ELECTRICAL PROTECTION — STATIONS AND CUSTOMER PREMISES EQUIPMENT

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1. GENERAL

1.01 This section describes the requirements for protection of telephone stations at customer premises. The purpose of station protection is to ensure the safety of telephone users and telephone employees. Station protection also reduces the possibility of damage to the customer premises and to the telephone plant. In certain cases, the use of protective devices such as gas tubes will help considerably in maintaining reliability of telephone service.

1.02 This revision includes the addition of bonding and grounding recommendations for use in high-rise and low wide-area commercial and industrial buildings, and the protection of electronic station equipment. Due to the extensive changes in this reissue, no revision arrows have been used to denote significant changes. The changes included in Addendum 876-300-100, Issue 1, have been incorporated in this revision. Revisions are made to mobile home and recreational vehicle requirements, to Bell System power exposure requirements, and to the classification of plant exposed to lightning in metropolitan areas. Minor revisions are made to agree with the 1978 ***National Electrical Code (NEC)*** requirements.

1.03 An essential part of any protective system is the adherence to good construction and maintenance practices. The possibility of an accident or of structural damage resulting from contact with electric wires or from exposure to lightning can be significantly reduced where standard clearances are observed and protectors are properly installed and maintained. A range exists within which protective devices operate. In some cases the level of protection afforded may not adequately protect personnel and equipment. Supplementary protection will then be necessary. Various methods, such as the following, are used to accomplish this required coordination:

(a) Telephone instruments and wiring are insulated with materials capable of withstanding dielectric stresses to which they are exposed (including a certain safety margin).

(b) When equipment components are sensitive to voltages and currents less than the minimum operating thresholds of the normal station protectors, supplementary protection is supplied or is specified.

1.04 In determining the protection requirements for a particular design of telephone plant, the exposure status with regard to power and low-frequency induction, ground potential rise and lightning must be considered. Lightning and power exposure status is related to the environment of the telephone plant, eg, whether the environment is metropolitan, suburban, or rural, as defined in Section 876-100-100, Appendix I. For example, aerial cable in metropolitan and in some suburban areas will generally be exposed to accidental contact with power wires, but may be minimally exposed to lightning because of the shielding afforded by overhead power wires and tall structures. In rural areas, however, aerial cable will most likely be exposed to both power and lightning. In rural areas and in some suburban areas, buried cable will usually be exposed to lightning, and all stations served by the cable will require protection even though there may be no exposure to power wires. Requirements for station protection are sometimes based on administrative considerations and on possible future rearrangements of outside plant construction, particularly with regard to changes in power distribution voltages that might affect the exposure status of telephone plant.

1.05 In general, block and house cable facilities are not exposed to power circuits carrying voltage high enough to require station protection. If exposure to lightning is a factor, however, station protection may be necessary. For example, telephone facilities serving extension stations or speaker locations of a farm interphone system may not be subject to contact with power wires, but could be exposed to lightning. Such stations would require protection.

1.06 In the following discussion, the term "fuse cable" generally refers to 26- or 24-gauge copper conductors. The term "fine gauge" is also used with the same meaning. If the plant consists of aluminum conductors, then 24- or 22-gauge would be considered as "fuse cable" or "fine gauge," respectively. These sizes of aluminum conductors have fusing characteristics comparable to 26- and 24-gauge copper conductors, respectively.

2. STATIONS REQUIRING PROTECTION

A. *National Electrical Code (NEC)* Requirement

2.01 The requirement for protecting communication circuits is defined in Article 800-2 of the 1978 *NEC** as follows:

> ***Protective Devices:*** "A protector approved for the purpose shall be provided on each circuit run partly or entirely in aerial wire or aerial cable not confined within a block. Also, a protector approved for the purpose shall be provided on each circuit, aerial or underground, so located within the block containing the building served as to be exposed to accidental contact with light and power conductors operating at over 300 volts [rms] to ground. The word 'block' as used in this article means a square or portion of a city, town, or village enclosed by streets and including the alleys so enclosed but not any street. The word 'exposed' as used in this article means that the circuit is in such a position that in case of failure of supports or insulation, contact with another circuit may result.
>
> ***Location:*** The protector shall be located in, on, or immediately adjacent to the structure or building served and as close as practicable to the point at which the exposed conductors enter or attach."

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2.02 The *NEC* requirements are primarily based on power exposure and only incidently on lightning exposure. Bell System requirements, however, must consider all sources of electrical disturbances or exposure, including lightning, power induction, and ground potential rise, and must assure that adequate protection is provided.

B. Bell System Requirements

2.03 Telephone circuits (cable, wire, strand, etc) that are subject to disturbances from ***lightning, ground potential rises (GPR),*** or possible ***contact*** or ***induction*** from electrical power circuits in excess of 300 volts [rms] to ground are called ***exposed circuits.*** A station served by such exposed circuits including an exposed line, drop, or terminal is therefore an ***exposed station*** requiring protection.

> ***Note: All references to electric power wires will apply to circuits operating in excess of 300 volts rms to ground.***

2.04 Protection against lightning surges is obtained by using spark gap station protectors. Protection against power exposure is obtained by using fusible links between the station and the exposure in addition to spark gaps. Additional protection of station equipment with low impedance paths to ground is obtained by using sneak current fuses. These protection applications are discussed subsequently in this practice.

2.05 Many grounding and fusing applications depend on the presence or absence of a multi-grounded-neutral power system. It is the responsibility of the protection engineer to obtain the locations of MGN and non-MGN power systems in his area. This information should be dispensed to all personnel involved in the design, construction, and repair of outside plant facilities, and those responsible for installation and maintenance of customer premises equipment. One method for identifying MGN and non-MGN areas would be to obtain maps from the local power utilities which indicate these areas. These maps could be updated periodically to reflect any changes in the MGN status of the power system.

3. CLASSIFICATION OF PLANT AND AREAS

A. General

3.01 From an administrative standpoint, it is not practical to consider each line or circuit individually to determine whether or not it is exposed to lightning, accidental contact with power wires, or hazardous induction. The usual practice, therefore, is to establish areas in which all stations are considered as exposed and requiring protection, or as unexposed and not requiring protection.

With the exception of a building or a group of buildings having a feeder cable used exclusively to serve stations within the buildings, the entire area of a block should be classified as either exposed or unexposed.

3.02 Station protection including protectors, fusible links (cable fuse), and station fuses as applicable, should be provided initially in areas that appear to be unexposed if the possibility exists that future plant rearrangements could result in exposure. In addition, sneak current protection (heat coils or sneak fuses) may also be required initially in plant serving station equipment having low impedance paths to ground, if future plant rearrangements could result in exposure to power.

3.03 In determining the exposure status of telephone plant, consideration should be given to the possibility of future changes and/or additions to the power distribution system. In some cases, it may be advisable to provide station protection initially as discussed in paragraph 3.02.

B. Plant Exposed to Power

3.04 All aerial plant (cable shield, supporting strand, or wire plant including distribution wire) is generally considered exposed, whether power is present or not, since there is no assurance that power will not be built at some later date. The only exception is when the aerial plant is located within a block.

3.05 Underground or buried plant subject to possible power faults resulting in a rise in ground potential or 60-Hz induction exceeding 300 volts (rms) must be considered as exposed. Buried and underground plant must be considered as exposed if connected to exposed aerial plant. Buried plant must be considered as exposed when placed at random separation with primary power distribution circuits (over 300 volts rms to ground).

C. Plant Exposed to Lightning

3.06 In general, it must be assumed that all telephone stations served by aerial plant are exposed to lightning, with the exception of stations in metropolitan areas where buildings are close together and sufficiently high (relative to the telephone plant) to provide "cone-of-protection" shielding. Two cones overlapping the telephone cable, one from each side, are preferable. (The cone-of-protection principle is explained in Section 876-210-100.) In such situations, lightning strokes are generally diverted from the telephone plant, and surge current is harmlessly dispersed over public water systems and/or other extensive buried metallic structures.

3.07 ***Underground or buried plant*** must be considered as exposed to lightning ***except:***

(a) Plant located in a metropolitan area under the conditions discussed in paragraph 3.06.

(b) Plant located in an area where the soil resistivity is approximately 100 meter-ohms or less and the incidence of thunderstorm days does not exceed an average of five per year. However, plant and stations located above the average altitude of the surrounding terrain or associated with structures such as fire towers, radio stations, etc, must be considered as exposed to lightning regardless of soil resistivity and thunderstorm incidence.

(c) Plant located where significant data is available to indicate that lightning damage is negligible.

D. Plant Serving Customer Premises Electronic Equipment

3.08 In view of the susceptibility to damage due to foreign voltages or transients in electronic station equipment, proper bonding and grounding must always be employed. If there is any question as to exposure of the cable plant or power circuits serving the equipment, then protection, should be applied to the facilities. If the building containing the electronic station equipment is exposed to lightning then the grounding requirements discussed in Part 9 should be employed. From an administrative standpoint, it may be advisable to require protection, bonding, and grounding, as described in this practice, in all installations serving electronic station equipment.

E. Unexposed Plant

3.09 Plant is considered ***unexposed*** when neither subject to possible contact with power wires operating in excess of 300V (rms) to ground, nor exposed to the effects of lightning, nor rise in ground potential, nor low frequency induction. Underground or buried cable is not considered exposed to power contact when placed in the same trench with primary distribution circuits, if standard separations (not random separation) are maintained, and the underground or buried plant is not fed by exposed plant (see paragraphs 3.10 to 3.13).

> ***WARNING: When telephone plant is considered unexposed in an urban environment because it is underground or buried all the way back to the central office, and cone-of-protection shielding is adequate, caution is advised if the associated power facilities are aerial without cone-of-protection shielding. Under such conditions, ac-powered telephone equipment may be damaged by lightning surges on the power facilities serving the telephone equipment. Even though the telephone plant is considered unexposed in this particular case, protectors should still be used, thus providing a method of common bonding and grounding (see paragraph 7.06).***

F. Exposed Cable Shield and Pairs

3.10 In reviewing a particular cable to determine its exposure status or the requirement for protection, it will be helpful to consider the cable in terms of ***exposed cable shield*** and ***exposed pairs.***

> ***Note:*** Protection applications must consider all sources of exposure; not only power contact but ground potential rise, power induction and lightning. Protection against lightning surges is obtained by using spark gap station protectors. Protection against power exposure is obtained by using fusible links between the station and the exposure in addition to spark gaps.

Exposed Cable Shield

3.11 Exposed cable shield is defined as any cable shield that has a possibility of coming in physical contact with power. The standard practice is to place fuse (fine gauge) cable at the aerial-underground junction (Fig. 1) to divide aerial cable shield exposed to power from unexposed underground cable. With fuse cable in all aerial branches, the requirements for fusing are satisfied; however this does not eliminate the need for carbon blocks and sneak current protection (heat coils or sneak fuses). If fuse cable is omitted at an aerial-underground junction the entire underground cable must be considered as ***exposed.***

3.12 The purpose of fuse cable is to prevent the overheating of protectors and terminating cable in the central office and at the station (resulting from power contact, induction, or ground potential rise of sufficiently high value and duration to operate the protectors), thereby eliminating a possible fire hazard. A fuse cable will usually fuse open before the time-current rating of coarser gauge underground cable pairs is exceeded, and it permits maintaining complements of exposed and unexposed pairs in the same cable (Fig. 2). Fuse cable cannot be depended upon to prevent damage. ***Fuse cable does not protect a connecting cable from lightning exposure because the operating (time-current) characteristics of fuse cable or a fuse link of any type are such that lightning surges will usually pass through the fuse without operating it.*** Section 876-101-100 should be used for comparisons of the time-current characteristics of cable, wire, station fuses, and operated protectors. The graphical data presented in that section shows that cable and wire pairs ordinarily used will fuse open ***before*** the time-current limit of an operated protector is exceeded, thereby eliminating a possible fire hazard at the customer premises as well as at the office main frame. Accordingly, the location of fusible links and the placement of station protectors must be such that, if a pair is fused open, any hazardous potential remaining on the energized section of the telephone circuit will not endanger the customer or customer premises.

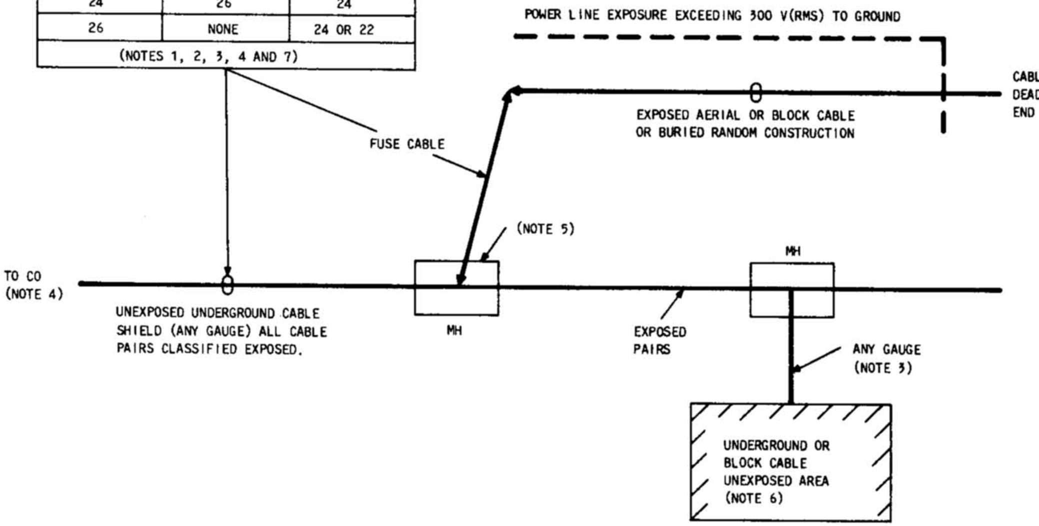
Exposed Cable Pairs

3.13 All pairs in aerial or block cable exposed to power or lightning are classified as exposed, regardless of whether or not they appear at terminals. These exposed pairs must be protected, however, only when they are in use (for example, in a ready-access terminal). Pairs in underground (unexposed) cable that connect to pairs in exposed cable are considered exposed (Fig. 1 and 2). Protection of the junction of aerial cable exposed to lightning with unexposed underground cable is discussed in Section 876-400-100.

