PREVENTION OF SERVICE INTERRUPTIONS

POWER PLANT BUS BAR AND WIRING

GENERAL EQUIPMENT REQUIREMENTS — POWER SYSTEMS

ATTACHMENT SECTION 802-005-180

1. GENERAL

1.01 This section face sheet is issued to assign its 9-digit number and title in place of the previous 9-digit number, 201-112-006, which was assigned to the section entitled "Prevention of Service Interruptions — Power Plant Bus Bar and Wiring — General Equipment Requirements — Power Systems — Attachment Section 802-005-180." The previous 9-digit assignment is canceled. Notice of cancellation and a cross reference to this section number will remain in the appropriate Division Index for a minimum of 12 months.

1.02 When this section is reissued, it will be issued in a standard format.

1.03 Recommendations for changes, additions, or deletions to this section should be forwarded as specified in Section 000-010-015.

1.04 The old section and any current addendum and attachments should be removed from their previous place in the file and attached behind this page and then filed by the new number.

PREVENTION OF SERVICE INTERRUPTIONS
POWER PLANT BUS BAR AND WIRING
GENERAL EQUIPMENT REQUIREMENTS
POWER SYSTEMS
ATTACHEMENT SECTION 802-005-180

1. GENERAL

1.01 The purpose of this section is to make Section 802-005-180, Issue 9 available to the central office maintenance force. This section covers power plant bus bar and wiring, general equipment requirements power systems, and may be used as a guide during installation of equipment by the Western Electric Company.

1.02 This section is reissued for the following reasons:

(a) Provide Issue 9 of attachment Section 802-005-180.

(b) Revise the title of this section to clarify the specific equipment covered by the attached section.

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

CONTENTS PAGE

1. GENERAL

Scope

1.01 This section covers the general equipment requirements for bus bars, bus-bar supports, cable and wire, armored cable, auxiliary framing, cable rack, conduit, and conduit supports for power systems, including taping and protective methods.

1.02 This specification is reissued to add information for cleaning contact surfaces of current carrying connections on bus bars; to specify that a coating of NO-OX-ID "A" or Alcoa No. 2 compound shall be applied to all external contact surfaces and to either the interior contact surface of the connector or the associated wire; to specify tools for applying crimp-type connectors to conductors; to specify the use of KS-20195 wire; to delete reference to the use of commercial 600-volt cable for ac power service cables; and to delete the assembly arrangement of unprotected tin plated crimp-type aluminum connectors to battery posts.

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.

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 NOTE 4)	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.

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, ma-

chines, 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. PAIRING AND SEPARATION

Pairing of 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. 21.

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.

Separation Between Conductors

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.

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.

Common Charge and Discharge Conductors

2.16 The common charge and discharge conductors are no longer used in new standard power plants. Part 9 provides reference on additions to old offices.

Separation From Equipment Units

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.

3. BUS BARS

3.01 Bus bars are of copper or aluminum and shall be 1/4 inch thick on 1/2 inch centers. Aluminum bus bars shall not be connected to lead or lead-coated bars, posts, or details. Unplated aluminum bus bars shall not be connected to terminals of fuse mountings, switches, shunts, or other heat producing apparatus. For special treatment of aluminum bus bars in open-cell battery rooms, see Part 10.

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.

