PROTECTIVE GROUNDING SYSTEMS

EQUIPMENT GROUND SYSTEM, CENTRAL OFFICES (CO GRD)

GENERAL EQUIPMENT REQUIREMENTS AND ENGINEERING INFORMATION

POWER SYSTEMS

CONTENTS PAGE

FIGURES

1. SCOPE

1.01 This section covers equipment requirements and engineering information pertaining to the establishment of the vertical and horizontal equalizers of the equipment ground system utilized in Central Offices. This sytem is referred to as the CO GRD (Central Office Ground) System.

1.02 This section is supplementary to Section 802-001-180, General Grounding Requirements for Communication Systems in Central Offices, Radio Stations and other Structures. The following sections are supplementary to this section:

801-001-190—Equipment Ground Systems Material, General Equipment Requirements
802-001-191—Office Ground Electrodes—General Equipment Requirements and Engineering Information
802-001-193—Equipment Ground System, Central Offices—General Interface Requirements for DC Power Plants and Communication Systems
802-001-194—Equipment Ground System, Central Offices—General Interface Requirements for Manual Toll Relay Rack Ground System
802-001-195—Equipment Ground System, Central Offices—General Interface Requirements for Electronic Switching Systems

1.03 The AC Equipment Ground system, also required in Central Offices, is covered in Section 802-001-198.

1.04 When Microwave Radio system equipment is installed in Central Office buildings, the CO GRD System is utilized in place of the exterior Ring Ground system to provide earth potential reference and a path for lightning discharge current, in accordance with requirements outlined in Section 802-001-197.

2. GENERAL

2.01 Generally, equipment grounding systems are designed for the purpose of affording protection to personnel and equipment from the effects of a fault in an electrical system or of lightning stroke. In buildings housing communication equipment, several unique conditions and requirements are encountered that precludes the use of a simple grounding network that would satisfy protection requirements (see Section 802-001-180, Part 7B). The CO GRD (Central Office Ground) system described herein is designed specifically to satisfy these additional requirements:

(a) ***Noise:*** Low impedance bonding is provided between circuit ground terminations on the common ground plane so that transmission of noise producing ground plane fluctuations is effectively reduced.

(b) ***DC Ground Current:*** DC Power Plants supply the bulk of power required to operate communication systems equipment. Generally, the DC current return path to batteries is not isolated from equipment ground planes. Multiple paths for ground current are available through equipment and building steelwork as well as engineered ground return paths. The CO GRD system provides a low impedance path for current flow between engineered ground conductors that effectively short-circuits inadvertent impedances in the incidental ground paths that occur throughout the communication equipment installation.

2.02 The CO GRD equipment grounding system provides:

(a) Equipment grounding of communication systems equipment units

(b) Earth potential reference for communication circuits

(c) Lightning discharge paths for communication system entrance cable protectors

(d) Ground current paths for equalization of DC power voltages.

2.03 The CO GRD system primarily consists of:

(a) A large conductor (ie, 750,000 CM) extended from the building principal ground point to CO GRD bus bars located on each floor of a building. This conductor is referred to as a vertical equalizer.

(b) Large conductors (ie, 750,000 CM) extended from CO GRD buses on each equipment floor to the ground systems of DC power plants, battery distributing fuse boards, power distribution equalizing centers and other principal DC distribution components. These conductors are referred to as horizontal equalizers.

(c) Miscellaneous conductors extended from the CO GRD buses, horizontal equalizers or points on the DC ground system to equipment frames, cabinets and other metallic objects on equipment floors. These conductors are referred to as relay rack, framework or equipment ground, and by other names derived from the served equipment or the function of the conductor.

2.04 The CO GRD system may be a complex branching system utilizing one or more vertical equalizers connected to numerous CO GRD bus bars on various floors of a large multifloor central office building or it may consist of a network extended from a single CO GRD bus bar in small single floor buildings.

2.05 A grounding system that provides a current return path from equipment frames operating on low-voltage DC power to the battery, sufficient to operate overcurrent devices efficiently, ensures adequate protection for personnel from shock hazard or equipment from damage or fires due to a fault in the DC distribution system. Protection from lightning is afforded by grounding of equipment to a grounding electrode. In central offices, however, an additional objective of major concern is the suppression of interference energy: noise on communication circuits. The use of DC power plants result in flow of ground current between various points in the office ground plane (802-001-180, "Discharge Ground"). Current flow through incidental ground paths can create noise. Reliable low impedance paths for flow of current are required if the system is to be effective in supressing noise. To accomplish this, a system of horizontal equalizer conductors connecting discharge ground points on individual floors, and vertical equalizers connecting various floor horizontal equalizers is employed. The vertical equalizer, used in multifloor buildings, extends from floor CO GRD bus bars to the office principal ground point (eg, water pipe) to furnish ground reference to the CO GRD system. In single floor buildings, a single CO GRD bus is established for horizontal distribution of equalizers and a bonding conductor (equivalent to a vertical equalizer) extends therefrom to the office principal ground point for ground reference.

2.06 The CO GRD system is an "integrated" ground system. There are two methods of employment of grounding systems to accomplish the intended objectives: Protection of personnel and equipment, and reduction of noise. They are 1) isolated ground systems, 2) integrated ground systems.

2.07 An isolated ground system utilizes a ground plane that is common to the individual electrical or communication system that it serves but is isolated from other grounded objects and from earth, except for a single point connection. The single point connection ensures potential equalization between the isolated and building ground planes. Single point integration assures that currents generated within the isolated system cannot flow through foreign ground paths or that stray currents generated outside the isolated system cannot flow within the isolated ground plane. This system is effective only when it is truly a single point system and least effective when additional ground paths occur in the least number (ie, one). The AC neutral grounding arrangement (Section 802-001-180, AC Service Ground) is a single point system devised to isolate AC current imposed on the neutral conductor from the AC equipment ground system. The "ground window" concept used with Electronic Switching Systems is also a single point system utilized to isolate the system ground network from stray foreign ground currents that might damage electronic system circuit components or otherwise disturb the operation of the system.

2.08 Integrated ground systems do not attempt to maintain a separation of different ground systems. Instead, they are most effective when numerous short bonding paths between all objects that represent grounded members assure that all such neighboring members are relatively of the same potential regardless of transient current flow. Additionally, all of the various paths to ground via incidental or deliberately engineered ground paths are combined by deliberate bonding into a single complex of lowest possible impedance to ensure a minimal difference of potential between the points in the complex or between such points and earth.

2.09 The CO GRD system is integrated with the DC power ground network by connections to discharge ground paths at various points: At power plants, DC power distribution points, and at load points. It also is integrated with incidental ground paths by deliberate bonds to building steel and to equipment units, as well as by continuity between equipment unit ground bus bars and equipment framework.

