GROUNDING AND SPECIAL PROTECTION REQUIREMENTS

DESCRIPTION

KEY TELEPHONE SYSTEMS

1. GENERAL

1.01 This section provides information on grounding and protection applicable to Key Telephone System (KTS) installations. It is intended to provide general background knowledge needed by the installer. More detailed coverage of related equipment and procedures can be found in the network protection practice, Section 460-100-400, Station Protection and Grounds.

1.02 This section is a complete revision and provides information that is more relevant to KTS service perople. It deletes certain information necessary only to the regulated telephone company. The Equipment Test List is not affected.

1.03 ***Glossary of Terms:*** The following terms listed are defined here with respect to their specific usage in this section.

(a) ***Ground:*** A conducting path, whether intentional or accidental, between an electric circuit or equipment and the earth or some conducting body that serves in place of the earth.

(b) ***Building Ground:*** An acceptable ground provided by the well-grounded structural steel of a building, a bare copper wire encased in a concrete building footing, or at least 20 feet of bare copper wire buried in the earth.

(c) ***Cold Water Pipe Ground:*** An acceptable ground provided by a continuous metal pipe with at least 10 feet buried in moist earth and carrying cold water into the building where the KTS is installed.

(d) ***Multigrounded Neutral (MGN) System:*** A power system in which the neutral conductor is continuously present along with the phase conductors and is grounded at least four times per mile.

(e) ***Circuit Ground:*** In KTS power supplies, the positive side of the dc output; the reference point for the negative output voltages and the return path for grounded signaling. Physically, it is the terminal labeled "LOC GRD," "GRD," or "G."

(f) ***Frame Ground:*** The path through which the frame, case, or chassis of the KTS power supply is connected to the commercial power service ground. The green wire of the power cord and/or the equipment grounding conductor of the branch circuit wiring establishes the path between the chassis and power service ground. Frame ground holds frame at near zero potential if ac power is accidentally shorted to power supply frame. ***Not*** the same as circuit ground.

(g) ***Coupled Bonding Conductor:*** A conductor that is connected to ground and run adjacent to pairs in an associated cable. The mutual coupling between the bonding conductor and the pairs reduces potential differences in terminating equipment. The conductor may consist of a cable shield, spare pairs of an inside wiring cable, or a wire tie-wrapped to the inside wiring cable.

(h) ***Single-Point Ground Terminal:*** A terminal provided with PBX and key systems. It is the only acceptable point for connection from the equipment to the external protection grounding system. The single-point ground terminal for key systems is called the power supply output circuit ground (local ground).

(i) ***Transient Voltage:*** A high-level voltage pulse of short duration and irregular waveshape induced into a telephone or power line by lightning or the switching of power loads.

(j) ***Surge Current:*** Sudden high current caused by a transient voltage.

(k) ***Potential:*** Voltage difference between two circuit points.

(l) ***Entrance Conduit:*** The conduit which carries the power service entrance cable into the building and terminates in the service entrance equipment which contains the means of power supply cutoff.

(m) ***Branch Conduit:*** The conduit which carries power distribution wiring from the service entrance box to points within the building.

(n) ***Potential Equalization:*** A means for maintaining two or more circuit points at approximately same potential; usually achieved by providing a single connection point for all circuits involved.

(o) ***High-Rise Building:*** A building over three stories high utilizing structural steel and/or reinforced concrete construction. Separate KTS installations may be located on any or all floors.

(p) ***Low-Wide Building:*** A building typified by the large shopping mall, factory, or warehouse. The key systems may be located remotely from the entrance facility protector, thus creating the need for paying special attention to grounding and bonding.

(q) ***Approved Floor Ground:*** A grounding medium on a floor of a high-rise building suitable for connection to the grounding terminal in the riser closet or to the single-point ground.

(r) ***Approved Ground:*** An acceptable grounding medium for grounding the building entrance protector, entrance cable shield, or single-point ground.

(s) ***Bonding:*** The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct any current likely to be imposed. Bonding provides equalization of potential between separate connections to ground.

(t) ***Building Entrance Facility (BEF):*** A space provided on the customer premises for termination of distribution cable. Station protectors are often located in the BEF.

(u) ***Equipment Closet:*** A space provided on the customer premises where telephone equipment such as PBX, key systems, and/or cross-connecting facilities are located.

(v) ***Protector Grounding Conductor:*** A wire that is run from the protector ground lug to an approved ground via the shortest and straightest route.

(w) ***Ground Riser:*** A No. 6 copper wire connected to ground and run as a coupled wire with a riser cable where the riser cable does not have a continuous metallic shield.

(x) ***Grounding Terminals:*** A suitable bar, bus, terminal strip, lug, or binding post to which grounding or bonding conductors can be connected. The 8A ground strip is frequently used in KTS installations.

2. BASIC PROTECTION REQUIREMENTS

2.01 Station protection is always required where the building is served by cable that is exposed to lightning or possible power contacts, ground potential rise, or induction more than 300 volts to ground. Protectors may also be required where the telephone cable is unexposed, but the building is exposed to lightning or the power serving the building is exposed to lightning. ***Therefore, all KTS installations shall be grounded and protected in accordance with this practice unless otherwise specified by local instructions.***

2.02 ***The KTS installations usually require station protection in lightning areas regardless of power exposure of the telephone plant.*** This condition is discussed in more detail in Part 3 of this practice. Briefly, however, the key station must be protected from the voltages that can be developed between any two ground points. These ground points include the KTS power supply ground, the commercial power ground, the station protection ground, and the CO or PBX ground. ***It is strongly recommended that protection of KTS lines always be considered in areas where thunderstorm activity can occur.*** The lack of such protection can result in damage to and failure of circuit pack and power supply components. A typical installation protected and grounded according to the requirements presented here is illustrated in Fig. 1.

2.03 This practice outlines grounding and protection arrangements that will satisfy the requirements for most installation situations. Illustrations of both good and poor grounding

