PROTECTIVE GROUNDING SYSTEMS
EQUIPMENT GROUND SYSTEM, CENTRAL OFFICES
GENERAL INTERFACE REQUIREMENTS
FOR DC POWER AND COMMUNICATION SYSTEMS
POWER SYSTEMS

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NOTICE

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1. SCOPE

1.01 This section covers equipment requirements and engineering information pertaining to the interconnections between the central office ground (CO GRD) system horizontal equalizers and various power and communication systems, and units thereof, to form an effective equipment grounding network for communication systems in central offices.

1.02 This specification is reissued:

(a) To add requirements for grounding of 140-volt power distribution system.

(b) To add a description of uniframe grounding facilities.

(c) To add a description of grounding requirements for IBM System/7 equipment.

(d) To make minor changes in text for purpose of clarification.

1.03 This section is part of a series covering protective grounding systems. Section 802-001-180 covers general equipment grounding requirements. Section 802-001-192 covers design requirements for a CO GRD system. This section and Sections 802-001-194 and 802-001-195 cover interface requirements between the CO GRD system and various power and communication systems normally installed in telephone central offices. Other protective grounding system sections supplementary to Section 802-001-180 are:

802-001-190—Equipment Ground Systems Material—General Equipment Requirements
802-001-191—Office Ground Electrodes—General Equipment Requirements and Engineering Information
802-001-197—General Equipment Ground Requirements for Microwave Radio Main and Auxiliary Stations
802-001-198—General Equipment Ground Requirements for AC Service Distribution Systems in Communication System Buildings

1.04 Section 802-001-194 covers grounding requirements for manual toll relay rack systems. Section 802-001-195 covers grounding requirements for electronic switching systems. This section covers grounding requirements for power and electromechanical switching systems, signaling, teletype and telegraph systems, switchboards, distributing and protector frames, cable sheathing, and other miscellaneous equipment units that require connection to the CO GRD system.

2. GENERAL

2.01 Central office buildings generally contain a variety of power plants and equipment units associated with more than one communication system. The ground plane formed by the physical relationship of specific system equipment may be broadly classified as (a) integrated or (b) isolated.

(a) ***An integrated ground plane*** is one wherein the communication system circuit ground points and the dc discharge ground conductors are not deliberately isolated from framework, and/or the framework is not deliberately isolated from contact via building steel or other incidental conductive paths to foreign communication system ground planes or to earth. Current imposed on an integrated plane is free to course through any member of the plane in seeking a path to earth or to its point of origination within the building.

(b) ***An isolated ground plane*** is one where the communication system circuit ground points and dc discharge ground conductors are deliberately isolated from framework that is part of an integrated ground plane, or the framework is made part of the isolated ground plane. All objects that comprise the isolated ground plane are insulated from contact with other ground planes, except for a single point connection that functions to equalize potential difference between the otherwise unconnected planes. A single point connection blocks current imposed on ground plane members that are not part of the isolated plane from flowing through any part of the isolated plane.

2.02 Power plants, except for parts of the 140-volt power plants that form a portion of the 140-volt dc distribution circuit (an isolated ground system) or 600-type converter plants that serve an electronic switching system (part of the ESS isolated ground plane); and communication systems except for those classified as electronic systems (eg, No. 1 ESS, No. 2 ESS, TSPS, AIS, ETS, and similar), are part of an integrated ground plane that includes building service equipment, building structural

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steel, and other metallic components. Various equipment arrangements and power distribution methods are used with different systems. This section contains descriptions of the various ground continuity configurations formed by power plant and individual communication equipment physical and electrical interrelationships. It also provides instructions on methods to be used to integrate the CO GRD system with these equipments to provide effective equipment grounding and ground equalization throughout each equipment complex and between complexes throughout the building.

2.03 A variety of different equipment and conductor configurations are employed to distribute dc power to the circuits of different communication systems. They include:

A. Electromechanical Switching Systems

(a) Direct distribution by means of paired battery and ground conductors from power plants to fuse panels in individual equipment bays. This method is standard for small step-by-step (ie, 355A) offices, various radio systems, and for miscellaneous distribution from power plants and converter power supplies having a requirement for few distribution circuits.

(b) Distribution by means of paired battery and ground conductors from power plants to centrally located fuse boards. Distribution from fuse boards to load units may be by means of paired battery and ground conductors or by means of individual battery conductors and a common ground return conductor connected between frame ground bus bars and the fuse board ground bus bar. Fuse boards are used with a variety of electromechanical systems, normally to supply power to miscellaneous circuits mounted on relay rack bays.

(c) Distribution by means of paired battery and ground conductors from power plants to battery distributing fuse boards (BDFB), thence by paired leads to individual equipment bays or bay lineups and to centrally located fuse boards [refer to (b)]. BDFBs are standard for step-by-step (No. 1, 350A) and panel electromechanical switching systems, manual switchboard systems, and toll carrier systems.

(d) Distribution by means of paired battery and ground conductors from power plants to equalizing centers, thence by cable equalizer conductors along the main aisle of an equipment block. Battery and ground conductors are tapped and extended to each frame line in the equipment block. The battery conductor is routed through a 100-ampere fuse at the head of the line, extended along the frame line and tapped to drop feeders connected to fuse panels in equipment bays. In No. 5 Crossbar systems, the ground conductor is extended by cable along the frame line and connected to ground terminals mounted in the frame by means of a drop feeder. In other applications, frames are equipped with interjunctioned ground bars along the frame line and connected at the head end to the ground equalizer with a cable. Equalizing centers are standard for No. 1, No. 5, No. 4A Toll, and Toll Tandem Crossbar Systems.

B. Electronic Switching Systems, L5 Carrier Systems

(e) Distribution by means of paired battery and ground conductors from a 140-volt dc power plant (415 type typical) to area bus centers (ABC) on each equipment floor of a central office. The 140-volt supplies are separated into branch circuits at an ABC. ABC branch circuits are extended with paired conductors to bulk converter plants (620A typical) to serve converters thereon. They are also extended to converters on various equipment bays. The 140-volt powered converters supply 24-volt, 48-volt, and other voltage-oriented power supplies required to operate the switching equipment. The 140-volt dc distribution system is maintained as an isolated ground system. Only one contact to the building integrated ground system is allowed. The isolated ground system is intended to minimize the probability that electrical noise caused by converter operation will be imposed on the ground plane of the communication circuitry. The 140-volt distribution system is used to power No. 4 ESS and L5 carrier system and may be used to serve other systems arranged to operate on voltages provided by the 140-volt powered converters. A description of the distribution system and grounding arrangements for No. 4 ESS is contained in Section 802-001-195.

(f) Distribution by means of paired battery and ground conductors to power distribution (PD) frames. Paired leads extend 24-volt and 48-volt power from PDs to ESS equipment bays. This system is standard for ESS switching systems other than No. 4 ESS. Refer to Section 802-001-195 for a description of the distribution system and grounding arrangements.

C. Microwave Radio Systems

(g) Distribution by means of paired battery and ground conductors from power plants to battery distribution circuit breaker boards (BDCBB). Branch circuits are extended from BDCBBs via paired leads to radio and associated equipment bays. This system is standard for TD-3 and TH-3 Microwave Radio stations. Grounding arrangements for microwave stations are covered in Section 802-001-197.

D. Frame Grounding Via Discharge Conductors or Direct Bonds

2.04 Often the discharge ground conductors of the various distribution systems used for electromechanical switching systems, manual switchboard systems, and the various toll carrier systems are terminated at ground buses mounted on power, battery distribution, fuse board, and equipment frames so as to have electrical continuity with frame metal. This affords an opportunity to equipment ground the majority of frames by extending the CO GRD system just to critical points in the discharge ground network. Critical points of CO GRD horizontal equalizer connection to discharge ground networks are the ground buses of BDFBs, the ground equalizer cable of equalizing centers and equivalent points in the dc distribution circuits not equipped with BDFBs or equalizing centers. The discharge ground conductors between these critical points and equipment frames thereby function as a combination discharge-framework ground.

2.05 Equipment units in these electromechanical systems that are not grounded via discharge ground conductors to BDFBs or equalizing centers connected to the CO GRD system on the floor containing the unit require direct bonding from the frame. Individual equipment bays, cabinets and other metallic units, cable sheathing, conduits, etc, may require a direct bond between the unit metal and a point on the CO GRD horizontal equalizer system. These units are generally identified by the following conditions:

(a) Communication frames not equipped with a frame ground bus bar having electrical continuity via discharge ground conductors to a BDFB ground bus or an equalizing center ground equalizer

(b) Units provided for the purpose of electromagnetic interference shielding

(c) Units mounting lightning protectors or otherwise susceptible to lightning induced voltages

(d) Units isolated from or having only incidental ground paths of continuity with the CO GRD system.

2.06 Representative units requiring direct bonding include:

(a) MDF, CDF, and protector frames

(b) Communication system entrance cable sheathing

(c) Conduits, armored cable, wire sheathing other than ac service raceway

(d) Miscellaneous frames, racks, cabinets equipped with units fed through paired dc battery and ground feeders

(e) Duct type framework.

2.07 Fig. 1 depicts a typical CO GRD system in a multifloor building and a variety of connections required from the CO GRD system to various types of equipment that may be installed in a central office. Descriptions hereunder are based on the configurations shown in the figure. It should be noted that connections shown may occur on any floor and may be duplicated numerous times on various floors, and that variations not shown but electrically equivalent to the connections shown may be employed to suit the physical arrangement of an office.

3. POWER SYSTEMS EQUIPMENT

3.01 DC power plants may be categorized as general purpose, dedicated system, special voltage, and converter plants.

(a) ***General Purpose Plant:*** Typically 100-, 300-, 400-, and 700-type battery plants used to provide 24-volt, 48-volt, and 130-volt power by direct connection to electromechanical switching, manual switchboard, toll carrier, microwave radio, and miscellaneous equipment. Individual plants are provided for each voltage and polarity required to operate equipment except when converters are interposed in the distribution circuit.

(b) ***Dedicated System Plant:*** Typically direct-connected battery plants dedicated primarily to serving ESS or similar systems that utilize an isolated ground plane, or other systems having special restrictions on serving more than one system from one plant. Individual plants are required for each voltage and polarity, except when converters are interposed.

(c) ***Special Voltage:*** 415A and similar type battery plants that provide a voltage (ie, 140 volts) suitable for feeding converters, but not normally suitable for direct connection to communication equipment.

(d) ***Converter Plants:*** Typically 600-type plants that convert dc power (such as from 302B 48-volt or 415A 140-volt plants) from an unsuitable voltage to voltage suitable to operate communication equipment.