2.10 The size of CO GRD vertical and horizontal equalizer conductors and the connecting arrangements specified herein have been chosen to provide optimum equalization of ground potential between the different load terminations of the various power distribution systems, within reasonable limits of practicability and economy. In general, under normal operating conditions, the CO GRD system is expected to maintain ground potential differential to less than one volt between any two points on the ground plane. The actual voltage differential between two ground points is dependent on impedance and momentary current flow. Impedance is determined by not only the CO GRD conductor size and length, but by the availability of parallel ground paths, incidental or otherwise. Current flow through the CO GRD conductors depends on the momentary load configuration of the DC distribution systems. Both factors are dependent on such a complexity of conditions that it precludes any possibility of calculating actual limits of ground current differential in any specific installation. During occurrences of faults in the DC distribution system or of lightning strokes on the building or electrical conductors entering the building, potential differential in the ground system will greatly exceed the expected one volt normal operation differential.

2.11 A CO GRD system shall be provided in every new Central Office building. It is recommended that a CO GRD system be added to existing buildings when:

(a) A building addition is added.

(b) A major addition of equipment is added in existing space

(c) Noise on existing communication circuits, determined or suspected to be caused by inadequate grounding, present a problem.

2.12 Existing offices not equipped with a CO GRD system of the type described herein are equipped with a simple grounding system consisting primarily of a conductor extended from the water pipe or equivalent principal ground point to the ground bus of the Main Distributing or Protector frame to provide earth potential reference and a path for discharge of lightning currents to earth. A second conductor is extended either from the MDF or Protector frame ground bus or the principal ground point to the discharge ground bus of the predominant DC power plant to provide earth potential reference to the DC power distribution system.

2.13 When a major addition of equipment is installed, a simple ground system, though previously adequate, may not suffice for the larger installation. This will not be apparent until the new equipment is put into service: evidenced by noise on talking paths and/or malfunction of switching devices. For reason of economy, it is recommended that a CO GRD system be applied to the new equipment area only and not retrofitted to existing equipment areas unless a previous noise or malfunction condition attributable to inadequate grounding existed.

2.14 Retrofitting of an entire existing office to reduce noise may require a considerable expenditure. Often, the general area of the noise source may be identified. A CO GRD system that serves that area only will generally serve to reduce noise at a minimum cost. It is recommended therefore that the CO GRD system be retrofitted into existing equipment areas on a selective basis, aimed at relieving noise conditions only. The additional personnel and equipment protection afforded by a complete CO GRD system is desirable, but not considered essential to the point that the cost of retrofitting a complete system is justified.

2.15 A list of Bell System publications relating to requirements for protective grounding is contained in Section 802-001-180, Bibliography.

3. DESIGN PARAMETERS OF HORIZONTAL EQUALIZER SYSTEM

A. Equipment Floors, Multistory Buildings

3.01 A CO GRD bus (Section 802-001-190, "CO GRD Bus Bars") is required on every equipment floor of buildings utilizing the CO GRD system. The bus shall be located on a column that serves as a vertical CO GRD equalizer, or on a column or wall or other accessible location that best serves the requirements of the physical design of the building when a cable conductor serves as the vertical equalizer. The location of CO GRD bus bars shall be such that:

(a) The maximum conductive run length between a bus and the furthest grounded equipment unit shall not exceed 200 feet and shall not extend beyond the perimeter of a square superimposed on a circle of 100' radius from the bus location. This restriction is based on the hypothesis that a single bus located in the exact center of a 200 X 200 ft building may serve all equipment located on the same floor. (See Fig. 1.)

(b) The ideal location for the placement of buses on equipment floors is approximately in the center of the equipment, which should result in approximately equal run lengths of horizontal equalizers and conductive extensions therefrom, and maximum equalization. Where the CO GRD buses cannot be centrally located, it is advantageous to locate them as near as practicable to the protector frames or MDF and CDF's equipped with protectors, so as to provide a direct path to ground for discharge of energy intercepted by protectors.

(c) A bond between the vertical equalizer and a CO GRD bus, which provides a conductive path for interchange of current between floors, shall be as short as practicable, so as to minimize impedance in the path. Preferably, the length shall be less than 20 feet.

(d) The vertical equalizer shall be located so that the horizontal portion of the run to the office principal ground point is as short as practical.

(e) All runs of CO GRD equalizer conductors shall be routed so that loops (U shaped configurations) are avoided, so as to minimize the length of such runs.

3.02 Figure 1 illustrates the maximum area that may normally be served by one CO GRD bus. It is recognized that physical design of buildings may exceed the parameters outlined above, in which case two or more CO ground bars per floor served by separate vertical equalizers individually terminated at the office principal ground point, may be required. Specific design requirements are covered herein under "Design Parameters of Vertical Equalizer System".

3.03 As indicated in Fig. 1 and 2, the general direction of horizontal equalizers that terminate at discharge ground buses of Battery Distributing Fuse Boards (BDFB) or on horizontal ground equalizers of Crossbar or Toll system discharge circuit conductors shall normally be diagonal to the walls of the building, and that at least one 750,000 CM horizontal equalizer shall be extended into each quarter section of the building. These conductors shall bond BDFB ground buses and ground equalizers therein to afford a path for the interchange of current between the various discharge ground conductors as increase and decrease of current flow occurs independently in each discharge circuit.

3.04 It is important that a reasonably direct equalizer path be established between discharge ground points for the reason that large current flow may be expected in equalizers whenever two or more power plant discharge circuits feeding BDFB and/or Crossbar equalizers terminate on the same floor and the load is heavy on one or more and at the same time light on others. Wherever horizontal CO GRD equalizers run within reasonable proximity to other such runs, or in proximity to 750,000 CM discharge ground equalizer conductors of Crossbar or Toll systems, they shall be bonded together so as to form a direct conductive path, supplementing the circuitous path afforded by connection of CO GRD equalizers to the CO GRD bus. Such bonds are illustrated in Fig. 2: As indicated by extension of the Crossbar Tandem ground equalizer to bond to the CO GRD equalizer serving the carrier BDFB in the lower left quadrant of the building, and a bond between CO GRD equalizers serving No. 5 Crossbar ground equalizers and Carrier BDFB's in the lower center section of the building. No precise formula for application of such bonding can be provided. As a rule of thumb, it may be said that conductors in proximity are generally eligible for bonding if:

(a) Points of proximity occur further than 35 conductor feet from the CO GRD bus and;

(b) Total conductor run length via the CO GRD bus between points of proximity is greater than 70 feet and;

(c) Direct bond between points of proximity will result in a path between discharge ground conductors of less than one-half the length of (b).

3.05 Examination of a job grounding schematic drawing after horizontal equalizers and main aisle ground equalizers are located thereon may reveal other conditions where supplementary bonds will reduce the length of ground current paths between discharge ground conductor terminations significantly.