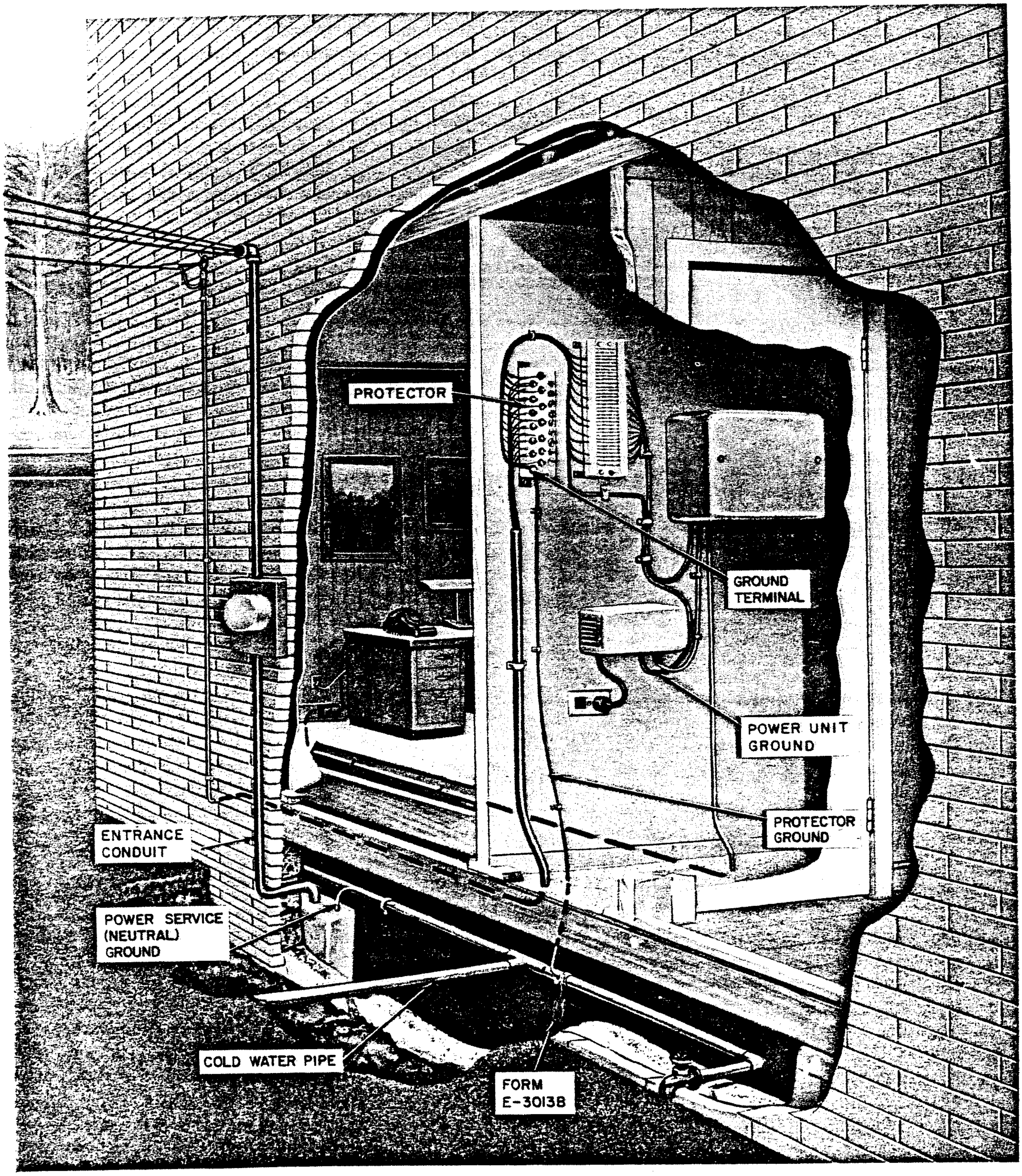


Fig. 1—Properly Grounded 1A2 Key Telephone System

methods are shown, but involved theoretical explanations have been avoided. Situations not adequately covered by this information should be referred to the responsible local supervisor or designated company representative.

2.04 ***High-Rise Buildings:*** The material in this practice applies equally well to KTS installations in high-rise buildings as it does to smaller structures. It is recognized, however, that special problems may be encountered in the location of satisfactory grounding points in high-rise buildings. Ideally, a specific telephone ground is provided on each floor during construction; this ground should be located and used. It is recommended that an 8A ground strip be used to extend the coupled bonding conductor at the building entrance facility and at the floor entrance facilities (Fig. 2).

2.05 ***Low-Wide Buildings:*** Low-wide buildings should also have coupled bonding conductors extended to all apparatus rooms from the building entrance facility. Use of the 8A ground strip is again recommended at all centralized KTS locations (Fig. 3).

2.06 A coupled bonding conductor must be provided from the riser closet grounding terminal in a high-rise building, or from the building entrance facility grounding terminal in a low-wide building, to each equipment closet grounding terminal by the regulated telephone company providing service. This coupled bonding conductor can be any one of the following:

(a) A No. 10 copper wire, tie-wrapped to the house cable from the riser closet or building entrance facility to the equipment room.

(b) The shield of the house cable from the riser closet or building entrance facility to each equipment room, provided that the house cable shield is continuous and constructed with permanent bonding hardware.

2.07 A single-point ground terminal should be provided for electronic station equipment. It is the only acceptable point for connecting the equipment to the external protection grounding system. To be consistent with PBX systems which may use the same cable, the single-point ground system should be connected to both the closest approved ground or the closest approved floor ground in a high-rise building and to the protector ground lug on the building entrance facility protector through the coupled bonding conductor. In low-wide buildings, the single-point ground is connected to the coupled bonding conductor which in turn is connected to the protector ground lug. If more than one protector is used, and if these protectors are separated by more than ten wire feet, each protector must be bonded to the telephone system and grounded independently to an approved ground.

2.08 These bonding and grounding recommendations satisfy requirements for KTSs in high-rise and low-wide buildings. This procedure is intended to accomplish common bonding and grounding of power and telephone at the subscriber station. Whenever the power and telephone grounds are connected to separate rods, they must be 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 may be used as part of the bonding run. Building steel may also be used. In both cases, the power and telephone must be bonded with a No. 6 copper wire. New construction very often uses plastic underground piping and existing metal systems are often repaired or replaced using plastic piping. Water pipe electrodes are no longer the first and only choice as a grounding electrode. In exposed areas do not install key telephone unit (KTU) equipment where the necessary station protection grounding cannot be provided (ie, if access to the water system or power ground is not possible and a ground rod cannot be driven). Advise the local supervisor or designated representative of the situation as soon as possible.

3. DESCRIPTION OF REQUIRED KTS PROTECTION

3.01 Improper protection of KTSs can result in station equipment damage that may require frequent visits to station locations for the purpose of replacing damaged line equipment, power supplies, lamps, and fuses. Damage of this type is usually caused by lightning or power-induced voltage transients. A good protection system can substantially reduce these problems.

3.02 A telephone station protection system consists of protection equipment and wiring that permits only relatively small voltage differences to develop between telephone equipment and other electrical equipment or grounded building fixtures when either lightning or power surge current is flowing.

