ASSEMBLY AND INSTALLATION OF POWER PLANT BUS BAR AND WIRING GENERAL EQUIPMENT REQUIREMENTS POWER SYSTEMS

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1. GENERAL

SCOPE

1.01 This section covers the general equipment requirements for the assembly and installation of bus bars and cable and wire.

1.02 This section has been reissued to revise information concerning bus bar connections and to remove the requirements for the assembly and installation of cable rack, conduit, and auxiliary framing which is now covered in Section 802-005-181. Since this reissue covers a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 The requirements covered in this section shall be followed except as modified by applicable specifications and drawings.

DEFINITIONS

1.04 ***Quiet*** conductors are those classified generally as talking, dc filament, and plate. They require no spacing from each other.

1.05 ***Talking*** conductors are those carrying talking current on the quiet side of a filter or those on which some other means has been provided for making them quiet, such as the running of separate conductors to which quiet circuits only are connected.

1.06 ***Filament*** conductors are those carrying direct current to filament circuits.

1.07 ***Plate*** conductors are those carrying current to plate circuits.

1.08 ***Telegraph*** conductors are those carrying current to telegraph or teletypewriter equipment.

1.09 ***Signal*** conductors are battery discharge conductors except telegraph and conductors classified as quiet.

1.10 ***Signaling*** conductors include those classified generally as telegraph, signal, ringing, and tone, and require no spacing from each other. For the purpose of this section, leads carrying ac filament supply shall be classified as signaling.

1.11 ***Charge*** conductors are those between the charging units and the battery or the point at which discharge conductors connect.

Note: Emergency cell and common charge and discharge conductors are classified as charge conductors.

1.12 ***Discharge*** conductors are those connected to carry discharge current from the battery.

Note: CEMF cell, electrolytic-capacitor, and inductor conductors in the discharge circuit are classed as discharge conductors.

1.13 ***Pairing*** means running the conductors of opposite polarity of a given circuit close together (but not necessarily twisted) so that the interlinking magnetic fluxes from currents in opposite directions neutralize each other and reduce impedance. Three conductors (ground, 24 volts, and 48 volts) are considered paired if run close together. Bus bars are considered paired if run on 3-inch centers, or as close as the plant equipment arrangements permit, not to exceed 6-1/2 inch centers for laminated bus bars.

1.14 ***Singly run*** conductors are those not paired with a conductor carrying current in the opposite direction.

1.15 ***Accessible for inspection,*** as applied to joints, terminals, taps, connectors, etc, means so located that they may be reached by hand to feel their temperature without disturbing wires, cables, or equipment. Ladders may be used and doors or covers may be removed if necessary. If equipment is found to be overheating, it shall be possible to get at it for tightening by wedging up or moving other cables, if necessary, without interrupting service. In general this will mean that joints in cables will be located at the sides or on an uncovered top layer of a bank of cables, unless otherwise specified or approved by the telephone company.

1.16 ***Sleeves*** are frequently used to conduct and protect cables passing through walls or floors. For convenience conduit nipples or short lengths of conduit, or smooth iron pipe free from burrs, or fiber duct may be used. Sleeves are not subject to rules covering conduits which are raceways from one point to another and may or may not go through walls or floors on the way.

1.17 In this specification the terms ***service*** leads or bus bars are used to designate bus bars, wires, or cables connected to outside power service or to a local engine-alternator set wherever such bus bars, wires, or cables are run in the telephone power plant or for frame lighting and outlet wiring, etc, in a central office. Note that this usage is broader than the technical National Electrical Code usage, where "service leads" terminate at the building service panel from which "feeders" and "branch circuits" are run to telephone power plants, lighting panels, and electrical equipment generally.

Code Requirements

1.18 The power plant installation shall meet any special requirements of local authorities, and the wiring (service leads) and equipment connected directly to the outside power service and the emergency alternator set shall also meet the requirements of the National Electrical Code.

> ***Note:*** To meet National Electrical Code requirements it is not ordinarily necessary for the installer to refer to the Code on work covered by instructions. Reference should be made to the Code on work not covered by instructions when equipment or wiring connected to the outside power service or to the emergency alternator set is involved, and it is, of course, desirable that the installer be familiar with the Code in all cases.

1.19 Before or upon completion of the power work, the Western Electric Company shall ascertain from the telephone company whether inspection by the city or underwriters of the emergency alternator set and of the wiring and equipment connected directly to the outside power service is desired; if so, such inspection shall be requested by the telephone company or, at their direction, by the installer. Any certificates of approval received by the installer shall be turned over to the telephone company. This does not include wiring, machines, batteries, etc, to which the telephone circuits are connected, since they are classed as signaling equipment under the Code and do not require approval of inspectors.

2. WIRING METHODS

Telephone Leads

2.01 ***In the charge circuit,*** pair the conductors, extending the pairing as nearly as practicable to their termination. This is to neutralize noise so it will not spread to other conductors.

2.02 ***In the discharge circuit,*** pair the battery conductors with their respective ground conductors, extending the pairing as nearly as practicable to their termination.

2.03 ***Arrange talking conductors*** so that the positive and negative leads alternate in both horizontal and vertical rows, as shown in Fig. 20.

2.04 ***Signal conductors*** need be paired only in one direction, either horizontally or vertically.

2.05 ***Run the plate lead*** from the control panel to the equipment fuseboard with the filament ground leads whenever practicable, in order to pair the plate and the filament ground.

2.06 ***Pair electrolytic capacitor leads*** to each capacitor.

2.07 ***Pair leads when run in conduit*** whenever possible.

2.08 ***Minimum separation*** requirements for conductors are covered in Table A. It is not always possible to meet these requirements at the rear of panels, particularly as regards alarm leads and bus bars, but they should be followed on as much of the run as practicable.

2.09 ***Space unpaired charge and unpaired talk, filament, and plate conductors on the rear of panels*** as far from each other as practicable and in no case run leads in the same cable form.

2.10 ***Leads enclosed*** and paired in iron conduit or armored cable, or lead-covered cable with the sheath grounded at both ends (except ringing and tone leads in armored cable, which are covered in Table A), need not be separated from other conductors similarly enclosed or run open.

2.11 ***For ringing, signaling, and tone leads*** see 4.30 through 4.32.

2.12 ***Space leads from 84-type interrupters*** at least 3 inches from talking, filament, or repeater plate leads. Space leads to the battery side of the interrupter supply filter at least 3 inches from the leads to the other side.

TABLE A

MINIMUM SEPARATION OF CONDUCTORS RUN OPENLY (See 2.05 through 2.15.)