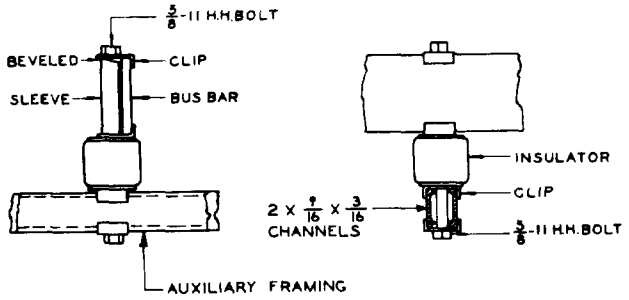


Fig. 1 — Bus-Bar Support — One Bus Bar

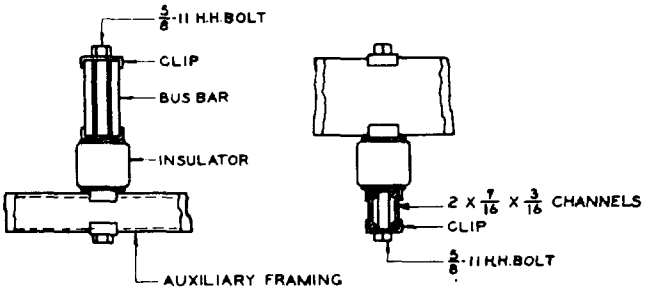


Fig. 2 — Bus-Bar Support — Two Bus Bars

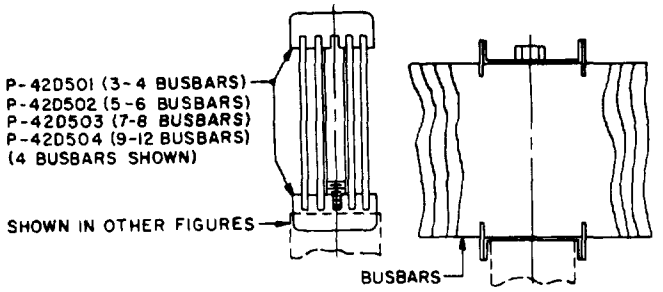


Fig. 3 — Bus-Bar Supports — Three to Twelve Bus Bars

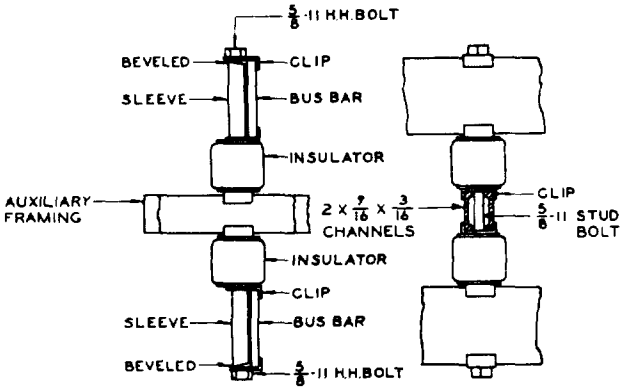


Fig. 4 — Bus-Bar Support — Double-level Bus Bar

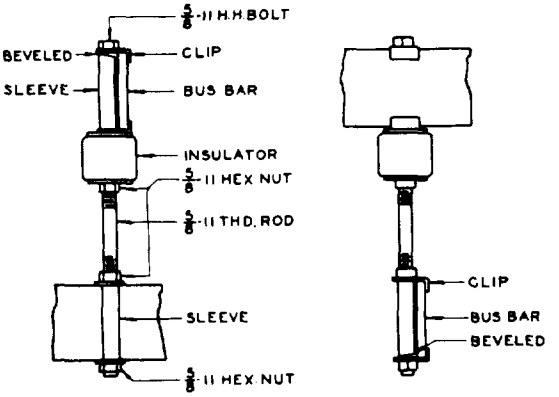


Fig. 5 — Bus-Bar Support — One Bus Bar from Another

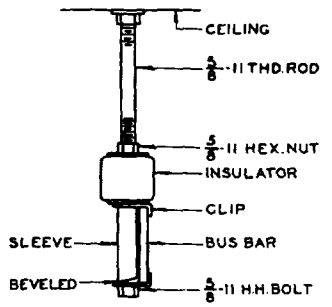


Fig. 6 — Bus-Bar Support from Ceiling—One Bus Bar

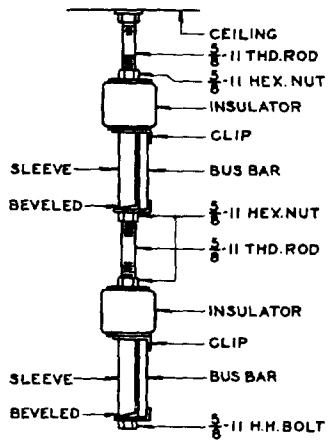


Fig. 7 — Bus-Bar Support from Ceiling—Two Levels

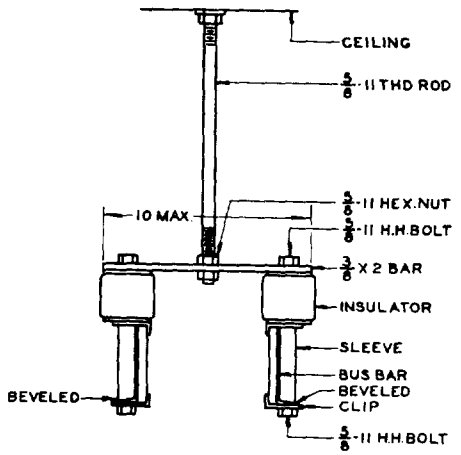


Fig. 8 — Bus-Bar Support from Ceiling—Same Level

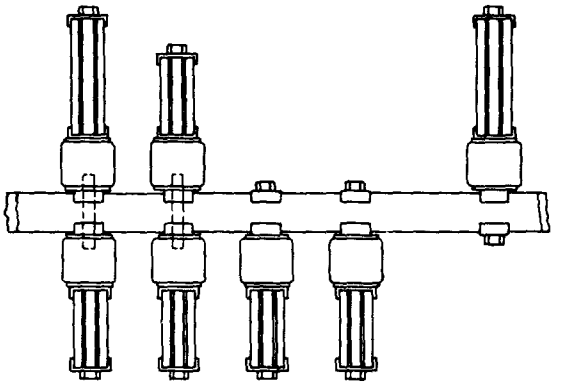


Fig. 9 — Typical Bus-Bar Support Arrangements

3.03 Insulators with steel inserts and steel clips, sleeves, bolts, nuts, rods, etc, are used with the present closed-cell installations.

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

3.05 Clips, sleeves, bolts, nuts, etc, are used to support up to two bars. Supporting bars with three to twelve laminations, refer to Fig. 3.

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

Clearance

3.07 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.