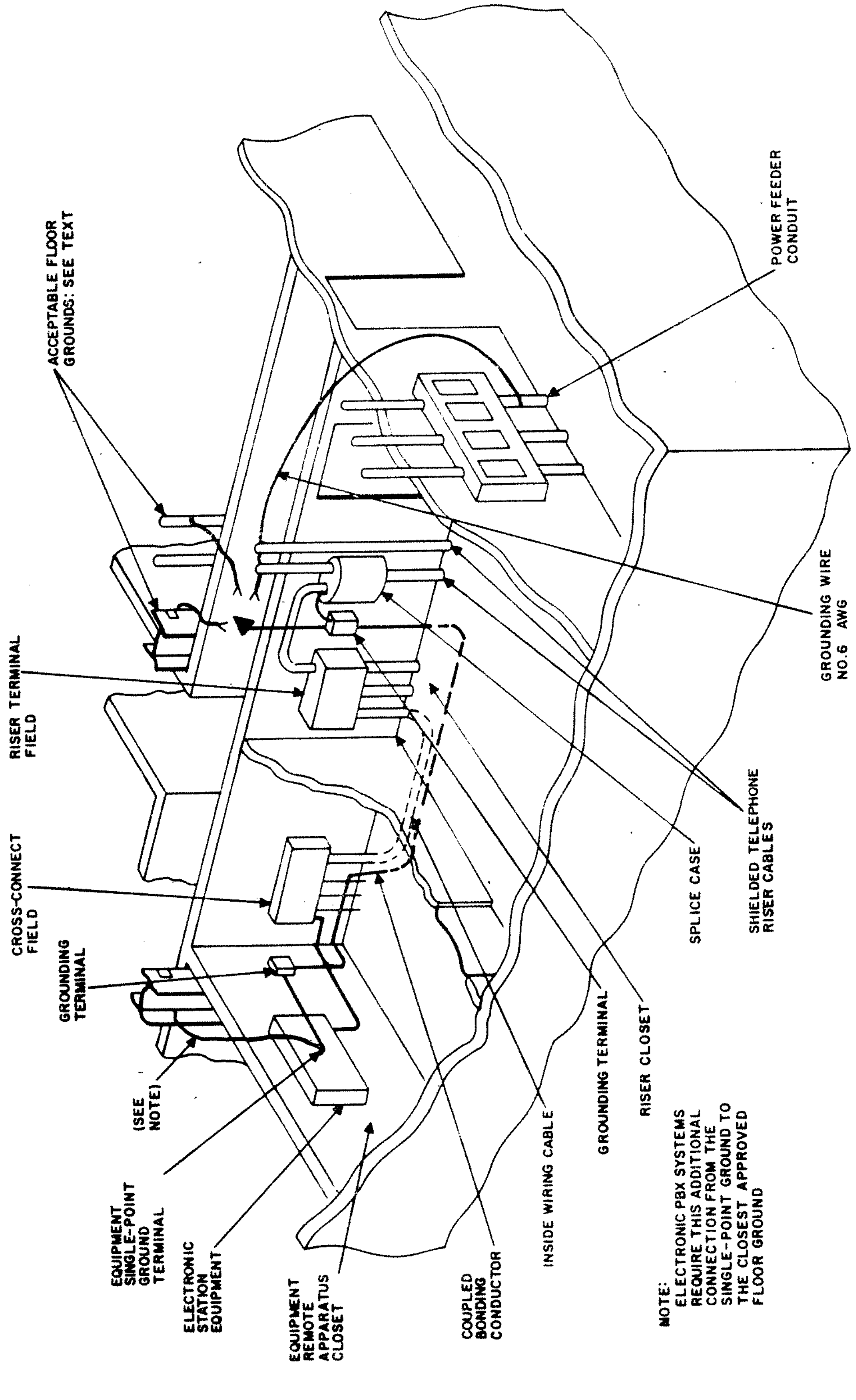


Fig. 2—Equipment Bonding—Typical High-Rise Building Floor

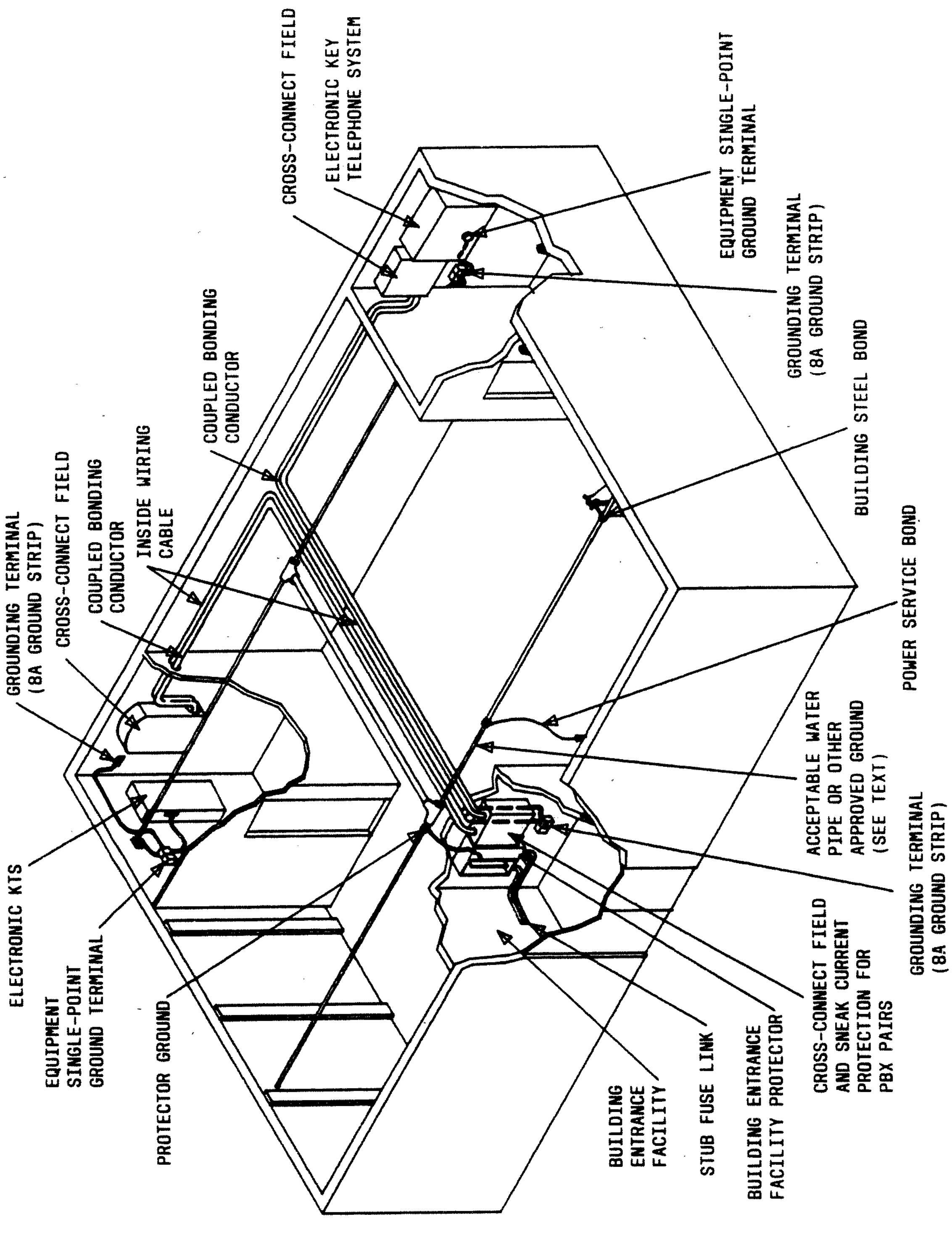


Fig. 3—Equipment Bonding—Typical Low-Wide Building

The primary danger of allowing high-voltage levels to develop between ground points is that current can arc across from one circuit to another if the potential difference becomes sufficiently high. This flow of current can damage equipment and possibly cause injury to persons in contact with the equipment.

3.03 The KTS protection usually consists of basic station protection (provided by the regulated telephone company) connected to an acceptable ground point and bonded to provide an equipment single-point ground. A typical KTS grounding arrangement that meets protection requirements if installed properly is illustrated in Fig. 4. Note that all grounded points are connected to the cold water pipe either directly or via a bond wire. Utilization of the same ground point limits the level of potential differences that can develop between system ground points. The water system was chosen as the system ground in the example of Fig. 4, but the common system ground could be building steel, footing ground, power service ground rod or telephone company ground rod, depending upon the local job situation.

3.04 In the following paragraphs, the various components and connections of the arrangement in Fig. 4 will be discussed in detail. The basic principles involved can be applied to most KTS installations.

GROUND SELECTION

3.05 The protector ground or the coupled bonding conductor serves as the primary KTS ground reference point. It is recommended in high-rise or low-wide buildings that the single-point ground be bonded to a local building ground to be consistent with requirements for electronic PBXs.