G. Examples of Exposed Pairs

3.14 The following examples of cable pair exposures are typical of situations frequently encountered

GAUGE OF UG CABLE IS	GAUGE OF FUSE CABLE	GAUGE OF TIP CABLE MUST BE
19 OR 22	24	22
19 OR 22	26	24 OR 22
24	NONE	22
24	26	24
26	NONE	24 OR 22
(NOTES 1, 2, 3, 4 AND 7)		



NOTES:

1. THE FUSE CABLE IN THIS CASE MAY SERVE 3 PURPOSES:
   (1) PROVIDES THE REQUIRED FUSE LINK FOR THE MAIN FRAME TERMINATING (TIP) CABLE.
   (2) ISOLATES EXPOSED AERIAL COMPLEMENT FROM UNEXPOSED UNDERGROUND COMPLEMENT.
   (3) PROVIDES REQUIRED FUSE LINK BETWEEN THE POWER EXPOSURE AND STATIONS SERVED FROM UNDERGROUND COMPLEMENT WHICH ARE MULTIPLED WITH EXPOSED PAIRS.
2. WHEN A CABLE CONTAINING BOTH VOICE PAIRS AND VIDEO PAIRS OR COAXIALS IS EXTENDED AERIALLY, ONLY THE VOICE PAIRS MUST HAVE FUSE CABLE. FOR THE PRESENT, THIS REQUIREMENT CAN BE MET BY USING SEPARATE CABLES IN THE LATERAL TO THE POLE OR STUBS IN THE MANHOLE.
3. IN ADDITION TO THE FUSE CABLE LOCATED AT AERIAL-UNDERGROUND CABLE JUNCTIONS, BUILDING OR BLOCK CABLE MAY ALSO REQUIRE A SPECIFIC COMBINATION OF CONDUCTOR GAUGES TO ELIMINATE A POSSIBLE FIRE HAZARD WHERE READY-ACCESS TERMINALS ARE USED (SEE SECTION 638-205-015).
4. ALL PAIRS REQUIRE PROTECTION AT THE CO. THE GAUGE OF THE CO TIP CABLE MUST BE AT LEAST TWO GAUGE SIZES LARGER THAN ANY FINE-GAUGE CONDUCTORS USED AS FUSE CABLE.
5. FOR LIGHTNING PROTECTION CONSIDERATION REFER TO SECTION 876-400-100.
6. STATION PROTECTION IS REQUIRED BECAUSE PAIRS ARE MULTIPLED WITH EXPOSED CABLE CONDUCTORS.
7. FUSE CABLE DOES NOT PROVIDE LIGHTNING PROTECTION.

Fig. 1—Underground Cable Containing Only Exposed Pairs

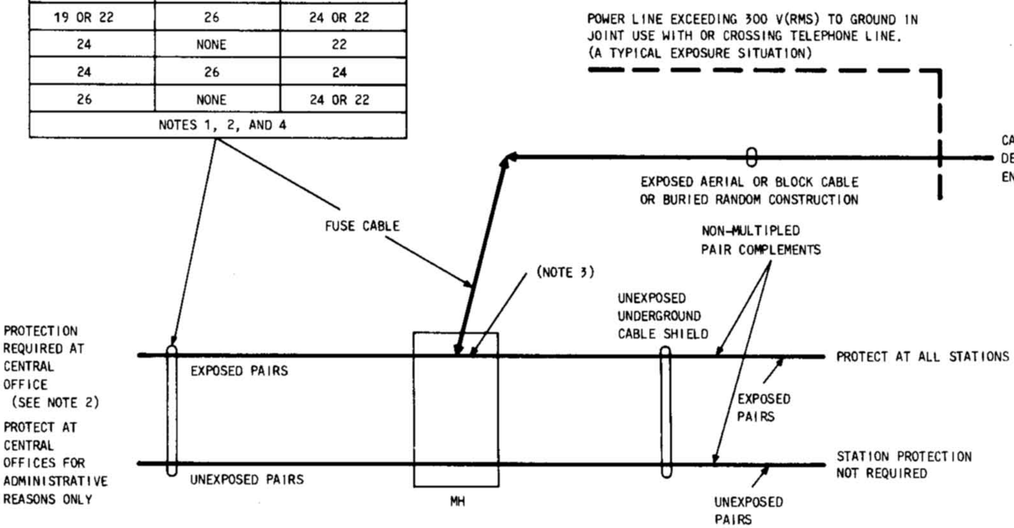
in the field or in the design of subscriber plant. The examples may be used as a guide in determining the exposure status of cable pairs or the requirements for station protection.

(a) Where underground cables contain both exposed and unexposed pairs (Fig. 2), two approaches are available for determining protection requirements.

(1) If most of the cable pairs are exposed, all pairs should be classified as exposed. Protection at the station and at the central office will then be required on all pairs, and either 26- or 24-gauge conductors will be used to coordinate with fuseless station protectors and the central office tip cable (Fig. 1).

(2) If both an exposed and an unexposed status are maintained for cable pairs, the

GAUGE OF UG CABLE IS	GAUGE OF FUSE CABLE	GAUGE OF TIP CABLE MUST BE
19 OR 22	24	22
19 OR 22	26	24 OR 22
24	NONE	22
24	26	24
26	NONE	24 OR 22
NOTES 1, 2, AND 4		



NOTES:

1. THE FUSE CABLE IN THIS CASE MAY SERVE 3 PURPOSES:
   (1) PROVIDES THE REQUIRED FUSE LINK FOR THE MAIN FRAME TERMINATING (TIP) CABLE.
   (2) ISOLATES EXPOSED AERIAL COMPLEMENT FROM UNEXPOSED UNDERGROUND COMPLEMENT.
   (3) PROVIDES REQUIRED FUSE LINK BETWEEN THE POWER EXPOSURE AND STATIONS SERVED FROM UNDERGROUND COMPLEMENT WHICH ARE MULTIPLED WITH EXPOSED PAIRS.
2. THE GAUGE OF THE CO TIP OR TERMINATING CABLE MUST BE AT LEAST TWO GAUGE SIZES LARGER THAN ANY FINE-GAUGE CONDUCTORS USED AS FUSE CABLE.
3. FOR LIGHTNING PROTECTION CONSIDERATION REFER TO SECTION 876-400-100.
4. FUSE CABLE DOES NOT PROVIDE LIGHTNING PROTECTION.

Fig. 2—Underground Cable Containing Exposed and Unexposed Pairs

fuse cable at the aerial-underground junction must conform to the requirements specified in Fig. 2. When these requirements are met, the status of the unexposed pairs remains unchanged and station protection will not be required on these pairs. However, central office protection should be placed on all pairs in the cable for administrative reasons, eg, to eliminate the need for maintaining precise records of the exposure status of each pair. The combination of conductor gauges prescribed in Fig. 2 provides the best protection for exposed and unexposed pairs that can be obtained with cables now available. These requirements should be applied in all new work and, where practical, to rearrangements and changes in existing plant. Twenty-eight gauge conductors would provide better protection for 26-gauge underground facilities than would 26-gauge fuse cable; however, the use of 28-gauge conductors is not feasible at present.

(b) Where an underground primary power circuit is brought to a distribution transformer mounted on a pole in an unexposed block area, the exposure status of the area is not changed, providing that the following conditions are met:

(1) The primary power wires are arranged so that contact with telephone plant is unlikely.

(2) The primary power wires are not extended aerially from the transformer.

(c) Unexposed cable pairs terminating in unexposed areas become indirectly exposed by extending (multipling) these same pairs into an exposed area, even though fuse cable is used at the aerial-underground junction, as shown in Fig. 3.

(d) The multipling of unexposed (underground) cable pairs with exposed (aerial) cable pairs through cross-connecting facilities at the junction of underground and exposed aerial cable should be avoided. Administrative measures should prohibit the bridging of underground cable pairs that feed exposed stations with pairs serving unexposed stations; these measures should also ensure prompt removal of bridle wires on nonworking circuits at the cross connection terminal.

(e) Where both exposed and unexposed pairs appear at a terminal in an unexposed area, an indirect exposure is created. ***All pairs*** appearing in such terminals are regarded as exposed and require station protection as indicated in Area B of Fig. 4. (The otherwise unexposed pairs require protection for administrative reasons only.) With this arrangement, adequate protection is ensured for all stations without establishing complicated rules to avoid the transfer of an unprotected station to an exposed cable pair.

(f) The unexposed pairs referred to in (e) are shown in Area A of Fig. 4. These pairs do not require protection.

(g) The use of a common shield for both exposed and unexposed pairs at non-electronic station equipment should, if possible, be avoided since all pairs must be considered as exposed and will require protection as indicated in Fig. 5. Where the exposed and unexposed pairs are in separate cables, only the exposed pairs need to be protected. This protection should be arranged so that it cannot be bypassed or eliminated if cross-connections are run between exposed and unexposed pairs.

(h) When customer premises electronic equipment (electronic station equipment) serves any mix of exposed and unexposed pairs (whether or not in same shield) protection should be applied on all pairs. All talking and signaling pairs (station lines, console cables, data lines, etc) associated with customer premises electronic equipment (electronic station equipment) that leaves the building in exposed plant must be protected at both ends. This protection should include fuse links, carbon blocks, and sneak fuses as applicable.

H. Exposed Drops from Unexposed Cable

3.15 When drop wire is run from an unexposed terminal into an exposed area (Fig. 6), the cable pairs need not be considered as exposed if (a) a protector is installed at the distribution terminal, and (b) if the cable shield is effectively grounded.

3.16 With the protection arrangement shown in Fig. 6, all pairs in the cable (including those serving the exposed drop wire) can be classified as unexposed. ***The effectiveness of the protection depends on having the cable shield electrically continuous to ground.*** Before protection is installed, a check should be made for insulating joints and cross-connecting terminals to ensure that there are no shield interruptions. If insulating joints are required for corrosion reasons, they must be bridged with a KS-14595, List 1 or 2 capacitor, or equivalent, to provide a path to ground.

3.17 Where exposed off-premises extensions are served from unexposed cable, protection as shown in Fig. 6 should be installed at the location where the exposed drop enters the building. The protector ground wire should be connected to a water pipe or to a grounding electrode of the power service. If these grounds are unavailable near the protector location, the house cable shield may be used as a ground, provided that the shield can be connected to a water pipe or power ground electrode within the building. [For protection of off premises extensions served by electronic station equipment, refer to paragraph 3.14(h) and Fig. 15.]

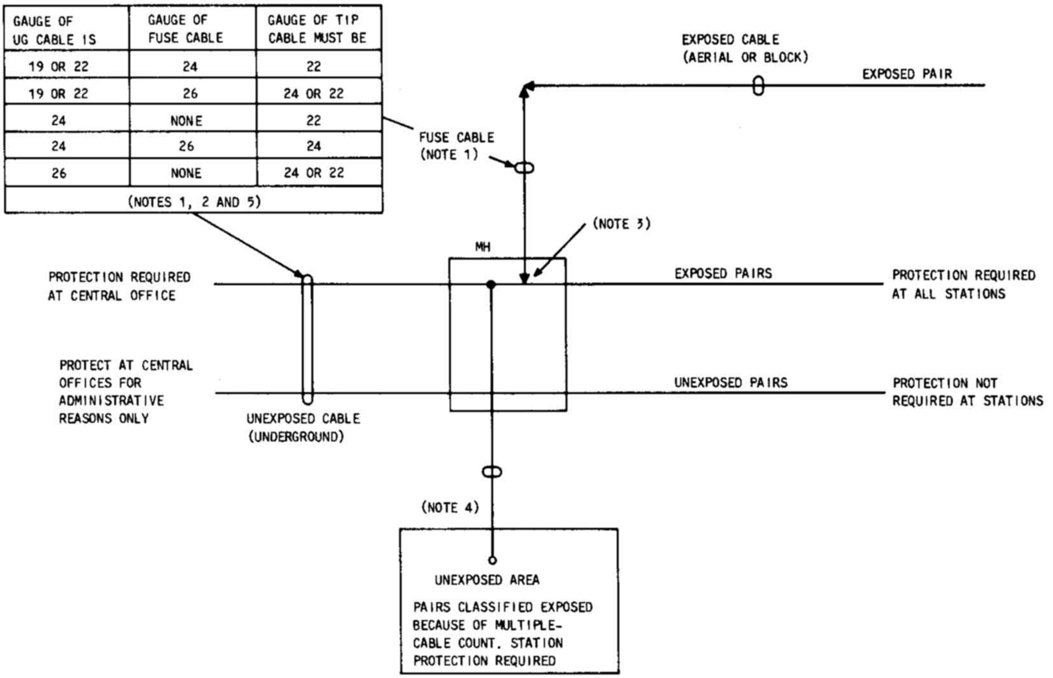
4. PROTECTORS FOR EXPOSED STATIONS AND PBXs

A. General

4.01 Protectors used at exposed stations are described in detail in Division 460. Information pertaining to the electrical characteristics of station protectors is contained in Section 876-101-100.