3.08 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

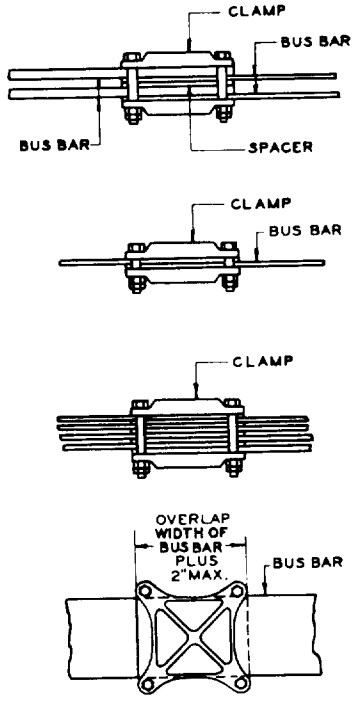


Fig. 10 — Bus-Bar Splice Joints

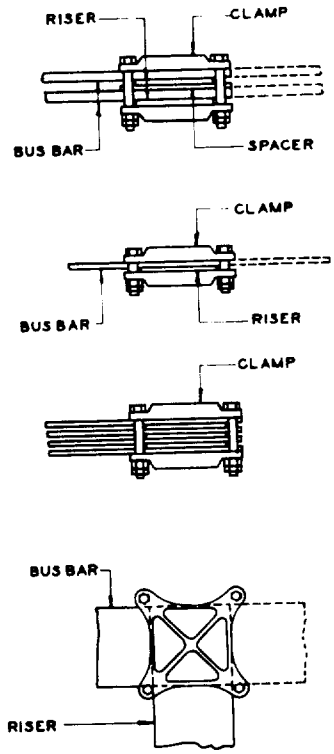


Fig. 12 — Bus-Bar Riser Joints

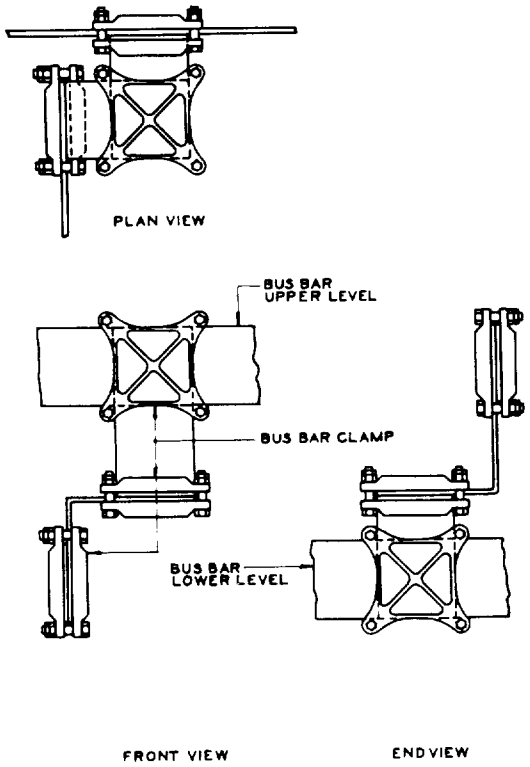


Fig. 11 — Typical Bus-Bar Connections with Intermediate Clamp

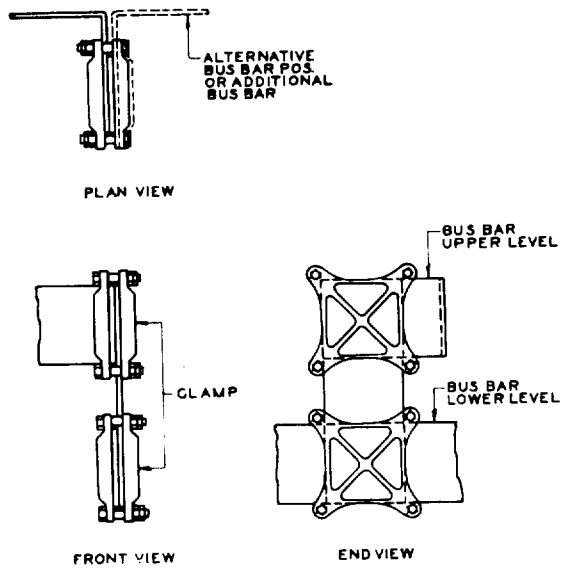


Fig. 13 — Typical Bus-Bar Connections

overlap of bus bars is the width of the bus bar; while the maximum is the width of the bus bar plus 2 inches. 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.

3.09 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.

3.10 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. (See Part 10.)

3.11 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" (Dearborn Chemical) or Alcoa No. 2 inhibitor compound shall be applied immediately after cleaning contact surfaces. See 3.11(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 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 sandpaper or abrasive cloth to remove the hard oxide insulating coating. Then immediately apply a coat of NO-OX-ID 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, within 5 minutes, if possible, without removing the inhibitor.

Taping — General

3.12 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.

3.13 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.

3.14 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.

3.15 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 3.19(d).

Taping Power Service Bus Bars

3.16 Tape all exposed live power service bus bars with two layers of varnished cloth tape and apply to 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

3.17 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.

3.18 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.