3.06 It may sometimes be difficult to decide whether a ground point is acceptable or not, and the installer will have to rely on his experience and judgment. In general, a ground point is ***unacceptable*** if it does not make good contact with earth ground. The definitions in paragraph 1.03 are a practical guide to selecting the right ground, in conjunction with the use of the flow chart. The following points must also be considered:

- No one type of grounding system (power service, cold water pipe, or building) should be regarded as basically superior to another.
- A metallic cold water pipe is acceptable ***only*** if it is known to meet the requirements of paragraph 1.03(c), Fig. 5, or Note 1.
- Plastic pipe is ***always unacceptable.*** Furthermore, even if the interior cold water pipe is metallic, it is possible that the buried service pipe is plastic.
- Insulating joints or sections are often installed in private water systems to reduce noise and vibration from pumps. They make metallic pipe ***useless*** for grounding unless they are bonded across to buried metallic pipe, or unless the pipe is bonded to another acceptable ground.

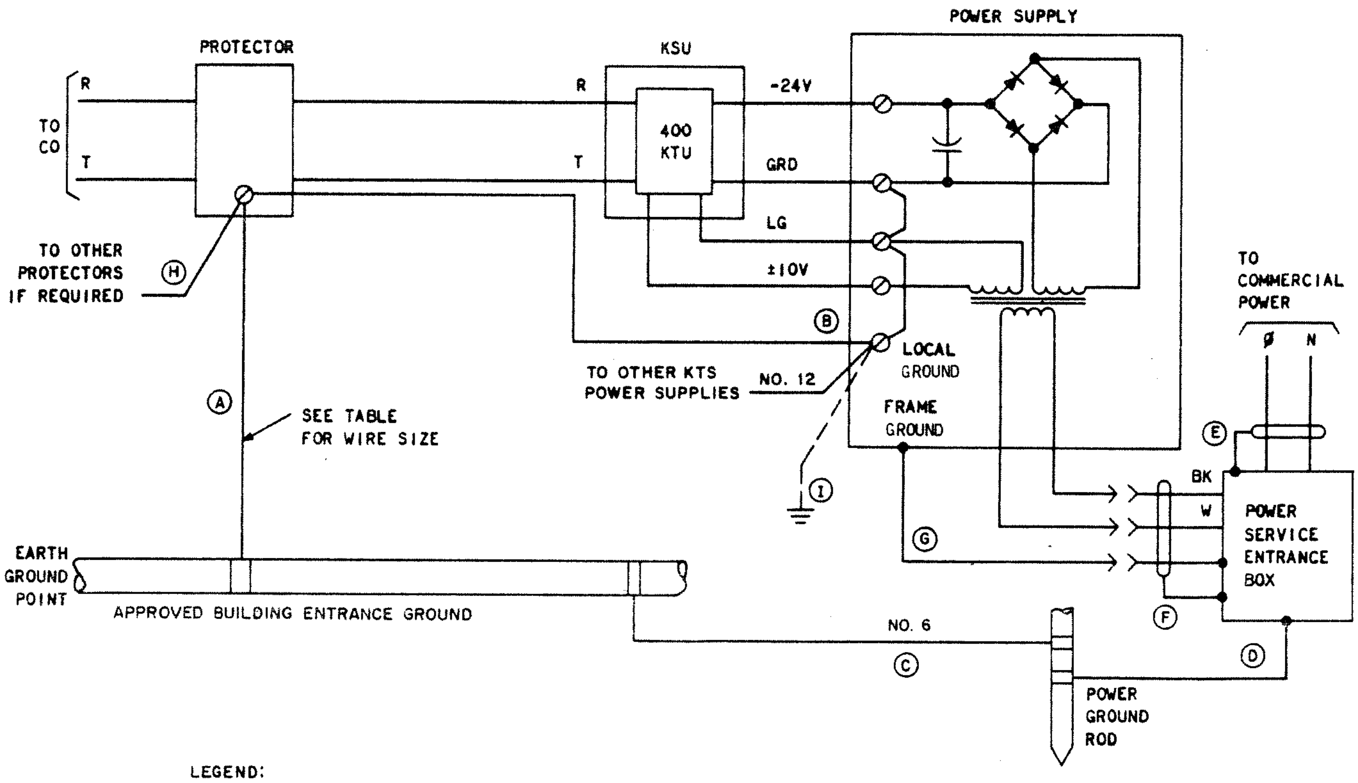
KTS POWER SUPPLY LOCAL GROUND (CIRCUIT GROUND)

3.07 The power supply output circuit (or local) ground must always be connected to the protector ground terminal. This connection (B in Fig. 4) provides a necessary ground for the power supply and also insures that the power supply and protector ground reference points will be at the same potential under all surge conditions. This is the coupled bonding conductor and should meet the specifications as described in paragraph 1.03(g). Where several power supplies are used, strap the ground terminal of each supply (with a 12-gauge wire) to the ground terminal of the one that is connected to the protector ground.

Never use branch electrical conduit (F) as the ground point for the power supply local ground (B). Branch conduit is totally unacceptable as a KTS ground because good electrical continuity usually cannot be guaranteed, the actual connection between the conduit and earth ground can be difficult to identify, and branch conduit runs usually involve unknown distances to ground.

Caution: Never modify the power supply plug by cutting off the ground prong to adapt it for use with a 2-conductor outlet.

3.08 ***Key Telephone System Power Supply Frame Ground:*** The case or framework of the power supply is normally grounded through the ac green wire circuit (G in Fig. 4). The green wire connects to the power service ground via the power supply cord, the ground prong of the power cord plug, and the mating connector of a 3-conductor power



LEGEND:

Ⓐ PROTECTOR GROUND (PRIMARY KTS GROUND)

Ⓑ POWER SUPPLY LOCAL GROUND (CIRCUIT GROUND) - PROVIDES FOR POTENTIAL EQUALIZATION BETWEEN TELEPHONE LINE AND POWER SUPPLY (COMMON BONDING CONDUCTOR)

Ⓒ GROUND WIRE BOND REQUIRED TO EQUALIZE KTS AND POWER SERVICE GROUNDS. THIS BOND MUST BE INSTALLED BY TELEPHONE COMPANY IF NOT ALREADY PROVIDED. BOND CAN BE CONNECTED, ON POWER SIDE, TO A DIFFERENT SERVICE GROUND POINT THAN SHOWN (EG, ANYWHERE ALONG GROUND WIRE Ⓓ OR TO SERVICE ENTRANCE CONDUIT Ⓔ)

Ⓓ POWER SERVICE GROUND WIRE

Ⓔ POWER SERVICE ENTRANCE CONDUIT

Ⓕ POWER SERVICE BRANCH CONDUIT - NOT ACCEPTABLE GROUND POINT FOR TELEPHONE EQUIPMENT

Ⓖ GREEN WIRE GROUND - CONNECTS FRAME GROUND OF POWER SUPPLY TO POWER SERVICE GROUND VIA GROUND PRONG IN 3-PRONG PLUG. NEVER CUT OFF GROUND PRONG TO FIT 2-PRONG OUTLET, USE ADAPTER DESCRIBED IN PARAGRAPH 3.07

Ⓗ BOND BETWEEN PROTECTORS. GROUND WIRE BETWEEN PROTECTORS SHOULD BE SAME SIZE AS GROUND WIRE Ⓐ

Ⓘ LOCAL BUILDING GROUND - NECESSARY IN HIGH-RISE OR LOW-WIDE BUILDINGS OR WHERE KTS AND PBX USE COMMON SINGLE-POINT GROUND