TYPE OF CONDUCTOR	CHARGE – PAIRED	CHARGE – UNPAIRED	RINGING OR TONE – ARMORED	TALK, DC FILAMENT – PAIRED (SEE NOTE 4)	TALK, DC FILAMENT – UNPAIRED (SEE NOTE4)	SIGNAL – PAIRED	SIGNAL – UNPAIRED	PLATE	PROGRAM TRANSMISSION EQUIPMENT
Charge — Paired	0	0	0	3″ (see note 2)	3″ (see note 1)	0	3″	3″	10′0″
Charge — Unpaired	0	0	0	3″ (see note 1)	As far as possible (5′0″ min.) (see 2.09)	3″	5′0″ if distance of exposure exceeds 10′0″ (see 2.09)	5′0″ if distance of exposure exceeds 10′0″ (see 2.09)	10′0″
Ringing or Tone — Armored	0	0	0	3″	3″	0	0	0	3′0″
Talk, Filament — Paired (see note 3)	3″ (see note 2)	3″ (see note 1)	3″	0	0	3″ (see 2.10 and note 2)	3″ (see 2.10 and note 1)	0 (see 2.05)	3′0″
Talk, Filament — Unpaired (see note 3)	3″ (see note 1)	As far as possible (5′0″ min.) (see 2.09)	3″	0	0	3″ (see 2.10 and note 1)	As far as possible (5′0″ min.)	0 (see 2.05)	10′0″
Signal — Paired	0	3″	0	3″ (see 2.10 and note 2)	3″ (see 2.10 and note 1)	0	0	0	10′0″
Signal — Unpaired	3″	5′0″ if distance of exposure exceeds 10′0″ (see 2.09)	0	3″ (see 2.10 and note 1)	As far as possible (5′0″ min.)	0	0	As far as possible (5′0″ min.)	10′0″
Plate	3″	5′0″ if distance of exposure exceeds 10′0″ (see 2.09)	0	0 (see 2.05)	0 (see 2.05)	0	As far as possible (5′0″ min.)	0	3′0″
Program Transmission Equipment	10′0″	10′0″	3′0″	3′0″	10′0″	10′0″	10′0″	3′0″	0

Notes

1. Six-inch separation if exposure is more than 50 feet.
2. Six-inch separation if exposure is more than 300 feet; except that when 1200-ampere, 65-volt, or 1500-ampere, 33-volt sets are used, the 6-inch separation shall apply above 100 feet.
3. The discharge leads from the battery to the point of separation of quiet and signal current are considered talk, filament, or plate leads in offices having no power filter. In offices having filters, regardless of whether the filter is common or decentralized, the discharge leads from the battery to the filter are considered signal leads.
4. See 4.30 through 4.32 for ringing and tone leads.

2.13 ***When it is necessary to cross signaling and quiet leads,*** they may touch at the point of crossing, but the crossing should be made at right angles as nearly as the bending radii of the cables will permit.

2.14 ***Run charge conductors and discharge conductors*** in separate conduit when conduit is used, except as covered in note 3 to Table A.

2.15 ***Run telegraph and teletypewriter discharge conductors*** in armored cable from the battery control board to the fuse panel, regardless of whether these leads are telegraph or combined telegraph and plate. In newer offices where quiet battery supplies are derived from decentralized filters, it is permissible to omit the armor or shielding formerly used with telegraph and teletypewriter discharge conductors on the same rack with other discharge conductors supplied from the same source.

2.16 The common charge and discharge conductors are no longer used in new standard power plants. Part 6 provides reference on additions to old offices.

2.17 The following spacings shall be maintained between power leads and program transmission equipment, whether in conduit or open, and regardless of walls or floors, except for leads specifically feeding such equipment.

(a) Charge, signal, telegraph, unpaired talk or unpaired filament, and plate leads shall be 10 feet 0 inch.

(b) Paired talk, paired filament leads, and plate, if run with paired filament leads shall be 3 feet 0 inch.

Power Service Leads

2.18 Run all of the service leads in the same conduit or armored cable if possible; otherwise, each lead shall be divided into two or more equal-size and approximately equal-length smaller leads and run as two or more separate systems. Any one conduit shall contain at least one of each of the service leads, except that 2-phase, 4-wire systems may be run as two single-phase systems.

2.19 When a grounded service lead is carried through to the power apparatus (such as in single-phase circuits with one lead grounded), the grounded neutral lead shall be white, and the first "live" lead shall be black. For 4-wire circuits, the grounded conductor insulation shall be white and the live conductors, black, red, and blue or by a distinctive marking at terminals during the process of installation. The equipment grounding conductor shall be identified by a green color.

2.20 Standard polarity connections for leads attached to receptacles or plug caps are shown on drawing ED-91181-01. When the device is equipped with a white (nickel- or zinc-plated) terminal, the grounded leg (white wire), where used, shall be connected to this terminal. On 2-pole parallel-polarized and the new 3-pole parallel-polarized grounding-type devices, the white terminal corresponds to the wide slot or blade; on 2-pole radial-polarized devices it is the radial slot or blade. Three-pole devices used for framework grounding are of two types. On the new parallel-polarized grounding type, the "U" slot of the receptacle is internally connected to the mounting bridge, and the long "U" blade of the cap is provided with a green hexagonal head screw for connection of the green conductor in the cord. On the angular-polarized design, the radial slot is connected to the bridge, and the green conductor is connected to the long radial blade. On receptacles of this type, the grounded leg is connected to the terminal adjacent in a clockwise direction (when facing the slots) to the radial slot. This terminal is usually identified by copper plating. The plug cap is wired to match, in the reverse direction, when facing the blades. With 4-pole devices the radial grounding terminal is opposite to the white grounded neutral terminal.

3. BUS BARS

3.01 Tin or silver plated aluminum and copper bus bars should be used where the total temperature (ambient plus rise) of connections does not exceed 70°C. Unplated aluminum or copper bus bars may be used where the total connection temperature does not exceed 70°C. Lead-plated bus bars shall be used in battery connections. The voltage drop across a joint should not exceed 1.1 times an equal length of bar.

3.02 Bus bar supports consist of epoxy glass or phenolic insulators with metal inserts, which are supported by auxiliary framing or other details and which in turn support the bus bar. Typical

support arrangements are shown in Fig. 1 through 9.