3.02 Components of general purpose direct-connected dc battery plants are discussed in the following Subpart 3A. Converter plants and components of special voltage plants are covered in 3B. Dedicated system plants used in ESS type installations are covered in Section 802-001-195.

A. Direct-Connected DC Power Systems

Power System—Battery Control Board (BCB)

3.03 Generally, several general purpose and dedicated system dc power plants of different voltage and ampere capacities are provided in a central office to serve the various communication systems. Every dc power plant, with the exception of dedicated plants serving a system that employs an isolated ground plane (ie, No. 1 ESS), requires a connection of the discharge ground bus bar to the CO GRD system for earth potential reference.

3.04 Often, when a group of general purpose power plants are located reasonably close together and provide power of different voltages to one or more battery distributing fuse boards (BDFBs), one is chosen as the predominant plant. Generally, the predominant plant is the one with the greatest ampere capacity. A BDFB is arranged so that a variety of fuse panels may be dedicated to different voltages but is equipped with a common ground bar. Because of this, it is expedient to provide a discharge ground (battery return) conductor calculated to serve as a combined ground current return path. The common discharge ground conductor is terminated at the ground bus of the predominant power plant, and bond conductors, calculated in accordance with engineering information provided in the plant circuit specifications for a predetermined maximum voltage drop, are provided. These bond conductors are connected between the ground buses of the predominant plant and other plants that share the combined ground current return path. The bonds serve to complete the ground current return circuits to the various batteries that supply the BDFB with power of different voltages and to provide earth potential reference to the batteries.

3.05 Power plant discharge ground bus bars are normally located in or above power plant battery control board (BCB) bays that mount fusing devices for the dc distribution circuits.

3.06 When a combined ground current return arrangement as described above is not used, each general purpose power plant requires a connection between its discharge ground bus and the CO GRD bus on that floor. The minimum size of the conductor shall be as specified on the circuit schematic drawing for the plant. Individual conductors may be provided to the floor CO GRD bus or the ground conductors may be tapped to a single conductor (No. 0000 AWG-single floor buildings, 350,000 CM multifloor buildings) extended from a power plant complex to the floor CO GRD bus.

3.07 When a combined ground current return path is employed, the bond conductor provided for current return between the ground buses of the predominant plant and other plants functions as an earth potential reference. Ground bonds are required as follows:

(a) From floor CO GRD bus to predominant plant BCB ground bus—350,000 CM conductor in multifloor buildings, No. 0000 AWG conductor in single floor buildings. Function: extends earth potential reference.

(b) From predominant plant BCB ground bus to each BCB ground bus of other voltage plants utilizing the combined discharge ground path—a calculated conductor based on current return requirement as specified in power plant schematic drawings. Function: current return to battery and earth potential reference.

(c) Individual bonds from each power plant BCB ground bus to CO GRD bus are not required. Refer to Fig. 1 for illustrations of bonds between BCB ground buses.

Power System—Battery Distributing Fuse Board (BDFB)

3.08 Every BDFB is equipped with a ground bus that serves as a common junction point for all discharge ground conductors. The bus is electrically adjoined to the framework. BDFBs are used to distribute one or more voltage supplies of dc power in step-by-step, panel, carrier, and manual toll systems. The ground bus shall be connected to the CO GRD bus with a 750,000 CM conductor. The conductor may be a continuous run or it may be a branch tap from a horizontal equalizer serving other BDFBs and/or crossbar or toll ground equalizers in a floor segment. BDFBs serving an installation of manual toll relay rack equipment may not require a direct bond between BDFB ground bus and CO GRD bus when the system employs a main aisle ground equalizer connected both to the BDFB ground bus and to the CO GRD bus with 750,000 CM conductor. Refer to Section 802-001-194 for specific information on grounding requirements for manual toll system relay racks.

Power System—Crossbar System Equalizing Centers (EQL CTR)

3.09 Crossbar systems utilize a dc power distribution system comprised of 750,000 CM main aisle battery and ground conductors that distribute 48-volt dc power to No. 00 frame line feeders through 100-ampere fuses or circuit breakers mounted in cabinets located on frame line end guards at the main aisle, and provides battery current return paths:

(a) In No. 5 Crossbar offices through No. 00 frame line conductors tapped to main aisle ground equalizers;

(b) In No. 1, Tandem, and 4A Toll Crossbar offices through frame ground bars adjoined with junction bars to form a continuous electrical path through the frame line, bonded from the first frame to the main aisle ground equalizer with No. 00 conductor.

3.10 Fig. 2 illustrates a typical No. 5 Crossbar battery discharge equalizer system, and CO GRD equalizer connections required thereto. When any crossbar system installation utilizes more than one equalizing center in a main aisle and is connected to a CO GRD system, the main aisle ground equalizer conductors shall be made continuous between equalizing centers. Double-sided ground equalizers shall be bonded together at each end. The CO GRD equalizer shall be connected to each main aisle ground equalizer. The point of connection shall be within 50 feet of both ends of each main aisle ground equalizer run; otherwise additional CO GRD bonds must be provided, preferably connected proportionately, to satisfy the requirement. Additional bonds that provide supplementary current paths between discharge ground circuits shall also be provided as outlined under "Design Parameters of Horizontal Equalizer System" in Section 802-001-192.

Power System—Equalizing Centers For Other Than Crossbar Systems

3.11 The equalizing center system of power distribution is also used for certain other types of switching, accounting, and carrier systems. Automatic message accounting (AMA), automatic number identification (ANI), and T-1 carrier are systems that occasionally employ this distribution system. CO GRD bonds shall be furnished as outlined for crossbar equalizing centers.

Power System—Fuse Boards (F BD)

3.12 Fuse boards (F BD) are used in most electromechanical switching, carrier, and toll systems as an intermediate fusing and distribution point to miscellaneous load units that generally mount on relay rack bays in the vicinity of the F BD. DC power is furnished to the F BD from BDFBs, equalizing centers, or directly from the power plants. With the exception of F BDs furnished in manual toll systems (Section 802-001-194), the F BDs, which normally are equipped with ground buses mounted electrically (bolted) to the frame, need not be bonded to the CO GRD conductors when the predominant power supply is furnished from (1. a BDFB, or (2. an EQL CTR, or (3. a power plant on the same floor, and (4. the length of the discharge ground (DG) conductor is 50 feet or less in length (see Fig. 3A). When the F BD receives its predominant power supply from a power plant on another floor, (see Fig. 3C) or the DG conductor exceeds 50 feet in length (see Fig. 3B), a bond between the F BD ground bus and a CO GRD bus, CO GRD horizontal equalizer, BDFB ground bus or equalizing center main aisle ground equalizer shall be provided. The bond may consist of continuity through adjoined frame ground bars, as normally occurs in systems such as No. 1, Tandem, and 4A Toll Crossbar. Otherwise it shall be a No. 00 conductor when only one fuse bay is served by the bond. When more than one fuse bay in a floor segment require bonding with a conductor, (see Fig. 3D) a single 350,000 CM bond, run in the most direct manner between F BDs, shall be used to bond them together and to the nearest acceptable junction point to CO GRD. The function of such bonds is to ensure that a low impedance ground current path exists between FBD ground bus bars and between such bus bars and the CO GRD system.

3.13 Miscellaneous fuse boards that are not equipped with a frame ground bus bar or occupy less than a full bay (fuse panels mounted on a miscellaneous relay rack bay), switch frames or other frames that contain a fuse panel for distribution of power to equipment mounted thereon, and power ringing and tone distribution frames (PRTDs) used in the No. 5 Crossbar system are considered to be adequately grounded through conductive paths inherent in the assembly of the system. These types of power distributing equipment do not require bonding as described in the preceding paragraph for the purpose of providing current paths between discharge ground conductors.

B. Converter—Interposed DC Power Systems

Converter Plants

3.14 The 600-type converter plants and other converters are used to convert a battery plant supply to another dc voltage. They are furnished when equipment operates on a voltage other than that supplied by battery plants in the office and it is not economical to add a battery plant or the voltage is such that it cannot be obtained from conventional battery plants.

3.15 The converters provide a buffer between the ground plane of the battery distribution system serving the converter and the dc distribution system on the output side of the converter. Power is transferred from the input to the output side of a converter through a transformer used to convert the voltage. The primary and secondary windings are insulated from each other and from the transformer case. Therefore the ground systems on the input and output sides of the converter are isolated from each other. Each side, therefore, may be parts of two different ground systems.

3.16 The isolation between input and output allows the converters to receive power from a general purpose or special voltage plant and supply power to an ESS type communication system that requires single point ground isolation.

3.17 The 600-type plants are generally equipped with a discharge ground bus bar. Normally the dc distribution system is grounded by means of a ground wire extended from this bus to a point on the ground system serving the communication equipment fed by the converters. When the bus is in contact with or bonded to the frame, it may be assumed that the frame is grounded via the wire. If the bus is isolated from the frame and it is necessary to isolate the distribution system ground, the frame must be grounded as described under "Power Sytems—Miscellaneous" in Part 3C.

Power System—140-Volt DC Power Distribution System

3.18 The 140-volt dc power distribution system utilizes a "special voltage" plant that produces a power supply of optimal voltage for serving converters. The converters change the supply into such voltages as are necessary to operate communication equipment in a central office. The ground systems of the input and output sides of the converters are isolated from each other. Therefore the 140-volt system may be employed to supply power for ESS systems that require ground isolation.

3.19 Certain early installations of the 140-volt system use 413A power plants. The 413A power plant was superseded by the 415A plant. From the grounding standpoint, both installations are identical. For purpose of illustration, the 415A plant will be referred to herein.

3.20 The 140-volt system is now authorized to provide power for L5 Carrier and No. 4 ESS Toll Switching systems. It is expected that other applications will be authorized. It is not the intent of this publication to advise on specific communication systems that may use the 140-volt system for power.

Components of the 140-Volt Distribution System

3.21 The 140-volt distribution system is composed of the following equipments (see Fig. 4):

(a) 140-Volt Power Plant (415A)

(b) Area Bus Centers (ABC)

(c) 24- and 48-Volt Converter Plants (620A Typical)

(d) 140-Volt Input Converters

140-Volt Power Plant (See Fig. 4.)

