangement:	Deg. No.	CODE
			V	S			
1	1	3'x3'	3'-0 1/4"	2'-6"	60KV Main & Aux. Bus Structure (one switch-main bus side)	425556 406852	15-5036
2	1	3'x4'	3'-0 1/4"	3'-6"	230KV DCB Structure (ground switch)	400984	15-5044
3	1	3'x5'	3'-0 1/4"	4'-6"	60KV Switch & Fuse Structure (without ground switch)	413799	15-5045
					60KV DCB Structure (one switch only)	413799	
					230KV Double Bus Structure (one switch - bus parallel bay)	44787	
					230KV Bus Selector Switch Structure	323151	
					500KV Switch Structure (disconnect switch only)	328254 328609	
4	1	3'x6'	3'-0 1/4"	5'-6"	60KV Switch & Fuse Structure (with ground switch)	413799 321611	15-5046
					60KV Main & Aux. Bus Structure 2 or 3 switches - aux bus side	425556 406852	
5	1	3'x7'	3'-0 1/4"	6'-6"			15-5047
6	2	3'x8'	3'-0 1/4"	3'-9"	60KV DCB Structure (2 or 3 switches)	413799	15-5034
					60KV Regulating Transformer Structure (2 or 3 switches)	310226	
					230KV DCB Structure (disconnect and bypass switches)	400984	
					230KV DCB Structure (2 or 3 switches)	210654 326496	
					500KV Switch Structure (disconnect and ground switches)	328609	
7	2	3'x9'	3'-0 1/4"	4'-3"			15-5048
8	2	3'x10'	3'-0 1/4"	4'-9"	230KV Double Bus Structure (2 switches)	44787	15-5031
9							
10	1	4'x4'	4'-0 1/4"	3'-6"	44KV to 70KV Switch On Wood Pole (for station use only)		15-5049
11	1	4'x5'	4'-0 1/4"	4'-6"			15-5050
12	1	4'x6'	4'-0 1/4"	5'-6"	60KV Air Switch Structure (disconnect switch only)	313197	15-5051
					115KV Main & Aux. Bus Structure (one switch-main bus side)	312032	
					115KV DCB Structure (one switch-bus parallel DCB)	422983	
					115KV Double Bus Structure (one switch-bus parallel bay)	309950	
					115KV Bus Selector Switch Structure	425555	
13	1	4'x7'	4'-0 1/4"	6'-6"			15-5052
14	2	4'- 8'	4'-0 1/4"	3'-9"	60KV Air Switch Structure (disconnect switch & ground switch)	313197	15-5053
					115KV DCB Structure (2 or 3 switches)	422983 420188	
15	2	4'x9'	4'-0 1/4"	4'-3"			15-5054
16	2	4'x10'	4'-0 1/4"	4'-9"	115KV Main & Aux. Bus Structure (2 or 3 switches-center column)	312032	15-5055
					115KV Double Bus Structure (2 switches)	309950	

APPROVED BY									
RA	60								
DATE	3-30-75	Retyped. This sheet formerly Sheet 2							
REV.									
DESCRIPTION					ENGR	SUPV.	CHKD	APVD.	



BY	
SUPV.	L. W. FISHER
DATE	
CHKD.	
S.E.	4.1.4
DATE	6-24-63
SCALE	

ENGINEERING STANDARD
STEEL GRATING TYPE
SWITCH OPERATING PLATFORM
 DEPARTMENT OF ENGINEERING
PACIFIC GAS AND ELECTRIC COMPANY
 SAN FRANCISCO, CALIFORNIA

SUPERSEDES	
SUPERSEDED BY	
SHEET NO. 3 OF 3 SHEETS	
DRAWING NUMBER	REV.
034851	4
MICROFILM	4



296550

PURPOSE AND SCOPE

1. THIS DRAWING PROVIDES DESIGN PARAMETERS, APPLICATION AND ORDERING INFORMATION FOR GROUNDING OF EQUIPMENT, STRUCTURES, ETC. IN DISTRIBUTION SUBSTATIONS.
2. GROUNDING OF NON-CURRENT CARRYING METALLIC PARTS AND STRUCTURES TO LIMIT POTENTIAL GRADIENTS DURING GROUND FAULT CONDITIONS FOR PROTECTION OF PERSONNEL IN THE AREA..
3. GROUNDING OF NEUTRALS TO STABILIZE CIRCUIT POTENTIALS WITH RESPECT TO EARTH AND PROVIDE MEANS FOR CIRCUIT RELAYING TO CLEAR GROUND FAULTS.
4. GROUNDING FOR LIGHTNING AND SWITCHING SURGE PROTECTION.