4.02 There are two general types of station protectors: "fused" (equipped with two

GAUGE OF UG CABLE IS	GAUGE OF FUSE CABLE	GAUGE OF TIP CABLE MUST BE
19 OR 22	24	22
19 OR 22	26	24 OR 22
24	NONE	22
24	26	24
26	NONE	24 OR 22
(NOTES 1, 2 AND 5)		



NOTES:

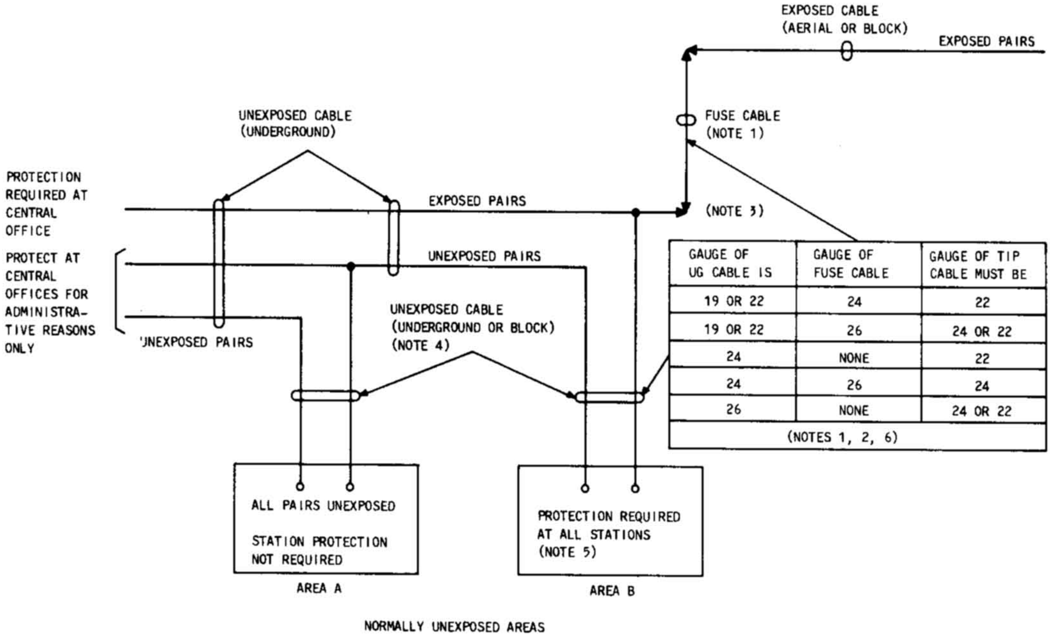
1. THE FUSE CABLE IN THIS CASE MAY SERVE 3 PURPOSES:
   (1) PROVIDES THE REQUIRED FUSE LINK FOR THE MAIN FRAME TERMINATING (TIP) CABLE.
   (2) ISOLATES EXPOSED AERIAL COMPLEMENT FROM UNEXPOSED UNDERGROUND COMPLEMENT.
   (3) PROVIDES REQUIRED FUSE LINK BETWEEN THE POWER EXPOSURE AND STATIONS SERVED FROM UNDERGROUND COMPLEMENT WHICH ARE MULTIPLED WITH EXPOSED PAIRS.
2. THE GAUGE OF THE CENTRAL OFFICE TIP OR TERMINATING CABLE MUST BE AT LEAST TWO SIZES LARGER THAN ANY FINE-GAUGE CONDUCTORS USED AS FUSE CABLE.
3. FOR LIGHTNING PROTECTION CONSIDERATION REFER TO 876-400-100.
4. UNEXPOSED UNDERGROUND OR BLOCK CABLE, ANY GAUGE, EXCEPT WHERE READY-ACCESS TERMINALS ARE USED. SEE SECTION 638-205-015 FOR SPECIFIC COMBINATION OF GAUGES.
5. FUSE CABLE DOES NOT PROVIDE LIGHTNING PROTECTION.

Fig. 3—Indirectly Exposed Cable Pairs

7-ampere fuses) and "fuseless." Fuseless protectors are available in single-pair and multiple-pair units for use at indoor and outdoor locations. All station protectors are equipped with voltage limiting devices such as carbon block assemblies having 3-mil gaps or gas tubes. On circuits with ground-start exposed to power serving PBXs (except battery feeders), and circuits which are likely to be exposed in the future (paragraph 3.02), 60-type sneak current fuses or heat coils are required in addition to the regular station protection. Sneak current protection is also used on certain special services and leased lines when required by local company practices.

B. Fuseless Protectors

4.03 The fuseless protector has a much higher current-carrying capacity than a fused protector. In conjunction with the use of fuseless protectors where power exposure exists, a fusible element or link between exposed plant and the protector is necessary to minimize any fire or shock



GAUGE OF UG CABLE IS	GAUGE OF FUSE CABLE	GAUGE OF TIP CABLE MUST BE
19 OR 22	24	22
19 OR 22	26	24 OR 22
24	NONE	22
24	26	24
26	NONE	24 OR 22
(NOTES 1, 2, 6)		

NOTES:

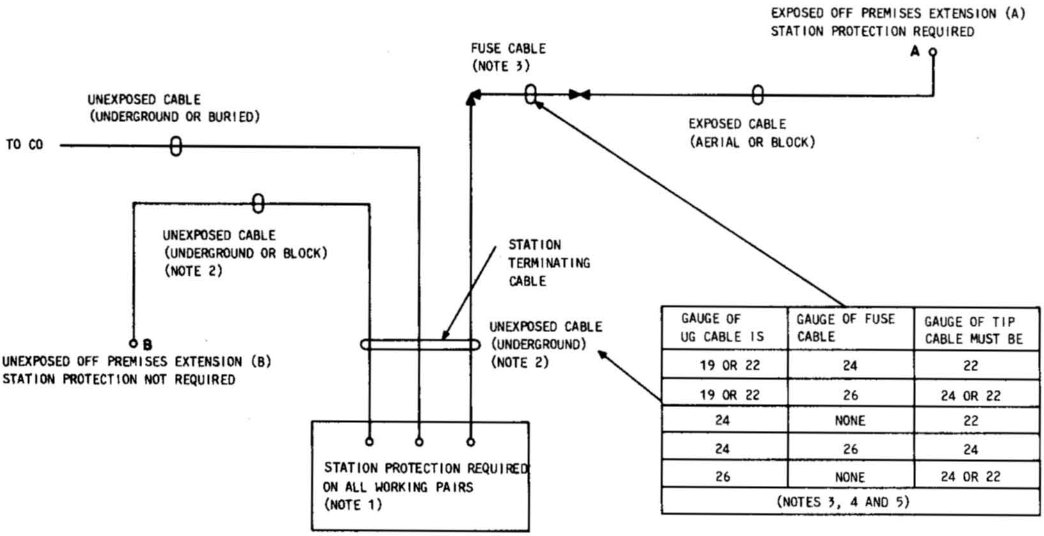
1. THE FUSE CABLE IN THIS CASE MAY SERVE 3 PURPOSES:
   (a) PROVIDES THE REQUIRED FUSE LINK FOR THE MAIN FRAME TERMINATING (TIP) CABLE.
   (b) ISOLATES EXPOSED AERIAL COMPLEMENT FROM UNEXPOSED UNDERGROUND COMPLEMENT.
   (c) PROVIDES REQUIRED FUSE LINK BETWEEN THE POWER EXPOSURE AND STATIONS SERVED FROM UNDERGROUND COMPLEMENT WHICH ARE MULTIPLED WITH EXPOSED PAIRS.
2. THE GAUGE OF THE CO TIP OR TERMINATING CABLE MUST BE AT LEAST TWO SIZES LARGER THAN ANY FINE-GAUGE CONDUCTORS USED AS A FUSE CABLE.
3. FOR LIGHNING PROTECTION CONSIDERATION REFER TO SECTION 876-400-100.
4. AREA B: WHERE READY ACCESS TERMINALS ARE USED, SEE SECTION 638-205-015 FOR SPECIFIC COMBINATION OF GAUGES.
5. PROTECTION REQUIRED ON UNEXPOSED PAIRS FOR ADMINISTRATIVE REASONS ONLY.
6. FUSE CABLE DOES NOT PROVIDE LIGHTNING PROTECTION.

Fig. 4—Effect of Indirect Exposure on Unexposed Pairs

hazard at the station in the event of a sustained power contact. The fusible link may be the 24- or 26-gauge conductors in the cable terminal stub, such as the 26-gauge stub cable supplied with the multiple pair (134-type) station protector, the 24-gauge conductors of urban wire, or E block wire (or equivalent) bridling between drop wire and open wire or rural wire.

4.04 Because of the savings in investment and maintenance expense, fuseless protectors should be used at all stations served by grounded metal shield cable (lead, alpeth, stalpeth, etc). Isolated sections of aerial cable are considered as open wire for the purpose of station protection, unless the cable is effectively grounded to a multigrounded neutral or to an extensive water (metallic pipe) system.

4.05 Fuseless protectors must be used at stations served from buried distribution cable directly connected to exposed aerial cable, provided either cable has 24- or 26-gauge conductors so located that they will serve as a fusible link. This



GAUGE OF UG CABLE IS	GAUGE OF FUSE CABLE	GAUGE OF TIP CABLE MUST BE
19 OR 22	24	22
19 OR 22	26	24 OR 22
24	NONE	22
24	26	24
26	NONE	24 OR 22
(NOTES 3, 4 AND 5)		

NOTES:

1. WHEN SERVING NON-ELECTRONIC STATION EQUIPMENT A SEPARATE SHIELD SHOULD BE PROVIDED FOR THE EXPOSED CABLE SO THAT ONLY EXPOSED PAIRS WILL REQUIRE PROTECTION. WHEN ELECTRONIC STATION EQUIPMENT IS SERVED BY A MIX OF EXPOSED AND UNEXPOSED PAIRS, WHETHER OR NOT THEY ARE IN SEPARATE CABLES, ALL PAIRS REQUIRE PROTECTION.
2. WHERE READY ACCESS TERMINALS OR MAIN FRAME TIP CABLES ARE USED, SEE SECTION 638-205-015 FOR SPECIFIC COMBINATION OF GAUGES.
3. THE FUSE CABLE IN THIS CASE PROTECTS STATION TERMINATING CABLE OR MAIN FRAME CABLE AND OFF PREMISES EXTENSION (B), BUT DOES NOT PROTECT OFF PREMISES EXTENSION (A) STATION PROTECTORS SERVED BY THE EXPOSED COMPLEMENTS SINCE THE FUSE CABLE IS NOT BETWEEN THE STATION AND THE EXPOSURE. THEREFORE AN ADDITIONAL FUSE LINK IS REQUIRED BETWEEN POWER EXPOSURE AND STATION (A).
4. THE GAUGE OF THE TIP OR TERMINATING CABLE MUST BE AT LEAST TWO SIZES LARGER THAN ANY FINE-GAUGE CONDUCTORS USED AS FUSE CABLE.
5. FUSE CABLE DOES NOT PROVIDE LIGHTNING PROTECTION.

Fig. 5—Indirect Exposure at Stations

requirement can be met if the fine-gauge conductors are located at one of the following points:

(a) In the aerial or buried cable at the junction pole (see note)

(b) In the buried cable section between the first pedestal terminal and the aerial junction (see note)

(c) In the connecting block wiring at the pedestal terminal.

Note: A minimum of 2 feet (not including connections) of fine-gauge (24- or 26-gauge) cable is satisfactory for protection reasons.

4.06 Only 24- or 26-gauge copper distribution cable (or equivalent) should be used in random separation construction with buried distribution closures. This permits the use of fuseless station protectors. (Fuse links cannot be constructed in a buried splice, however fuse links are present when buried service wire is connected at a pedestal.) The recommendation to use 24- or 26-gauge distribution cable is made with the view of simplifying administrative procedures and ensuring proper coordination of fusing requirements. As an alternative to specifying 24- or 26-gauge distribution cable, fuse type station protectors may be used with any gauge distribtuion cable.

4.07 Fuseless protectors may also be used at all stations served by open wire, multiple line

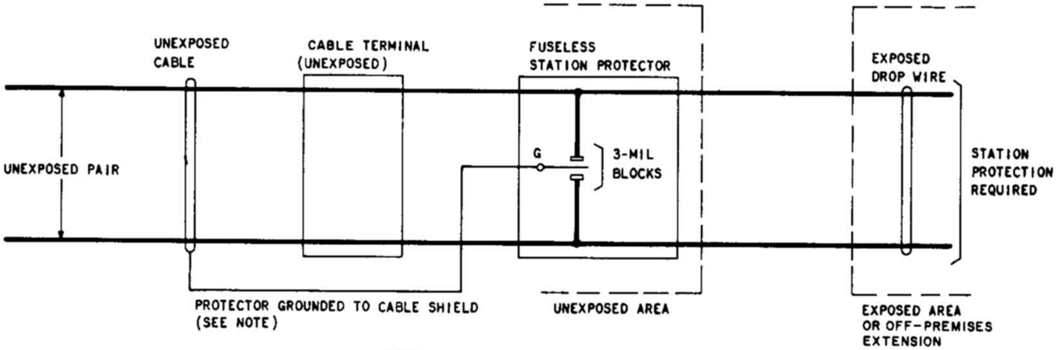


Fig. 6—Exposed Drop From Unexposed Cable

wire (19 through 24 AWG), or C rural wire (single pair, 14 AWG) subject to the following conditions:

(a) The protector must be grounded to a metallic water pipe (buried for at least ten feet) or to the ground electrode (rod) or grounding conductor of a multigrounded neutral power system. Where a unigrounded power system is involved, bond to an acceptable grounded secondary neutral. A grounded secondary neutral acceptable for bonding is one which serves a minimum of three customers with the power service grounded on the premises.