3.22 The 140-volt dc power plant (415A) at full capacity is composed of one ac distribution bay, nine (maximum) 200-ampere 140-volt rectifiers, four distribution bays and four batteries. The normal arrangement places the 14 bays in two back-to-back rows, with distribution bays at outer corners and the ac bay in the center of one row. The assembly of one distribution bay, one, two or, three rectifiers, and one battery is referred to as a "module" (MOD 1, 2, 3, 4). Four modules comprise a 200-kilowatt capacity plant. When the capacity of one plant is exceeded, additional plants can be added in the same or other areas of a building.

3.23 The 140-volt distribution circuits are extended from the MOD 1, etc, distribution bays to ABC bays throughout the central office. Each of the distribution bays is equipped with a battery ground bus, isolated from contact with the frame. From this bus, ground conductors are extended to battery, to rectifiers, to other modules (ring), and to ABCs and miscellaneous units requiring 140-volt power.

3.24 Certain small installations may consist of only one or two modules, serving converters directly instead of through ABC bays.

Battery and Ground Ring Conductors

3.25 Individual modules of one or several plants are bonded into a battery and ground ring to allow any battery (and rectifier) to supply any load on any plant of a common (ring connected) 140-volt distribution complex.

3.26 As shown in Fig. 4, large (500,000 CM) battery and ground conductors are extended between modules. The battery ring is fused in some instances. The ring ground lead is paired with the battery lead. It interconnects the battery ground buses of the 415A distribution bays into a ring that affords two paths of continuity between any two modules (ref: SD-82189-01).

3.27 The ring ground conductors are kept isolated from any contact with grounded equipment except through a single point, as described later.

Power Systems—Area Bus Centers (ABC)

3.28 ABCs are located on equipment floors to facilitate the distribution of 140-volt power to converters. A typical ABC (J86330B typical) is composed of eight fuse panels equipped with various fuse blocks. Each panel contains a ground bus. Each panel is fed from the 415A plant by means of a separate circuit. The ground buses furnished with the panels are isolated from each other and from panel metal and other grounded objects.

3.29 The 140-volt power is split into branch circuits on the ABC and extended to the input side of converters in 620A and similar plants and to converters located in equipment bays.

Power Systems—Bulk Converter Plants

3.30 A variety of bulk converter plants (620A, 625A, 625B, 630A typical) are available for use in converting 140-volt dc power to 24- and 48-volt power suitable for powering ESS and other types of communication systems.

3.31 One typical configuration, the 620A 24-volt plant, consists of a power distribution bay arranged for two-load distribution of 24-volt dc power to switch frames. It may be equipped with up to four bays of converters: two 24-volt 100-ampere converters per bay.

3.32 A second arrangement, the 625B plant utilizes up to eight floor-mounted converters and a distribution bay similar to the J86331 battery distribution fuse board.

3.33 The 140-volt battery and ground conductors terminate at the input side of the converters. The ground-conductor is kept isolated from contact with the converter chassis.

3.34 The output leads of the converters are extended to buses in the power distribution bay, where circuits are branched as required to serve 24-volt and/or 48-volt operated equipment.

Power Systems—Equipment Bay Mounted 140-Volt Input Converters

3.35 Converters are also mounted on various equipment bays: Generally those that require operating voltage other than that provided by bulk converter plants in the area. They are fed by 140-volt circuits extended from an ABC. The ground conductor is isolated from contact with other than the converter input terminal, so as to maintain isolation of the 140-volt system from incidental grounds. The output is normally distributed to units on the same frame.

Power Systems—140-Volt DC Distribution System Grounding Requirements

3.36 Grounding requirements for the 140-volt system are categorized as follows:

(a) 140-volt distribution system grounding

(b) Converter plant distribution system grounding

(c) Bay mounted converter grounding

(d) Frame grounding.

140-Volt Distribution System Grounding

3.37 The 140-volt distribution system is composed of batteries, output side of rectifiers, distribution equipment on the 140-volt plant and on ABCs, the input side of converters, and the interconnecting conductors. All of these components are isolated from contact with any grounded equipment, other than at a single point.

3.38 Single point grounding is employed to ensure that electrical interference caused on the 140-volt distribution conductors by interruptions (chopping) of the input supply in the conversion process is not impressed on communication circuits.

3.39 Single point grounding of the otherwise totally isolated ground portion of the 140-volt distribution system is accomplished by use of a No. 0 AWG 140-volt ground conductor. The wire is connected to the 140-volt system from a CO GRD bus on the distribution system's midpoint floor level.

3.40 The midpoint floor level is determined on the basis of building floors encompassed in a single 140-volt power distribution system. The system is restricted to serve equipment on five floors above and below the midpoint floor on which the CO GRD bus is located.

3.41 More than one 140-volt plant may be provided in a 140-volt distribution system. The plants may be located together on one floor or separated on one floor or located on different floors. The distribution system served by the several plants is made common by use of the ring conductors.

3.42 If only one plant is provided, connection from the midpoint CO GRD bus shall be made by connecting the No. 0 AWG conductor to the battery ground bus of MOD 1 of the 415A plant. The plant need not be on the midpoint floor.

3.43 If more than one 415A plant is provided and the interbonding ring conductors are not extended through the midpoint floor, the No. 0 conductor shall be connected to MOD 1 of the plant nearest the midpoint floor.

3.44 If ring conductors extend through the midpoint floor, connection shall be made to one of the two ground conductors of the ring on the midpoint floor as shown in Fig. 4: to the ring ground lead extended to MOD 3 of the 415A plant located on closest floor above the midpoint floor from MOD 4 of the plant located on the closest floor below.

3.45 If one of the several 415A plants is located on the midpoint floor, the single point ground connection shall be made to MOD 1 of that plant instead of to a ring conductor.

3.46 The CO GRD bus to which the No. 0 lead connects should always be the one at midpoint of the existing installation, not that of the anticipated ultimate office. It will be necessary to relocate the connection to another floor if expansion of the distribution system to additional floors shifts the midpoint of the system.

3.47 The maximum ultimate vertical growth of a 140-volt distribution system, which encompasses ring interbonded 415A plants and all connected ABCs and converters, is restricted to five floors above and below the CO GRD connection (11 floors) or 75 feet (vertical) in either direction, whichever is lesser. The restriction is intended to minimize the probability of insulation breakdown during a lightning stroke or other severe electrical disturbance in the building by limiting vertical distance between the CO GRD point and extremities of the 140-volt system. During a stroke on a building, a rapidly changing potential is impressed along the vertical path of the lightning current. An extreme difference of potential may build up between different floors. Stress on insulation of transformers and 140-volt conductors is a product of the rate of current change in, and the inductive impedance of, the lightning current path between the CO GRD point of the 140-volt system and the CO GRD bus of the floor on which the 140-volt powered equipment is mounted. The CO GRD point is the voltage reference point for the 140-volt system therefore voltage impressed instantaneously there is reflected through the system, including primary windings of converter transformers. The voltage momentarily impressed on the secondary windings and equipment enclosures on each floor is that obtained from the floor, CO GRD bus. By restricting the vertical distance between these points of potential reference to the minimum necessary and never more than 75 feet, a limit on potential difference is imposed that is expected to minimize insulation breakdown.

3.48 When equipment floors exceed 11 contiguous floors or when the allowed distance of 75 feet from the midpoint floor CO GRD bus to CO GRD busses on uppermost or lowermost floors would be exceeded, a new installation of 140-volt distribution equipment, including 415A plant, ABCs and associated ring and distribution conductors is required to serve those floors outside the parameters. The second system shall have its own midpoint CO GRD connection. Two 140-volt distribution systems can serve different ABCs on the same floor, if expedient.

Converter Plant Distribution System Grounding

3.49 The dc power distribution system served by a bulk converter plant is divided into branch circuits fused on the plant's distribution bay. The branch circuits are extended with paired leads to individual bays requiring 24- and 48-volt power.

3.50 The distribution system must be referenced to ground. In both ESS and electromechanical system applications a ground bus is mounted on cable rack or otherwise supported above the distribution bay of each bulk converter plant. Within the distribution bay, two ground buses (load A and B) are normally provided for terminating branch circuit ground conductors. A conductor sized as noted in the bulk plant's engineering specifications is dropped from the overhead bus to each ground bus in the bay. Ground equalizer conductors interconnect the overhead ground buses. The equalizer connects directly or through a ground window to the floor CO GRD bus, dependent on the requirements of the system served by the bulk converters.

3.51 When bulk converter plants are used to power electromechanical switching system equipment, L5 carrier bays, No. 4 ESS transmission area equipment and similar communication complexes that employ an integrated ground plane, grounding is accomplished by extending a 750 MCM CO GRD horizontal equalizer conductor from the floor CO GRD bus into the area occupied by the frames. The conductor is branched and extended to the ground buses above the distribution bays.

3.52 For ESS systems that employ an isolated ground plane a horizontal equalizer arrangement similar to that used in the network area of the No. 4 ESS is recommended. In that system a ground bus above a bulk converter plant is designated as a main ground bus and grounded (single point) with a No. 0 AWG wire to the floor CO GRD bus. The area around the main ground bus is referred to as a ground window. The 750 MCM horizontal ground equalizer conductors are extended from the main ground bus in a ring configuration to other overhead buses. Refer to Section 802-001-195 for more detailed information on No. 4 ESS system grounding requirements.

3.53 The ground equalizers, through their interconnection of ground buses, provide a path between bulk converter plants for return of current to originating converters. Current supplied to communication equipment does not necessarily return to the current source on the ground conductor paired with a battery lead. Often the current is conveyed through signaling and control conductors from one bay to another before the current passes through a dc operated device and goes to ground. Frequently the battery and ground conductor pair that serves the second bay is routed to another bulk converter plant than the one that provided the current. The ground equalizer conductors interlink the converter plants to complete the ground return path back to the originating converters.

Bay Mounted Converter Grounding

3.54 It is expected that methods of grounding the output side of 140-volt input converters mounted on communication equipment bays, will be outlined in the specifications provided for the installation of the communication equipment. General requirements are outlined below and may be applied to field mounted converters as well as those that are premounted on a bay.

3.55 When 140-volt input converters are mounted on a communication equipment bay, the converter distribution circuit requires a connection to the horizontal equalizer ground system. Normally, this can be accomplished by means of a No. 12 AWG (minimum) wire extended from the output ground terminal to a ground bus at the nearest bulk converter plant. However the connection can be made from any point on the converter distribution ground conductor to any point on the horizontal equalizer ground system. When permitted by the communication system specifications, a bond from the converter outout ground terminal to a ground conductor paired with a 24- or 48-volt supply serving the converter equipped bay may be used to ground the converter output. Conductors provided for the purpose of frame grounding are not intended for circuit grounding and should not be recognized as such even though the conductors may parallel the circuit grounding conductor.