GROUND GRID SPECIFICATIONS

5. THE GROUND GRID SHALL BE BURIED 1'-6" MINIMUM BELOW GRADE IN THE AREA WITHIN THE SUBSTATION SECURITY FENCE, AND TERMINATE NOT LESS THAN EIGHT FEET FROM THE FENCE. THE FENCE SHALL BE GROUNDED SEPARATELY FROM THE GRID UNLESS THE ARRANGEMENT DRAWING WITH THE APPROPRIATE NOTE SO SPECIFIES. FOR FENCE GROUNDING SEE E.S. 020607.
6. MAXIMUM GRID RESISTANCE TO GROUND, DRY SOIL IS 1Ω. IF MEASURED GROUND RESISTANCE EXCEEDS 1Ω, CONSULT PROJECT ENGINEER. DO NOT USE COKE BREEZE OR CHEMICALS TO LOWER GROUND RESISTANCE IN GROUND GRIDS.
7. THE PERIMETER GRID CONDUCTOR SHALL BE PLACED THREE FEET MINIMUM, SIX FEET PREFERRED, FROM ANY GROUNDED STRUCTURES OR EQUIPMENT. GROUND GRID MUST EXTEND SUFFICIENTLY TO ALLOW PERSONNEL TO BE WITHIN THE GRID AREA WHEN OPERATING OR SERVICING EQUIPMENT OR CONTACTING METALLIC STRUCTURES.
8. GROUND RODS, 12 FOOT LENGTH TO BE SPACED 30 TO 50 FEET APART MINIMUM NUMBER OF 12 GROUND RODS PER STATION..
9. 250 KCMIL MHD COPPER IS STANDARD FOR ALL GROUND GRIDS.

TYPICAL MATERIAL TO BE USED (FOR MATERIAL USED FOR FENCE GROUNDING SEE E.S. 020607)

CODE	DESCRIPTION	REMARKS
29-0033	CABLE, BARE, #4 AWG. MEDIUM HARD DRAWN COPPER, 7 STRAND, 0.232" DIA.	SEE APPLICATIONS-- SH. 2
29-0036	CABLE, BARE, #1/0 AWG. MEDIUM HARD DRAWN COPPER, 7 STRAND, 0.368" DIA.	SEE LIGHTING E.D.S. 459076
29-0040	CABLE, BARE, 250 KCMIL, MEDIUM HARD DRAWN COPPER, 19 STRAND, 0.574" DIA.	SEE APPLICATIONS - SH. 2
30-3542	BAR LUG, OFFSET, 2-ROLE NEMA TO 250 KCMIL CU. CABLE	▲ FOR CABLE-TO-FLAT. CADWELD STD. DUTY HOLD, TYPE GL, FOR 250 KCMIL USE CAT. NO. GLC-EG2V, & CARTRIDGE NO. 115
30-3519	BAR LUG, OFFSET, 1-HOLE, TO 250 KCMIL CU. CABLE	SEE FIG. 11 - SH. 4
18-7007	GROUND ROD, 3/4" X 12'-0"	ES 013109

▲ ALL GROUNDING MATERIAL EXCEPT CADWELD HOLDS AND CHARGES (CARTRIDGES) WHICH WILL BE FURNISHED BY THE CONSTRUCTION DEPARTMENT TO BE LISTED ON RESPECTIVE BILL OF MATERIAL FOR VARIOUS ARRANGEMENT DRAWINGS.