3.19 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 or approved equivalent wire or 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.

4.02 The KS-20195 wire may be used where a more flexible wire is required. Electrical connections must be made with an approved crimp connections.

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 wireway.

(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 Alcoa No. 2 compound shall be applied to all external contact surfaces and to either the interior contact surface of the connector or associated wire.

(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 NO-OX-ID or Alcoa No. 2 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 may be required, especially during the first few years the equipment is in service.

4.11 Make all lead connections to switch studs, NEC 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 3.11 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 NO-OX-ID or Alcoa No 2. 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 below.

(a) Only one lead should be soldered in a power-type terminal lug unless designed to take more than one conductor. By power-type lug is meant one depending upon solder or a clamping screw to hold the wire. 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.

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 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, as shown in Fig. 21. 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. 22. 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.

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 (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.

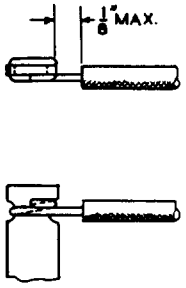


Fig. 14 — Single- or Double-Notched Terminals (double notch shown)

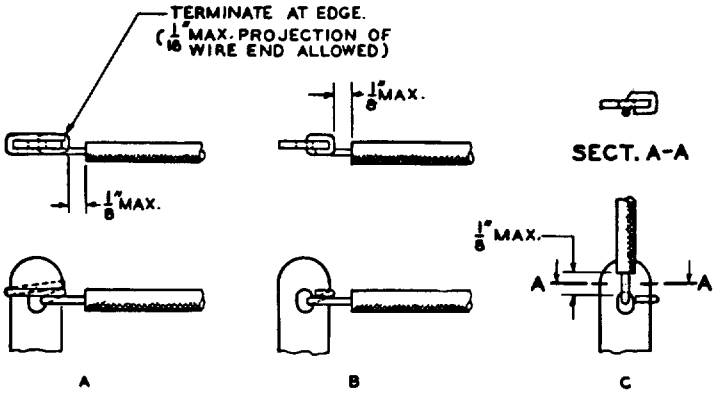


Fig. 15 — Drilled or Punched Terminals (optional arrangements)