GROUND WIRE CAPACITY

SIZE	NO. OF PROTECTED CKTS	
	FUSELESS	FUSED
NO. 12	2	6
NO. 10	6	7
NO. 6	7 OR MORE	8 OR MORE

NOTE: WIRE BETWEEN PROTECTORS SHALL BE SAME SIZE AS WIRE BETWEEN PROTECTOR AND GROUND

Fig. 4—Typical Key Telephone System Grounding Arrangement

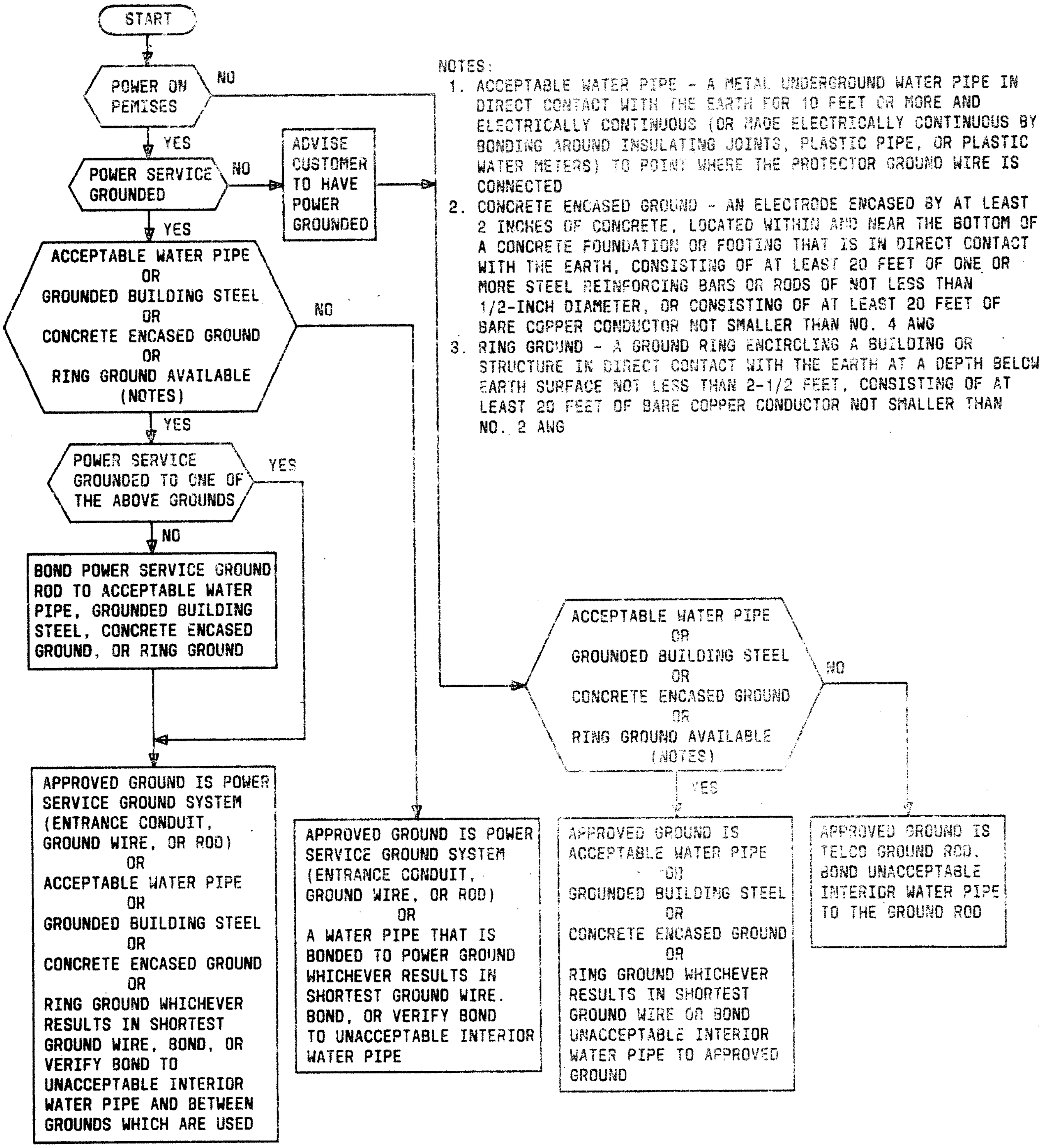


Fig. 5—Protector Ground Selection

outlet. If only a 2-conductor power outlet is available and the outlet box is known to be grounded, a Hubbell BL12433 adapter (or equivalent) may be used to match the 3-prong plug to the outlet. When the available power outlet box is not grounded, the framework ground of the power supply must be directly connected to the nearest acceptable system ground point through a 12-gauge, or larger, wire.

4. OPERATION OF A GOOD PROTECTION SYSTEM (Fig. 6)

4.01 The operation of a properly protected KTS can be described by considering what happens when a high-voltage transient enters a telephone line as a result of a lightning stroke.

4.02 A typical lightning surge entry into a telephone line associated with a properly protected KTS is shown in Fig. 6. The arrows show the directions in which current can flow from the entry point to earth ground. The path toward the CO is usually high impedance due to the cable length involved, and only a relatively small current flows in that direction. High-current levels do flow, however, toward the telephone station since the impedance is significantly lower. The current flows through the drop wire and across the carbon block air gaps to the water pipe. The current flow continues through the pipe system until the energy is finally dissipated into the earth.

4.03 Meter M1 (a symbolic way of showing the magnitude of the voltage difference between points) indicates that the voltage difference between the KTS protector ground and the power service ground is minimal; they are connected to the same water pipe. Therefore, since the KTS power supply ground is connected to the protector ground, the voltage between the power supply and the commercial power service is small, and the possibility of internal arcing between circuits is eliminated.

4.04 Meters M2 and M3 indicate that a small voltage difference, approximately equal to the firing voltage of the carbon blocks, does develop between the telephone line and both the KTS power supply and the commercial power service. However, its maximum peak is not high enough to cause arcing from one circuit to another.

5. KTS INSTALLATIONS EXPOSED TO SURGE DAMAGE DUE TO IMPROPER GROUND CONNECTIONS

PROTECTOR GROUNDED TO GROUND ROD (Fig. 7)

5.01 An installation similar to the one shown in Fig. 6 is illustrated in Fig. 7, except a ground rod rather than a water pipe, was provided as the protector ground, and there is no bonding between grounds in Fig. 7. The difference between these two installations might seem trivial at a glance, but a more detailed evaluation of the possible effects will demonstrate that a vast difference in protection capability can actually exist.

5.02 As was the case in Fig. 6, the protector blocks will operate and surge currents will flow toward earth ground by way of the protector ground. However, because the current must flow through the ground wire and ground rod, a high-voltage difference (possibly several kilovolts) can develop between the protector ground terminal and the water pipe system (meter M1). Since the line side of the protector is at approximately the same potential as the ground side while the carbon blocks are conducting, the telephone line potential (M2) above the power supply local ground (which is connected to the water pipe ground) will be almost the same as that indicated by M1. Meter M3 shows that the same potential difference also exists between the telephone line and the commercial power leads.