REFERENCES:

- TYPICAL ARRANGEMENT OF CONDUITS AND GROUNDS-SH. 1 _____ E.D.S. 459126
- METHOD OF GROUNDING FENCES _____ E.S. 020607
- TERMINATION & STRUCTURE FOR 12KV AND 21KV UNDERGROUND FEEDERS - LOW PROFILE SUBSTATIONS _____ E.S. 050861
- REQUIREMENTS FOR GROUNDING BUSHING POTENTIAL DEVICES _____ E.D.S. 102825
- COPPER AND ALUMINUM POWER CONNECTORS _____ E.S. 046267
- STEEL GRATING TYPE SWITCH OPERATING PLATFORM _____ E.S. 034851
- CORROSION RESISTANT GROUND RODS AND GROUND ROD CLAMPS _____ E.S. 013109
- INSTALLATION OF GROUNDS ON WOOD POLE TRANSMISSION AND DISTRIBUTION LINES _____ E.S. 021904

APPROVED BY	7	5-21-80	Revised Cadweld Mold Cat. No.	019	CHB	mm	GA
PKV	6	12-13-79	Rev. Note 8.	010	Ka	BLH	DB
NET	5	9-18-79	Added Fig 4, Sh 3	010	R.P.	CHB	HT
SBZ	4	7-22-78	Added Note 5	011	HT	0003	11
REV	DATE	DESCRIPTION	SUPV.	DWN	CHKD	APVD	
SUPV.	KLG	ENGINEERING STANDARD GROUNDING REQUIREMENTS FOR OUTDOOR DISTRIBUTION SUBSTATIONS DEPARTMENT OF ENGINEERING PACIFIC GAS AND ELECTRIC COMPANY SAN FRANCISCO, CALIFORNIA				SUPERSEDED BY	
DSGN	C G BOLL					SUPERSEDED BY	
DWN.	S DAVIS					SHEET NO 1 OF 4 SHEETS	
CHKD	CHB					DRAWING NUMBER	REV.
O.K.	CHB					055962	7
DATE	4-9-76	SCALE	NONE	MICROFILM		7	



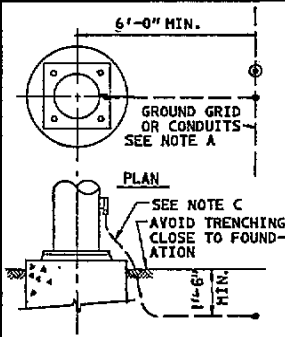


296590

APPLICATIONS:

- (A). STRUCTURES: STRUCTURES MUST HAVE AT LEAST ONE GROUND CONNECTION. IF BASE AREA EXCEEDS 5 SQUARE FEET, TWO CONNECTIONS SHALL BE MADE ON DIAGONALLY OPPOSITE CORNERS.
- (B). AIR SWITCHES: THE OPERATOR AND PLATFORM TO BE BONDED AS PER ES, DWG. 034851. SEE FIGS. 2 AND 3-SH. 3.
- (C). POWER TRANSFORMERS: FOR 3 Ø TRANSFORMER NEUTRALS (NO. XO) USE ONE 250 KCMIL CU. CABLE, SEE FIG. 7-SH. 4. FOUR WIRE SYSTEMS NEUTRAL SEE APPL.(E). SINGLE PHASE EQUIPMENT NEUTRAL SEE APPL.(D). FOR TRANSFORMER CASE GROUND USE TWO 250 KCMIL CU. CABLES PER TANK PLACED ON DIAGONALLY OPPOSITE CORNERS.
- (D). NEUTRAL BUS FOR SINGLE PHASE EQUIPMENT: NEUTRALS FOR BANKS OF SINGLE-PHASE TRANSFORMERS, OR REGULATORS, SHALL BE MADE UP SEPARATELY FROM THE GROUND GRID - ON A NEUTRAL BUS MOUNTED ON INSULATORS - AND CONNECTED TO THE GRID ON ONE END WITH TWO 250 KCMIL CU. CABLES. ALL NEUTRAL BUSHINGS SHALL BE CONNECTED TO THE NEUTRAL BUS UNLESS OTHERWISE SPECIFIED ON ARRANGEMENT DRAWINGS, AND THE APPROPRIATE NOTE SO SPECIFIES.
- (E). FOUR WIRE DISTRIBUTION: USE TWO 250 KCMIL CU. CABLES FROM TRANSFORMER LOW VOLTAGE NEUTRAL (XO) TO GROUND GRID, SEE FIG 8-SH. 4, AND FROM FEEDER TERMINATION STRUCTURE TO GROUND GRID, SEE FIG. 12-SH. 4. THE TWO CABLES SHALL BE ROUTED IN SEPARATE TRENCHES TO DIFFERENT POINTS ON THE GROUND GRID.
- (F). POWER CIRCUIT BREAKERS: TWO 250 KCMIL CU. CABLE CONNECTIONS FOR SKID MOUNTED PCB'S OR PER TANK FOR NON-SKID MOUNTED BREAKERS. FRAME MOUNTED BREAKERS SHALL HAVE TWO 250 KCMIL CU. CABLE CONNECTIONS TO THE FRAME. THE TWO CABLES SHALL BE PLACED ON DIAGONALLY OPPOSITE CORNERS. FOR BONDING OF BUSHING POTENTIAL DEVICES SEE EDS 102825.
- (G). REGULATORS: THREE-PHASE REGULATORS SAME REQUIREMENTS AS OUTLINED IN APPL.(C) EXCEPT NEUTRAL TO BE UNGROUNDED PER ELECT. DES. MANUAL SECT. 29. FOR SINGLE-PHASE REGULATORS SEE APPL.(D) AND (E).
- (H). CARRIER COUPLING CAPACITORS AND POTENTIAL DEVICES: ONE 250 KCMIL CU. CABLE CONNECTION TO COMBINATION GROUND TERMINAL AND CASE GROUND.
- (J). POWER CAPACITORS: CAPACITORS HOUSING OR SUPPORTING STEEL RACKS SHALL HAVE TWO 250 KCMIL CU. CABLE CONNECTIONS.
- (K). STEEL CONDUIT, JUNCTION BOXES AND RECEPTACLES: ONE #4 CU. CABLE CONNECTION TO STRUCTURE GROUND. MATERIAL TO BE SUPPLIED BY CONSTRUCTION DEPT.
- (L). LOW VOLTAGE POTENTIAL TRANSFORMERS, STATION SERVICE TRANSFORMERS, DISTRIBUTION PANELS AND EQUIPMENT INDOORS: ONE #4 CU. CABLE CONNECTION TO STRUCTURE GROUND.
- (M). METER AND RELAY CABINETS (P.D.A.C.) ETC: ONE #1/0 CU. CABLE CONNECTION TO MAIN GROUND GRID.
- (N). METALLIC CONTROL BUILDINGS: TWO 250 KCMIL CU. CABLES TO DIAGONALLY OPPOSITE CORNERS OF THE BUILDING. ONE CABLE TO SWITCHBOARD GROUND BUS. SEE ADDITIONAL INFORMATION FIG. 5-SHEET NO. 3.
- (O). LIGHTING STANDARDS: ONE #1/0 CU. CABLE CONNECTION.
- (P). FENCE GROUNDING: REFER TO ES 020607 - "METHOD OF GROUNDING FENCES".
- (Q). PULL BOXES: IT IS NOT NECESSARY TO GROUND CABLE SUPPORTS OR COVER PLATE SUPPORTS IN PULL BOXES.

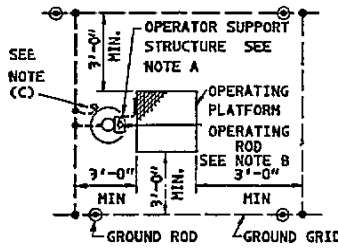
ENGINEERING STANDARD GROUNDING REQUIREMENTS FOR OUTDOOR DISTRIBUTION SUBSTATIONS	P. G. & E. CO.		055962	3
	SHEET 2	OF SHEETS		



NOTES:

- (A) GROUND GRIDS AND CONDUITS SHALL BE ARRANGED IN SUCH A WAY THAT TRENCHES ARE A MINIMUM OF 6 FT. FROM DEADEND STRUCTURES
- (B) IF GROUND GRID CROSSES CONDUIT RUNS, GROUND GRID SHALL BE ABOVE CONDUIT RUN.
- (C) GROUND CONNECTION SHALL BE SHAPED AS SHOWN IN FIG. 6.