3.03 Bus bars shall be supported on 6-foot 0-inch maximum, centers.

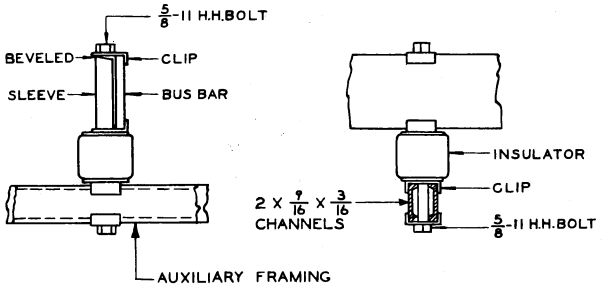


Fig. 1—Bus Bar Support—One Bus Bar

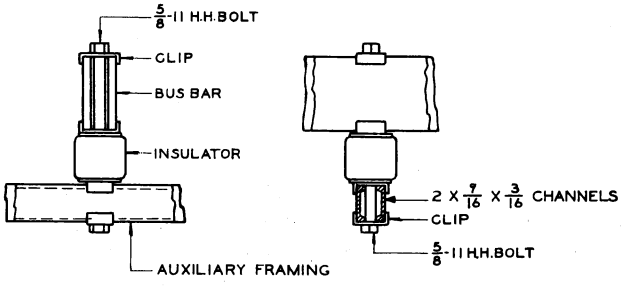


Fig. 2—Bus Bar Support—Two Bus Bars

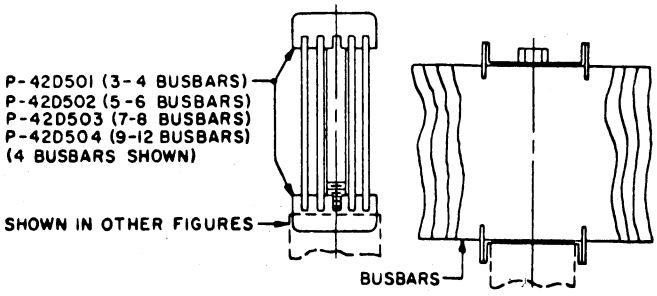


Fig. 3—Bus Bar Supports—Three to Twelve Bus Bars

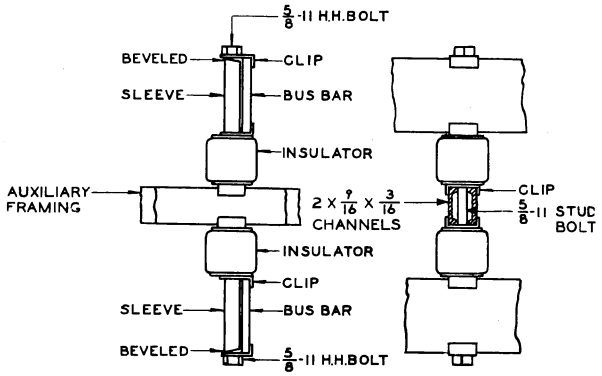


Fig. 4—Bus Bar Support—Double-level Bus Bar

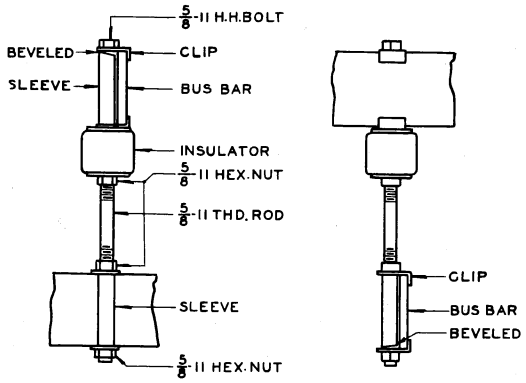


Fig. 5—Bus Bar Support—One Bus Bar from Another

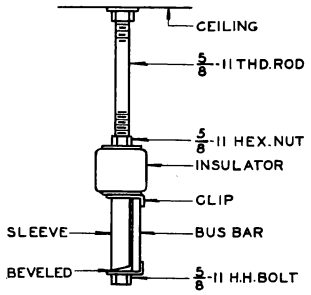


Fig. 6—Bus Bar Support from Ceiling—One Bus Bar

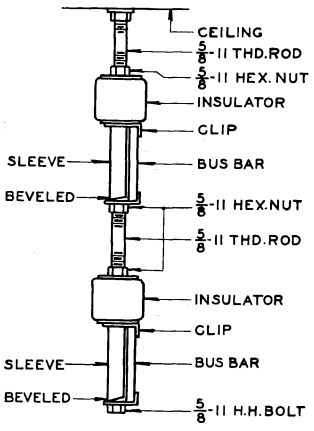


Fig. 7—Bus Bar Support from Ceiling—Two Levels

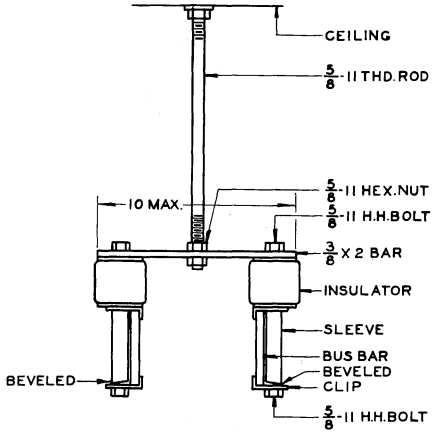


Fig. 8—Bus Bar Support from Ceiling—Same Level

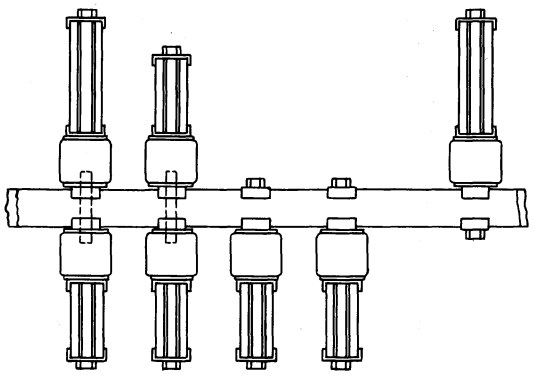


Fig. 9—Typical Bus Bar Support Arrangements

3.04 Clips, sleeves, bolts, nuts, etc, are used to support up to two bars. Supporting 1/4-inch thick bars on 1/2-inch centers with three to twelve laminations, refer to Fig. 3.

3.05 Place supports as close to right-angle bends and risers as practicable.

Clearance

3.06 Bus bars should maintain a spacing of at least 3 inches from metal pipes, cable racks, auxiliary framing, etc, where this spacing can be obtained without excessive expense. If practicable, this clearance should be increased to 1 foot 0 inch, and in no case should it be less than 1/2 inch for voltages up to 125 and 3/4 inch for voltages between 125 and 250 to ground. Allow 7 foot 0 inch clearance over passageways, sufficient clearance over open-tank batteries for removal of plates, and sufficient clearance over cells on stands for maintenance.

3.07 Bus bar joints are made either with clamps or with bolted connections. Bolted joints are ordinarily used with the smaller details on the rear of power boards and for copper bars forming parts of most shop-built assemblies. Typical clamp joints are shown in Fig. 10 through 13. At joints, the minimum overlap of bus bars is the width of the bus bar. Malleable iron clamps with corrosion protective finish shall be used on all bus-bar connections where clamp-type connectors are permitted. Bronze clamps are permitted on copper to copper and aluminum on aluminum to aluminum. Aluminum bars shall not be tapped for fastening lugs. Use through bolts or clamp joints.

3.08 To compensate for the offset in the bars, caused by the lap joint, place alternate bars in any run in the same direction in line. Joints in horizontal bus runs shall not be made at the point of attachment of risers from the generator panel.