5.03 The arrows show how current can flow toward the water pipe ground if sufficient potential is present to arc from the telephone line to another circuit path. For example, an arc can develop between the telephone leads and the power supply leads on a 400-type KTU printed wiring board at about 2 kilovolts. Therefore, in the case illustrated by Fig. 7, KTU component damage is most likely to occur as a result of surge current flow from the telephone line to the power supply ground (cold water pipe) through KTU components.

5.04 A surge current that enters a poorly grounded circuit will seek a better ground path associated with adjacent circuitry if circuit paths are close enough together to permit an arc to develop. Therefore, it is extremely important that all system grounds be provided from the same ground source to minimize interaction between system grounds and reduce damaging potential differences.

5.05 Figure 7 also illustrates that an arc path can develop between the telephone set and nearby

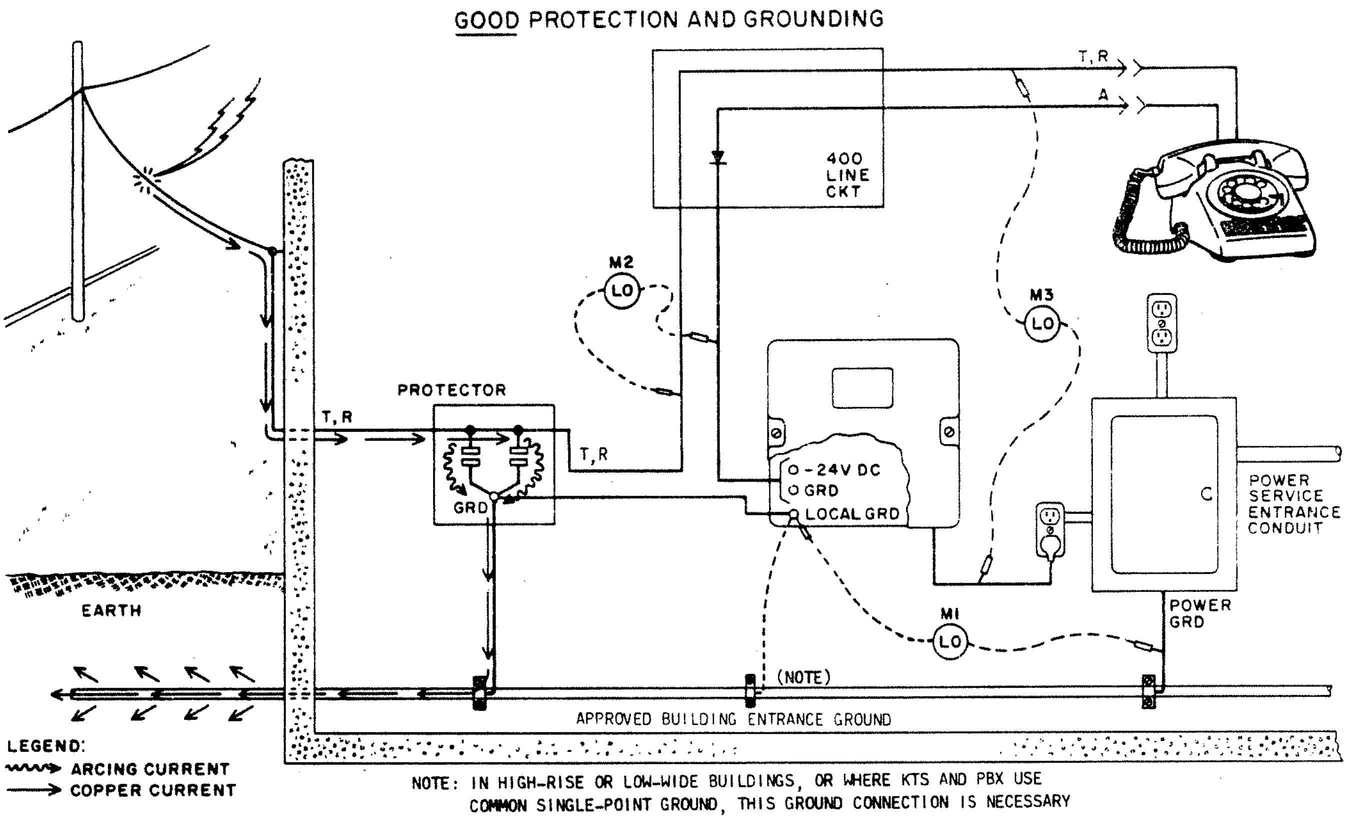


Fig. 6—All Grounds Bonded to Cold Water Pipe

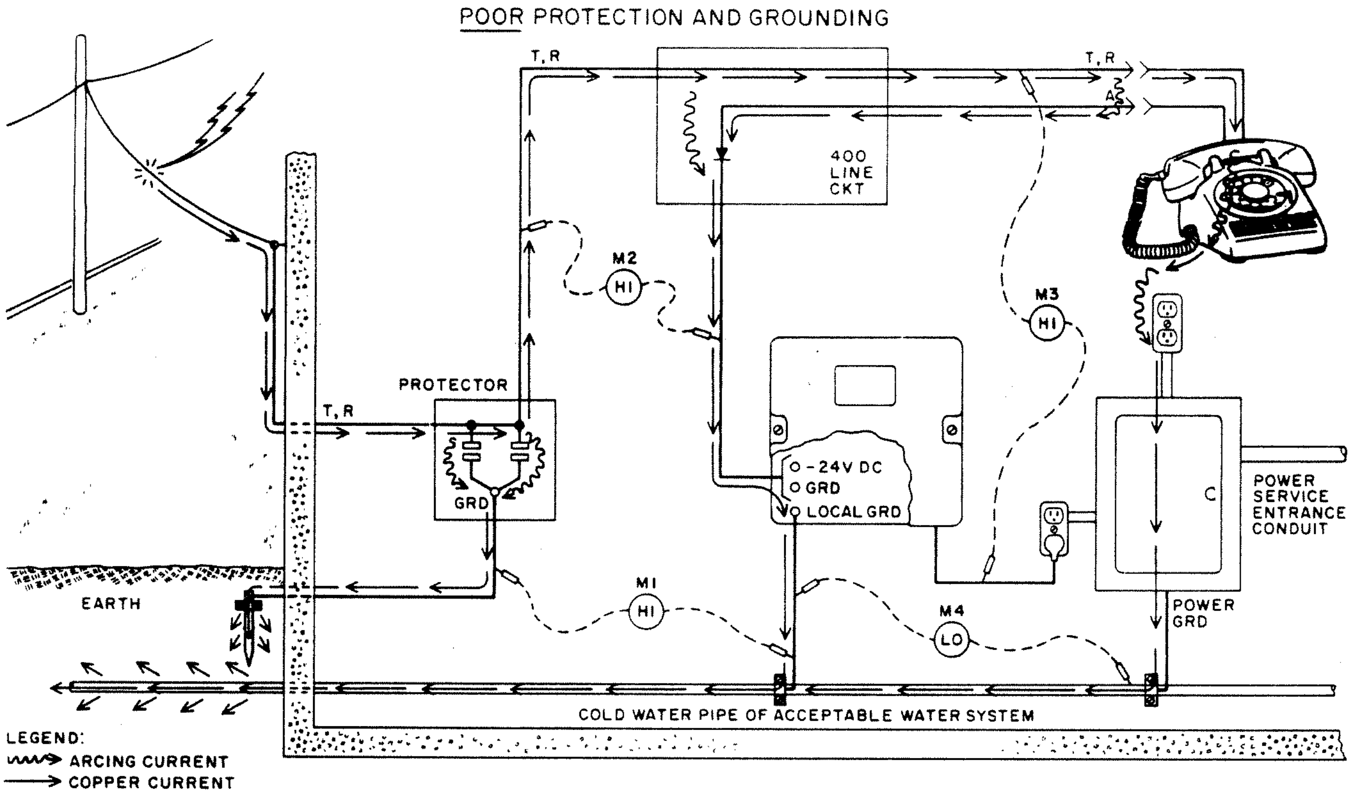


Fig. 7—Protector Ground Bonded to Ground Rod and KTS Power Supply and AC Power Grounds Bonded to Cold Water Pipe

electrical outlets or other grounded systems, resulting in damage to the set. Another vulnerable area in this arrangement is the telephone mounting cord connector, where arcing can occur from the T and R leads across to the A lead and back to the water pipe ground through the KTU and the power supply, resulting in KTU damage.