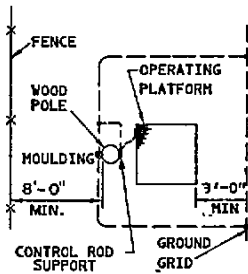
FIG. 1 GROUNDING DEADEND (TENSION) STRUCTURE



NOTES:

- (A) GROUND PAD ON OPERATOR SUPPORT STRUCTURE SHALL BE LOCATED AS SHOWN.
- (B) FOR BONDING OF PLATFORM SEE E.S. 034851.
- (C) IF GROUND SW IS USED RUN ONE 250 KCHIL CU. FROM GRID TO SW. BASES SEE FIG. 4

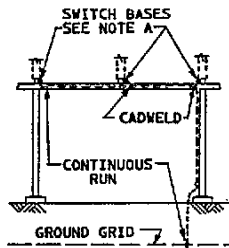
FIG. 2 GROUNDING OF OPERATOR SUPPORT STRUCTURE



NOTES

- (A) GUYS SHALL BE LOCATED WITHIN FENCE.
- (B) GROUND SWITCH BASES. DO NOT GROUND ANCHOR GUYS. MIN. DISTANCE FROM GROUND WIRE TO GUY BOLT OR GUY WIRE IS 6". INSTALL TWO INSULATORS IN EACH GUY WIRE MIN 8" ABOVE GROUND AND MIN 6' FROM POLE.

FIG. 3 GROUNDING KPF SWITCH WITH FIBERGLASS CONTROL ROD ON WOOD POLE



NOTES

- (A) CONNECTIONS TO SW BASES AND STRUCTURE LISTED ON APPROPRIATE B/M

FIG. 4 GROUNDING OF GROUND SWITCHES

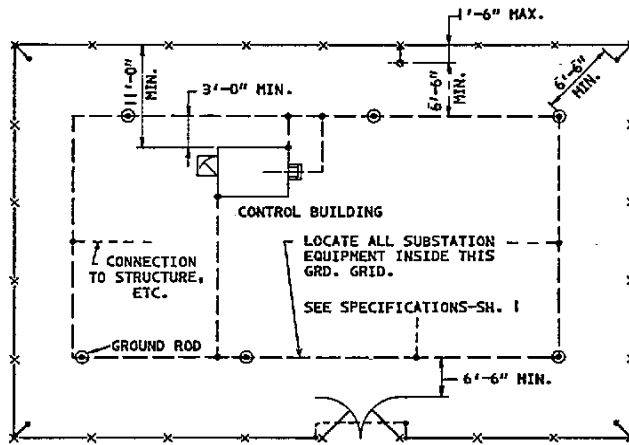


FIG. 5 TYPICAL ARRANGEMENT OF GROUND OUTDOORS

SEE E S 020607 FOR GROUNDING OF FENCES
SEE EDS 459126 FOR TYPICAL ARR. COND. & GRDS.

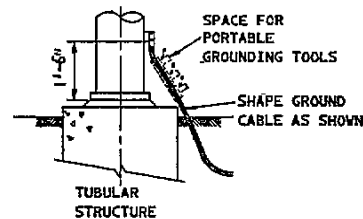
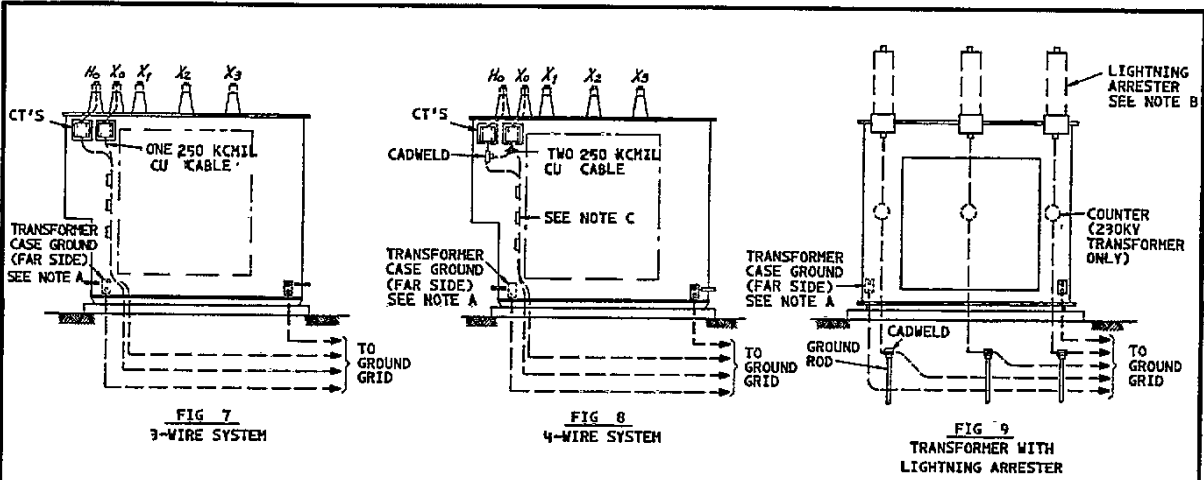