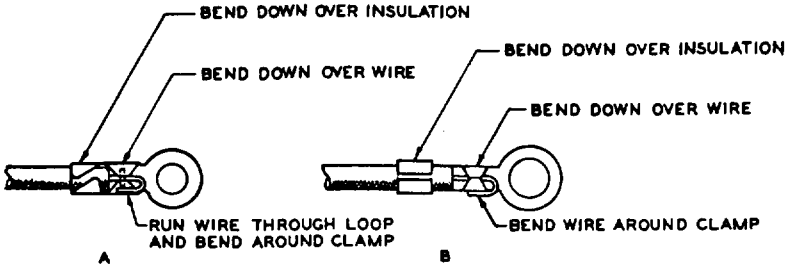


Fig. 16 — Terminals With Two Clamps (F. R. Zierick- or H. B. Sherman-type terminal)

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.***

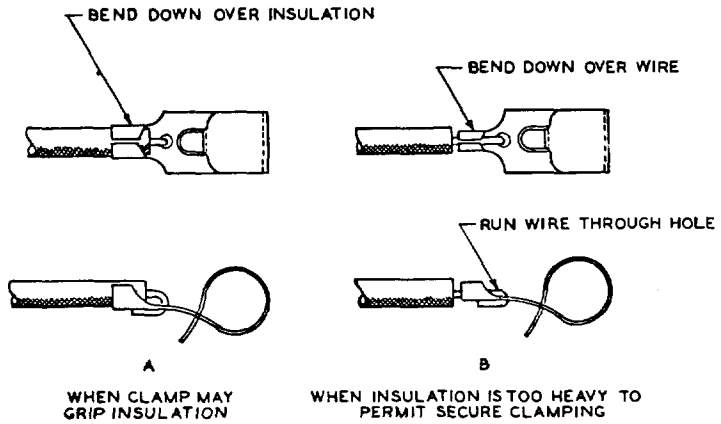
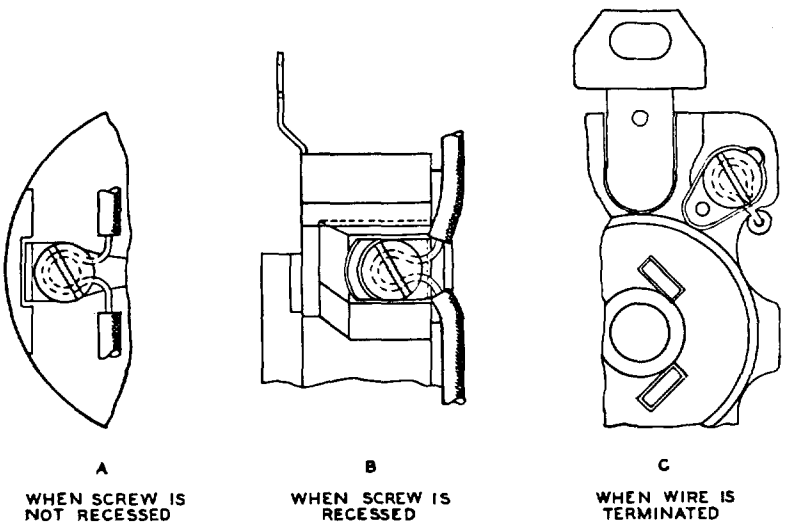


Fig. 17 — Terminals With One Clamp (National Grid Clip shown)



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

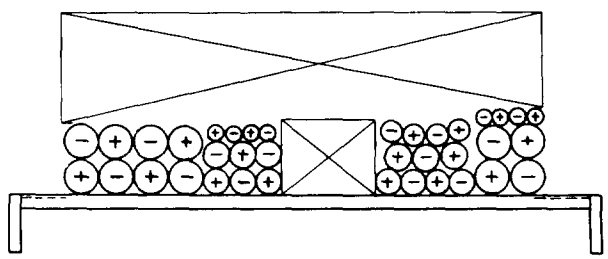


Fig. 20 — Power and Switchboard Cable on Cable Rack — Typical Section

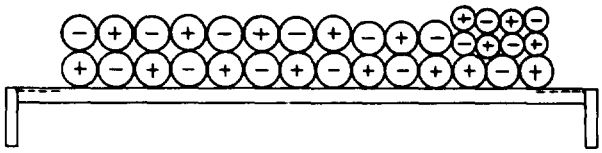


Fig. 21 — Pairing of Talking Conductors on Cable Rack—Typical Section (See 2.03)

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 as in 8.15. 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 8.15.

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.