3.06 Frames, cabinets and other metallic objects that have continuity to the CO GRD system via discharge ground conductors extended from a CO GRD bonded BDFB ground bus or main aisle equalizer to frame mounted ground bus bars bolted directly to frame metal do not require further equipment grounding. Other units in an equipment area must be equipment grounded to the CO GRD system [referred to as framework grounding (FRWK GRD)]. These units may be connected directly to the CO GRD bus, CO GRD horizontal equalizers, BDFB ground buses, main aisle ground equalizers, or to equipment frame ground buses that are utilized as combined discharge-equipment ground paths. The minimum size of a bond for framework ground to a single bay or cabinet or other individual unit requiring FRWK GRD shall be a No. 6 AWG wire. Additionally, a line of duct bays equipped with a 1-inch support pipe interconnecting the bay line may be connected with a single No. 6 wire, as shown in Fig. 2. Where a group of bays or miscellaneous units, or more than one line of duct bays are to be grounded through a single conductor, it will generally prove more economical to extend a No. 2 AWG wire from the CO GRD bus or from a horizontal equalizer, with multiple No. 6 bonds extended therefrom, than to extend individual No. 6 bonds from 750,000 CM equalizer because of the high cost of suitable parallel cable connectors. In

Fig. 2, this is illustrated by the bonds afforded for framework grounding of carrier duct bays. Specific interface requirements between a variety of different equipment units and the CO GRD system are covered in Sections 802-001-193, -194, -195 and -197. Fig. 4 shows typical equipment connected to horizontal equalizers and CO GRD buses.

BASEMENT POWER ROOMS, MULTISTORY BUILDINGS

3.07 The location of the CO GRD bus in the basement of a building equipped with water pipe ground and power equipment in the basement need not be in vertical alignment with other floor CO GRD buses. Ideally, it should be located in the vicinity of some point on the CO GRD vertical equalizer run in the basement, and also in a position that affords the shortest practical run length of the bond between the vertical equalizer and the predominant power plant BCB ground bus (see Fig. 4 and Section 802-001-193.) Unless major intermediate battery distribution equipment such as BDFB's are installed in the basement (requires 750,000 CM horizontal equalizer) equipment ground conductors connected to the basement CO GRD bus, other than those provided to power plant BCB ground buses, are generally furnished to provide framework grounding. These bonds carry no significant battery return current. They may be No. 6 AWG wire when thay serve a single equipment unit or No. 2 AWG wire when they serve multiple units. The normal restriction of 200 feet maximum conductor length from the CO GRD bus to the furthest connected unit (3.01a) may be ignored. When BDFB's do exist in the basement, the CO GRD bus shall be no further than 200 (conductive path) feet from the furthest bay served by CO GRD bus, otherwise a second CO GRD bus in vertical line with other floor ground buses may be established, with horizontal equalizers to serve such equipment. Fig. 3 shows such an arrangement.

SINGLE FLOOR BUILDINGS OTHER THAN RADIO RELAY AND MICROWAVE STATIONS

3.08 A single floor building may utilize one or more CO GRD buses. In a building of less than 100 × 100 ft dimension, a single bus located near the entry point of the ground electrode conductor and bonded to the principal ground point with a No. 0000 AWG wire may suffice as the ground point for the horizontal CO GRD system. It can generally be improved, however, by establishment of a second CO GRD bus within the equipment area if more than one BDFB and/or crossbar equalizer will ultimately be installed in the building. When the building exceeds dimension (more than 100 X 100 ft) that will result in a conductive length of more than 200 feet between the CO GRD bus and the furthest equipment unit utilizing a frame mounted busbar or similar ground current return path, a second CO GRD bus must be employed. Connection between CO GRD buses shall be with 750,000 CM conductor. This arrangement provides a conductive path generally equivalent to that illustrated in the basement portion of Fig. 3.

3.09 Horizontal equalizer distribution from CO GRD buses in a single floor building shall be in accordance with the requirements outlined previously for multifloor building applications.

4. DESIGN PARAMETERS OF VERTICAL EQUALIZER SYSTEM

4.01 A vertical equalizer is required in a multifloor building to bond the floor CO GRD buses together and to provide earth potential reference to the CO GRD system. The vertical equalizer functions as a current path for ground current interchange between discharge ground circuits on various floors during periods of load unbalance, as a low impedance path to battery for fault current and, through its low impedance connection to the earth potential electrode, effectively extends an approximation of earth potential to each of the CO GRD buses connected thereto. When this arrangement is provided, any floor CO GRD bus may be considered as an appearance of the grounding electrode and any equipment requiring connection to a grounding electrode for proper operation and/or protection shall be connected to the CO GRD bus on the same floor as the equipment.

4.02 Figure 3 illustrates typical routing and connections of a CO GRD system vertical equalizer. A vertical riser may consist of a continuous length of 750,000 CM conductor or it may be the steel of a building column (see Section 802-001-190), CO GRD Bus Bars). When a 750,000 CM conductor is used, the vertical run shall be as straight as practicable, preferably with only minor bends to avoid obstructions such as floor beams. Sharp bends are prohibited. Splicing of the vertical equalizer by any means other than cadwelding is prohibited.

4.03 When a vertical steel column is employed as the CO GRD conductor, that column must be connected to the water pipe principal ground point with a 750,000 CM copper conductor run in as short a manner as practicable. The conductor shall be cadwelded or brazed directly to the column steel, or connected to a ground bar arranged similar to that shown in Fig. 5 of Section 802-001-190.

4.03 Certain types of building columns may be employed as a CO GRD system vertical equalizer. Other types cannot be used for this purpose but require bonding to floor CO GRD buses to ensure equalization of lightning induced voltage between building and equipment steel. Certain columns should not be bonded to the CO GRD system.

4.04 When column steel consists of structural steel sections, such as normally used in steel frame buildings, and all section butt ends of the column on which the floor CO GRD buses are mounted are bridged with a welded steel plate or a cadwelded or brazed 750,000 CM copper bond, as described in Section 802-001-190, CO GRD Bus Bars, the column may be used as a CO GRD system vertical equalizer. The CO GRD buses must be bonded to the column steel with 750,000 CM copper wire, or with welded studs as illustrated in Fig. 5 of Section 802-001-190, or equivalently interconnected.

4.05 When structural steel of a column is not so bonded or when the column is of reinforced concrete construction, with reinforcing bars welded or wire wrapped, it cannot be used as a CO GRD vertical equalizer but it is considered effective in discharging lightning current. A surge of lightning current through such a path could raise the potential of the building frame work by thousands of volts relative to the potential of equipment bays unless the two systems were integrated. An equalizing bond shall be provided therefore between the steel of the column in closest proximity to floor CO GRD buses and each bus. The bond shall be the same as required when the column is used as a CO GRD vertical equalizer.

4.06 When columns are reinforced concrete and reinforcing bars are not welded or wire wrapped, it is assumed that continuity to earth does not exist and that the probable path for lightning current will not be through the column. The 750,000 CM CO GRD vertical equalizer will probably act as a principal path for lightning current and will take on a high potential which will be impressed on equipment bonded to the CO GRD buses. This potential, if impressed on reinforcing bars closely spaced but isolated by concrete, could cause an arc between bars resulting in structural damage. For this reason, column reinforcing bars not known to be electrically continuous to earth shall not be bonded to the CO GRD bus bars.