FIG. 6 PROVISION FOR ATTACHING PORTABLE GROUND TOOLS

ENGINEERING STANDARD
GROUNDING REQUIREMENTS FOR OUTDOOR
DISTRIBUTION SUBSTATIONS

PG & E CO.		DRAWING NUMBER	REV.
SHEET 3	OF	055962	5

296960



GROUNDING OF TRANSFORMERS

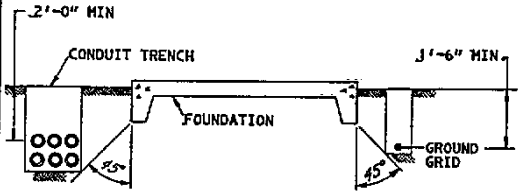
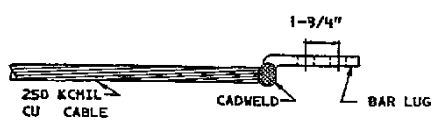


FIG 10
FOUNDATION CLEARANCES
(MINIMUM DISTANCE OF TRENCH PARALLEL WITH FOUNDATION FOR TRANSFORMERS, PCB'S, ETC)

NOTES

- (A) CASE GROUND TWO GROUND CONNECTIONS ON OPPOSITE CORNERS CASE GROUNDS SHALL BE SEPARATE FROM NEUTRALS
- (B) LIGHTNING ARRESTERS GROUND DIRECTLY TO A GROUND ROD NEAR TRANSFORMER AND THEN CONTINUING TO GROUND GRID
- (C) SEE E S DWG. 046267 FOR BOLTED BRONZE CONNECTORS.



CU CABLE ABOVE GROUND SHALL ALWAYS BE TERMINATED AS SHOWN
USE BRONZE ALLOY HARDWARE ("EVERDUR", "DURIUM" TYPE)
FOR ALL CONNECTIONS TO STRUCTURES OR EQUIPMENT