(b) The bridling between the service drop wire and open wire or multiple rural wire or C rural wire must consist of at least 2 feet of E block wire (0.027-inch diameter) fusible link (or equivalent), installed as described in Section 462-240-200. (See Table A for acceptable combinations.)

(c) The service loop must consist of either a single-pair drop wire or F multiple drop 22-gauge. ***Older types of multiple drop wire (0.027-inch diameter) or block wire must not be used because this wire cannot be protected against fusing on the premises (available fuse-link E block wire has approximately the same fusing characteristics as the multiple drop wire and will not provide proper fusing coordination).***

TABLE A

PLANT	DROP	E BLOCK BRIDLE FUSE REQUIRED
Open Wire	1 pr. or F mult.	Yes
19 AWG Rural	1 pr. or F mult.	Yes
22 AWG Rural	1 pr.	No
22 AWG Rural	F mult.	Yes
24 AWG Urban	1 pr. or F mult.	No
C Rural	1 pr.	Yes

C. Fuse-Type Protectors

4.08 If the grounding or bridling requirements in paragraph 4.07 cannot be met, a protector with fuses must be used.

4.09 A fuse-type protector is required when it is necessary to run more than one drop or block wire for battery supply.

D. Protected Terminals

4.10 With fuseless protected building terminals, it is necessary to have a short length of 24- or 26-gauge protective cable between exposed plant and the terminal to prevent dangerous overheating of protectors and possible fire hazard within the terminal enclosure as a result of a power contact with exposed cable. In NH cable terminals or 1A4A terminal blocks, the 24-gauge stub cable serves as a fusible link. The 134-type protector is also equipped with a stub cable (26-gauge) that serves as a fusible link. Conductor fusing is, therefore, confined within the sheath and reduces the potential fire hazard. Ready-access terminals, however, present a special problem because the PIC cable conductors, terminated on connecting blocks, cannot serve as fusible links without creating the danger of fire within the enclosure. For example, if an exposed cable is 24-gauge and if 24-gauge PIC cable is extended to a ready-access terminal in the building, it is likely that conductor fusing will occur at or near the terminal posts of the protector. This tendency to fuse where the conductors are separated, rather than under the sheath, is because conductors within a cable sheath are closely packed and pairs adjacent to the wires carrying current help to dissipate the heat. To eliminate a possible fire hazard, the PIC cable terminating on the protectors must be at least two gauges (AWG) larger than the fuse cable. Where a ready-access terminal is installed on the exterior of a noncombustible wall or in a fire-resistant enclosure on the exterior of a combustible wall, 24- or 26-gauge PIC cable in the terminal may serve as the fusible link. Specific applications of fine-gauge protective cable to provide safe fusing arrangements for ready-access terminal installations are described in Section 638-205-015.

E. PBX Protection—General

4.11 Protection requirements for exposed lines serving PBX equipment, and for some off-premises lines, may be different from those of a station served from a central office. (Off-premises lines originate at the PBX and are usually exposed, ie, PBX lines serving stations remotely located from the PBX.) Protection requirements are similar in that a protector (spark gap and fusing as applicable) is required on all exposed lines terminated in a PBX, lines served by a PBX, or stations served from a central office. This requirement applies to both electromechanical and electronic PBXs.

4.12 Where only a few exposed Central Office trunks serve a PBX, fuseless station protectors can be used in accordance with the provisions of paragraphs 4.04 through 4.07. Where two or more drop wires are used for battery-feed purposes, fuse-type protectors are recommended (instead of fuseless protectors) to simplify the special wiring methods necessary for limiting current drain through one protector mounting.

4.13 Where exposed cable pairs are extended into buildings, 134-type protectors with 26-gauge conductors in the terminal stub cable are often used for PBX protection. With this or similar type protectors, 60-type fuses must be installed on each line conductor exposed to power as described in paragraph 4.02. Mounting arrangements and hardware for 60-type sneak fuses with fuseless type protector mounts are described in Section 460-100-400. It should be recognized that stub fuse links or station fuses are ***not*** substitutes for sneak fuses where sneak fuses are required (paragraph 4.14). Sneak fuses can be operated on low magnitude currents that will not affect stub fuse links or station fuses. ***Sneak fuses do not provide lightning protection.*** When main frame type equipment that is not listed by Underwriters Laboratories (such as the 302- or 303-type connectors) is used in subscriber buildings, it must be mounted in a dedicated, enclosed space exclusively for telephone communications equipment (main frame room) and under control of the telephone company. The application of 302- or 303-type connectors equipped with 4A protectors with heat coils is described in Section 636-320-100 and 636-330-100, respectively.

4.14 As stated in paragraph 4.13, electromechanical and electronic-type PBX circuits require additional protection in the form of sneak fuses (60-type) or heat coils. These devices must be provided for central office trunks, tie trunks, off-premises extensions, and ringing feeders or any other circuits exposed to power (paragraph 3.02) that have a low impedance path to ground (see applicable practices for sneak fuse requirements, eg, 460-100-400).

F. Customer Premises Electronic Equipment Protection

4.15 Electronic-type station equipment installations must meet definite lightning protection and grounding requirements. Most of these requirements are in addition to the general requirements described above and are further discussed below. It is recommended that SDs and BSPs for a particular type of Electronic Station Equipment be reviewed for requirements peculiar to that equipment.

4.16 ***The building entrance facility protector must always be connected to an approved ground via the shortest and straightest practical route (see Section 631-400-102).*** Figures 7 through 14 illustrate methods for selecting an approved protector ground.

4.17 A Single Point Ground (SPG) terminal is provided on electronic station equipment. It is the only acceptable point for connection from the equipment to the external protection grounding system. The Single Point Ground terminal is designated differently for various types of electronic station equipment; refer to applicable BSPs and SDs. For example, the PBX Single Point Ground terminal for the DIMENSION® has been called the "Wall Mounted Ground Window." The PBX Single Point Ground terminal for the 800/801 systems is called the "T&B" (Thomas and Betts) lug. The Single Point Ground terminal for key systems is called the power supply output circuit ground (local ground).

Electronic PBX Protection

4.18 The PBX Single Point Ground terminal must always be connected to the ***closest*** approved ground or closest approved floor ground in a high-rise building. Approved ground can be determined by using the guidelines in paragraph 7.07 and approved floor ground determined by the guidelines in paragraph 9.08.

4.19 The PBX Single Point Ground terminal must ***also*** be connected to the ground lug located on the building entrance facility protector (carbon block or approved gas tube) with a coupled bonding conductor. The reason for bonding the PBX Single Point Ground terminal to the protector ground lug, with a conductor closely coupled to the pairs feeding the PBX, is to minimize potential differences between the PBX pairs associated with the building entrance protector ground and the local ground associated with the sensitive electronic circuitry. The mutual impedance of this coupled bonding conductor to the pairs feeding the PBX causes transformer action similar in effect to that obtained when a neutralizing transformer is used. The following options exist for the coupled bonding conductor between the PBX Single Point Ground terminal and the ground lug on the protector:

(a) If the installation conforms to the definition of a high-rise or low-wide building stated in Part 9, then the PBX Single Point Ground terminal is connected to the coupled bonding conductor which has been provided in accordance with Part 9. The construction described in Part 9 assures a connection to the protector ground lug.

(b) If the installation does not conform to the definitions of a high-rise building as stated in Part 9, then the coupled bonding conductor can be obtained via:

(1) A wire tie-wrapped to the cabling between the protector and PBX;

(2) Spare pairs in the cabling between the protector and PBX;

(3) The shield of the cable between the protector and PBX, providing the cable has a continuous metallic shield.

The BSPs describing PBX equipment specify gauge of this coupled bonding conductor and the number of spare pairs required. Typical values for the bond connection are 10-gauge copper for (1) above, or a minimum of 6 spare pairs of 24 gauge inside wiring cable for (2) above. If option (3) is employed, it is imperative to maintain shield continuity as well as verify that construction of bonds has been completed with acceptable permanent hardware and ***not*** with temporary hardware such as two B Bond clips with a single 14-gauge appliance wire. If this continuity cannot be assured, then one of the other options must be employed. If the option of 6 spare pairs is used to provide the bond as specified in (2), then at every point where these pairs are connected, cross-connected or accessible, Form-3013B must be used to tag and identify these pairs as grounding conductors for the PBX. Splices in bonding or grounding conductors reduce reliability and must be avoided.

4.20 Electronic PBX systems are vulnerable to surges entering the telephone cable plant, associated AC power facilities, and lightning strikes to the building housing the PBX. (Refer to paragraphs 3.02, 3.08, 3.09, 3.14 and Part 9 for appropriate guidelines.) Care must be taken to ensure that all talking and signaling pairs associated with electronic PBX systems that leave the building housing the PBX in exposed facilities are protected at both ends. If the facilities are exposed to only

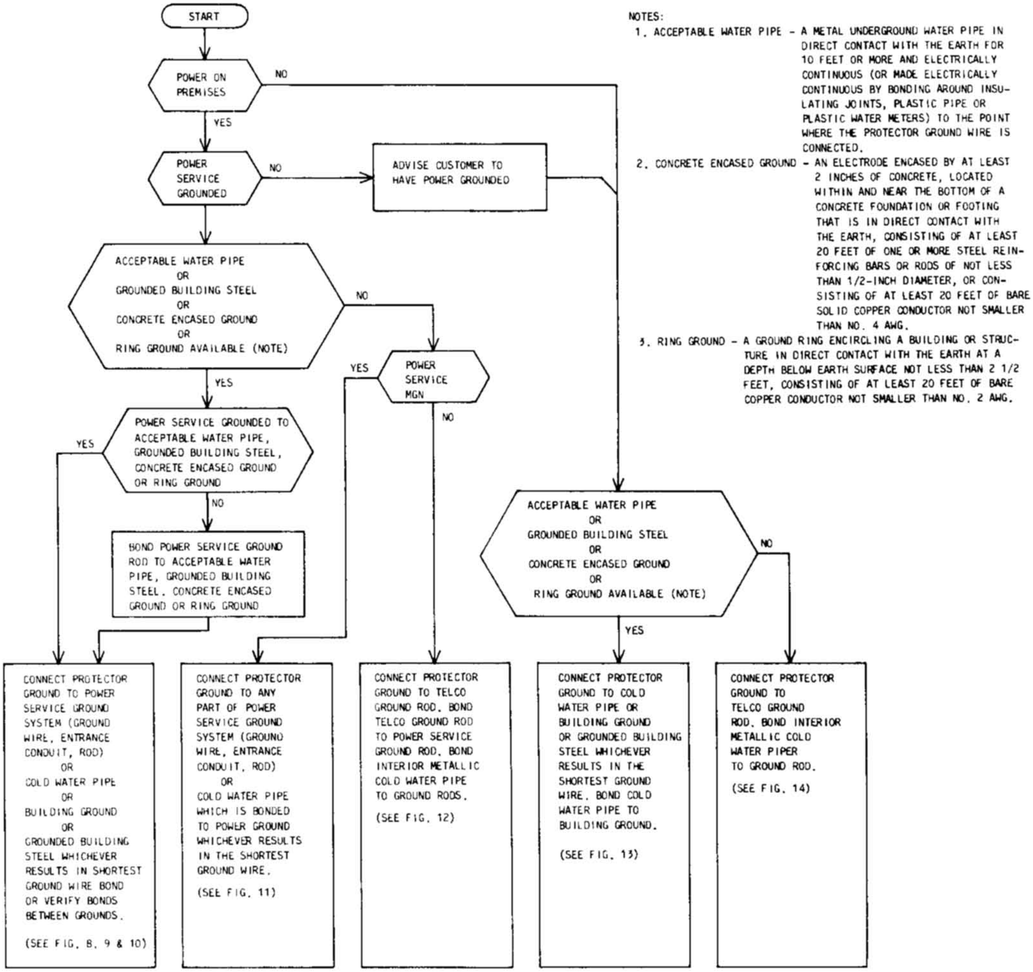


Fig. 7—Selecting an Approved Ground

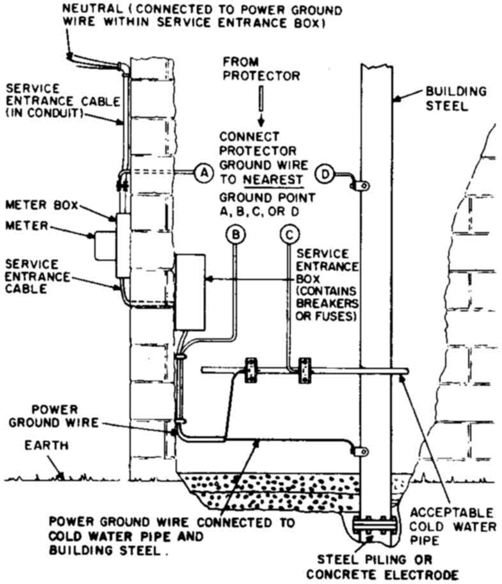


Fig. 8—Acceptable Water System or Building Ground—Power Service Grounded to Cold Water Pipe and Grounded Building Steel

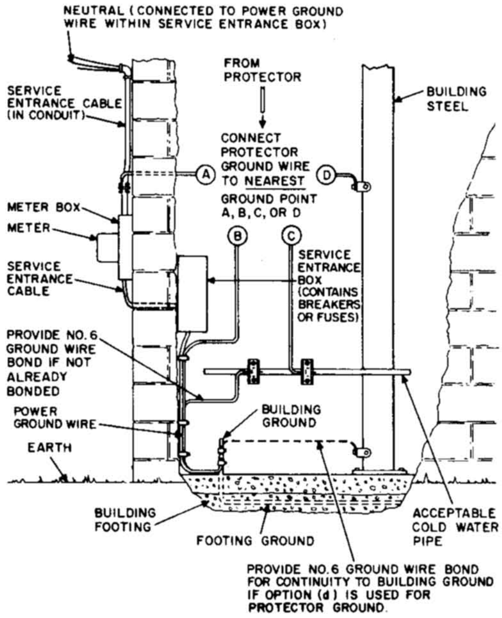


Fig. 9—Acceptable Water System or Building Ground—Power Service Grounded to Building Footing Ground

lightning, then station protectors are required at both ends. If the facilities are exposed to lightning and/or power, then station protectors, and fuse links (cable fuse) are required at both ends. Sneak current fuses are required on circuits exposed to power that have a low impedance path to ground.