Framework Grounding

3.56 Frameworks of the 140-volt plant, ABCs, and of converter plants must be grounded.

3.57 A ground bus is provided in the 415A plant for frame grounding. It extends through the bays. The distribution, rectifier, and ac service bay frameworks are connected to the bus with No. 6 AWG wire. The bus is connected to an appropriate grounding point in the CO GRD system with a No. 2 AWG wire.

3.58 The frames of the ABC bay and of the 620A, 625A, 625B, and 630A bulk converter plants can be optionally equipped with insulating hardware similar to that used with ESS equipment bays. The option is used when it is expedient to locate these frames in the area populated with switch frames similarly isolated. The ABC and converter plant frames are grounded by extension of the isolated ground system's framework ground network.

3.59 When located with frames that do not require isolation, the ABC and converter plant frames shall be grounded by bonding to the CO GRD system. In the No. 4 ESS transmission frame area for example, a bare No. 6 AWG wire is tapped to one of the ground buses provided for termination of CO GRD horizontal equalizers above converter plants. The wire is extended and branched as required to run along frame lines and is connected to each frame in the area, including ABC and converter plant frames.

C. Power System—Miscellaneous

3.60 Various frames and other component units of a power plant not afforded equipment grounding by having electrical continuity to the CO GRD system through ground bus bars in contact with the frame metal must be equipment grounded. These components include frames in a power board line, rectifier bays, and metallic battery stands. Exceptions are principally battery control boards and distribution bays equipped with discharge ground bus bars bolted to the bay framework. Each frame, cabinet, etc, shall be bonded by means of an individual No. 6 AWG wire extended to a nearby point of continuity to the CO GRD bus. This point may be a discharge ground bus, a CO GRD horizontal equalizer, a CO GRD bus, or a No. 2 AWG conductor extended from the CO GRD bus for the purpose of providing equipment grounding facility. Plastic battery stands (KS-20760 typical) do not require grounding. Refer to Section 802-001-192, Part 2, for notes on retrofitting in existing installations. Ordinarily, existing battery stands and other units that do not contribute electrical noise are not required to be grounded on a retrofit basis. They may be grounded, however, if deemed desirable.

4. COMMUNICATION SYSTEMS

A. Step-by-Step (SXS) Switching Systems

4.01 SXS central office switching systems are coded 355, 350A, and No. 1. The 355 system normally utilizes 9-foot high frames and is generally used for small central offices with a limited growth (1500 lines). The 350 system utilizes 11-foot 6-inch or 9-foot high frames and is used for small to moderate size central offices (1500 through 10,000 lines). The No. 1 system, utilizing 11-foot 6-inch frames, is applied to larger offices.

355 SXS System CO GRD Requirements

4.02 Relay rack ground bars are not generally applied to 355 system frames. Power is normally distributed from a small 100-type power plant directly to frame fuse panels by means of No. 6 paired discharge conductors. Equipment grounding for this type of frame and dc distribution arrangement consists of grounding each frame to a CO GRD bus connected to the office principal ground point. The bond between the CO GRD bus and office principal ground point shall be No. 0000 AWG wire. The bonds between the CO GRD bus and equipment frames shall be one or more No. 6 AWG wires branched and extended above frame lines, with No. 6 AWG wires tapped thereto and connected to frame metal of every frame except the dc power plant battery control board (BCB). The BCB ground bus shall be connected to the CO GRD bus as specified under "Power System—Battery Control Board".

350A SXS System CO GRD Requirements

4.03 Relay rack ground bars are not generally applied to 350A system frames except for fuse boards. Power may be distributed directly from the power plant to switch frames by means of discharge battery and ground conductors, or, in larger offices, through one or more BDFBs. When a CO GRD system is established, a CO GRD bus and a grid of No. 6 AWG wire similar to that described above for 355 SXS systems shall be employed to ground individual frames.

4.04 When more than one BDFB is installed in a 350A office, the BDFB ground buses shall be bonded together and to the office CO GRD bus as described under "Power System—Battery Distributing Fuse Board" except that the horizontal CO GRD conductor need not exceed the circular mil size of the largest discharge ground conductor, or multiple conductors, serving any one of the BDFBs, when such conductors are less than 750,000 CM.

4.05 Fuse boards shall be bonded as specified under "Power Systems—Fuse Boards".

4.06 The power plant BCB ground bus shall be bonded to the office CO GRD bus, which in turn shall be bonded to the office principal ground point, as specified under "Power Plant—Battery Control Board".

No. 1 SXS System CO GRD Requirements

4.07 No. 1 SXS systems may be installed in either single floor or multifloor buildings. The horizontal and vertical CO grounding systems described for such buildings shall be applied as described in Section 802-001-192. Individual switch frames shall be bonded to horizontal CO GRD equalizers, floor CO GRD buses or other suitable sources of ground reference as described for frames, cabinets, and other metallic objects contained under "Equipment Floors—Multifloor Buildings" in Section 802-001-192. Framework ground (FRWK GRD) bonding shall take the form of a network of No. 2 AWG wire routed along frame lines, bonded to frames with No. 6 wires. The No. 2 frame line runs shall be bonded together at head end of frame lines with a No. 2 wire extended to a CO GRD bus on the floor for ground reference.

4.08 It is recommended that interconnection of stranded wire not exceeding No. 2 AWG wire size be made with crimp type parallel cable taps described in Section 802-001-190, under "Parallel Cable Connectors."

B. Crossbar Systems

No. 1 and Tandem Crossbar Switching Systems CO GRD Requirements

4.09 These systems utilize lines of 11-foot 6-inch high framework equipped with 1/8- by 1-inch ground bus bars near the top that are adjoined by junction bars to form a continuous path along the frame line for return of ground current from frame mounted equipment to the battery. Power is distributed by means of equalizing centers to frame lines as described under "Power System—Crossbar

System Equalizing Centers" in Part 3A. The system differs from that shown in Fig. 2 only in that the frame line ground conductor is the ground bar run described above, instead of the No. 00 conductor depicted. Frames are equipment grounded through electrical continuity between ground bars and frames, therefore a FRWK GRD network similar to that described for SXS system frames is not required for No. 1 or Tandem frames. Various power plant and other system frames, bays, cabinets, and other metallic objects not so equipment grounded will require FRWK GRD bonding.

No. 4A Toll Crossbar System CO GRD Requirement

4.10 CO GRD requirements for 4A Toll Crossbar system equipment are identical to those described above for No. 1 and Tandem Crossbar systems. One additional difference from the arrangement shown in Fig. 2 is indigenous to the 4A system. This system supplies equalizing centers with two power supplies from the 48-volt power plant. The battery supplies are separately maintained so that no more than one-half of the equipment fed from an equalizing center is disabled by a BCB fuse failure. The two discharge ground conductors are adjoined at the equalizing center and from that point to load equipment function as a common ground current return path. CO GRD connections shall be made to main aisle equalizers as specified under "Power Systems—Crossbar System Equalizing Centers" in Part 3A. When an electronic translator system (ETS) is used with a No. 4A office, the ETS system requires isolated grounding through a ground window. Refer to Section 802-001-195 for information on isolated ground systems.

No. 5 Crossbar Switching System CO GRD Requirements

4.11 No. 5 Crossbar system equipment is similar to No. 1 and No. 4A Crossbar systems described above except that a No. 00 AWG conductor is used as the ground conductor along the frame line. Refer to Part 3A and Fig. 2 for a description of ground conductor arrangements. Frames are equipment grounded through electrical continuity established via a drop feeder connected between the No. 00 frame line ground conductor and a connector mounted on the frame. Instead of a RR ground bus at the top of the bay as provided for No. 1 crossbar frames, a No. 6 AWG solid copper wire is extended from the connector down the bay uprights. Circuit grounds are connected to the wire at the height on the frame that the circuit equipment panel is located.

C. Automatic Number Identification (ANI) and Automatic Message Accounting (AMA) Systems CO GRD Requirement

4.12 ANI and AMA equipment utilize No. 1 Crossbar type framework with ground bars adjoined by means of junction bars. These systems are installed in equipment areas served by either BDFBs or equalizing centers.

4.13 When installed in a crossbar area, they may be connected to main aisle ground equalizers with No. 00 conductors from the ground bus on the bay nearest the main aisle. When power is supplied from a BDFB, or directly from a power plant, the ground bar run shall be connected to the BDFB or power plant ground bus by means of a calculated discharge ground conductor. The number of frames involved in ANI or AMA systems are such that they can often be arranged in one frame line. When they are so installed, a bond from the ground bar run to a source of CO ground is required only if the length of the discharge ground conductor connected thereto exceeds 50 feet, in which case the bond shall be at least equal to the size of the discharge ground conductor but not larger than 350,000 CM. When frames are arranged in more than one line, the ground bar runs shall be bonded together with a 350,000 CM conductor. A single 350,000 CM bond to a nearby CO GRD bus, equalizer, main aisle ground equalizer or BDFB ground bus shall be provided from the interline ground bond when discharge ground conductors serving the frame line ground buses are more than 50 feet in length. For convenience in connecting the interline equalizer, the 350,000 CM conductor may be run and supported in the main aisle similar to a main aisle ground equalizer with No. 00 conductors tapped thereto and connected to frame line ground buses as practiced in No. 1 Crossbar installations.

D. Signaling System Ground Requirements

4.14 Signaling systems provide facility for passing information regarding the status of remote connected apparatus, such as subscriber's handsets and other office trunks, to central office networks, and for dial pulse detection. Generally, a signaling system is composed of signaling units and trunk units mounted on separate frames. Power is provided from a common central office plant through BDFB or equalizing center facilities in accordance with general power distribution requirements. Normal discharge ground facilities are adequate for the operation of such equipment when the entire office is supplied from one power plant.

4.15 Under certain conditions of power plant and signaling system apparatus arrangements, the power distribution circuit requires special consideration to ensure that the CO GRD system is not adversely affected by the presence of signaling system apparatus. Prime offenders are those communication systems utilizing E and M lead signaling.

4.16 In central offices where more than one general purpose dc power plant of the same voltage is employed to serve equipment in separate areas of the building, battery current emanating from the battery of one plant is often transmitted via intraoffice communications cable to discharge ground systems associated with the battery of the second plant. The ground current must find a path from this foreign ground system back to the originating battery. The horizontal and vertical equalizers of the CO GRD system suffice as a current path between the foreign ground system and the originating battery for nominal currents (see "Design Parameters of Vertical Equalizer System" in Section 802-001-192). In a multifloor building with batteries on separate floors the vertical equalizer serves as the sole path for current return, except for such incidental paths as may occur through building steel, and relatively modest current flow can force a differential of voltage between upper and lower floor CO GRD systems to unacceptable levels (more than 0.5 volt). The same effect can occur between two vertical CO GRD systems when two such systems are employed in the same or adjacent buildings and battery return current flows through CO GRD intersystem bonds.