FIG 11
TYPICAL DETAIL OF A CADWELD CONNECTION

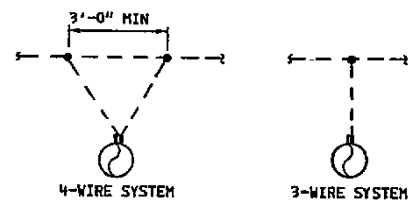
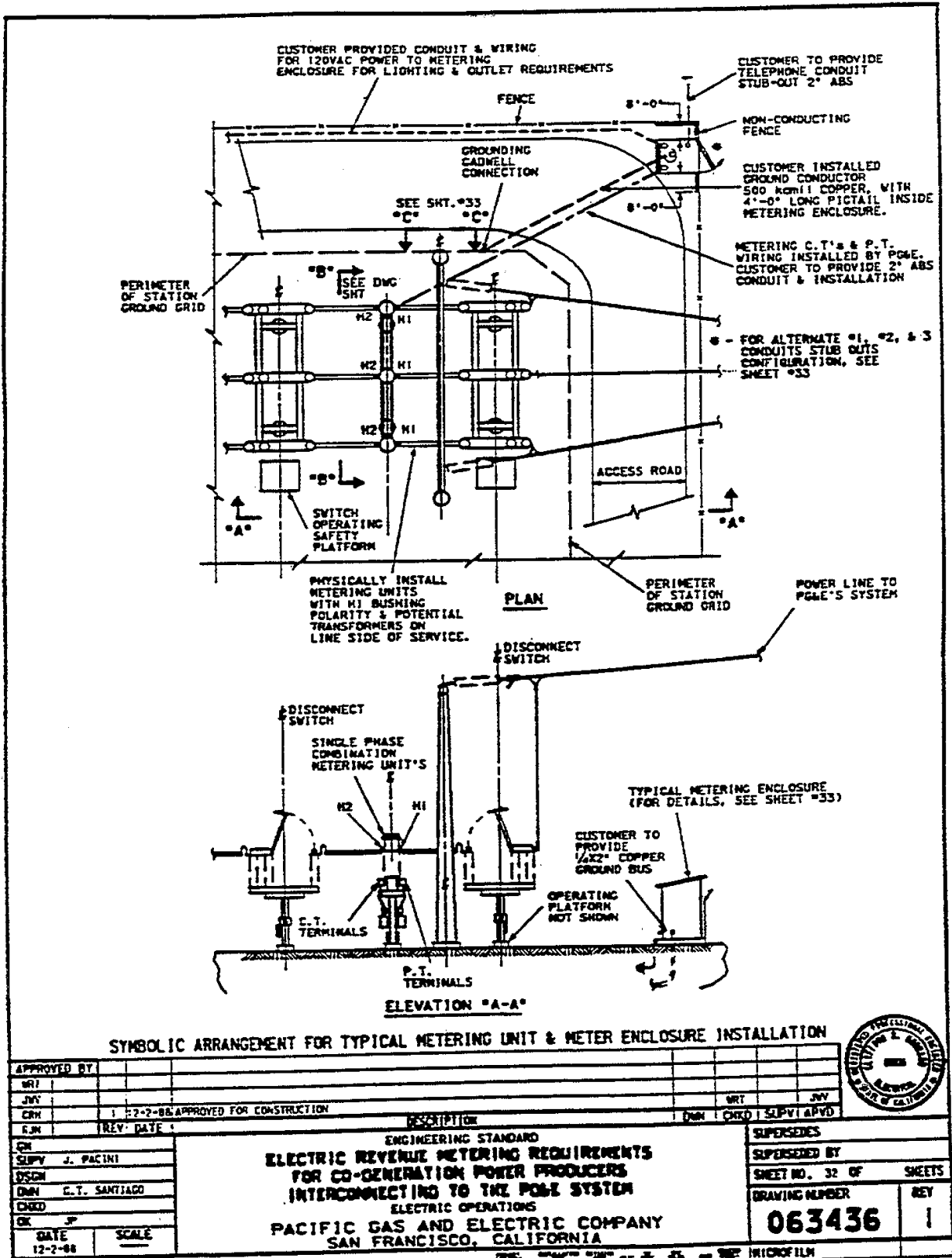
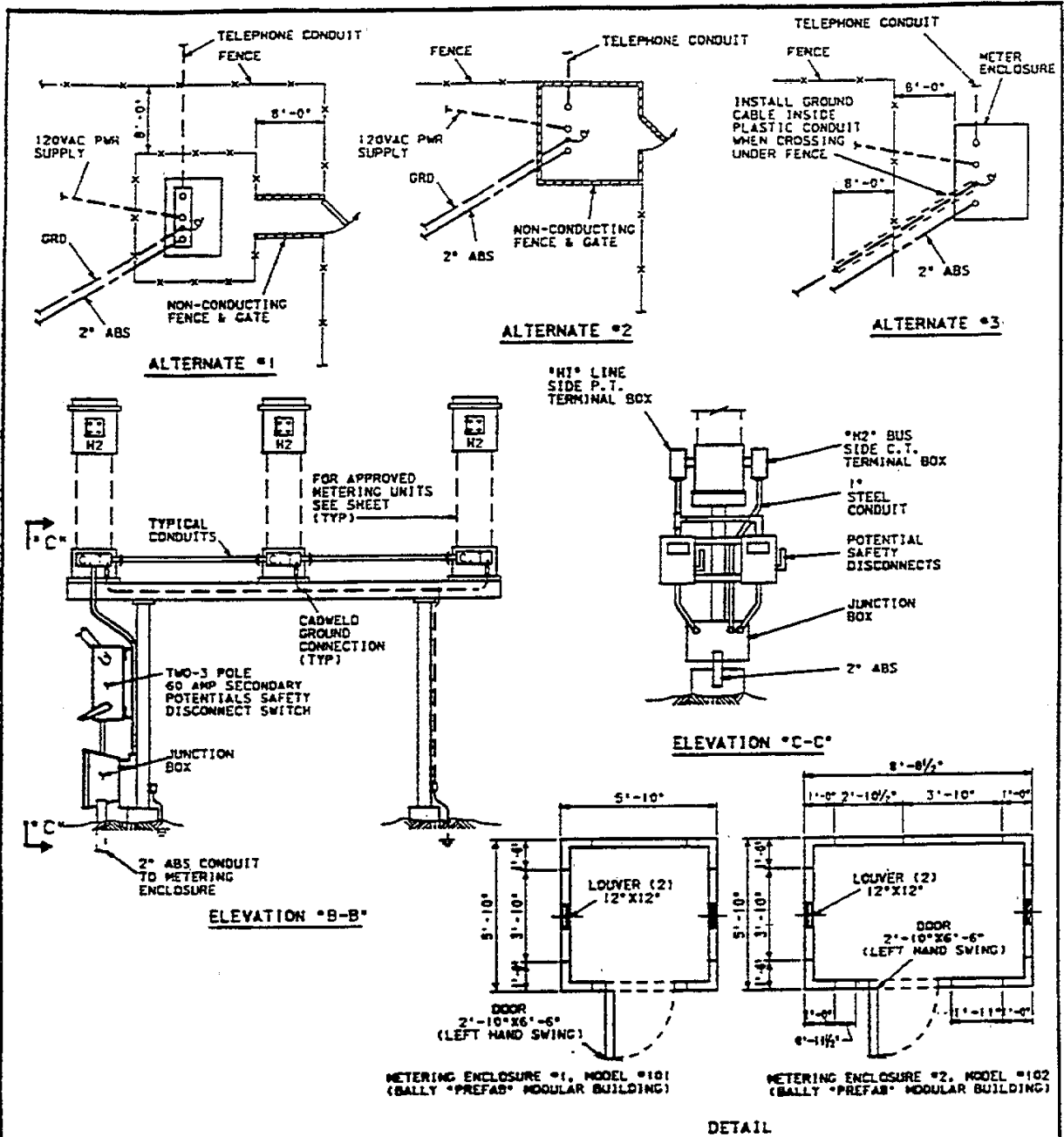