3.09 Ferrous bolts, screws, nuts, washers, bus-bar supports, and clips in fastening aluminum to aluminum, copper to copper, or combinations of metals shall be zinc- or cadmium-plated plus a chromate treatment except where lead-coated or lead-encased details are used in battery room. Zinc or cadmium finished parts are standard; however, copper finished parts may be used when furnished.

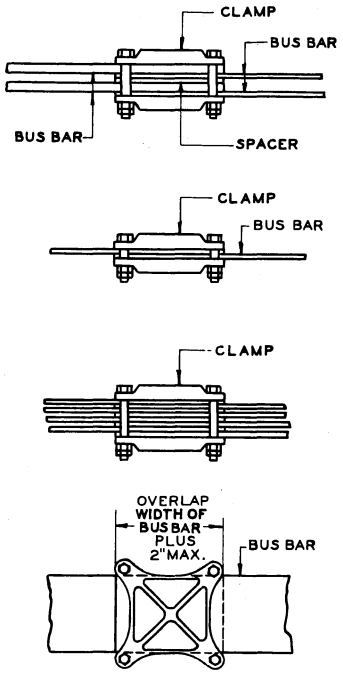


Fig. 10—Bus Bar Splice Joints

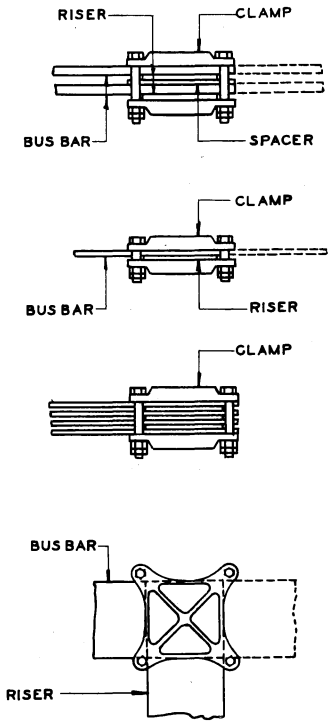


Fig. 12—Bus Bar Riser Joints

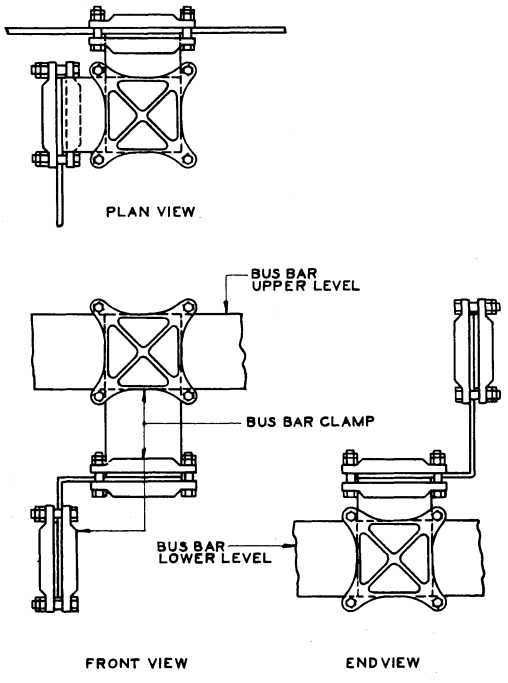


Fig. 11—Typical Bus Bar Connections with Intermediate Clamp

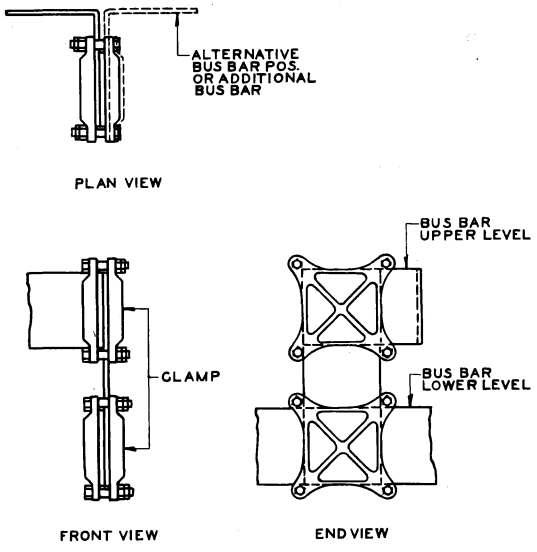


Fig. 13—Typical Bus Bar Connections

3.10 All contact surfaces of current-carrying connections shall be clean so that metal-to-metal contact is maintained. A coating of NO-OX-ID "A" or "A Special" (Dearborn Chemical) or Alcoa No. 2 inhibitor compound shall be applied immediately after cleaning contact surfaces. See 3.10(e) for aluminum. If required, use petroleum spirits to remove dirt and grease from contact area prior to treatment noted in the following:

(a) When copper or copper-alloy contact surfaces require cleaning, sandpaper, abrasive cloth, or KS-16736 compound may be used. Remove dust or residue of compound.

(b) Threads of studs or nuts need not be cleaned unless corroded or excessively dirty.

(c) Parts having an added metallic coating shall be cleaned to remove dust or residue, but coating should not be scratched. Coat with NO-OX-ID "A" or "A Special" or Alcoa No. 2.

(d) For protecting ground contact surfaces not normally carrying current, such as in grounding of racks, see Sections 800-614-154 and 802-001-180.

(e) Aluminum contact surfaces should be cleaned (dry) with wire brush, sandpaper, or abrasive cloth to remove the hard oxide insulating coating. Then immediately apply a coat of NO-OX-ID "A" or "A Special" or Alcoa No. 2 and use a wire brush to break up any new oxide that has reformed and reapply coating of inhibitor compound. Clamp the connections together without removing the inhibitor.

Taping—General

3.11 The purpose of taping is to prevent accidental contact by operating personnel with live higher-voltage bus bars or terminals, and to prevent short circuits of live parts by tools during maintenance. The following instructions are considered to cover good practice for usual conditions and shall be followed unless otherwise specified. They are not intended to prevent issue of special instructions for any particular equipment where greater protection is considered desirable.

3.12 If friction tape is used, follow with one coat of shellac on the outer layer; if bias-cut varnished-cloth tape is used, apply two coats of shellac. Plastic tape KS-14090, without shellac, can be substituted for friction tape except on power service voltages or where the taping will be subject to pressure or heat. Apply tape approximately half overlapped; when terminals are taped, extend the tape at least 1/2 inch along the cable.

3.13 Whenever shellac over tape is specified, it is permissible to use one of the authorized substitutes. Gray friction tape, if available, should be used in preference to black on gray cable or lead-covered cable.

3.14 No taping is required when fiber details or other insulation or guards are provided to protect live parts. Grounded neutral bus bars of power services or other grounded bus bars or equipment are not taped except under special conditions as outlined later under 3.18(d).