4.17 For the purpose of illustrating the magnitude of ground current generated through E and M lead signaling circuits, the following general description is offered. E and M lead signaling systems are comprised of a signaling unit, essentially a biased relay that operates on on-hook and off-hook signals transmitted from or to remote apparatus. This relay affords a ground current path from a companion trunk unit, creating a continuous flow of current from the trunk unit to ground at the relay when the trunk is in use. At busy hour, E and M trunks are estimated to be in use at a call second rate of 2700/3600, or 3/4 of the time, and the drain, dependent on trunk type, may be 0.13 through 0.25 ampere per trunk. In a 4A toll office, as an example, it is not unusual to have as many as 4000 trunks installed, with the signal relays widely separated from the trunk units. When both the signaling unit and the companion trunk unit receive power from the same battery, the discharge ground conductors control the voltage drop in the distribution system. If, however, 1000 of the 4000 trunks receive power from a second source a continuous load of (0.25 X 1000 X 2700/3600) 190 amperes may be imposed at busy hour on the CO GRD system conductors, in addition to other current that may flow as the result of other system circuitry current paths. If other systems produce a current flow of 100 amperes, a peak flow of 290 amperes could produce an imbalance of voltage potential between different points in the CO GRD system that would defeat the purpose of the CO GRD system, and may reduce the voltage in the battery supply circuits utilizing the CO GRD current return path to less than circuit minimum.

4.18 In order to eliminate such occurrences, it is recommended that the source of battery for E and M signaling and trunk units be ascertained when more than one source of battery is available. Where signaling units and companion trunks are connected to separate sources, the resultant busy hour ground current required to be returned to the source battery shall be calculated as follows:

(a) Determine busy hour current on E and M leads (or comparable medium of transmission) and direction of current flow (ie, from trunk to signaling unit).

(b) Determine number of circuits obtaining current from each battery and total current flow in each direction (in E and M leads, total flow is from trunk to signaling unit, but some trunk units may obtain from different batteries).

(c) Calculate difference in directional currents (ie, 1000 amperes from plant 1 battery to plant 2 ground + 100 amperes from plant 2 battery to plant 1 ground = 1000 − 100 = 900).

4.19 The resultant current derived from the preceding calculation represents ground current for which discharge ground conductors have been provided by standard power distribution calculations to the wrong power plant (a foreign ground system).

4.20 It is recommended that foreign ground system BDFB ground buses or equalizing center ground equalizer conductors serving as the ground current collector for signaling system units be connected, with special discharge ground conductors, to the ground bus on the battery control board of the power plant serving as the current supply for the companion trunk units. The discharge ground conductor shall be calculated for one-half of the allowable loop voltage drop specified on the current supply plant SD drawing circuit notes for the loop between BCB and BDFB or equalizing center. The current used in the voltage drop calculation shall be that impressed on the BDFB ground bus or main aisle ground equalizer by the E and M signaling circuits or other current producing signaling circuits. When such conductors are provided, the discharge ground conductors serving that BDFB or equalizing center from the other power plant may be calculated for a current that excludes the current returning to the power plant producing power for such circuits.

4.21 Fig. 5 provides an illustration of current paths in a multiplant installation where E and M signaling and trunk units are located in areas served by separate plants. In the hypothetical condition represented it is shown that a current flow generated by separation of 2100 signaling and trunk units (0.25 amperes $\times$ 2100 $\times$ 2700/3600 $\approx$ 400 amperes) plus a current flow of 100 amperes from miscellaneous circuit paths creates a ground voltage differential between BDFB and BCB of 1.85 volts, which is reduced to an acceptable 0.5 volts by addition of discharge ground conductors consisting of three 750,000-CM conductors 250 feet long. In the illustration, presence of incidental ground paths is ignored.

E. Toll and Traffic Service Systems Switchboard CO GRD Requirement

4.22 Switchboards, such as the 3CL switchboard used in manual toll systems, require a FRWK GRD connection to a CO GRD system. The bond may be made with a No. 6 AWG conductor run from a CO GRD bus, horizontal equalizer, or other suitable extension of the CO GRD system to the stile strip ground bus of the first position in each switchboard line. The stile strip ground is continuous between positions and electrically conductive to the switchboard frames, thereby serving to ground the frames.

4.23 The discharge ground system employed in 3C and 3CL switchboard power supply circuits, shown on SD-81142-01, provides access to the CO GRD system by means of one or more calculated conductors run between the switchboard stile strip ground and the ground bus of a relay rack bay or bays that mount transformers and distribution fuse panels for 6.7-volt ac supply for ac lamps mounted in the switchboard. This conductor acts as a combination ac neutral-dc ground path, carrying unbalance current of the two supplies of the three-wire ac system plus return current from dc lamps. Through connection to the RR GRD bus it has continuity to the CO GRD system serving the manual toll RR bays (Section 802-001-194). When this conductor exists and the switchboard and RR bays are on the same floor, it functions as a combination discharge-framework ground and the No. 6 FRWK GRD bond may be omitted.

4.24 Other manual toll and traffic service systems switchboards generally employ a paired dc battery and ground supply system directly from the power plants in the central office, similar to 3CL switchboards. A FRWK GRD connection from the floor CO GRD system as described above for the 3CL switchboard is required to provide ground reference to the framework. When a direct bond between the switchboard stile strip ground and RR GRD, as described above for the 3CL switchboard, exists it shall function as the FRWK GRD, otherwise a No. 6 bond to CO GRD is required.

F. Information and Operating Room Desk CO GRD Requirement

4.25 Each lineup of information or operating room desks requires a FRWK GRD connection to the CO GRD system. A No. 6 AWG shall be extended from the ground bar of the fuse bay serving the line or from another suitable point in the CO ground system and terminated at a point on each desk section of a line that will effectively ground the desks. Branch taps from the No. 6 wire to desk frames may be made with No. 14 AWG minimum wire.

G. Telegraph Systems CO GRD Requirement

4.26 Modern telegraph system equipment does not require any special grounding considerations.

Ground connection to the CO GRD system shall be as specified in the system specification. Each equipment bay and service board requires FRWK GRD, which shall be furnished in accordance with general practices for grounding equipment units requiring FRWK GRD.

4.27 Certain older telegraph systems rely on earth as a current return conductor for grounded telegraph circuits. They utilize ground compensator generator sets to compensate for resistance in the earth conductor in some cases. Where compensators are used in an office, installation of modern equipment will require a separate 130-volt battery source. The No. 2 and 9B telegraph service boards are typical equipments having this requirement.

H. Teletypewriter System CO GRD Requirement

4.28 Teletypewriter switchboards generally utilize stile strip and position ground buses similar to that of manual and toll switchboards. Ground connection shall be provided similar to that described under "Toll and Traffic Service System Switchboard CO GRD Requirement".

4.29 Relay racks similar to those used in the manual toll system, equipped with ground bars junctioned to form a continuous path, are normally used for mounting teletype equipment units. These bays shall be connected to the CO GRD system in the same manner as described in Section 802-001-194 for RR bays—Toll Manual System.

I. Digital Transmission Systems CO GRD Requirement

T4M Digital Transmission System

4.30 The T4M system is comprised of equipment bays utilizing uniframe type framework arranged in conventional relay rack frame lines. The T4M equipment is principally solid-state type circuitry similar to that employed in electronic switching systems. The T4M system does not employ an isolated ground plane for protection of components as is used in the electronic switching systems.

4.31 The T4M system employs an integrated ground system and utilizes low voltage power obtained from 48-volt power input converters. The 48-volt power is obtained from a general-purpose dc power plant via BDFBs or equivalent distribution equipment.

4.32 The frames are grounded by means of a No. 6 AWG wire extended from the CO GRD system as covered in ED-97784-10. The frames are insulated from the floor per ED-97785-10, otherwise there is no requirement to isolate any part of the T4M from incidental or deliberate connection to the building integrated ground plane.

J. Other Systems CO GRD Requirement

4.33 The preceding descriptions of CO GRD requirements for various switching, toll, and miscellaneous systems normally installed in central offices cover the majority of physical configurations employed in communication systems to afford effective grounding. A variety of other systems, equipment units and miscellaneous apparatus not mentioned herein may also require ground connection for protection and/or voltage equalization purposes. Effective grounding of these units may be accomplished by comparison of the discharge circuit system and physical arrangement to that of systems described, and devising comparable grounding facilities.

5. MISCELLANEOUS EQUIPMENT UNITS

A. Distributing Frame and Protector Frame CO GRD Requirements

5.01 The arrangement of ground bus bars on protector and distributing frames is described in Section 802-001-190, "Distributing Frame and Protector Frame Bus Bars." A ground conductor shall be provided from the frame ground bus bar, normally mounted at the bottom of protector frames or distributing frames that mount protectors. The conductor serves principally to provide a ground path for high voltage energy that may be imposed on trunk and subscriber cables entering the office through the cable vault. It shall be terminated at a floor CO GRD bus when available or directly to the water pipe (or other) office principal ground point. A protector or distributing frame ground conductor, when protector units are mounted thereon, shall be of the size indicated in Table A. The run shall be as short as practical, without sharp bends and with minimal number of bends.

5.02 Main (MDF), Intermediate (IDF), or Combined (CDF) distributing frames equipped with

TABLE A

PROTECTOR OR DISTRIBUTING FRAME GROUND LEADS

OFFICE		ULTIMATE NUMBER LINES AND TRUNKS	MIN SIZE OF LEAD (AWG)
TELEGRAPH OR REPEATER		ALL SIZES	NO. 0
CENTRAL		ABOVE 1500	NO. 0
CENTRAL		201 TO 1500	NO. 6
CENTRAL		0 TO 200	NO. 6
PBX	101 ESS	ALL SIZES	NO. 0
	OTHER	ALL SIZES	NO. 6

ground bus bars are effectively framework grounded through continuity between bus bar and frame steel. When a ground bar is not provided, the frame shall be FRWK grounded with at least one No. 6 AWG conductor. When the DF exceeds 25 feet in length it is recommended that additional bonds be provided at approximately 25-foot intervals. The bonds may be connected to the ground conductor serving a nearby protector frame if available, or may be terminated at a floor CO GRD bus, horizontal CO GRD equalizer or any extension therefrom suitable for FRWK GRD connections. Multiple ground bonds may utilize a single No. 2 AWG conductor to the point of connection to the CO GRD system.