FIG 12
STRUCTURE FOR UNDERGROUND FEEDER TERMINATION OR NEUTRAL CURRENT LIMITING REACTOR

5	5/21/80	Revised Fig. 11	WIA	CBG	WMA	SL
4	2/13/77	Rmvd. finned from Fig. 11	WIA	K. P. WASH	WMA	SL
REV	DATE	DESCRIPTION	SUPV	DWN	CHKD	APVD

ENGINEERING STANDARD GROUNDING REQUIREMENTS FOR OUTDOOR DISTRIBUTION SUBSTATIONS		PG & E CO		DRAWING NUMBER	REV
		SHEET 4 OF 4 SHEETS		055962	5





SYMBOLIC ARRANGEMENT FOR TYPICAL METERING UNIT & METER ENCLOSURE INSTALLATION

APPROVED BY:									
WRT:									
JWY:									
CRH:	1	12-2-88	APPROVED FOR CONSTRUCTION						
RJM:		REV. DATE		DESCRIPTION		DWN	CHKD	SUPV	APVD
GR:				ENGINEERING STANDARD					SUPERSEDES
SUPV:	J. PACINI			ELECTRIC REVENUE METERING REQUIREMENTS					SUPERSEDED BY
DSGN:				FOR CO-GENERATION POWER PRODUCERS					SHEET NO. 33 OF SHEETS
DRN:	G.T. SANTIAGO			INTERCONNECTING TO THE PG&E SYSTEM					DRAWING NUMBER
CHKD:				ELECTRIC OPERATIONS					REV
GR:	JP			PACIFIC GAS AND ELECTRIC COMPANY					063436
DATE:	12-2-88			SAN FRANCISCO, CALIFORNIA					1
SCALE:									