4.07 A vertical CO GRD equalizer may serve a horizontal CO GRD system which does not exceed 200 conductor feet from a CO GRD bus to the furthest equipment frame, as explained under "Design Parameters of Horizontal Equalizer System". When these parameters are exceeded, a second vertical CO GRD equalizer, with associated CO GRD buses and horizontal equalizers, is required. The quantity of BDFB's and/or crossbar equalizers ultimately connected to each should preferably, but not necessarily, be approximately equal. The vertical conductors shall preferably be located within 200 feet of each other, so that horizontal equalizers therefrom can serve a contiguous floor area. The vertical runs shall be bonded together at every third floor (ie, in building with basement, at third, sixth, ninth, etc, floors) with 750,000 CM conductor to provide equalization paths. The vertical equalizer of the second system shall be terminated at the office principal ground point except when the horizontal portion of the first vertical equalizer extends from the principal ground point in the direction of the second vertical equalizer location. In this case, the second vertical equalizer may be terminated at a CO GRD bus served by the first equalizer or tapped to the equalizer conductor on the floor containing the principal ground point if the resultant run length from the principal ground point to the vertical portion of the second equalizer is not greater than 120 percent of a direct run between the two points. Termination at a CO GRD bus shall be with a two-hole bolted tongue crimp connector. A cable to cable tap shall be made with a cadweld connection when first and second vertical equalizer conductors are joined to share a common 750,000 CM path to the principal ground point. Multiple vertical risers installed in a building shall be designated CO GRD NO. 1 and CO GRD NO. 2. The designation shall be stamped on CO GRD buses and on 145-C number tags tied to vertical equalizer termination at the principal ground point. When a single vertical equalizer serves a building, the numerical portion of the stamping shall be omitted.

4.08 Multistoried buildings separated by an alleyway or permanent building wall and having separate water meters require a separate vertical CO GRD equalizer in each building. The riser shall be designated CO GRD No. 1 and CO GRD No. 2 when AC or DC supplies of either building provide power to equipment in the other building. The equalizers shall terminate on the water pipe of the building each is in, and a bond shall be provided between the water pipe ground points of a size as indicated in Table 1 of Section 802-001-191.

4.09 The primary objective of bonding vertical CO GRD risers together at every third floor (4.07) is to limit the difference of potential between the bond points to no more than 1/2 volt during normal operation. Often, building complexes separated by permanent building walls or alleyways are the result of building growth for accommodation of expanded switching facilities. These facilities may obtain SC power from the plant or plants in the original building, in which case the discharge ground conductors serve as the primary return path to battery for ground current. When a second plant is provided in the new building, that plant or the original plant may be the originating source for currents transmitted via communication circuits to equipments ground connected to the opposite plant. These ground currents must be returned to the originating battery. Horizontal 750,000 CM bonds (every third floor) between the vertical CO GRD risers may serve as the conductive medium for nominal ground current return. Nominal (allowable peak) current that may be imposed on a bond of specific length that will not exceed the 1/2 volt drop limitation may be calculated as:

$$I_{nom} = (33784/L) \leq 475$$

Where: L = Length of horizontal bond in feet

And: 475 = Ampacity of 750,000 CM wire

And: 33784 = Ampere-foot resistance factor for limiting voltage drop of 750,000 CM wire to 1/2 volt

The amperes of current therefore that may be considered as nominal and may be exchanged through horizontal bonds between two vertical equalizers is limited to the cumulative total, derived from the formula for each bond. Normally, bonding at every third floor will provide sufficient conductivity, and calculation to determine the magnitude of current interchange is not required.

4.10 Generally, it is assumed that a moderate interchange of current will occur between vertical equalizers. When an installation is comprised of two buildings with a power plant of the same voltage in each it is possible that either of the following conditions may apply:

(a) Ground current interchange between the ground planes of the separate buildings may be negligible. This condition occurs when communication system intercabling between buildings contains very few circuits that obtain power from the DC plant in one building and connect to the discharge ground system of the second plant. It is often difficult and expensive to run horizontal bonds at different floor levels between the vertical equalizers in the two buildings. If it can be definitely ascertained that current interchange will be negligible, the horizontal bonds may be omitted. Paths through building steel, buried water systems and other metallic paths may be depended on to transmit small amounts of current back to the originating battery while maintaining effective equalization between the ground planes.

(b) Ground current interchange between the two buildings may exceed the capacity of the horizontal bonds. This occurs when communication systems intercabling between buildings consist in part of many circuits that obtain power from the DC plant in one building and connect to the discharge ground system of the second plant. In this case, horizontal bonds must be provided between vertical equalizers at every third floor and additional conductors must be provided, as described in following paragraphs 4.11 and 4.12.

4.11 When an existing multifloor building requires the addition of a vertical equalizer for condition (b), above, or for reduction of noise or other reason, it occasionally is impossible to find sufficient free space to run a 750,000 CM vertical equalizer up through the building, without incurring extraordinary costs. In a steel frame building, column steel may be used as a vertical equalizer, even though column section butt ends are not bridged with a welded bond as specified for new construction. Testing to ensure low resistivity in the column is not practical. Reliability of an unbonded column is considered to be significantly less than that of a bonded column or a 750,000 CM vertical equalizer. Such a column should not be used as a vertical equalizer unless the cost differential is great. When an ESS type installation is added in a building that utilizes an unbonded column, a No. 0 conductor shall be run from the Main Ground bus in the ground window to the principal ground point, in addition to the bond provided to the floor CO GRD bus.

4.12 Certain equipments, especially signaling systems utilizing E & M lead control, may introduce ground currents of such magnitude that an equalization between two ground systems of 1/2 volt cannot be maintained by bonds at every third floor. When such systems are installed so that the ground current is expelled into a ground system that does not provide discharge ground conductors back to the battery control board (BCB) ground bus of the current originating plant, suitable discharge ground conductors shall be provided. They shall be calculated for voltage drop on the basis of one-half of the specified allowable loop voltage drop between equalizing centers or BDFB and BCB, as listed in the circuit notes of the current originating plant SD drawing (ie, SD-80965-01). Refer to "Signaling Systems Ground Requirements" in Section 802-001-193.

4.13 It should be noted that the circuit system utilized by E & M signaling system and other older communication systems, wherein ground currents are dumped into the ground plane at a point remote from a fuse board or similar distribution facility that supplies power to the circuit, is recognized as undesirable. In modern systems, a loop closure arrangement that provides a ground conductor paired with the conductor(s) carrying battery current to a remote load or control point is a standard design requirement. Pairing of battery and ground conductors reduces transient noise and assures an adequate path for return of ground current to the originating battery.

5. BUILDING FACILITIES

5.01 The location of vertical equalizers should be determined by the Telephone Company. Installation of sleeves in floors and columns and other requirements indigenous to the building construction should be included in construction specifications. The vertical equalizer cable may be provided by the Telephone Company, and so may the CO GRD bus bars, or they can be installed as part of the installation of power and communication equipment. The vertical equalizers may be placed adjacent to columns or walls supporting the CO GRD buses, or they may be placed in nearby closets or accessible shafts. When sleeves are placed at columns, care should be exercised to offset them from the column so as to miss horizontal beams but not to interfere with clear equipment aisle space. When placed in closets or other enclosures, the arrangement shall be such that cable and connectors are available for inspection and maintenance, and provision for 2-inch sleeves through walls of enclosures for connections between vertical equalizers and CO GRD buses shall be made. Where more than one vertical equalizer system is required in a building and bonding is required between them, suitably located sleeves through intervening walls that will result in shortest practical run lengths shall be provided.