Taping Power Service Bus Bars

3.15 Tape all exposed live power service bus bars with two layers of varnished cloth tape and apply two coats of shellac. Tape all other exposed live parts, including studs, nuts, etc, carrying service current at the rear of power boards or similar panels, except fuses and their associated mountings. Use either one layer each of rubber tape and friction tape, or two layers of varnished-cloth tape. With the general use of enclosed fuse cabinets in present-day offices there should be very little power service equipment requiring taping.

Taping Battery and Signaling Bus Bars

3.16 Tape exposed live battery bus bars, studs, nuts, etc, operating at over 150 volts to ground, to within 1/2 inch or less of panel, with two layers of friction tape followed by a coat of shellac, or with two layers of plastic tape KS-14090 without shellac.

3.17 In determining the voltage of equipment connected to storage batteries of the lead-acid type, for taping protection, the voltage may be taken as 2 volts per cell. For example, a 70-cell battery will be regarded as 140 volts, even though it may be floated at approximately 150 volts or slightly higher. It is believed that there will be very little equipment requiring taping under this heading, since high-voltage power equipment is usually enclosed.

3.18 Exposed live battery supply bus bars operating at 150 volts or less to ground shall be treated as below. When taping, use one layer of friction tape or plastic tape, and apply to within 1/2 inch or less of panel.

(a) On power boards, battery control panels, and on other panels lined up with the power board, tape is not required. On bus bars to and from storage batteries and to and from charging machines, tape is not required.

Note: On some older power boards, bus bars and equipment operating at less than 150 volts (usually 130 volts) were taped. In such cases the new bus bars shall also be taped.

(b) On open-type battery distributing fuse boards not in a power board line-up, live vertical bus bars, including horizontal extension to the first fuse post, and horizontal bus bars connecting bays shall be taped. Live terminals (such as choke coil terminals) and their connections, but not fuse posts and their connecting terminals, projecting more than 3 inches from the surface of a panel shall be taped.

(c) Laminated bars, where taping is required, may be taped collectively. Terminal lugs in a row on a bus bar may be taped collectively up to about three lugs in a group. Bus bars supported by fiber clamps need not be taped where they pass through the clamps.

(d) Grounded bus bars require no tape except on fuse panels or other locations not lined up with the power board, where the grounded bars are directly in the rear of fuse posts or other live equipment which must be worked on with maintenance tools. In such cases, taping that part of the grounded bar is necessary to eliminate the probability of short circuits.

4. CABLE AND WIRE

Type of Wire

4.01 In general, use KS-5482-01 cable for telephone power plants where AWG No. 14 or larger is required. Use multiconductor KS-5482-01 cable for color identified service circuits or single conductors, painted the proper color at both ends. Use KS-20747 for lighting and other applications where insulation is not subjected to mechanical stress.

4.02 The KS-20921 wire may be used where a more flexible wire is required. Electrical connections must be made with KS-21053 crimp connectors.

4.03 For applications requiring lead-covered cable, furnish single-braided or taped, lead-covered, 600-volt wire and cable. Unless otherwise specified, lead sheaths, except short lengths, shall be grounded in a manner similar to conduit (see Section 802-001-180).

4.04 Switchboard wire such as BH, or KS-13385 wire and cable are used when specified for control, alarm, signal, and miscellaneous leads. For installing methods refer to Section 800-614-152; for splicing methods refer to Section 800-612-158. Lead-covered cable shall be used in raceways and conduit in floor fills below street level, except the RW or RUW wire may be used in raceways if space conditions do not permit the use of lead-covered wire.

Continuity of Leads

4.05 Run all leads in continuous lengths where practicable. If necessary on long runs, in order to utilize lengths of cables effectively, one or two splices per run may be made on horizontal cables when the joint is not stressed by nearby vertical runs. Such splices should be made by National split tinned copper connectors (splicing sleeves made by National Telephone Supply Company) or equivalent, soldered and taped with rubber and friction tape. Cables may be tapped by means of solderless cable taps. Solderless connections should be accessible for inspection and tightening (see 1.15).

4.06 Dress braided rubber-covered or varnished-cloth (varnished cambric) cables so that the radii of any bends outside of conduit fittings shall not be less than the following:

AWG OR CM SIZE OF WIRE OR CABLE	MINIMUM RADIUS TO INSIDE EDGE – INCHES RUBBER-COVERED	VARNISHED-CLOTH
14 Stranded	1/8	
14 Solid	1/4	3/4
12-10 incl Str or Solid	1/2	1
8-4 incl	1	1-3/4
2-0 incl	1-1/2	2-3/8
00-0000 incl	3-1/2	4
300,000-500,000 CM, incl	5	5-5/8
600,000-800,000 CM, incl	7	7

4.07 The minimum bending radius of lead-covered cables, measured on the inner bend of the cable, is ten times the diameter.

Splicing, Joining, and Connecting Leads

4.08 Any splices required in leads run in conduit shall be made in fittings, pull boxes, or at other accessible points.

4.09 Splices in wires should be made as follows.

(a) No. 10 AWG and smaller wires carrying current from power service grounding circuits should be spliced with approved solderless or crimp connectors when the connection is in a conduit fitting or in a wire-way.

(b) Where wire nuts will cause excessive congestion in small fittings the wires shall be soldered. Wires should be twisted and soldered to maintain a minimum of 1-1/4 turns, then taped with one layer of rubber splicing compound half overlapped and one layer of friction tape half overlapped.

(c) Make splices (except on long runs as discussed in 4.05) or taps, in all leads No. 8 AWG and larger, with approved crimp or solderless cable taps or connectors, such as KS-5537, if available. This also applies to lead sizes No. 10, 12, and 14, tapped from leads No. 8 or 6.

4.10 Copper and tin-plated aluminum crimp-type and copper alloy solderless connectors shall be installed in accordance with the following after removing dirt with petroleum spirits if necessary. A coating of NO-OX-ID "A" or "A Special" or Alcoa No. 2 compound shall be applied to all unplated copper or aluminum contact surfaces following copper surface preparation per paragraph 3.10(a) and aluminum surface preparation per paragraph 3.10(e).

(a) Connectors, if of the solderless type, shall be of the proper size to fit the cables and shall be tightened to give a secure grip on the cable. The exposed end of the lead shall extend approximately 1/8 inch (1/16 inch in small sizes) beyond the clamping plate or screw of solderless connector or barrel of crimp-type connectors. Crimp-type connectors per KS-15977 shall be applied to cable with the mechanical tool per KS-15976 or the hydraulic tool per KS-19961 and KS-19964. When commercial type crimp connectors are used, the tool shall be of the same manufacture as the connectors or the connectors shall be approved by the tool vendor for use with the tool. The commercial tool shall be properly maintained and operated in accordance with the tool vendors instructions. Satisfactory crimps on commercial connectors shall be determined by conformance of crimp deformations to tool vendor's specifications if available or by checking die dimension conformance. The crimp or crimps shall be made on the indicated markings when provided and in all cases shall be so located to provide full width of crimp or crimps on the inserted wire. When an inhibitor compound is applied to contact surfaces, exercise care to minimize inhibitor compound coming in contact with cable insulation. If the conductors are insulated and no connector covers are provided, the joints or splices shall be taped with rubber tape and friction tape to a thickness at least as great as the respective insulation on the leads. A coat of shellac shall be applied over the tape.