4.21 All station protectors including those for trunks and off-premises extensions ***in the same building*** should have the ground terminals bonded to the PBX equipment Single Point Ground terminal and to the approved ground in accordance with the external wiring and spacing criteria shown in Fig. 15A or Fig. 15B as applicable.

4.22 If gas tube protector units other than the 11A1A, 11B1A or equivalent are used to reduce maintenance, they must be paralleled with carbon block protectors (see gas tube limitations Section 876-101-100). ***Gas tube and carbon block protectors should be installed at the same location for maximum effectiveness at reasonable cost.*** If any protectors are installed near the PBX at a separate location from and, in addition to, the building entrance facility protectors, sneak current fuses will be required in each pair between the separate protectors to guard the branch cabling against excessive current flow. The addition of sneak current fuses made necessary by separated protector locations could easily negate the maintenance cost advantages of using gas tubes.

G. Key Telephone System Protection

4.23 The grounding and special protection requirements for key telephone systems (KTS) are generally similar to those for PBXs although somewhat less complex due to the smaller size and complexity of the KTS systems. (Refer to Section 518-010-105 for a thorough coverage of the grounding and special protection requirements for KTS.)

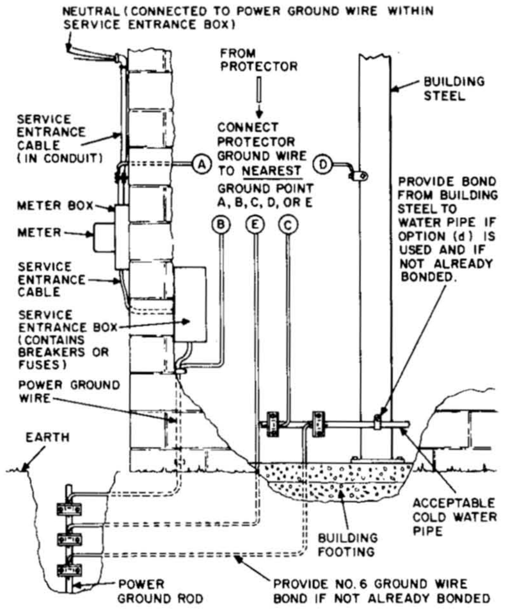


Fig. 10—Acceptable Water System—MGN Power Service Grounded to Ground Rod

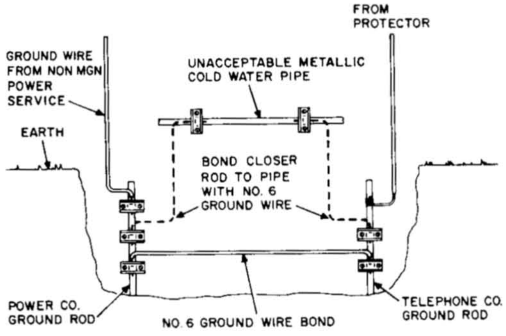


Fig. 12—Acceptable Water System or Building Ground not Available—Non-MGN Power Service Grounded to Ground Rod

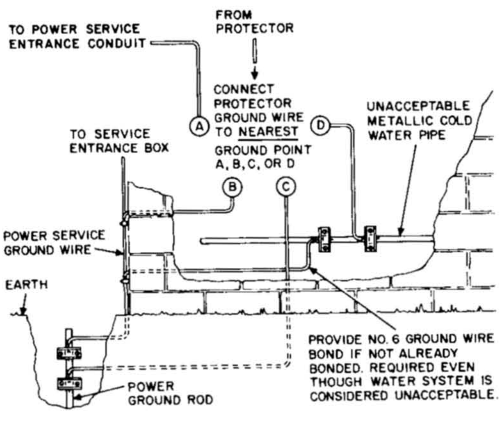


Fig. 11—Acceptable Water System or Building Ground not Available—MGN Power Service Grounded to Ground Rod

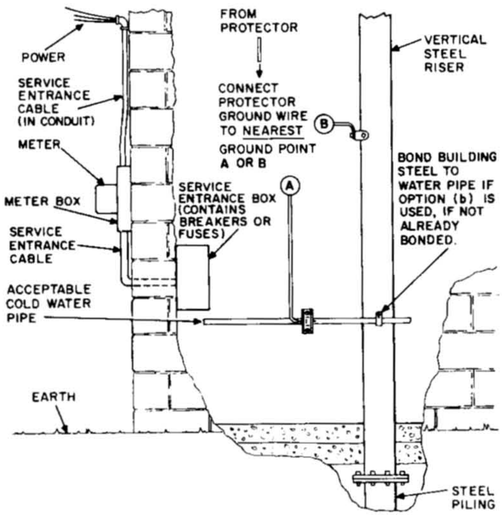


Fig. 13—Acceptable Water System or Building Ground—Power Service not Grounded or No Power on Premises

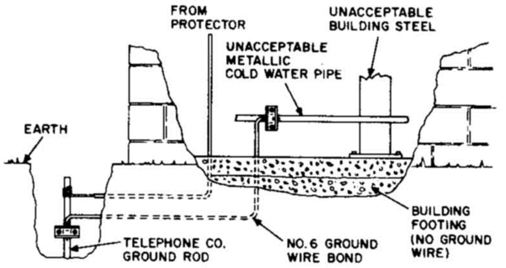


Fig. 14—Acceptable Water System or Building Ground not Available—Power Service not Grounded or No Power on Premises

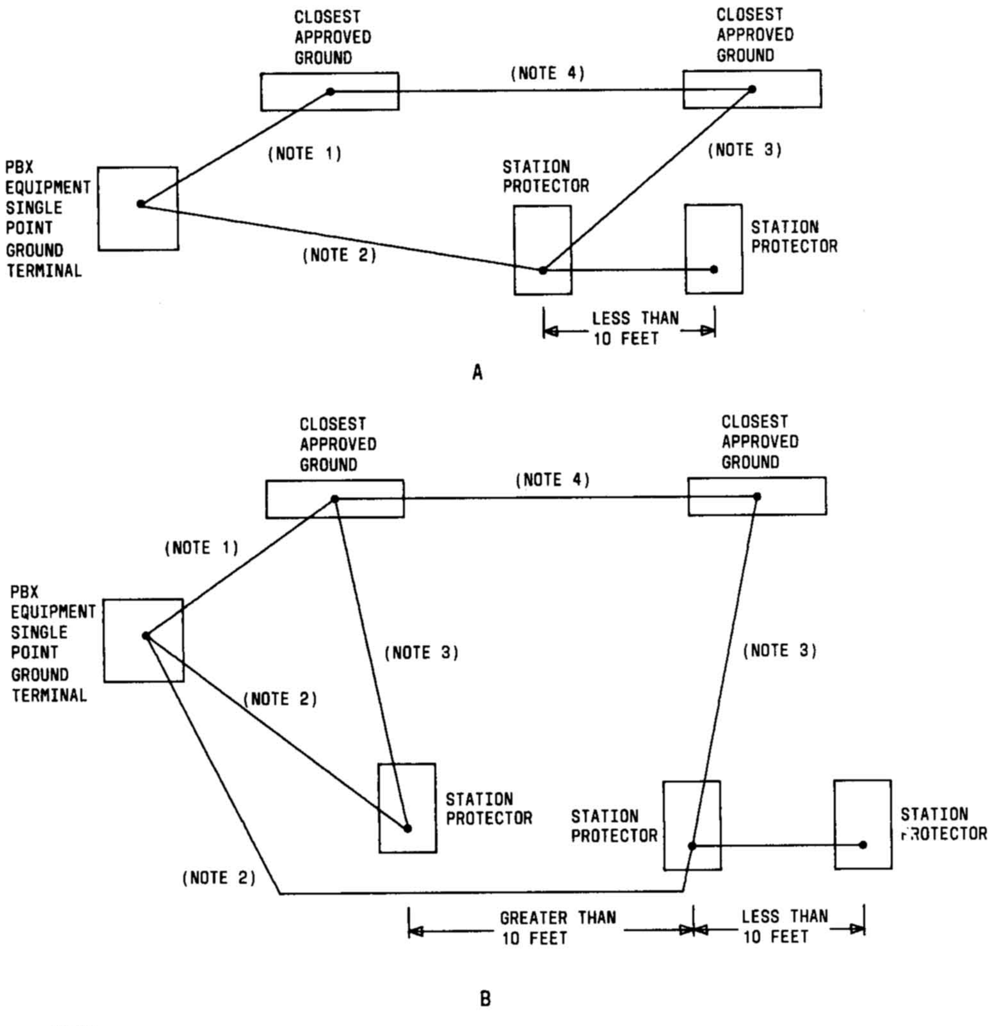
4.24 Key telephone power supplies are presently designed in such a manner as to only require a coupled bonding conductor from the power supply Single Point Ground terminal to the station protector ground lug. This bond, when provided in accordance with this section, satisfies all necessary and sufficient ground connections for KTSs and an additional connection to a nearby approved ground (as is required for PBX systems) shall not be made. If a key telephone installation conforms to the definition of a high-rise or low-wide building as stated in Part 9, then the coupled bonding conductor to the protector can be provided using the same guidelines outlined in paragraph 4.19(a) for PBX systems. If a key telephone installation does not conform to the definition of a high-rise or low-wide building, then the guidelines outlined in Section 518-010-105 for providing this coupled bonding conductor should be followed.

4.25 The following additional recommendations for the KTSs are made:

(a) Where remote stations are connected to the KTSs via exposed facilities, then protection is required on both ends of the facility. This protection may consist of station protectors at both ends if facilities are only exposed to lightning, or fuse links (cable fuse) and station protectors if facilities are exposed to lightning and/or power. The KTSs do not presently require sneak current protection since the equipment does not contain a low impedance path to ground.

(b) When more than one station protector is used to serve a single KTS, then the requirements for bonding can be obtained using the same criteria outlined in paragraph 4.21 (Fig. 15) for PBX systems. As stated before, no connection from the key telephone power supply Single Point Ground terminal to a nearby approved ground should be made.

(c) If gas tube protectors other than the 11A1A, 11B1A, or equivalent, or if any protectors are used at the KTS in addition to and at a separate location from the building entrance protector, then the recommendations in paragraph 4.22 must be followed, ***including*** the use of sneak current fuses.



NOTES:
1. SEE PARAGRAPH 4.18 (KEY TELEPHONE SYSTEMS SHOULD NOT HAVE THIS CONNECTION)
2. SEE PARAGRAPH 4.19
3. SEE PARAGRAPH 4.17
4. ALL APPROVED BUILDING GROUNDS ARE OR MUST BE COMMON BONDED
5. SOME ELECTRONIC PBX SYSTEMS SUCH AS THE 201S (DIMENSION) REQUIRE ADDITIONAL CONNECTION TO SINGLE POINT GROUND. REFER TO APPLICABLE SDs AND BSPS

Fig. 15—PBX External Wiring for Protection Grounding and Bonding

5. LOCATION OF PROTECTORS

A. General

5.01 Detailed instructions relating to the installation of protectors at both indoor and outdoor locations are contained in Division 460. Some general considerations involved in selecting protector locations are outlined in the following paragraphs.

B. Indoor Stations

5.02 Where protectors are placed inside a building, it is desirable to select a location accessible for maintenance as near as possible to the point where the power service enters the building. Also, protectors should be located with the idea of limiting the length of line conductor and ground wire within the premises. With fuseless protectors, the line conductors remain grounded for the duration of a power contact and the voltage on the wire cannot rise sufficiently to create a hazard. To ensure this safety feature, the length of ground wire from the protector should be as short as possible in order to provide a low-impedance path to ground. Protectors such as the 123- and 128-types can be mounted directly on a water pipe by means of a 72A or 90A bracket, respectively. Minimizing the length of bond wire from the protector to the power ground is also important. Protectors should be located to minimize the length of ground wires and bonds to the power grounds.

5.03 In selecting a location for fused protectors, a compromise between length of ground wire and length of drop conductors may be necessary. In such cases, it is preferable to have the conductors on the line side of the protector as short as possible. This is recommended because the line conductors are likely to remain energized for some time after the fuses operate.

C. Outdoor Stations

5.04 In general, outdoor stations served by exposed conductors require standard station protection with the ground connected as specified in Section 460-100-400. Figure 16 shows that carbon block protectors should be used for many stations (particularly coin telephones) that have in the past been treated as unexposed. For example, protectors are necessary because of lightning exposure of the serving buried or underground plant erroneously thought to be unexposed to lightning, or lightning exposure of aerial power facilities serving the station or booth. The warning in paragraph 3.09 describes the latter situation. (Refer to Section 506-410-400 for treatment of single-slot coin telephones under exposure conditions.) However, some outdoor stations require special grounding arrangements to prevent a possible shock hazard to persons using the telephone. These stations are as follows:

(a) ***Public Telephones:*** Metallic outdoor station assemblies, such as booths and drive-up or walk-up telephones that have a power supply for lighting, should be grounded as instructed in Section 508-100-100. At these stations, the telephone set housing and booth structure must be connected to the electric service ground to prevent exposed metal parts from becoming accidentally energized by a short circuit in the internal power wiring. Grounding the station assembly to the power ground ensures operation of the branch circuit fuse, thereby preventing a possible shock hazard. Common grounding of power and telephone protection is automatically provided when the station protector ground is connected to the housing assembly of the subscriber set or to the booth structure.