5.02 When it is intended that structural steel columns be used as vertical equalizers, instructions for bonding of the structural steel sections as described in preceding paragraphs shall be included in building specifications.

5.03 When bonding of floor CO GRD buses to building steel is required, as described in preceding paragraphs, the Telephone Company shall arrange for the addition of ground studs depicted in Fig. 4 of Section 802-001-190 or the addition of 750,000 CM conductors cadwelded or brazed to building steel before pouring of concrete, located suitably to extend to floor CO GRD buses.

6. CO GRD SYSTEM MATERIAL

6.01 Conductors of the CO GRD system shall be KS-5482-01 type RHW copper wire or equivalent commercial wire as specified in Section 802-001-190, Equipment Ground Wire. Connectors at water pipe shall be cadweld or clamp type pipe connectors. Connectors of the vertical equalizer system shall be cadweld, parallel cable connectors and two-hole crimp type bolted tongue connectors. Cadwelding may be employed in place of crimp or parallel connectors at the option of the customer, but is not a requirement. Connectors of the horizontal equalizer system shall be two-hole crimp type bolted tongue or parallel cable connectors, or, where 750,000 CM equalizers are located so that a 90 degree tap is advantageous, they may be cross tap connectors. Refer to Section 802-001-190 for application information. Termination of extensions from CO GRD buses or conductors for the purpose of equipment ground only may be made with one-hole crimp type bolted tongue connectors or with miscellaneous commercial type ground connectors as an alternative to two-hole crimp connectors, as outlined in Section 802-001-190.

7. METHOD OF SUPPORTING VERTICAL AND HORIZONTAL CO GRD EQUALIZER CONDUCTORS

7.01 Equalizer runs shall be run exposed so as to afford visual inspection of the entire system and access to connectors for maintenance purposes. Horizontal runs shall be supported along the exterior of cable rack stringers or from framing bars by means of clips or similar devices that do not form a closed metallic ring about the conductor. Short runs through walls shall be supported within 2-inch PVC plastic or other nonmetallic conduit as specified in Section 802-001-190, CO GRD System Raceway Applications.

7.02 Vertical equalizers shall be run between floors in 2-inch PVC plastic or other nonmetallic sleeves or openings that do not form a metallic ring about the conductor, as defined in Section 802-001-190. Vertical equalizers shall be supported from a wall or column in accordance with general Bell System requirements, except that the general requirement to provide a minimum of 20 feet of conductor supported on horizontal cable rack every third floor shall not be applied. The vertical conductor may be supported from a vertical run of wall or column supported Unistrut between floors, plus an auxiliary support every second floor consisting of either wedge plugs in the top of sleeves or cable support grips suspended from ceiling by means of "J" bolts in expansion shields.

7.03 The cable supports and sleeves provided for the routing of CO GRD conductors shall not be utilized for routing of any type of cable or wire other than ground wire.

7.04 Typical methods of supporting vertical and horizontal equalizers and suitable material for such supports are shown on ED-97729-( ).

8. EQUIPMENT GROUNDING IN METAL SHEATHED STRUCTURES

8.01 Metal sheathed buildings and prefabricated structures are increasingly being utilized to house communication facilities. Generally, the metal sheath can be utilized as part of the ground plane, simplifying the ground network required to provide equipment grounding to units therein. Types of metal sheathed structures are categorized as follows:

(a) EMP (electromagnetic pulse) shielded buildings

(b) Modular type prefabricated buildings

(c) Portable huts.

(d) Modular metallic platform assemblies

EMP Shielded Buildings

8.02 These buildings are shock hardened structures, often buried below grade level. They are completely enclosed in a metallic shield to protect the contents from exposure to electromagnetic energy produced by nuclear explosions. The magnetic shield is applied to either the outer or inner surface of the building walls, roof and floor and welded to form a continuous shield. The shield always provides sufficient low impedance coupling with the earth surrounding the structure that in itself it constitutes an earth electrode. Other earth electrodes, such as a water pipe or driven ground electrode, are not required. Earth potential reference may be obtained by direct connection of a ground bond to any point on the shield.

8.03 Certain structures employ metal decking to support poured concrete ceilings (ie, "Keystone" decking). The metal is exposed to the floor area below and may be utilized as a ground point, if expedient. Wall shielding is generally not exposed. A means of extending continuity from the shield to the building interior (ie, studs) and facility for terminating ground conductors (ie, bus bars) is required when it is desirable to terminate ground conductors on walls.

8.04 When grounding at wall shields is employed, it is recommended that a CO GRD bus be provided at an approximate center point on each wall surface (ie, four buses per floor). The buses shall be made electrically continuous to the shield by brazing or by use of welded studs similar to the method shown in Section 802-001-190, Fig. 5.

8.05 The shield eliminates any requirement for provision of a CO GRD vertical equalizer.

In general, the requirements for a CO GRD horizontal equalizer system is identical to that described for conventional buildings in Part 3. In the shielded building, however, four CO GRD buses and/or the decking will be available for ground connections. Any CO GRD horizontal equalizer or other equipment ground conductor may be run to the most convenient ground point without regard for provision of direct paths for current exchange between points on the various discharge ground conductors.

8.06 Every requirement for ground reference or for provision of ground current equalizing paths can be satisfied by connection to the nearest CO GRD bus. Electrical systems normally installed in EMP shielded buildings that may be grounded in this manner include:

(a) AC system (neutral)

(b) DC Power systems

(c) Crossbar equalizing centers

(d) Battery distribution fuse boards

(e) ESS type ground windows

(f) Microwave radio stations.

8.07 Microwave radio stations normally require an external driven ground ring system, an internal peripheral ground ring and supplementary buses run above and bonded to individual frames and other metallic objects in the station area (Section 802-001-197). When installed in an EMP shielded building, an external ring electrode is not required and internal peripheral ground rings may not be required. When wall CO GRD buses are used and the radio equipment occupies only a portion of a room, a No. 2 AWG peripheral bus shall be routed around the perimeter of the radio equipment area and connected to CO GRD bus bars to form a ring around the installation. A peripheral bus is not required when ceiling decking is used as the ground point. Supplementary buses must be connected at both ends: to the No. 2 peripheral bus or to ceiling decking.

Modular Type Prefabricated Buildings

8.08 Certain versions of switching systems (ie, No. 2A ESS and No. 5A Crossbar) are shop assembled and wired, and shipped to sites in modules of 12 x 48 feet size or less. Several modules are assembled on a concrete pad or foundation at the site to establish a Central Office. Small radio repeater stations are assemblied in metal huts for location on concrete pads.