(b) Where cable taps with composition covers are so located that they may be pressed against a sharp grounded surface such as the edge of an auxiliary framing bar or parts of a cable rack, cover the metallic structure under the connector with fiber to a thickness of 1/32 inch or more, or provide other suitable protection to prevent injury to the insulating cover.

(c) Solderless connectors and terminal lugs shall be checked, and if necessary, tightened, toward the end of the installation period. Periodic checks and tightening is required, especially when connections are subjected to cycling half to full load conditions.

4.11 Make all lead connections to switch studs, fuse studs, circuit breaker studs, shunt studs, etc, by clamping terminals between nuts on the studs. Where stud length permits, space should be left between the nuts clamping the terminal and the nut securing the stud to the panel, to permit tightening the latter nut. See 3.10 for cleaning.

4.12 Crimp-type tin plated aluminum and solderless terminal lugs, where connected directly to battery and alkaline type CEMF cell studs, shall be attached to the cable and then immersed in one of the following compounds to a minimum distance of about 1/2 inch above the end of the lead insulation:

Clear varnish (See Section 802-007-180.)

Light-gray paint (See Section 802-007-180.)

The clear varnish is preferred. Clean the contact surfaces thoroughly and coat with an inhibitor compound (NO-OX-ID). After the lug is fastened in place, recoat the exposed surfaces around the terminal post to insure that no surface remains unprotected.

4.13 Terminate leads at solder lug terminals as follows:

(a) Only one size 14 AWG and larger lead should be soldered in a terminal lug unless designed to take more than one conductor. An exception may be made on the large ringing and tone-interrupter brush holders, where two leads may be terminated or a tap may be made under the table.

(b) At switchboard-type solder terminals, with notches, holes, or clamping ears, it is sometimes necessary that power service wires be made mechanically secure before soldering, and under some conditions this is also true on nonservice wires such as grounding wires. When, and only when, it is specified that connections be made mechanically secure before soldering, or that connections be per ED-80872-01, it shall be accomplished by looping the wire around the terminal or by bending it back and clamping the insulation as shown in Fig. 14 through 19. The methods shown in Fig. 14 through 19 should not be used on telephone-type relays, resistors, and capacitors mounted in rectifiers, or in telephone power plants where Underwriters' Laboratories requirements for mechanically secure connections before soldering do not apply.

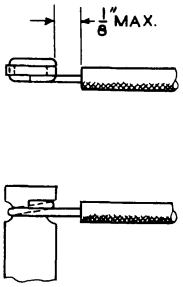


Fig. 14—Single- or Double-Notched Terminals (double notch shown)

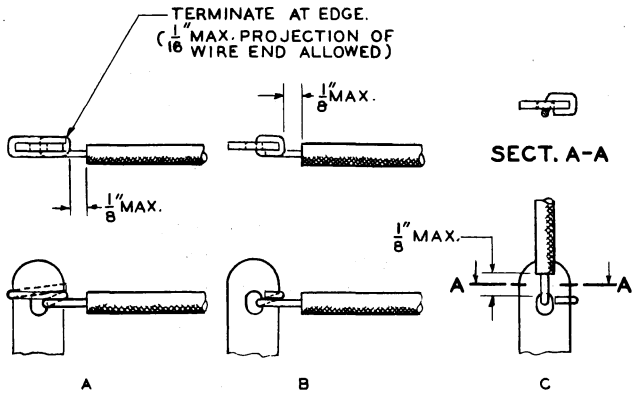


Fig. 15—Drilled or Punched Terminals (optional arrangements)

4.14 Lugs or punchings may be omitted when apparatus has connecting points designed to connect directly to wires without lugs or punchings. Power devices frequently provide such terminals up to No. 8 solid wire as maximum.

Leads on Cable Racks

4.15 Unfused battery leads and their accompanying ground leads such as those between the

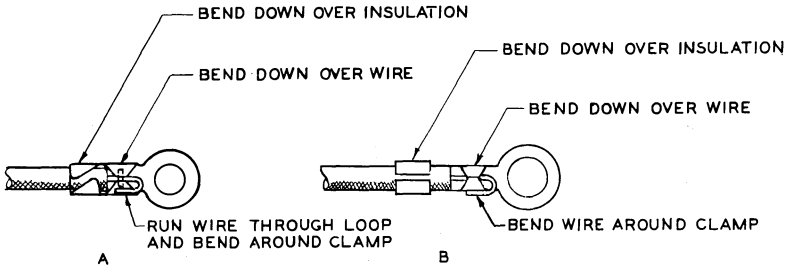


Fig. 16—Terminals with Two Clamps (F. R. Zierick- or H. B. Sherman-type terminal)

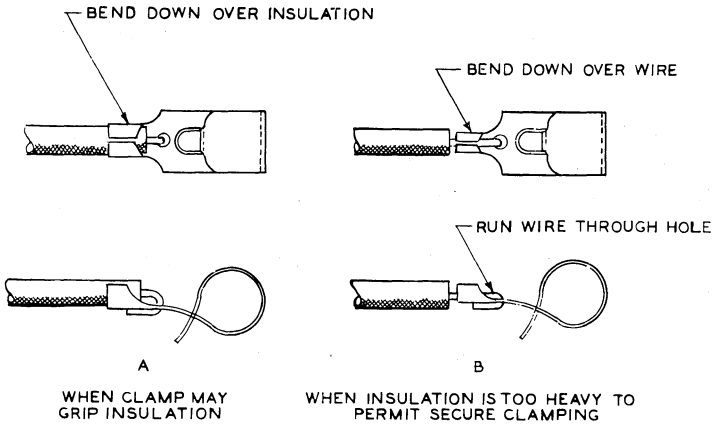
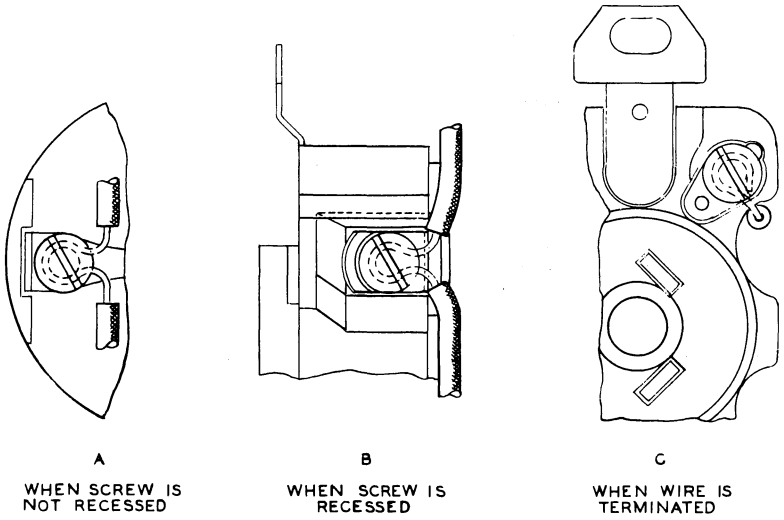