(b) ***Stations on Wood Poles:*** Where a station served by exposed conductors is to be installed on a wood pole, a location having the best available ground for the protector should be selected. The most desirable location is a pole that has an existing vertical ground wire connected to a multigrounded neutral conductor and a driven ground electrode. The vertical ground wire should be used for grounding the station protector. Where a vertical run of ground wire is to be established, telephone company personnel may drive the ground rod and run the wire to the top of the telephone space. At this point, the wire should be bonded to the cable strand and left in a coil of sufficient length for the power company to extend to the neutral conductor. ***A station should not be placed on a pole having a power vertical ground wire for lightning protection unless the ground wire is connected to a multigrounded neutral conductor.*** The reason for this precaution is to avoid the effects of a rise in voltage-to-ground resulting from the operation of lightning protection devices on the power system. This condition might present a shock hazard or interrupt telephone service by grounding the station protector. If an acceptable grounding medium (such as a multigrounded neutral) is not available, the protector should be grounded to a station ground rod placed about 2 feet from the base of the pole, provided that the station is served from cable. Where the station is served from wire plant (open, rural, urban), the ground rod should be supplemented by a ring of B ground wire placed approximately 6 inches deep and enclosing the ground area on which a telephone user would stand.

(c) ***Stations on Metal Poles:*** The use of metal poles for telephone stations should be avoided, wherever possible, because special installation and maintenance measures may be necessary, which can increase the cost of the job. More important, however, is the possibility of electric shock and damage to station equipment, which may be difficult to eliminate. To guard against such hazards, the following precautions must be observed:

(1) Where telephone conductors are unexposed and the power circuits on the metal pole are not in excess of 300 volts (rms) to ground, station protection or special precautions are not required. [The presence of power circuits on a single pole may not affect the exposure status of the telephone plant, as explained in paragraph 3.14(b).] Where exposed telephone conductors are involved, however, the station protector ground should be connected to the metal pole. This precaution must be observed in all cases, even though other means of grounding the station protector are employed. If the metal pole is bonded to a low-impedance ground (such as a water pipe) or to a multigrounded neutral or equivalent, no additional grounding of the station protector is required. If the metal pole is not effectively grounded, the protector ground should be connected to a station ground rod placed about 2 feet from the pole. The ground rod should be bonded to the pole near the ground line.

(2) Where a metal pole supports power circuits (open-wire or in conduit) of more than 300 volts (rms) to ground, the telephone station should not be installed unless the pole can be grounded to a metallic water pipe or to a multigrounded neutral. Where telephone circuits are exposed, the protector ground need only be connected to the pole, which must be bonded to a metallic water pipe or to a multiground neutral.

6. STATIONS AND PBXs REQUIRING SPECIAL PROTECTIVE MEASURES

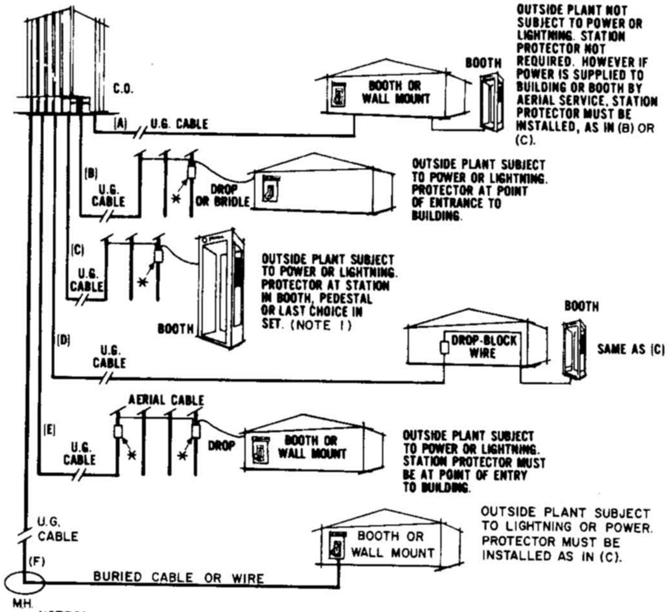
A. General

6.01 Special protective measures are generally required for stations located in areas where abnormal electrical disturbances outside the telephone system can create a shock hazard or cause damage to telephone facilities. Station installations requiring special protection considerations are as follows:

(a) At power substations or generating stations where excessive ground potential rise may be experienced.

(b) Where privately owned communication circuits are connected to Bell System facilities and the privately owned circuits are in structural conflict or in joint use with power circuits not suitable for general joint use.

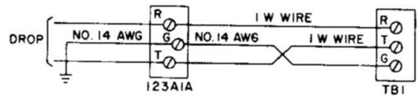
(c) Where Bell System facilities are leased for the operation of "foreign" signaling circuits that might apply excessive voltage on the system facilities.



NOTES:

1. FOR ADDITIONAL INFORMATION ON STATION PROTECTOR AND SIGNALING GROUNDS, REFER TO SECTION 460-100-400.
2. WHEN PROTECTOR IS MOUNTED INSIDE SET, CONNECT WIRING PER THIS SKETCH.

* CROSS CONNECT BOX



3. FOR ADDITIONAL INFORMATION SEE SECTION 508-100-100.

Fig. 16—Coin Telephone Protection Requirements

(d) Where customer-owned PBX, station, or terminal equipment is connected to Bell System facilities through Bell System owned interconnecting units.

6.02 The application of special environmental protective measures at power substations to protect wire-line communications facilities serving the power substation is described in Section 876-310-100. Measures applicable to the situations in paragraph 6.01(b), (c), and (d) are described in Division 876, Layer 6. Described in paragraphs 6.03 through 6.08 are other installations where it is desirable to employ special or auxiliary protection so that maintenance of station protectors may be reduced.

B. Power Substation Vicinity

6.03 Careful consideration should be given to the problems and consequences of serving subscriber premises located within the influence of a power station ground mat. For example, if a residential development or an industrial or business complex is affected, then large numbers of strategically placed protectors equipped with gas tubes may be required, particularly if grounding structures are not extensive throughout the area. When potential rise exposure magnitudes are large and when the dielectric strength of the serving facilities could be exceeded (affecting service reliability), isolating or neutralizing transformers may be required (ie, a large business with a PBX may require neutralizing transformers). Telephone cable serving a power station should be dedicated to that purpose. Other subscribers within the influence of the same power station should be served, if possible, by a separate cable; or, as an alternative, the splice point from a common cable serving the power station and other subscribers should be made at a sufficient distance from the power station so that ground potential rise limits will coordinate with requirements of the power station communication services. Section 876-310-100 should be consulted for protective transformers, cable splicing, and grounding requirements if these exposure conditions are encountered. Section 876-400-100 describes procedures for minimizing potential differences between conductors and shield in the common use cable serving subscribers when that cable passes through the ground potential rise influence of a power station ground mat.

C. Remote Locations

6.04 Telephone stations are sometimes bridged on circuits of trunk open-wire lines and are called "toll stations." These stations and remote rural subscriber stations may serve fire warden towers, airports, etc, where continuity of service is very important. At such stations, lightning exposure may be severe, and prompt maintenance of service is often difficult because of the remoteness of the location. To improve the maintenance at these highly exposed stations, the regular carbon block station protectors may be supplemented with gas tubes.

D. Commercial Radio and Television Transmitting and Receiving Stations

6.05 In general, telephone facilities at commercial radio and television transmitting or receiving stations located in built-up areas where low-resistance grounds are available will not require special protective measures. Common grounding is essential at all stations, however, to limit differences in voltage and to reduce the effects of high-frequency induction. At locations outside of urban areas, radio and television towers are exposed to frequent lightning strokes, and special protective measures are recommended as follows:

(a) If the station is served aerially, the cable in the pole-to-building span should have polyethylene-insulated conductors. Where the entrance cable is underground or is buried, PIC cable with PASP-type sheath should be used. When the entrance cable is in metal conduit, the shield should be bonded to the conduit at the underground pole and in the building. At all stations, the shield of the entrance cable should be grounded in the building to the radio station grounding system. At the junction of the main distribution cable and the entrance cable the shield should be bonded, if necessary, to provide electrical continuity. If an insulating splice is required for corrosion reasons, a KS-14595 List 1 or 2 capacitor (or equivalent) should be bridged across the splice to maintain a path to ground. Small-diameter aerial branch cables, even though supported on strand, may not have sufficient current-carrying capacity to prevent lightning damage. To provide additional conductivity for the shield, a B ground wire should be placed parallel with the cable in the pole-to-building span. This wire should be connected to each end of the strand dead-end and to the station ground. Also, any branch cable not supported on strand, either in the aerial span or on the building, should be paralleled at these locations with a B ground wire connected between the last point of strand attachment and the station ground. Similar reinforcement of the shield should be provided for a branch cable in an underground dip or buried between the entrance pole and the station.

(b) Full-count protection should be provided at the cable terminal in the building. Precautions should be taken to ensure that protection is kept intact at all times. The protector ground wire should be connected to the feeder cable shield and to the station ground.

(c) Where drop wire is used for service to the station, 6-mil protector blocks should be provided between the cable shield and all pairs (including nonworking pairs) in the cable terminal. Standard station protection must be placed in the building, and the ground terminal of the protector should be connected to the radio or television station ground. Gas tubes such as the 6A or 6B type may also be added to reduce maintenance of carbon block protectors.

(d) In addition to the arrangements covered in items (a), (b), and (c), full-count protection with 6-mil blocks should be employed on the branch cable if the branch cable is connected to a main cable containing pulp- or paper-insulated conductors. Drop wires from terminals on the main cable within 1000 feet of the branch cable should also be protected with 6-mil blocks. A low-resistance ground consisting of D ground rods or a counterpoise ground of 104-mil or 128-mil copper wire should be installed on the main cable near the branch cable junction. This ground should be located outside the influence of the radio station ground. However, this will not be possible when a buried parallel wire is used to increase shield conductivity, as discussed in item (a). Where exposure to lightning is usually severe, 6-mil blocks may be necessary; if maintenance is a problem, the use of gas tube protectors on all pairs in the main cable at the branch cable junction may be justified.

6.06 The purpose of full-count protection is to limit and equalize the voltage between cable shield and all conductors at protector locations. Between protector points, a conductor-to-shield voltage can develop where there are paths to ground via telephone anchor guys or arcing to power ground wires that have normal clearance to telephone plant. The magnitude of the voltage for a given shield current will depend upon the conductivity of the shield and the spacing between protectors. Under severe lightning conditions, the voltage developed in relatively short sections between protector points may be high enough to cause dielectric failure of paper- or pulp-insulated cable conductors. An excellent solution to this problem is the use of PIC cable for all new installations and for replacement purposes at radio stations.

6.07 Protection considerations for Bell System radio stations are described in Section 876-210-100.

E. Mobile Homes and Recreational Vehicles

6.08 The metallic structure of many types of mobile homes and recreational vehicles and their location (usually in suburban and rural environments) may contribute to severe lightning and power exposures. Experience has indicated the advisability of using the B voltage tester to verify that the mobile home body or chassis is not energized prior to installation work. The station protector should be placed as near the mobile home as possible. ***A separate station protector ground wire, bonded to the mobile home chassis, must be provided.*** If a mobile home has a seal that shows it is wired to meet requirements of ***ANSI*** A119.1 and ***NEC*** C1 ***AND*** if the mobile home is permanently wired using conduit (***not*** plug and cord connected) it will not be necessary to bond the mobile home chassis to ground as it is already bonded through the conduit or power ground conductor. The power service green wire must not be used as the station protector ground. The telephone station protector ground and the power ground must be commonly bonded together. The mobile home is treated as a permanent type home where telephone service is concerned in that the mobile home is usually moved into place and remains there indefinitely. Protection and grounding requirements for mobile homes is covered in Section 461-220-100. Recreational vehicles such as small camp trailers, camper trucks, motor homes, or boats are moved about often. The telephone service, protection, and grounding requirements for these vehicles differ from that of mobile homes and is covered in Section 461-220-101.

7. STATION AND PBX PROTECTOR GROUNDING

A. General

7.01 If telephone equipment and wiring are isolated from ground (earth) and from metallic or grounded structures such as gas and water pipes, heating systems, power conduit and wiring, and "foreign" communication facilities, abnormal voltages may develop on these systems as a result of power contacts or lightning disturbances. The voltage differences that may exist between the various structures must be equalized or limited by common grounding to reduce shock hazard and to prevent arcing and damage to equipment or property.