No. 2A ESS System Modular Building

8.09 The No. 2A ESS system is packaged in prefabricated enclosures of 12 × 48 feet, primarily. Several modules are composed on a common foundation to form a building. The modules are bonded together with steel plates at foundation and roof levels. The module frames and panels are metal, joined in a manner that ensures excellent ground continuity througout the building. A driven ground system is used around the foundation to establish a ground electrode (Section 802-001-191). Each module frame is connected to the buried conductor of the driven ground system at two points, one at or near each end of a module. The connecting wire is No. 2 AWG solid tinned copper wire of the same type as that used for the driven ground system. This arrangement establishes the entire frame at a potential of no significant difference from the electrode. A principal ground point is provided in one module by welding a ground bar to the frame. The detail is drilled to accept terminal lugs. The principal ground point is provided for convenience only. Any point on the frame can serve as a ground point.

8.10 The No. 2A ESS frames are isolated from any contact with the module frame or conductive objects having continuity with the frame except for a bond provided through a ground window, as practiced in No. 1 ESS and other electronic systems (see Section 802-001-195).

8.11 Equipment frames that are members of isolated ESS ground plane are bonded together with No. 6 AWG wire having continuity to the Main Ground bus in the ground window. An equalizer network is provided between terminations of DC power plant discharge ground conductors at PD frames. Power plant bays and battery stands are bonded to the principal ground point. The ground window bus also is bonded, with a No. 0 AWG wire, to the principal ground point. The distributing frame is bonded to the module frame. With the exception of conductors between modules, all wiring is provided and connected during factory assembly.

Portable Huts

8.12 Small radio repeater stations are shop assembled and wired in metal huts, and shipped to sites as a complete unit. The huts are mounted on concrete pads. The hut constitutes a metal structure with excellent ground continuity throughout. Normally, the hut is equipped with a "J" rail that runs on the interior wall near the ceiling. Equipment is grounded by connection to the "J" rail.

8.13 A driven ground system (Section 802-001-191) is required around the pad to establish an earth electrode. Generally, two ground studs are provided on opposite ends of the metal hut. These studs shall be connected to the driven ground system, using wire of the same type and size as that used in the driven ground system, to ground the hut.

Modular Metallic Platform Assemblies

8.14 The No. 5A Crossbar modular system consists of groups of communication and power equipment frames assembled for shipment on several structural steel platforms. A steel grid mounted atop the frames supports cable, lighting fixtures and other equipment. The platforms are inserted into a pre-constructed building, which may provide space for communications equipment in addition to the platform mounted frames. Generally, a water pipe or driven ground electrode is used to establish the principal ground point. This type of installation shall generally be grounded in accordance with normal requirements except that the platforms shall be bonded together, and to the principal ground point. The platform may be considered as a grounding medium for frames bolted thereto and measures to provide equipment grounding (CO GRD) to frames are unnecessary.

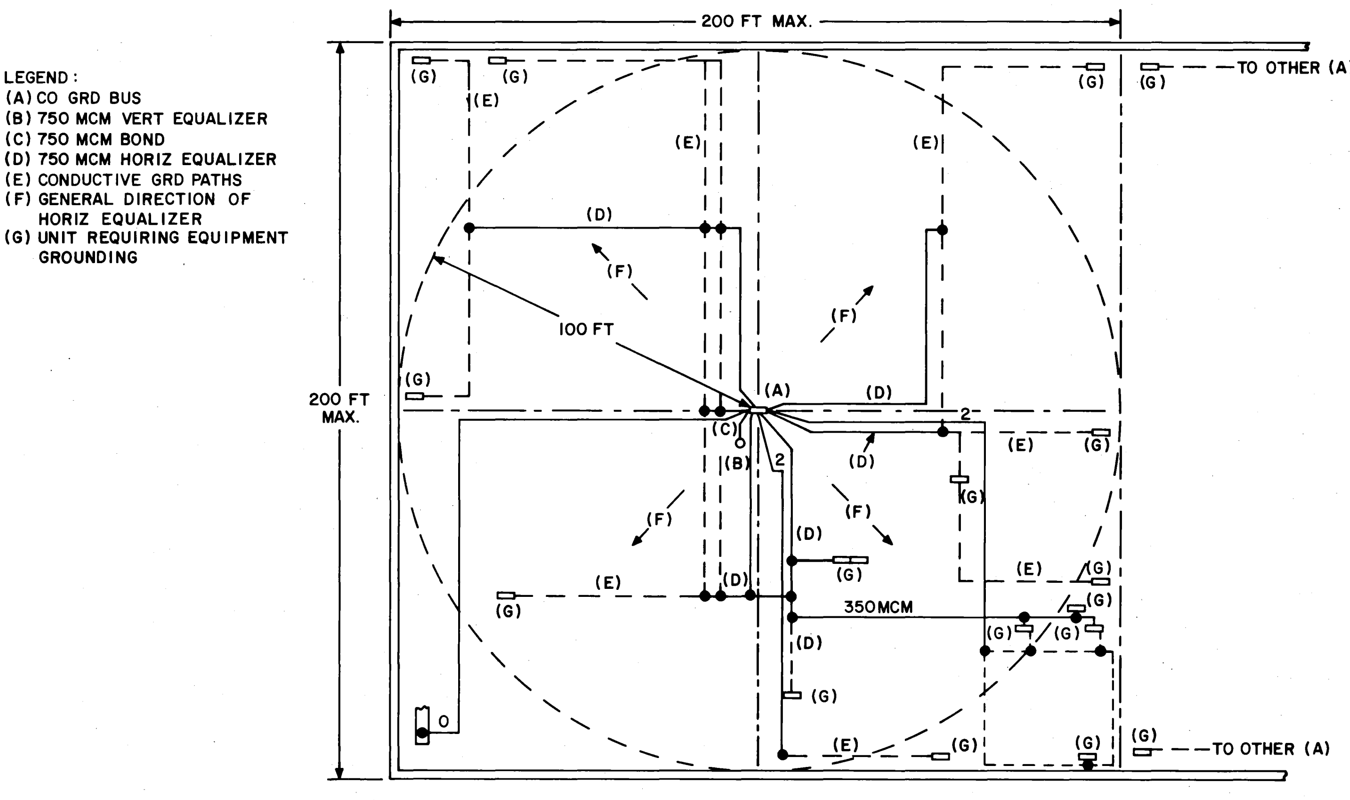
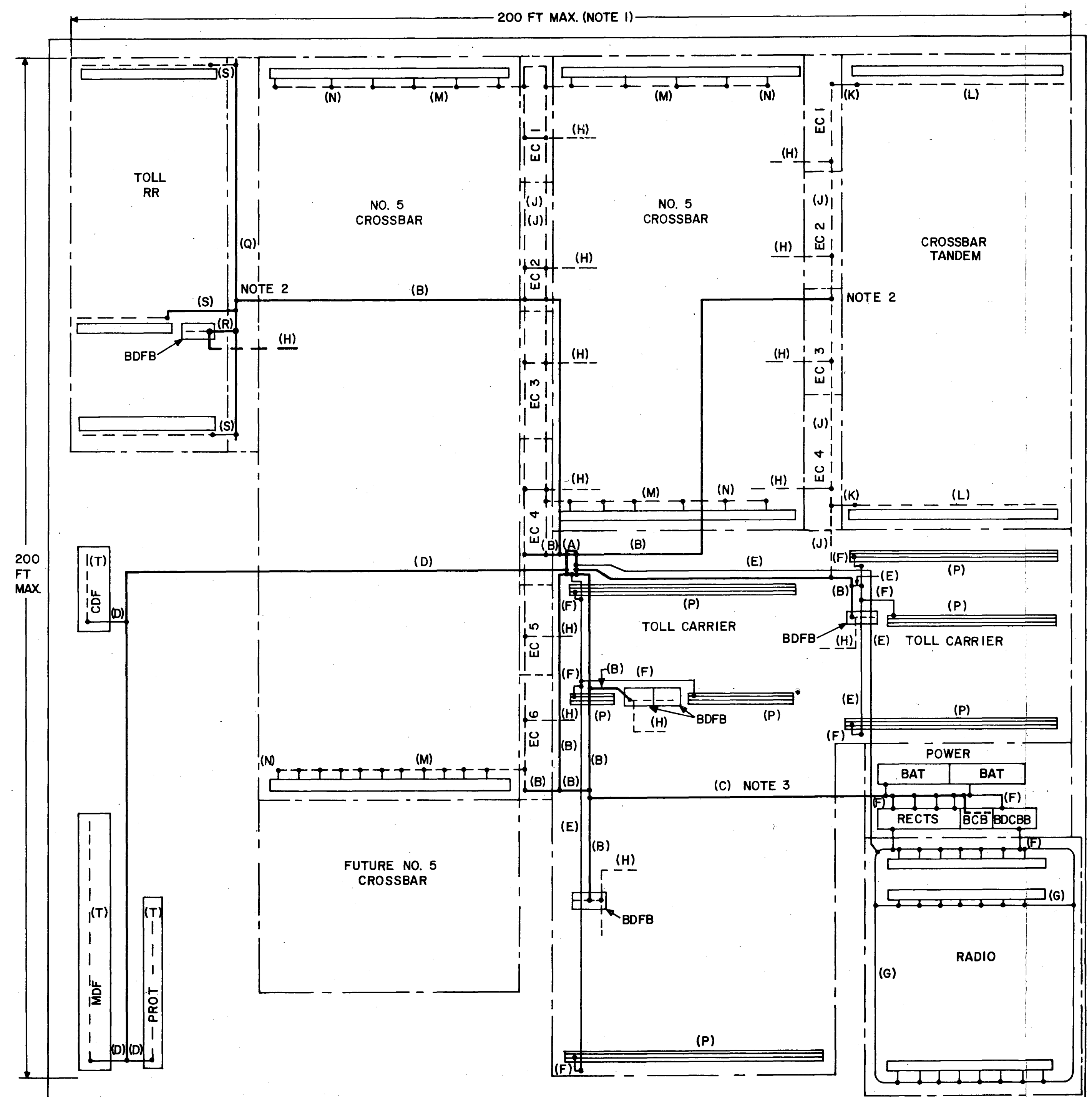