B. Shielded Entrance Cable

5.03 The metallic sheath of cables that enter the building via the cable vault shall be bonded to the framework ground bus bar of protector frames or distributing frames at which the cable conductors terminate. When the sheath is not continuous from vault to frame, a conductor per Fig. 5 shall be extended from the framework ground bus bar, following the path of cable routing, to the point of sheath discontinuity. The sheaths shall be bonded together and connected to the conductor so as to form a continuous path from sheaths to ground. For cable vault grounding details refer to Section 638-300- series.

C. Conduits, Armored Cable, Shielded Wire for Other Than AC Service

5.04 The application of enclosing raceway for CO GRD system conductors is covered in Section 802-001-192 and for ac service in Section 802-001-198. Application of enclosing raceway for support, protection or inductive shielding of other communication conductors is covered below.

5.05 Rigid conduit or other metallic raceway employed solely as a support or as protection against mechanical damage to communication conductors (ie, extension from cable rack to a unit) need not be equipment grounded when at least one point of the run is solidly fastened to metal objects such as equipment frames, cable rack, or framing channels that may reasonably be assumed to have continuity to ground.

5.06 Rigid or flexible metallic conduit, armored cable, or cable or wire equipped with a metallic sheath, when provided for the purpose of reducing transference of inductive energy in accordance with system specification requirements, shall be bonded to the CO GRD system at both ends and bonds shall be provided across any intermediate points of shield discontinuity unless system specifications specifically provide other bonding instructions.

5.07 Rigid or flexible conduit, armored cable, or other metallic raceway used primarily to afford inductive shielding may be considered adequately bonded when terminated at both ends, with fittings approved for ac equipment grounding, at metallic enclosures that are equipment grounded in accordance with CO GRD system requirements. When such raceway is not so terminated it shall be bonded from the point of discontinuity to a suitable ground bus, frame, or other point of assured continuity with the CO GRD system. In general, the bond shall be a No. 6 AWG wire, but where the shielding raceway is small (ie, 1-inch conduit or less) and not subject to possible physical damage it may be reduced to a reasonable size, not less than 14 AWG. Multiple shielding raceways terminating at a common equipment may be bonded together and grounded with a single conductor.

5.08 Cables or wires equipped with woven metal braid or similar inductive sheathing shall be bonded at both ends to a suitable ground bus or other point of continuity with the CO GRD system. Any intermediate points of sheath discontinuity shall be bridged or bonded to a suitable ground point. The sheaths of multiple conductors terminating at a common equipment may be bonded together and grounded with a common ground bond of reasonable size, not less than No. 14 AWG, unless system specifications specifically direct otherwise.

D. Miscellaneous Frames, Racks, Cabinets

5.09 Every metallic frame, cabinet, battery stand, or other unit of metallic structure that is floor or wall mounted in an equipment area served by a CO GRD system, with the exception of minor units mounted at a height where they are not normally contacted by personnel (ie, wall mounted clocks) should be grounded. Certain equipment units that utilize ac service are equipment grounded through the ac equipment ground system and under certain circumstances, as outlined in Section 802-001-198, do not require connection to the CO GRD system. Equipment frames that are bonded to the CO GRD system via combination discharge-framework ground conductors (see 2.04) do not require a separate framework ground bond connection to the CO GRD system. Other metallic units shall be grounded to the CO GRD system with individual FRWK GRD bonds. Units of this type include any equipment mounting facility that does not have an obvious conductor path to the CO GRD system.

E. Duct Type Framework CO GRD Requirement

5.10 Duct type framework is currently employed to mount bay equipment in a variety of new communication systems, such as carrier, microwave, power, and various common systems. Duct type bays may require special consideration for grounding purposes. Certain of these bays utilize a 1-inch galvanized pipe as a junction between bays and as a support from auxiliary framing. The pipe runs horizontally and continuously within the legs of the top angle of bays in a frame line and is bolted to the top angle of the bays and to auxiliary framing. This pipe may be utilized as a FRWK GRD for the bays. It should never be utilized to serve as a circuit ground. These bays may comprise a complete bay line or may be interspersed individually or in groups in lines of bays mounted on various other types of framework. An effective framework ground for duct type bays may be made by extending a single No. 6 AWG bond from a suitable CO GRD bus or conductor to each pipe and where more than one pipe occurs in a frame line the pipes may be made continuous by use of a No. 6 AWG bond. The ground path is extended to the framework of each bay with a No. 6 AWG wire and connectors furnished with each framework. The wire bonds the pipe to a point on the frame with two-hole terminal connectors as specified in ED-3C014-( ), Method of Grounding Equal and Unequal Flange Duct Bays.

5.11 The No. 6 AWG wire pipe to frame bond was not used in early designs of duct bay; instead, a set screw through the frame top angle was depended on to maintain contact with the pipe. This method is not reliable since motion in the structure tends to relax pressure at contact points. When such existing bays are to be connected to a CO GRD system for FRWK GRD purpose, connections shown in ED-3C014-( ) shall be provided at each bay.

5.12 Terminals shall be fastened to the pipe and frame with thread forming screws (ie, "Taptite"). These screws roll their own thread in the metal to form a more secure connection than obtained by a machine screw in a tapped hole. Grounding holes are provided in the latest design of duct type framework. The installer is required to drill holes in the pipe and, when retrofitting the bond to early designs of framework, into the frame metal.

5.13 Certain duct bays, such as those used in ESS systems do not use a pipe at the top of the bay line. These bays require individual bonding to a conductor run along the top of the bay line that connects to a CO GRD bus or other suitable ground path extension therefrom. The minimum size of a FRWK GRD conductor serving a frame line shall be No. 6 AWG. When a single conductor is utilized as a FRWK GRD conductor serving a multiplicity of frame lines, the minimum size shall be No. 2 AWG except when system specifications dictate other arrangements. ESS systems specifications allow use of No. 6 AWG wire throughout the grounding network, and obtain ground reference by connection to power distribution

(PD) discharge ground buses, which are bonded via the ESS main ground bus at the ground window to the CO GRD system.

F. Uniframe Framework

5.14 A type of framework has been developed to conform with the requirements expressed in Equipment—Building Interruptions Specification X-74500. This framework is referred to by the name, "Uniframe". These 7-foot high frames are arranged for grounding by means of a No. 6 AWG wire terminated on the frame with 2-hole bolted tongue crimp connector as specified in ED-97784-( ).

G. IBM System/7 Computer Equipment

5.15 IBM System/7 equipment is used as a processor in CAMA-C installations. CAMA-C scanner cabinets and IBM System/7 cabinets are normally located in a special equipment room or area isolated from other central office equipment. The IBM cabinets are portable and often moved for maintenance purposes, therefore they are not grounded by direct bonding to the CO GRD system. Instead, they are grounded through a "green wire" grounding system. IBM grounding requirements are outlined below (see SD-5P000-01).

5.16 Each cabinet of System/7 equipment is served by an ac service branch circuit from a nearby ac power service cabinet. Frame grounding is accomplished by means of an equipment ground conductor (green wire) run with ac branch circuit conductors from the cabinets to an equipment ground bus in the ac power service cabinet.

5.17 Each IBM cabinet is equipped with an ac service cord. A green wire included in the cord is connected to the cabinet frame and at the other end to a ground finger in the cord cap. An outlet box equipped with a receptacle suitable for connection to the cap must be provided at each cabinet.

5.18 A green wire conductor is extended from the receptacle in the raceway that contains the ac branch circuit conductors to the ac power service cabinet equipment ground bus.

5.19 IBM grounding requirements specify that the ac power service cabinet equipment ground bus be connected to a "stable ground point." This requirement is met when either or both of the following Bell System standard grounding requirements for power service cabinets are met (see Section 802-001-198, Part 4C):

(a) When the equipment ground bus is connected to a ground bus in the house service board by a green wire conductor run in raceway with the ac feeder conductors, or

(b) When the equipment ground bus is connected with a No. 6 AWG bond wire to a CO GRD bus on the CAMA-C floor.

5.20 In some existing ac power service cabinet installations, neither of the preceding grounding requirements is met. The system depends on continuity through raceway between the power service cabinet and the house service board for equipment grounding. This is not sufficient to meet IBM specifications.

5.21 When a CAMA-C installation is added and ac service will be obtained from an existing ac cabinet grounded only through raceway it is not necessary to retrofit a green wire in the feeder raceway, or to provide a CO GRD system if one does not exist.

5.22 If a CO GRD system does exist the ac cabinet equipment ground bus shall be bonded to the floor CO GRD bus with a No. 6 AWG wire. Otherwise, IBM grounding requirements may be met by bonding:

(a) ***Preferably,*** if the building is of steel frame construction, to building steel on the CAMA-C floor.

(b) ***Alternatively,*** if the building is of reinforced concrete or other construction that may not afford a low impedance path to earth, to a major water pipe in the vicinity of the ac cabinet.

5.23 Scanner cabinets used with the IBM System/7 cabinets are not connected to an ac system. They are powered by 48-volt dc 3-wire circuit from a BDFB or equivalent distribution unit which may be on the same or another floor. Two 48-volt leads and a common ground lead are extended above the scanner cabinets where drop feeders are tapped and extended into the scanner cabinets. The ground drop feeders are connected to the frames.

5.24 Ground continuity between scanner and IBM cabinets on the CAMA-C floor is necessary to ensure adequate protection. To accomplish this, a No. 6 AWG wire shall be extended from the ac cabinet equipment ground bus to cable rack above the first scanner frame served by the 48-volt circuit. At that point the No. 6 wire shall be tapped to the dc circuit common ground conductor, thereby completing a ground path between scanner and IBM cabinets through the equipment ground bus of the ac power service cabinet.

6. CO GRD REQUIREMENTS SPECIFIED IN SYSTEM SPECIFICATIONS

6.01 Where specific grounding requirements are specified in the circuit drawings or other specifications of a communication system equipment, these requirements take precedent over the general requirements of this section. Where specific grounding requirements are not furnished in system specifications or are determined to have not been updated to the requirements outlined herein, a ground system equating to the requirements covered herein shall be provided. System circuit and equipment specifications originated prior to the introduction of the CO GRD system do not reflect grounding requirements that take into consideration the existence of the horizontal and vertical equalizer systems.