5.06 ***Protector and Power Supply Grounded to Ground Rod (Fig. 8):*** The grounding arrangement shown in Fig. 8 eliminates any possibility of arcing between the telephone line and the KTS because both the protector and the power supply are grounded to the same point. Meter M1 indicates that a peak voltage, approximately equal only to the carbon firing point, exists between the telephone line and the KTS equipment. However, a large potential can exist between the KTS and the commercial power system because the latter is connected to a different ground (M2 and M3).

OTHER COMBINATIONS OF KTS GROUNDS (Fig. 9 and 10)

5.07 Possible circuit arc paths can develop when more than a single type of ground is provided for the KTS. Figure 9, eg, illustrates another grounding arrangement that exposes the KTS equipment to possible damage from line surges. The water pipe ground that is shown connected to the power supply is a better ground (lower resistance) than the ground rod; therefore, some of the surge current in the telephone line will attempt to arc across local circuitry in order to discharge energy into the better ground.

5.08 A ground rod is used to ground all system points in the installation shown in Fig. 10. This diagram illustrates how a ground, which is not the best available, can offer system protection as long as all grounds are connected to this point. Note, however, that high-voltage levels can develop between this system and the local water system (meter M1) or with respect to local building steel. Arcing could occur from some part of this installation to a nearby water pipe.

5.09 ***Commercial Power Line Surges:*** Commercial power line surges can also cause KTU, lamp, and power supply damage. Some system damage can result when these high-level transient voltages are coupled through the KTS power supply by transformer action. However, equipment damage occurs more frequently as a result of the neutral wire being connected to a different ground than the KTS. The arc paths that develop are usually between the power wiring and the telephone line or between the primary and secondary windings of the power transformer.

6. SUMMARY OF REQUIREMENTS FOR ADEQUATE KTS PROTECTION AND GROUNDING

6.01 The following procedures summarize the basic minimum requirements for achieving adequate KTS protection and grounding.

(a) Items to be done by telephone installer are as follows:

(1) Route local ground wire over shortest possible path.

(2) Connect KTS power supply local ground to a grounding terminal (8A ground strip or equivalent) with a coupled bonding conductor.

(3) Be sure commercial power outlet has grounding-type receptacle.

(b) Items to be cared for by regulated telephone company providing service are as follows:

(1) Terminate all conductors of exposed entrance cables on station protectors. Ground the shields of unexposed entrance cables to an approved ground.

(2) Select best available system ground for protector ground connection (use flowchart in Fig. 5).

(3) Bond protector ground to power service ground if they are not the same.

(4) Provide terminal (8A ground strip) for coupled bonding conductor and bond it to approved ground.

6.02 The following procedures must be avoided when protecting a KTS installation:

(a) Do not use branch circuit conduit for ground.

(b) Do not use sprinkler system, gas, or hot water pipes for ground.

(c) Do not splice ground wire more than once.

(d) Do not connect power supply circuit ground and frame ground together.

(e) Do not cut off the ground prong on the power supply plug.

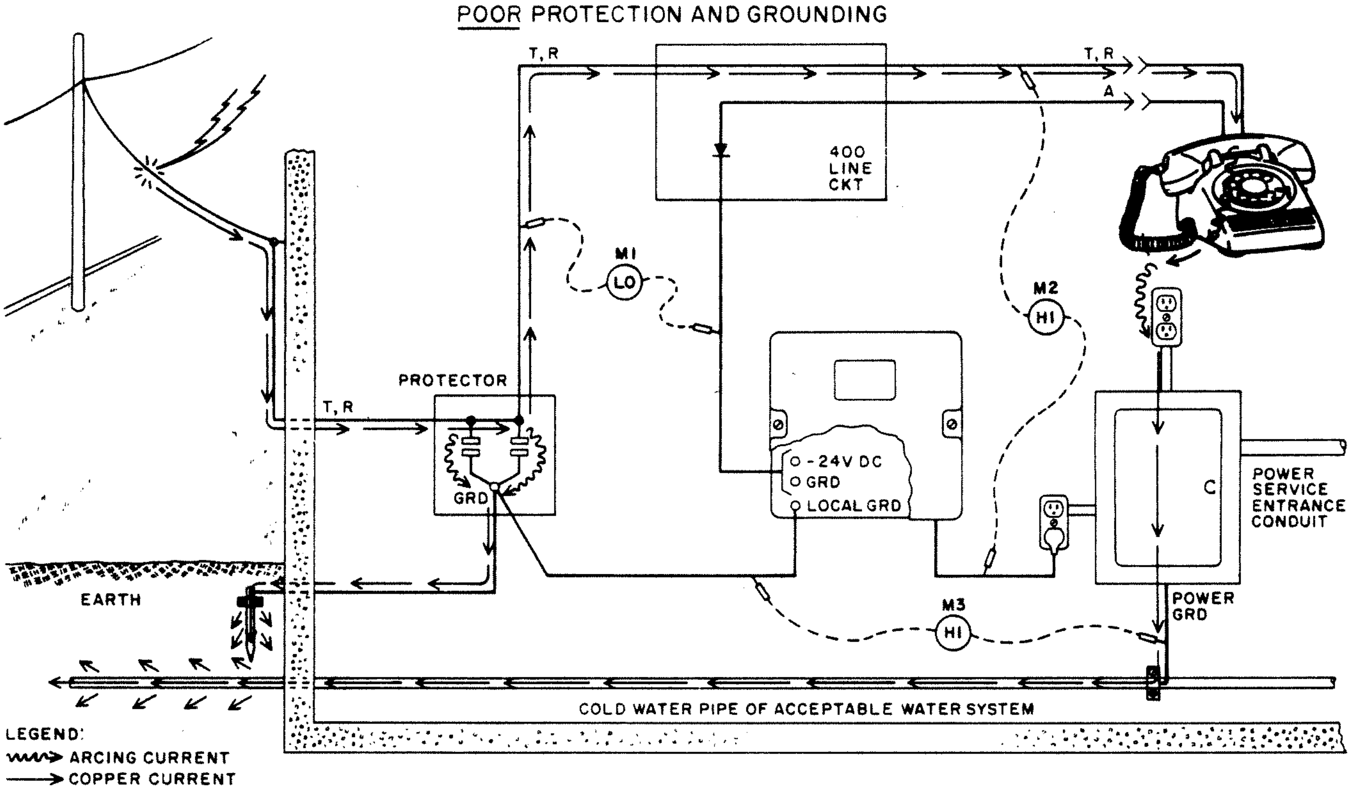


Fig. 8—Protector and KTS Power Supply Grounds Bonded to Ground Rod and AC Power Ground Bonded to Cold Water Pipe