Fig. 1—Representation of Maximum Area To Be Served by a Single CO GRD Bus (See Fig. 2)



LEGEND:
(A) FLOOR CO GRD BUS
(B) 750 MCM CO GRD EQUALIZER
(C) 350 MCM CO GRD EQUALIZER
(D) #0 CO GRD EQUALIZER
(E) #2 CO GRD EQUALIZER
(F) #6 FRWK GRD BOND
(G) #2 RADIO RING GRD
(H) DISCH GRD CONDUCTOR
(J) 750 MCM CSBR GRD EQLR
(K) #00 GRD BAR BOND
(L) CSBR FRAME E/W GRD BAR
(M) #00 OR 2-00 DISCH GRD
(N) DISCH GRD DROP FEEDER
(P) DUCT BAY E/W 1" PIPE
(Q) 750 MCM COMB DISCH/FRWK GRD MAIN AIS EQUALIZER
(R) 750 MCM BDFB GRD BOND
(S) 350 MCM RR GRD BOND
(T) DIST OR PROT FR GRD BUS

NOTES:

1. MAX RUN LENGTH TO FURTHEST POINT OF GRD CONDUCTANCE SHALL NOT EXCEED 200 FT FROM CO GRD BAR. AREA SERVED BY A CO GRD BUS SHALL NOT EXCEED THAT BOUNDED BY A SQUARE SUPERIMPOSED ON THE PERIMETER OF A 200 FT DIAMETER CIRCLE CIRCUMSCRIBED ABOUT THE CO GRD BUS LOCATION. THE VERTICAL RISER AND HORIZONTAL EQUALIZERS SHALL BE RUN AS DIRECT AS POSSIBLE. SEE FIG. 1.
2. HORIZONTAL EQUALIZER CONNECTION TO CSBR AND RR MAIN AISLE EQUALIZER CONDUCTORS SHALL OCCUR WITHIN 50 FT OF EACH END OF SUCH CONDUCTORS.
3. HORIZONTAL EQUALIZERS OTHER THAN THAT USED FOR GROUNDING OF RADIO RING OR PROTECTORS MAY BE USED AS MULTI-PURPOSE CO GRD CONDUCTORS (IE, EQUALIZER FOR TOLL RR MAY BE TAPPED TO EXTEND CO GRD TO FRWKS OR CABINETS, OR DISTRIBUTING FRAMES IN VICINITY). WHEN SO USED, EQUALIZERS OTHER THAN 750 MCM SHOULD BE INCREASED TO EQUATE CONDUCTANCE OF NORMAL CONDUCTOR SIZES FOR BOTH APPLICATIONS (IE, NORMAL #0 REQD FOR BCB GRD INCREASED TO 350 MCM WHEN ALSO USED FOR POWER EQPT FRWK GRD).