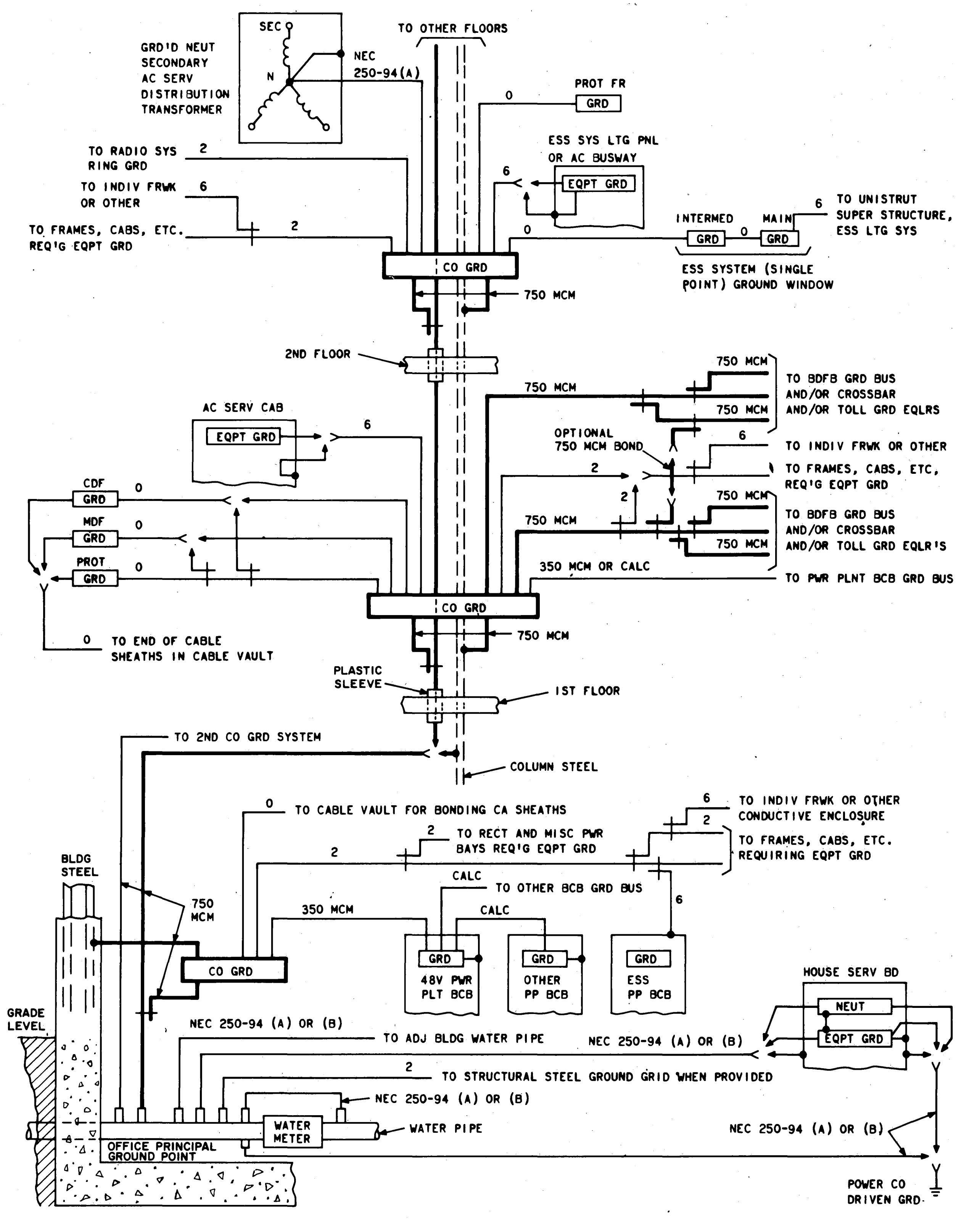

Fig. 1—Typical Equipment Connected to CO GRD System

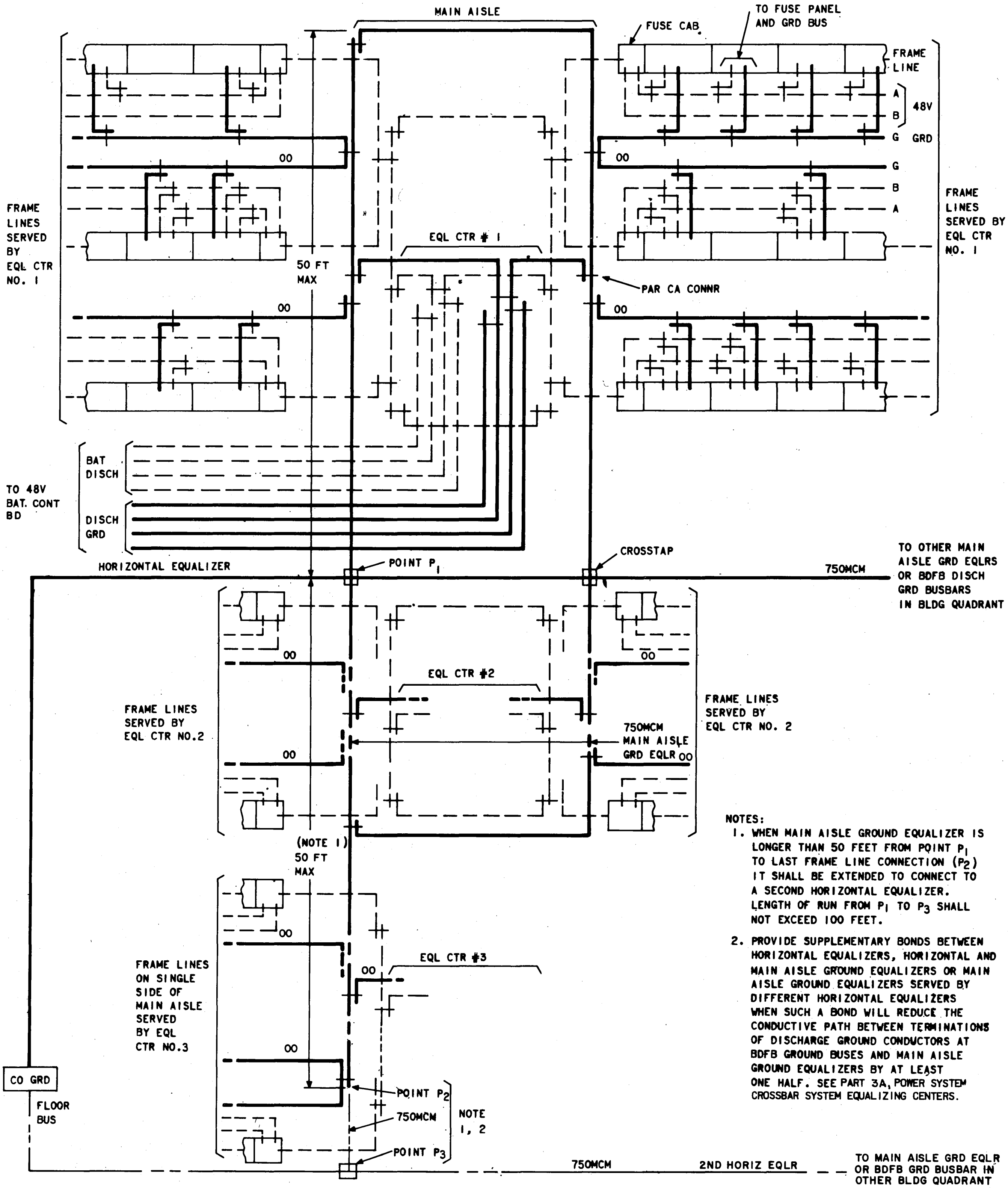

Fig. 2—Method of Connecting CO GRD Horizontal Equalizer to Main Aisle Ground Equalizers (Typical No. 5 Crossbar Equalizing Center Arrangement Shown)

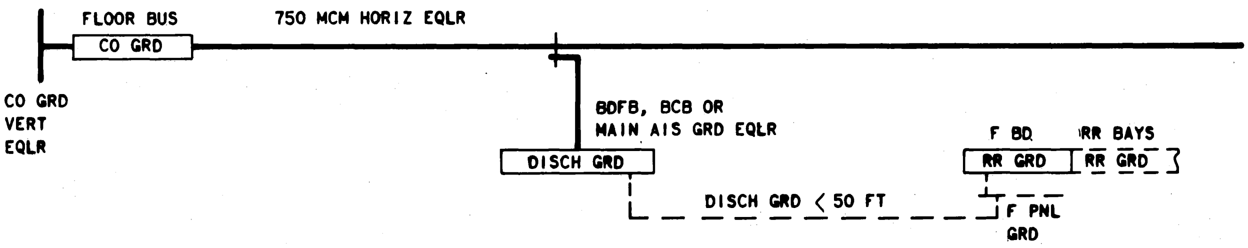

Fig. 3A—Single Fuse Board, Discharge Ground Feeder $<$ 50 Ft Long (Note 1)

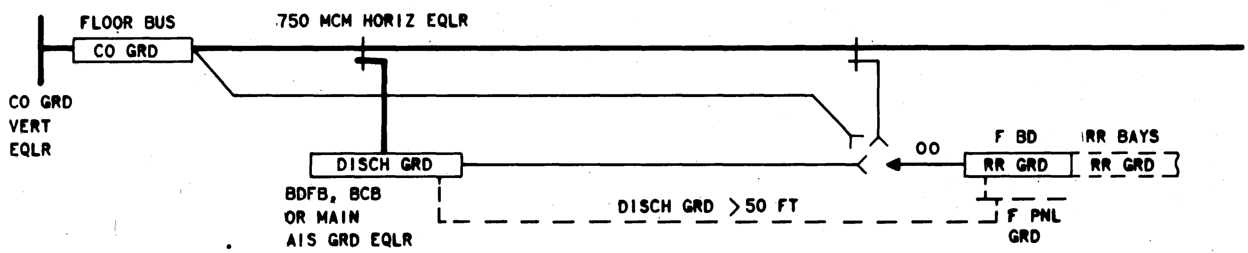

Fig. 3B—Single Fuse Board, Discharge Ground Feeder $>$ 50 Ft Long

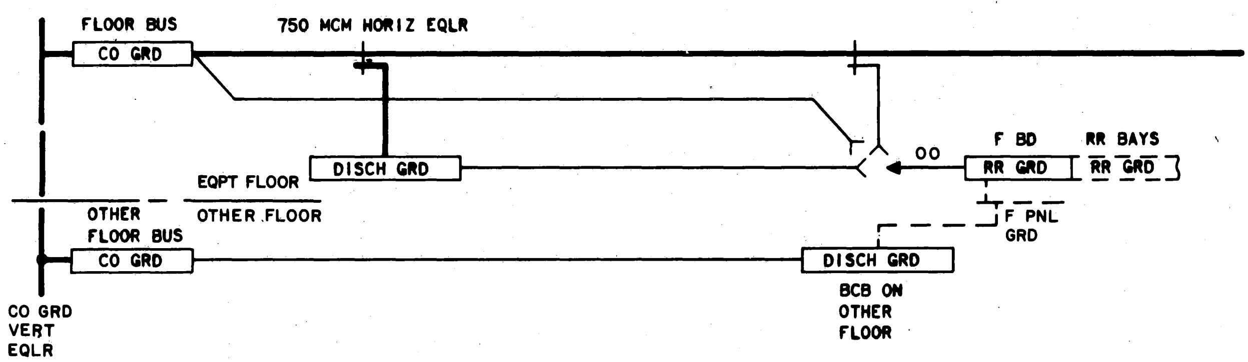

Fig. 3C—Single Fuse Board, Discharge Ground Feeder Terminated On Other Floor

NOTES:

1. CONNECTION TO CO GRD THROUGH DISCHARGE GROUND CONDUCTOR ALLOWED.
2. —< ←— DENOTES OPTIONAL CONNECTION TO CO GRD THAT RESULTS IN SHORTEST BOND BETWEEN DISCHARGE GROUND CONDUCTORS SERVING THE FUSE BOARD AND OTHER FUSE BOARDS, BDFB'S OR MAIN AISLE GROUND EQUALIZERS IN CLOSEST PROXIMITY TO THE FUSE BOARD.

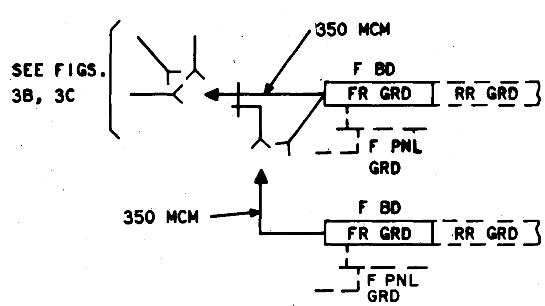

Fig. 3D—More Than One Fuse Board, Discharge Ground Feeder $>$ 50 Ft Or Terminated On Other Floor, And Fuse Boards Not Individually Connected Per Fig. 3B Or 3C To CO GRD

Fig. 3—Requirement to Bond Fuse Board Ground Bus Bars to CO GRD (See Part 3.A, Power System—Fuse Boards)

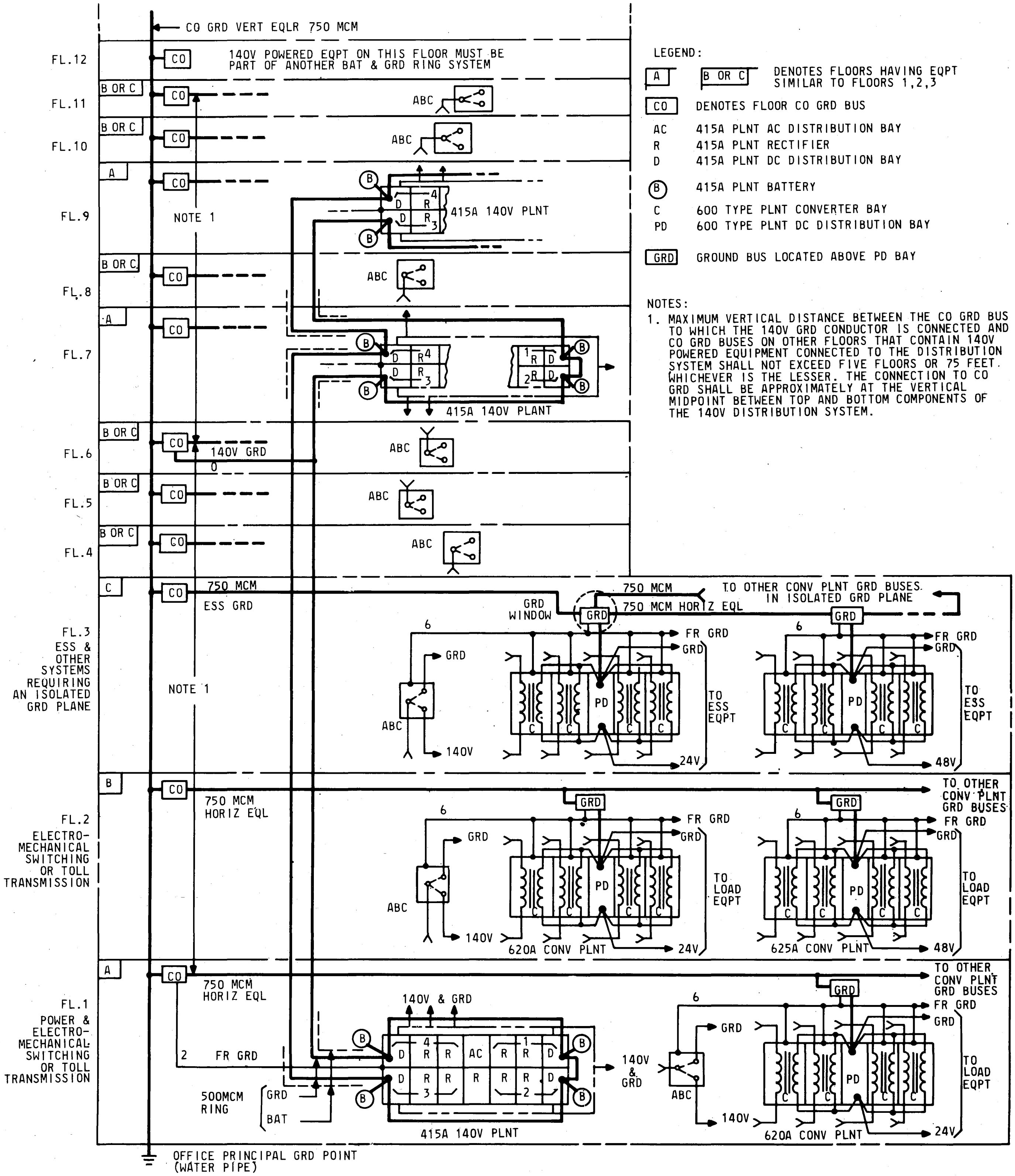

Fig. 4—140-Volt Power Distribution System Equipment Grounding Requirements

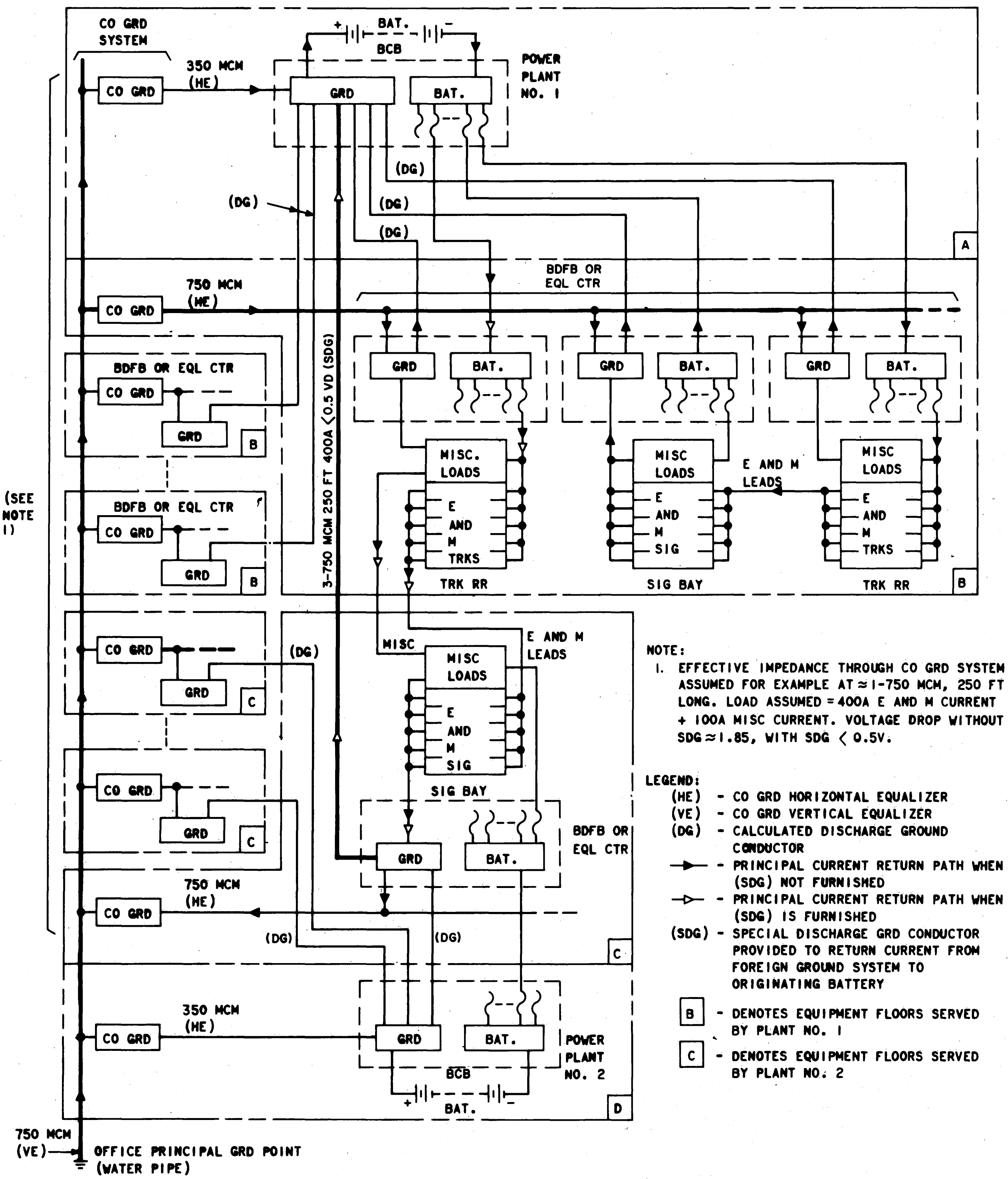

Fig. 5—Ground Current Paths When E&M Leads Connect Signaling and Trunk Units Served by Different Power Plants and Special Discharge Ground Conductors Are or Are Not Provided to the Originating Battery