B. Effective Station Grounding Systems

7.02 Effective voltage equalization between conducting surfaces is a basic consideration in achieving effective grounding. Equalization between a station ground and power ground is accomplished by providing low-impedance connections or bonds between the station protector ground and the power ground system. The effectiveness of any telephone station power neutral ground system in limiting lightning surge voltages to earth and in providing adequate voltage equalization (to coordinate with the dielectric strength of associated equipment) is a function of the surge impedance (rather than resistance) of the entire grounding system. This includes not only the impedance of the grounding electrode but also the impedance of the connections between the equipment and the buried grounding electrode. This entire front-of-wave voltage drop via the grounding connection to earth (IZ) is expressed as V_F and defined in the expression

$$V_F = L_G \ell \, (di/dt)$$

where

L_G = Self-inductance of the ground connection in *Henrys per foot* (an appropriate average value for telephone purposes is 0.4×10^{-6} Henrys per foot)

ℓ = Distance from end to end of the grounding conductor in feet

di/dt = Ratio of change in current in amperes per unit of time in seconds

The subsequent discussion is concerned with practical application of the above expression. (Refer to Section 876-101-130 for a list of references and extensive discussion of grounding theory, impulse characteristics of grounds, effective grounding systems, self-inductance, surge impedance, etc.)

7.03 Figure 17 illustrates the transient voltage relationships that exist when a telephone protector is discharging lightning current. Assume that lightning either strikes the drop or the associated plant in the vicinity of a subscriber station. Some proportion of the total stroke current will discharge through the protector gaps and flow on the grounding conductor to the cold water pipe at point *b*. Ultimately this stroke current reaches earth via the buried section of water pipe. Voltage V_3, produced by current I_S flowing between points *a* and *d*, will appear between the telephone set and the power equipment enclosure. Potential V_1, appearing between the telephone sets and plumbing, is somewhat less than V_3 since it is only that voltage drop developed between points *a* and *b*. Another source of extraneous longitudinal potential that can appear in the vicinity of a telephone set is from lightning surges entering the premises over the power service conductors and producing a potential drop in the neutral grounding conductor between points *c* and *d*. The magnitude of such voltage is a function of the length of the power neutral grounding conductor over which we have little control.

7.04 To obtain some quantitative feel for the magnitude of inductive voltage likely to develop when stroke current enters a station conductively, two of the voltages shown in Fig. 17 should be considered: (a) V_1, which develops in the protection ground lead between points *a* and *b*, and (b) V_3, consisting of the voltage appearing between points *a* and *b* ***plus*** V_2 developed in the section of pipe from point *b* to point *d*. In each case the discharge voltage developed in the protector and mounting will supplement the potential drop appearing in the ground path. Under heavy current discharges, the drop across the protector may equal that of its initial sparkover. Referring back to the formula in paragraph 7.02, assume the following conditions:

(a) The simplified waveshape of lightning stroke current from Fig. 18 (di/dt) at the station is 1000 amperes/microsecond.

(b) ℓ = length of conductor from *a* to *b* = 10 feet; from *b* to *d* = 5 feet.

(c) LG = 0.4×10^{-6} Henrys/foot self-inductance (a good average figure for telephone work due to mutual impedance effects of nearby conducting objects).

V_1 voltage

$$V_F = (0.4 \times 10^{-6}) \times 10 \left(\frac{1.0 \times 10^3}{10^{-6}}\right)$$

$$= 4{,}000 \text{ volts}$$

V_2 voltage

$$V_F = (0.4 \times 10^{-6}) \times 5 \left(\frac{1.0 \times 10^3}{10^{-6}}\right)$$

$$= 2{,}000 \text{ volts}$$

$$V_3 = V_1 + V_2$$

$$= 6{,}000 \text{ volts}$$

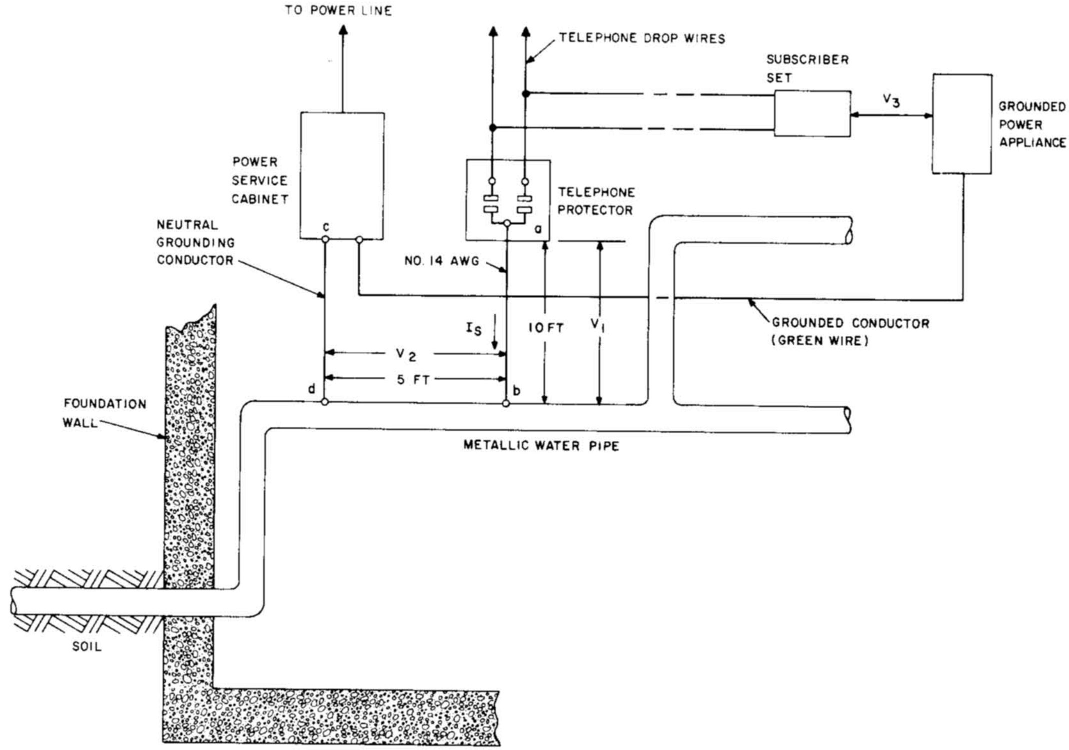


Fig. 17—Subscriber Station Protection Problem

7.05 The calculations in paragraph 7.04 show that the voltage that might appear between components of the subscriber set and a grounded power enclosure (V3, Fig. 17) would be about 6000 volts on the front of the surge. Although this magnitude of voltage is rather high, it exists for a very short interval of time (approximately 10 microseconds). This example should demonstrate clearly why effort should be made to avoid long ground leads in the planning of a subscriber installation. Ideally, all three utilities (power, telephone, and water) should enter the premises at approximately the same point to minimize the length of the grounding conductors. A helpful step in reducing the length of ground leads is the practice of mounting the station protector directly on a water pipe with a grounding strap. This minimizes voltages between station apparatus and conducting objects associated with the plumbing. Even with this improvement, a significant length of water pipe ground conductor may remain between the point where the station protector is mounted on the pipe and the point where the power neutral grounding conductor is connected to the pipe. The remedy in this case is to mount the station protector on the pipe as close as is practical to the point where the power neutral conductor is connected to minimize potential differences.

C. Hazard of Separate Grounds

7.06 If separate grounds were to be used for telephone and power protection, a person using a telephone located near a lamp or other grounded object might be exposed to electric shock. This hazard has been reduced as much as possible by providing high dielectric strength in the station equipment. The possibility of equipment damage would be increased with separate grounding systems. For example, in telephones employing 60-Hz power

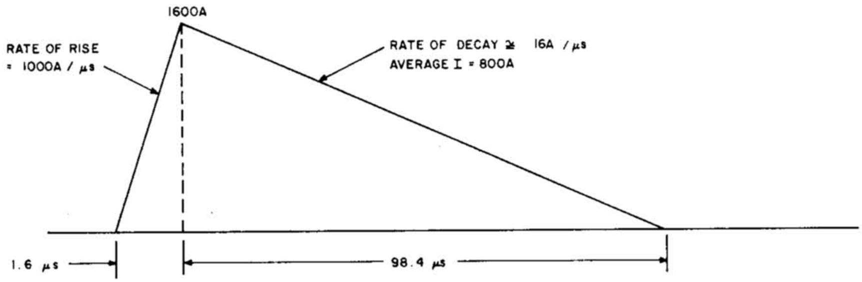


Fig. 18—Simplified Waveshape of Stroke Current in Station Ground Lead

for the dial light, the transformer is exposed continuously to voltage differences between the primary winding associated with the power source and the secondary winding connected to telephone wiring. The prevention of electric shock and station damage points up the need for common grounding to equalize or limit hazardous voltage differences.

D. Selection of Grounds

7.07 The increasing use of a nonmetallic underground piping (such as those made of concrete or plastic) have made both public and private water systems substantially less reliable as grounds than previously when water systems were constructed of metal piping. New construction very often uses plastic underground piping and existing metal systems are often repaired, replaced or altered using plastic piping. The ***1978 National Electrical Code*** now recognizes this fact in both Articles 250 covering grounding of power services and Article 800 covering grounding of communication protectors. Water pipe electrodes are no longer the first and only choice as a grounding electrode. The ***NEC*** now stresses the bonding together of all available electrodes into a system and the preferential choice for grounding the power is to any point on that system. The first choice for grounding of protectors is to the nearest available location on the system ***or*** to the power service conduit or grounding electrode conductor which is connected to the system, ***whichever results in the shortest run of grounding conductor.*** The system consists of a bonded-together assembly of all of the following electrodes which are available at the premises or structure:

(1) A metal underground public or private water pipe with at least 10 feet of metal pipe in direct contact with the earth

(2) The metal frame of a building where effectively grounded

(3) A concrete encased electrode described in the ***NEC**** as follows: "An electrode encased by at least 2 inches of concrete, located within and near the bottom of a concrete foundation or footing that is in direct contact with the earth, consisting of at least 20 feet of one or more steel reinforcing bars or rods of not less than 1/2 inch diameter, or consisting of at least 20 feet of bare solid copper conductor not smaller than a No. 4 AWG."

(4) A buried ground ring is described in the ***NEC**** as follows: "A ground ring encircling the building or structure, in direct contact with the earth at a depth below earth surface not less than 2-1/2 feet, consisting of at least 20 feet of bare copper conductor not smaller than No. 2 AWG."

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7.08 Article 250-81 of 1978 ***NEC**** states: "Continuity of the grounding or the bonding connector to interior piping shall not rely on water meters." Connections to water pipe electrodes should be made at a point where normal maintenance of meters and pumps or the installation of insulating sections for reducing vibration will not interrupt the grounding circuit. Insulated sections of pipe should be bypassed with a No. 6 bond wire (after consultation with the property owner) to maintain common grounding of the interior piping section.

7.09 In addition, it is required that the protector ground, power ground and interior metal water piping ***always*** be bonded together. Do not use a gas pipe as the grounding electrode for a protector.

7.10 Where the elements of the grounding system exist at the premises, the selection of protector ground and the required bonding, covered in Fig. 7 to 14, will result in the best choice of ground and all of the necessary bonding.

7.11 Where the elements of the grounding system do not exist, it is still essential that power and telephone grounds be common and bonded to interior water piping even though unacceptable as an electrode. Where the power service is other than MGN and is grounded to a ground rod, it is not permissible to ground the protector directly to the power. In this case a separate telephone ground must be used and bonded to the power as shown in Fig. 12.

7.12 Grounded metallic structures (such as buried tanks, pipes, conduits and building steel) may be used for protector grounds when such structures will provide a better ground than a driven electrode. If the electric service is grounded to a buried metallic structure, the telephone protector ground should also be connected to the same structure. Also make sure there is a bond to the interior water pipe.

7.13 Where none of the previously described grounding electrodes is available, standard ground rods must be used for grounding station protectors.

8. BONDING OF POWER AND TELEPHONE GROUNDS

8.01 The procedures outlined in paragraphs 7.06 through 7.13 are intended to accomplish common grounding of power and telephone protection at the subscriber station. Wherever the situation results in separate grounds, the following arrangements must be followed:

(a) Special environmental protection is required for cable serving power stations or power switchyards. (Refer to Section 876-310-100 for complete information on protection in this hostile environment.)

(b) If an acceptable public or private water system is available and the power service is grounded to a driven electrode, the telephone protector ground must be connected in accordance with Fig. 10.

(c) Where power and telephone grounds are connected to separate rods, they must be commonly bonded together. If structural conditions make it impractical to run wire for the entire distance between rods, a metallic pipe of a cold water system (which is not likely to be disconnected or rearranged) may be used as part of the bonding run, although the pipe may not be acceptable for grounding station protectors. Building steel may also be used as part of the bonding run. In such cases, both the power and telephone ground rods must be bonded to the water pipe with a No. 6 wire. (See Fig. 12.)

(d) Where a power ground is not provided, the telephone protector must be grounded to an acceptable ground. A follow-up procedure must be established where the customer has the power grounded in accordance with the ***National Electric Code*** and then informs the telephone company when the ground is installed. The bond must then be placed by the telephone company.

8.02 To conform with recommendations of the ***National Electrical Code, 1978,*** a No. 6 copper wire should be used for bonding the telephone and power grounds. This is the minimum size wire having sufficient current-carrying capacity for practically all power fault conditions at subscriber stations.

8.03 Any grounding or bonding conductor which is run through a metallic conduit should be bonded to the conduit at both ends.

9. BONDING AND GROUNDING IN HIGH-RISE AND LOW-WIDE COMMERCIAL AND INDUSTRIAL BUILDINGS CONTAINING ELECTRONIC STATION EQUIPMENT

A. General

9.01 Current telephone company experience reveals low lightning trouble rates for telephone equipment in all types of tall buildings. However, in high-rise and low wide-area industrial or commercial buildings, the sensitivity of modern electronic equipment to surges that can appear on telephone cables and ground conductors indicates that improved and specific grounding methods are needed to avoid future problems with this equipment. Therefore, a universal set of recommended guidelines for telephone company use, applicable to these types of buildings, appears desirable. It is recommended that required bonding be specified on work prints by the engineer and not be left to the judgement of the construction forces. A positive statement such as, "provide bonding as shown" or "no bonding required" would ensure proper instruction to the construction forces. High-rise residential-type buildings do not appear to require any special grounding and bonding procedures beyond the standard practices presently used, because very little if any sensitive electronic equipment is used in these buildings.