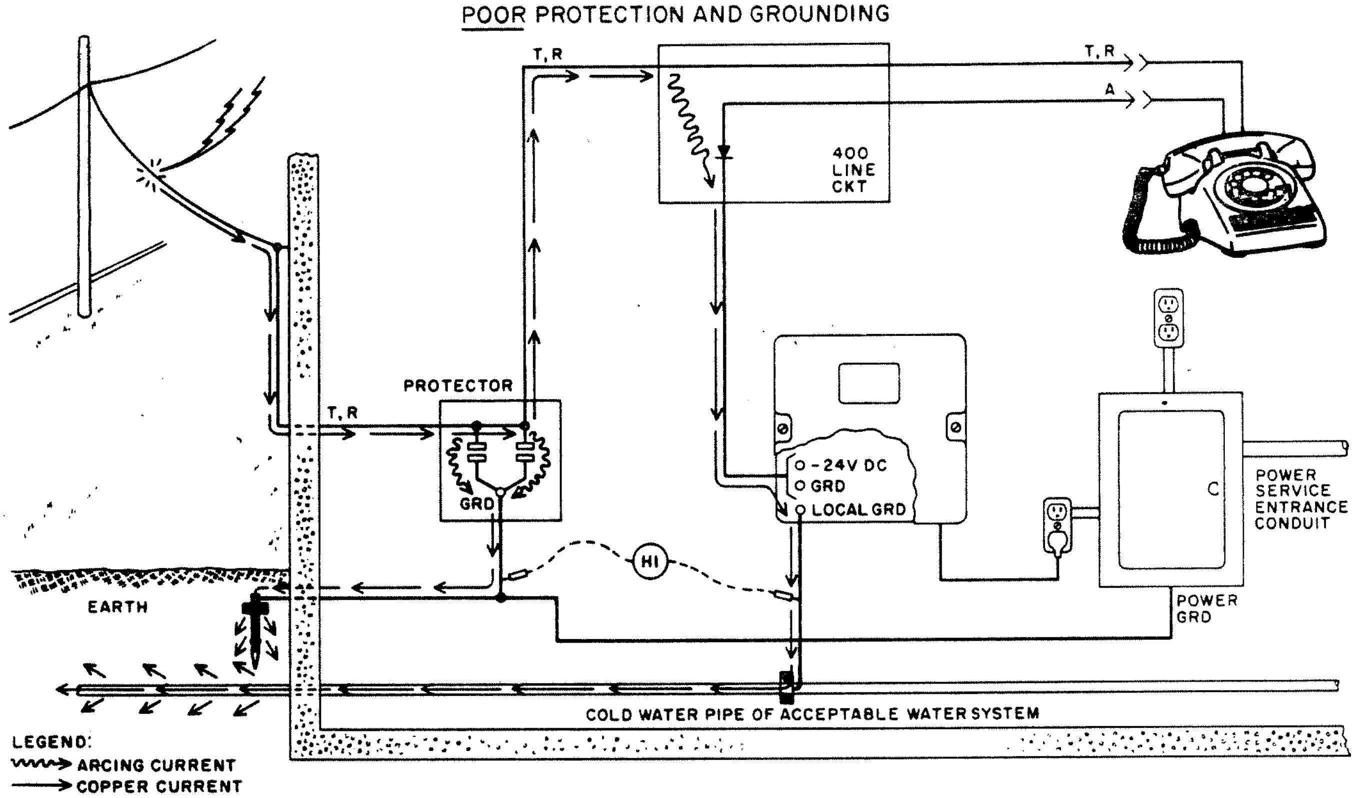


Fig. 9—Protector and AC Power Grounds Bonded to Ground Rod and KTS Power Supply Ground Bonded to Cold Water Pipe

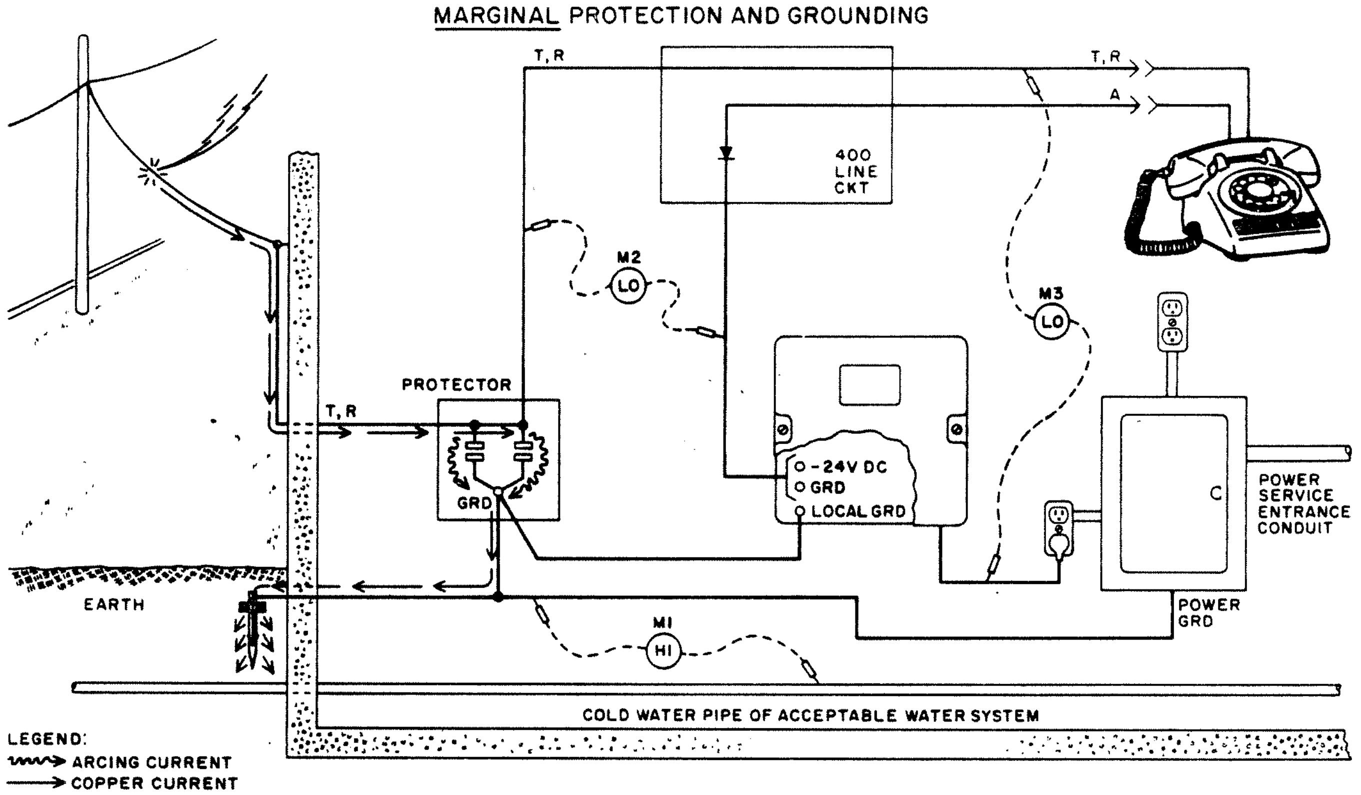


Fig. 10—All Grounds Bonded to Ground Rod