Fig. 17—Terminals with One Clamp (National Grid Clip shown)

batteries and battery control boards shall not be run on a rack with any other conductors. Other power leads may be run on a cable rack with switchboard-type cables. On new installations it will generally be desirable to run the power leads either on a separate rack, or below, or on either side of the switchboard-type cable. On additions to existing installations, however, it is satisfactory to run the additional power cables above the switchboard-type cable already installed. Paired talking power cables on a cable rack are shown in Fig. 20. For pairing of leads see Part 2. For accessibility of connections see 1.15. For methods of securing leads to cable racks refer to Section 800-614-152.

4.16 Vertical runs should preferably be carried on cable racks through slots in the floor fastened in accordance with the general equipment requirements for leads on cable racks. The rack may be spiraled to permit taking off leads at different levels.



Note: The lead should come in at left and continue around clockwise at least 270 degrees to the right but should not cross over itself. An upturned lug or confined space adjacent to the terminal screw plus the looping of the lead should be sufficient to prevent the lead from becoming disconnected if the terminal screw should come loose. Fig. 18 joints need not be soldered unless specified.

Fig. 18—Screw Terminals

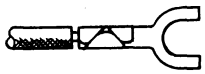


Fig. 19—Patton-MacGuyer-type Terminals—Approved Only when Applied to Wire by Attaching Machine which Crimps and Solders at Once

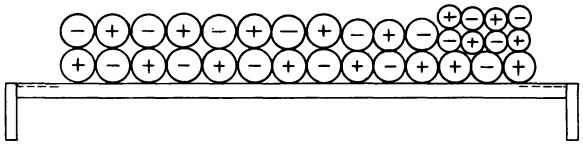


Fig. 20—Pairing of Talking Conductors on Cable Rack—Typical Section (See 2.03.)

Leads in Conduit or Ducts

4.17 Support leads in vertical conduit runs at the intervals listed below. Pull boxes shall be installed at the various points of support as determined by the largest-size lead, and all leads entering the pull box from below at this point shall be supported. Fit a Russell and Stoll or an O. Z. support or equivalent into the upper end of the conduit and use the inserts to hold the cable or cables in place.

SIZE OF LEAD	MAXIMUM VERTICAL DISTANCE BETWEEN SUPPORTS FOR COPPER (Feet)
No. 14-0	100
00-0000	80
250,000-350,000 CM	60
400,000-500,000 CM	50
550,000-750,000 CM	40
800,000 CM	35

4.18 Support leads in tile ducts at the intervals given above by Russell and Stoll, O. Z., or equivalent supports located in steel plates over the ducts.

Treatment of Leads at Power Panels

4.19 Repairs to damaged braid or refinishing for color may be done as follows.

(a) Frayed or torn braid may be repaired with butt lacquer or library paste. If badly damaged, the outer braid may be replaced with a piece of sound braid obtained from a cable of the same size, in accordance with Section 800-614-152. The finish on KS-5482-01 cables may be touched up with gray flameproof paint RM-645895 or with cable filler paint RM-644153.

(b) When the telephone company specifies that other-colored wire be painted gray, use gray flameproof paint RM-645895, which will generally give a good color match with KS-5482-01 cable by applying one coat, or use cable filler paint RM-644153, one or two coats as necessary. If the power cables have an appreciable coat of wax, first remove this with a cloth well moistened with KS-7860 petroleum spirits.

4.20 Lead-covered leads shall have the lead stripped to the edge of the power board or fuseboard, or if there is sufficient room, the sheath may extend along the framework uprights to the edge of the unit panel on which the leads terminate. Leads which have a braided insulation underneath the lead covering need not be painted. Leads which have a taped insulation under the lead covering shall be taped with one layer of friction tape and given one coat of shellac.

Supporting Leads at Power Panels

4.21 Form groups of small wires to be run for several feet of panels into cables, and sew unless distributing rings or wiring strips are provided.

4.22 For supporting cables along power board framework, use iron details or brackets or clips (Section 800-612-156). For supporting local cables against the power panel, use cable clamps (Section 800-612-156).

Ammeter Shunt Leads

4.23 Any excess in ammeter shunt leads after the shunt is in place shall be enclosed in a fiber tube (P-68235) or superimposed on existing wire forms on the rear of the power board in an unexposed place, preferably near the associated ammeter. If the leads are run on a cable rack, the excess length may be stored on the rack. ***Never cut ammeter shunt leads.***

Leads in Floor Fills

4.24 Power leads run in floor fills which are in contact with the earth or are below the street level and not over a drained excavation shall be lead-covered or neoprene-jacketed-type cable to eliminate the possibility of deterioration and short circuit by water. They shall be run in conduit or ducts.

Leads in Conduit or Sleeves

4.25 Where wire or cable, not lead covered, is run in conduit or sleeves passing through rooms having different atmospheric conditions which may result in excessive condensation of moisture, all openings to the conduit shall be sealed by packing first with oakum and then sealing with RM-641575 compound. Switchboard-type cable shall not be run in the same conduit with power service leads, unless this is specified in the engineering information.

Leads in Tile Ducts

4.26 Use lead-covered cable for leads in tile ducts, except for MDF ground leads, for which BRC cable is ordinarily required.

4.27 Use bushings for leads passing through wood or metal sections.

4.28 Use iron conduit or smooth pipe sleeves for both talk and signal leads through walls or floors where it is not feasible to extend the cable rack. Equip each end of the sleeve with a bushing. Seal if necessary per 4.25.

Leads at Switchboards

4.29 Where power leads extend through switchboard sections, terminate and tape leads in the last installed section in such a manner that solderless connectors can be used to extend these leads through future sections.

Ringing, Tone, and Ringing Signal Leads

4.30 Ringing, tone, and ringing signal leads between the 20-cycle ringing power board and the ringing machine mounting framework shall be run with armored cable or with wire electrically shielded with a metallic braid, or shall be run in conduit unless the board and machine table are adjacent.

4.31 Leads between the 20-cycle ringing power board and the fuse panels shall be armored cable or shielded wire, except that rigid conduit may be used if more economical.