9.02 A high-rise building is considered to be any multistory building, over three stories, of structural steel or reinforced concrete construction. A reinforced concrete building is equivalent, electrically, to a structural steel building. This equivalency results from the use of steel reinforcing bars that are wire-tied so that they will remain in place while concrete is poured. The low wide-area building is typified by the large shopping mall, factory, or warehouse.

B. Recommendations

9.03 To improve the bonding and grounding methods used in high-rise industrial and commercial buildings, and to minimize longitudinal potential differences at the interface between local equipment ground and the talking pairs, the following recommendations are made. A typical high-rise building floor is shown in Fig. 19 to illustrate application of these recommendations. A typical low-wide building is shown in Fig. 20.

9.04 ***Shielded riser cables*** should be used. These are now used in most buildings. If unshielded riser cables are used or if shield continuity cannot be assured, see paragraph 9.10.

9.05 ***Shield ground at entrance:*** The cable shield should be bonded to an approved ground at the point of entrance as now required in Section 631-460-102.

9.06 ***Shield continuity*** should be maintained over the entire cable length as now required in Section 631-460-102. If shielded house cables are used, continuity should be maintained between the house cable shield and the riser cable shield.

9.07 A suitable grounding terminal must be provided at the Building Entrance Facility (BEF) and in each equipment space and riser closet. This applies to both high-rise and low-wide buildings. The grounding terminal in the BEF must be on or as close to the protector as possible (if entrance is protected) and bonded to the entrance cable shield and protector grounding lug with a No. 6-gauge copper wire.

9.08 ***Shield ground on floors:*** The ***riser cable shield*** should be bonded to an approved floor ground, using a No. 6-gauge copper bond wire, at every point where the conductors enter or leave the shielded riser cable. Where pairs enter or leave the cable to feed more than one floor above or below the floor where the riser cable shield is grounded, an additional shield ground is required on the floor that is fed. If conductors do not enter or leave the cable on a floor, the cable shield does not require grounding on that floor. The connections from the shield to the approved floor ground must be done in the riser closet. The shield must be connected to the grounding terminal in the riser closet (paragraph 9.07) and the grounding terminal connected to one of the following approved floor grounds:

- Building steel
- Metallic water pipes
- Power feed metallic conduit supplying panel board(s) on the floor
- The grounding conductor for the secondary side of the power transformer feeding the floor. (If this option is selected, the connection to the grounding coductor should be made by a licensed electrician.)
- A grounding point specifically provided in the building for the purpose.

DANGER: If the approved ground (or approved floor ground) can only be accessed inside a dedicated power equipment room, then connections to this ground should be made by a licensed electrician.

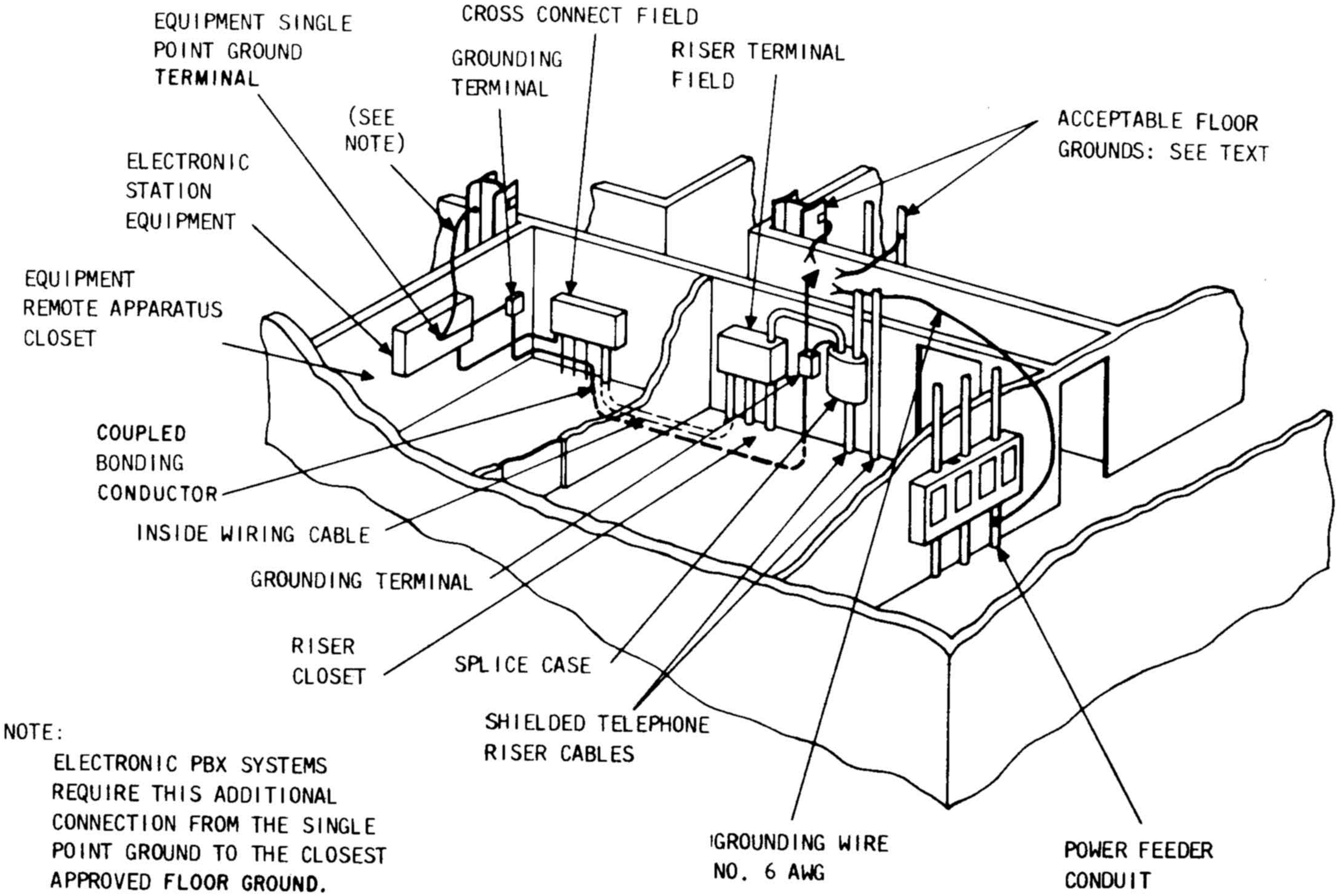

Fig. 19—Equipment Bonding—Typical High Rise Building Floor

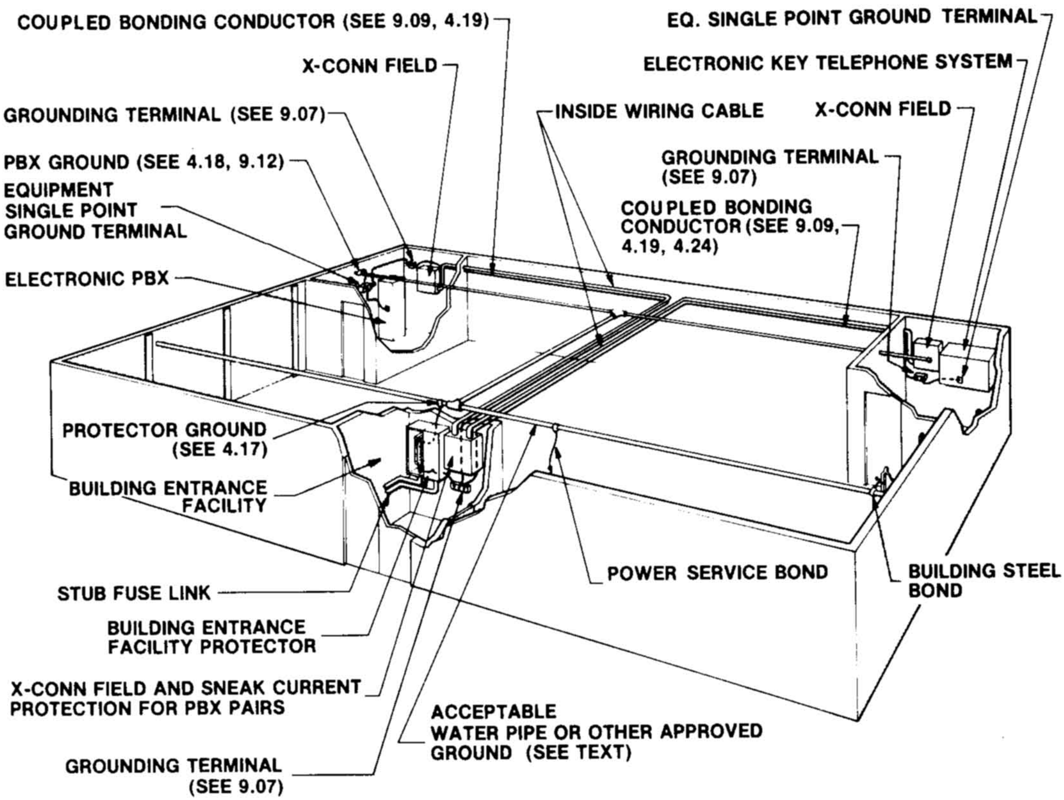

Fig. 20—Equipment Bonding—Typical Low-Wide Building

9.09 ***A coupled bonding conductor*** must be provided from the riser closet grounding terminal in a high-rise building or from the BEF grounding terminal in a low-wide building to each equipment room (remote apparatus closet) grounding terminal. This coupled bonding conductor can be any one of the following: (1) a 10-gauge copper wire, tie wrapped to the house cable from the riser closet or BEF (low-wide building) to each equipment room, (2) the shield of the house cable from the riser closet or BEF (low-wide building) to each equipment room provided that the house cable shield is continuous and constructed with permanent bonding hardware such as D-bond clamps and ***not*** temporary bonding hardware such as two B-Bond clips with a single 14-gauge appliance wire, (3) a minimum of six spares of 24-gauge copper wire.

9.10 ***Unshielded riser cables:*** If it is not economically feasible to use shielded riser cable, or if shield continuity cannot be assured, a No. 6-gauge copper ground riser should be run with each unshielded riser cable route. The effect of this ground riser is approximately equivalent to a cable shield. The ground riser should be grounded as if it were the cable shield in accordance with recommendations in paragraphs 9.05, 9.06, 9.07 and 9.08.

9.11 ***Riser location:*** Riser cables should be run as close as possible to vertical grounded conductors and in the central portion of the building. Lightning currents are minimal near the central portion of the building, and the mutual induction of the riser cable and vertical grounded conductors minimizes induced potentials on the talking pairs. Although the riser shaft locations are not under telephone company control, a choice may exist and the BIC should request a favorable riser cable route.

9.12 These bonding and grounding recommendations satisfy requirements for key telephone systems in high-rise and low-wide buildings. It should be noted that Electronic PBX systems require an additional connection from the equipment single-point ground terminal to an approved floor ground or an approved ground closest to the equipment as shown in Fig. 19 and 20.

10. REFERENCES

10.01 The following practices pertain to station and PBX protection:

SECTION	TITLE
201-202-101	Main Distributing Frames—Type of Protection
201-207-801	300-Type Connectors and Associated Protection Units Including 121-Type Protectors
460-100-400	Station Protection and Grounds
461-220-100	Mobile Home Wiring Permanent Type
461-220-101	Recreational Vehicle Wiring Nonpermanent Type
518-010-105	Key Telephone System—Grounding and Special Protection Requirements
553-100-210	Switching Cabinets and Consoles—J58849 (A, B) (MD) and (D, E)—Installation, Connections, and Installation Tests—Nonpackaged 800A PBX
553-100-211	Switching Cabinets and Consoles—Installations, Connections, Service Options, and Installation Tests—Packaged 800A PBX
553-201-200	Installation, Connection, Service Options and Installation Test—801A PBX
553-205-200	Switching Cabinet and Console—Identification, Installation, Connection, Service Option and Tests 805A PBX
553-212-200	Installation, Connectors, Service Options and Installation Tests 812A PBX
554-101-101	Dimension* PBX Customer Switching System 201S Preinstallation Information

SECTION	TITLE
631-400-102	Cable and Terminal Grounding in Subscriber's Buildings—General
636-300-100	300-Type Connectors—Description, Installation
636-320-100	Description, Installation, and Marking—302-Type Connectors
636-330-100	303-Type Connectors—Description
638-205-015	Fuse Cable Requirements
802-001-ZZZ	Protective Grounding Systems (see key-numbered sections for specific types of ground systems)
876-101-100	Electrical Protection Devices
876-101-130	Electrical Protection Grounding
876-210-100	Electrical Protection of Radio Stations
876-310-100	Electrical Protection of Wire Plant Communication Facilities Serving Power Stations
876-400-100	Electrical Protection—Cable
916-559-770	Cable Termination Facilities—Central Office Type-General

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10.02 The following additional references apply to PBX protection.

CPCN-135KY	(Customer Product Change Notice) PBX Systems, 801A PBX Class A Change, November 27, 1973
EL 876	800A PBX Protection and Grounding
EL 2047	800A Lightning Protection (Supplements EL 876)
EL 5393	PBX Systems—DIMENSION® 100 and 400 PBX's Revision in AC Power and Grounding Requirements
SBM 5301	Engineering Complaint Final Report 801A PBX Internal Grounding (available from BTL field representative)