Fig. 2—Typical CO GRD Horizontal Equalizer System—Equipment Floor

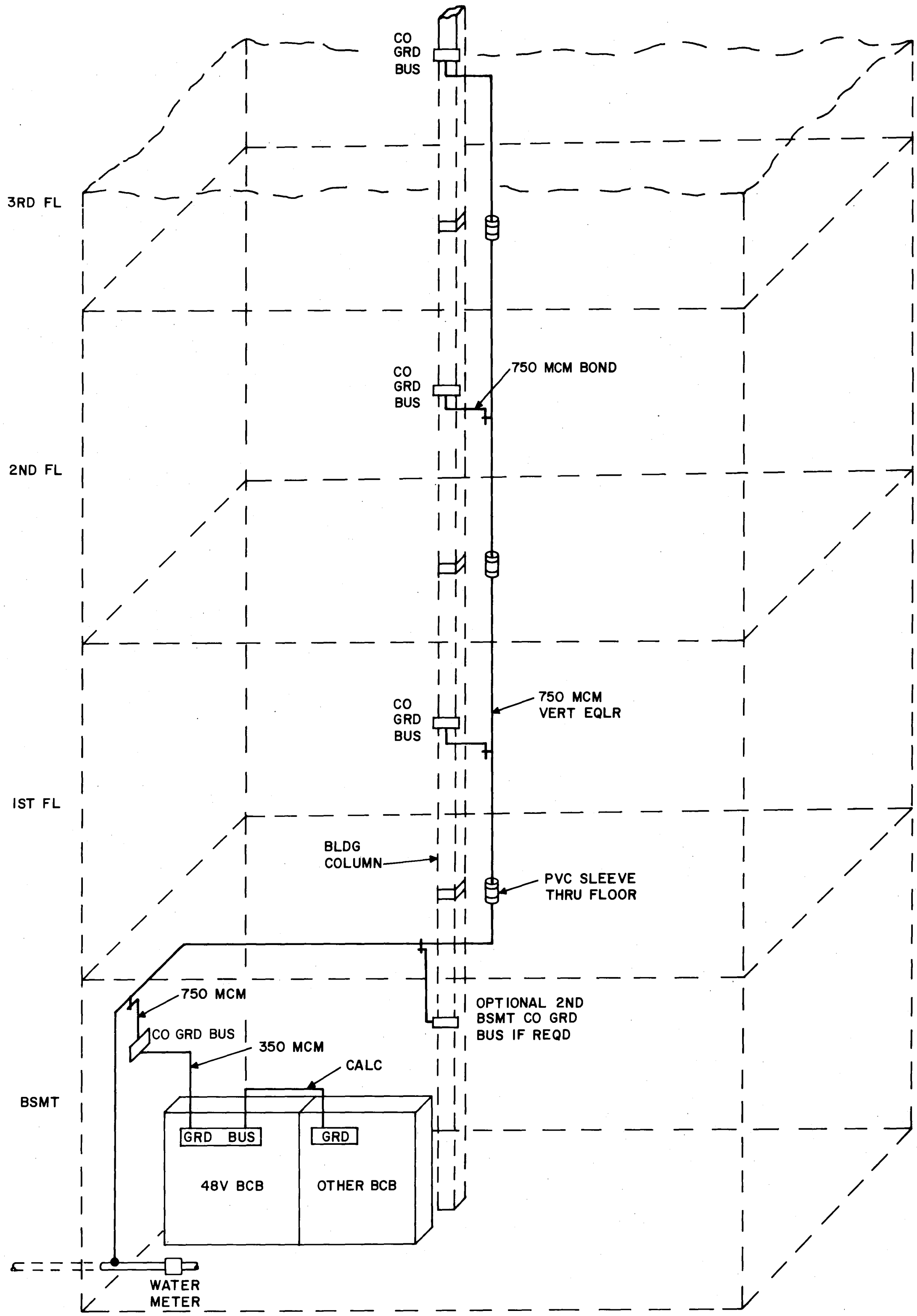


Fig. 3—Typical Routing of Vertical Equalizer and Placement of CO GRD Buses in a Multifloor Building With Basement

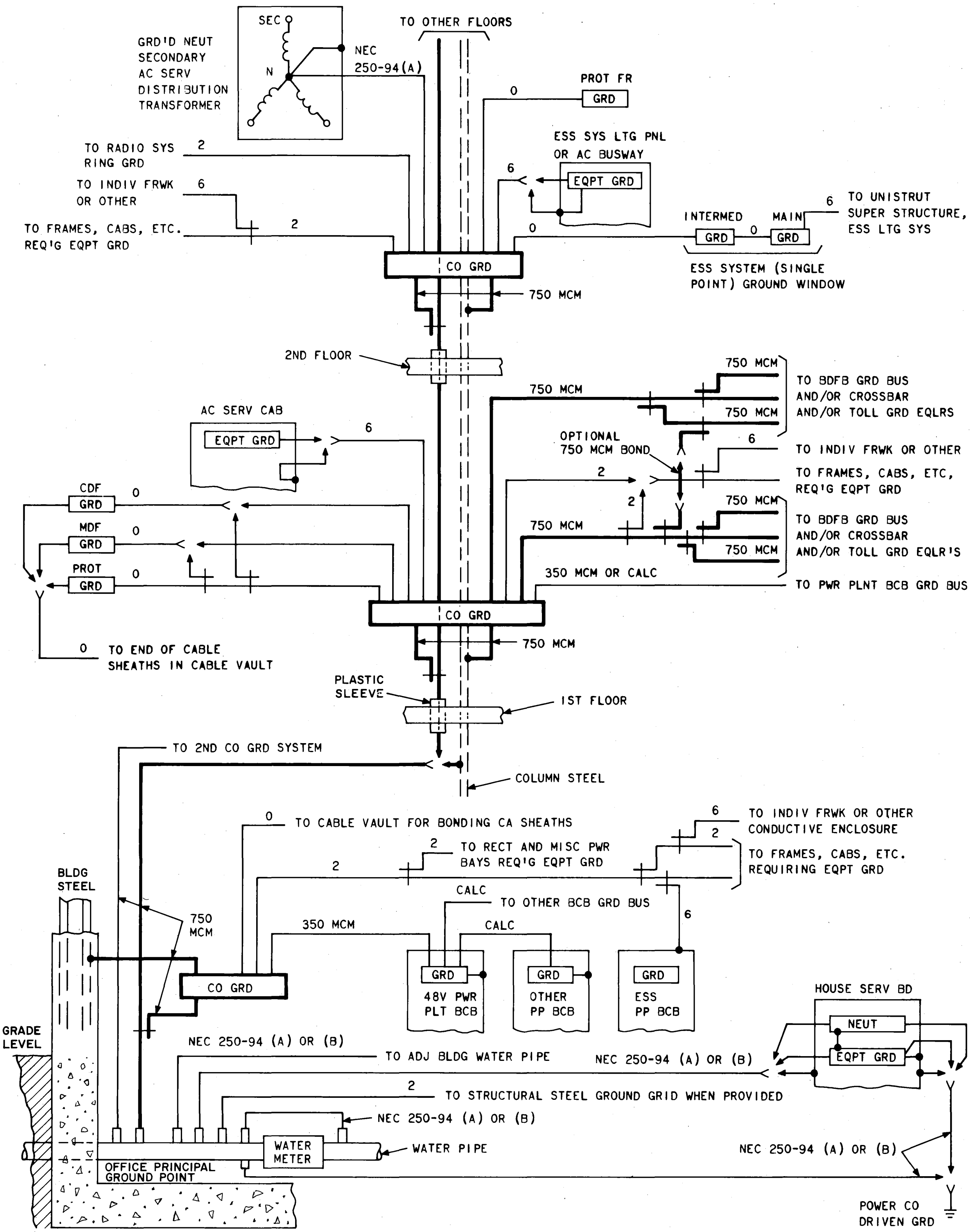


Fig. 4—Typical Equipment Connected to CO GRD System