4.32 When conduit, shielded wire, or armored cable is used for the leads described above, the leads shall occupy as few cables (or conduits) as possible and meet the following conditions.

(a) Tone and nontone shall not be run together.

(b) Continuous high-tone leads except howler HT2 may be run together.

(c) Howler leads HT2 and HLR shall be run together, and no other leads shall be run with them.

(d) Continuous low-tone leads may be run together.

(e) Low-tone leads and high-tone leads shall not be run together.

(f) Interrupted low-tone leads which are not interrupted simultaneously shall not be run together.

(g) Continuous low-tone and interrupted low-tone shall not be run together.

(h) Machine-ringing shall not be run with audible continuous ringing.

(i) Machine-ringing leads from one interrupter brush to the fuseboard shall not be run with similar leads from any other brush unless the make and break interruptions are simultaneous. For running of machine-ringing leads beyond the fuse panel, see Section 800-612-162.

Protection of BRC Cables Against Attack by Oil

4.33 In some types of offices, power cable run open on racks may be deteriorated by oil leaking from gear boxes or other equipment over a period of years. If so deteriorated or if exposed in a manner making deterioration likely, treat as follows.

(a) Wipe the cables and adjacent framework clean of oil, using a cloth saturated with petroleum spirits (Section 065-330-101). This should be done when the room temperature is below 100F, the minimum flash point of the cleaner; and it is further suggested that a few nearby windows be opened unless other ventilation is provided.

(b) Sandpaper off any loose frayed braid and scrape out any oil-soaked rubber which is too soft to stay firmly in place. Where braid is loose, remove it from the cable.

(c) Fill in holes where rubber is missing with bunched rubber splicing tape and apply one layer of rubber tape, half-overlapped, around the cable in the areas so treated.

(d) Apply one layer, half-overlapped, of bias-cut varnished-cloth tape.

(e) Apply one layer of friction tape, half-overlapped, wrapping in the direction opposite to the layer of varnished-cloth tape.

(f) Apply one coat of oil-resisting clear Glyptol No. 1202 varnish (General Electric Company). If the first coat appears to have soaked into the tape so a gloss finish has not been obtained, apply a second coat after thoroughly dry, a day or more later.

Temporary Guarding of Live Parts During Construction in Working Offices

4.34 When any work is to be done on working circuits, secure the specific approval of the authorized telephone company representative and agree upon procedures and schedule.

4.35 In connection with work done on live or working circuits, all reasonable precautions shall be taken to avoid physical injury to personnel, interruption of service, damage to equipment, or short circuits.

5. ARMORED CABLE

5.01 KS-5497-01 armored cable, formerly designated flexible steel-covered cable, is used for power service from the power service cabinet to motors, rectifiers, etc; for telegraph discharge conductors; and for ringing, signals, and tone, as required. Do not run armored cable in open-cell battery rooms.

Bending Radius

5.02 The minimum safe bending radius of armored cable is five or more times the diameter of the cable measured on the inner side of the bend.

Supporting Armored Cable

5.03 Armored cable should be run on cable racks, carried on cable details, along frameworks, on straps, channels, iron, or wooden details; or it may be run in raceways, in enclosed spaces in frames or equipment. Except when in a raceway it will usually require support at intervals by clamps, brackets, bars, rings, or hooks in a manner covered on numerous detailed drawings, some of which hold it rigidly in place, others of which merely confine the cable loosely in position. When spacing is not specified, use a maximum of 4 feet 6 inches between supports. When type of clamp is not specified, P-69690 form support is satisfactory for one or two cables on a flat surface, or one of the cable clamps per specification AT-6933, Western Electric Company drawing A-162953, may be used for a single cable. Equivalent commercial clamps are also acceptable. Lacing armored cable to some existing detail with wax cord is permissible when clamping details for the cables have not been provided.

5.04 Use a fiber bushing between the conductors and armor, regardless of the type of termination. The fiber bushing goes inside this wire so that the insulating bushing does not separate the grounding wire from the armor.

5.05 At cabinets, starters, knockout boxes, etc, use a box connector and locknut. If the leads are No. 4 or larger and carry commercial power service where entering a raceway or a cabinet, the bushing shall be of the insulating type, or substantial insulating material shall be fastened in place.

5.06 At power boards, switchboards, and similar protected locations, strip the armor to the edge of the board; or if there is sufficient room, the armor may extend along the framework uprights to the edge of the unit panel on which the leads terminate. Where insufficient room is available to meet the required armor bending radius at the board, the armor may be stripped farther back. Use friction tape around the outside to hold the fiber bushing in place and guard outside rough edges. If the leads inside the armor are twisted, it is not necessary to untwist them after removing the armor.

5.07 To splice or tap armored cable use an outlet box or a conduit fitting of a size required for the wires, with connectors and reducers as required. The fitting should be large enough to allow connectors to be handled and inspected.

6. COMMON CHARGE AND DISCHARGE LEADS

6.01 Common charge and discharge leads were formerly provided in some power plants, but since 1926 the standard practice has been to use separate leads. The "common lead" refers to the connection on the live side between the battery and the battery fuse panel or battery control board, at which point the charge and the discharge circuits were connected. Impedance in the common lead to the battery tended to introduce noise from charging generators into the discharge circuit, and special precautions were necessary to keep this at minimum value. These precautions should still be observed on additions to or changes in old power plants having these leads common and where filters are not provided.

6.02 Run as short and direct as possible. Cables having the same points of termination shall be of equal size and length.

6.03 The following maximum combined lengths of common charge and discharge leads apply only when there is no filter in the discharge circuit.

(a) 24 volts; 25 feet where generators are used, 15 feet where disc rectifiers are used, 20 feet for mercury-arc type rectifiers.

(b) 48 volts in manual plants; 50 feet.

(c) 48 volts in toll plants; 25 feet.

(d) 48 volts in panel plants with 24-volt transmission on districts and incomings; 100 feet.

(e) 48 volts in all other dial plants; 25 feet.

Note: In determining the total length for meeting the above maximum requirements, connections of 2 feet 0 inch or less between cells may be disregarded. If both the positive and negative discharge conductors from batteries connected to permanently in parallel are attached to the same battery, the intercell and interbattery connections for the other parallel batteries may be disregarded.

6.04 The positive- and negative-charge conductors should be paired as far as practicable, regardless of whether either or both are common charge and discharge. Likewise, the discharge leads should be paired separately. If the ground leads are separate charge and discharge, the discharge ground lead may be run in the same conduit with paired charge leads if desired. If, however, the separate ground leads are run open and the charge leads are not paired, the charge and the discharge ground leads should be separated by at least 5 feet 0 inch when practicable (see Table A).

6.05 Use brass pipe, iron-pipe size, when nonmagnetic conduit is specified for common charge and discharge leads carrying talking current. Ream or file any burrs at ends of each length so the conduit will not injure the cable.

Bell Telephone Laboratories, Incorporated

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