Power Service Leads

5.08 The same requirement for keeping all the phase leads together applies to armored cable as to conduit.

6. AUXILIARY FRAMING

6.01 Install the auxiliary framing in accordance with the general equipment requirements for auxiliary framing. In power plants, bracing to the ceiling is usually not required except over floor-mounted batteries.

6.02 Keep the area above equipment as free as possible of bars and hangers, consistent with support requirements. Use only one level of framing if possible, except at generator bays. Support the framing from frameworks and stands whenever possible.

6.03 If it is necessary to support to the ceiling in areas without frames or stands (as for cable rack carrying discharge conductors and for bus bars at the tanks in open-cell battery rooms), install 5/8-inch, 11 Star Loxin expansion bolts or equivalent in ceilings of concrete construction if inserts are not available, and run rods directly to them. Use beam clamps in ceilings of tile arch and cinder fill construction, with framing in accordance with the general equipment requirements for auxiliary framing.

6.04 Steel auxiliary framing and support details are used for closed-cell installations and outside of the battery room in open-cell installations.

Permissible Load

6.05 The following values are supplementary to the general engineering requirements for auxiliary framing and cable racks. Permissible loads are as follows.

	LOAD POUNDS
5/8-inch, 11 threaded rod	1200
Ceiling insert (Kneas socket or equivalent)	1200
Acme Beam Clamp	800
5/8-inch Star Loxin Shield or equivalent (in rock concrete)	500
3/8-inch Lag screws in wood (2 inches or more)	300
Framing (One pair, 2- by 3/8-inch steel bars, or one pair, 2- by 9/16-inch by 3/16-inch channels)	
Span between supports	
Up to 2 feet 0 inch	2000
2 feet 0 inch to 3 feet 0 inch	1500
3 feet 0 inch to 5 feet 0 inch	1000
5 feet 0 inch to 7 feet 0 inch	700
7 feet 0 inch to 10 feet 0 inch	500

7. CABLE RACK

7.01 In general, install cable rack in accordance with the general equipment requirements for cable rack. Leads on cable racks are shown in Fig. 20 and 21.

7.02 In general, cable rack is supported in power plants by resting on frameworks or on auxiliary framing, but isolated runs over areas without framework or auxiliary framing may be supported directly from the ceiling.

8. CONDUIT

8.01 KS-5351 conduit shall be used: in open-tank battery rooms; from the building service entrance to the power service cabinet for power service; from emergency alternators to power service cabinet or other termination; if the number of conductors is too small to warrant the use of a cable rack. Since 4-inch conduit is difficult to install, it should in general be used only where it is impracticable or uneconomical to run multiple leads in smaller conduits.

8.02 Flexible steel conduit may be used in place of pull boxes or at bends in rigid conduit; also for terminating rigid conduit at vibrating apparatus. Single-strip should be used where available. Approved aluminum conduit and fittings may be used interchangeably with steel conduit and fittings in the same or separate conduit runs except that conduit elbows shall be of steel.

Service Leads, Color Code, and Polarity

8.03 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.

8.04 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, if they are No. 6 or smaller. For No. 4 and larger the identification shall be secured either by white, black, and red, or by a distinctive marking at terminals during the process of installation. In 3-wire single-phase or polyphase, the other live-phase leads are red, blue, and yellow, in order.

8.05 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. If grounding is not used or no grounded neutral is present, such as with a 3-wire, 3-phase circuit, all terminals and conductors may be live. With 4-pole devices the radial grounding terminal is opposite to the white grounded neutral terminal.

Supporting Conduits

8.06 Support conduits as in Fig. 22 and 23, except for small conduit installations where single-hole pipe clamps, 2-hole pipe straps, or

hangers will generally prove satisfactory. Conduits may also be supported by fastening to the wall with single-hole pipe clamps. A spacing of 6 feet, maximum, between supports shall be used to agree with aisle lighting.

8.07 A few conduits may be supported underneath a cable rack by means of J-bolts and iron bars, or if a single conduit only is involved, along the side of the rack stringers, using J-bolts or U-bolts, and short iron bars. If no rack is available, a single conduit may be supported by a pipe hanger, one type of which is illustrated in Fig. 24. Fig. 25 shows two conduits supported on 5/8-inch, 11 threaded rod and short lengths of bar or channel. If one of the conduits thus supported is larger than the other, it should be located close to the supporting rod, and in any case the bars or channels should not extend more than 12 inches from the supporting rod.

8.08 Support conduits at power boards with metal details or U-bolts fastened to the framework.

Conduit Bends

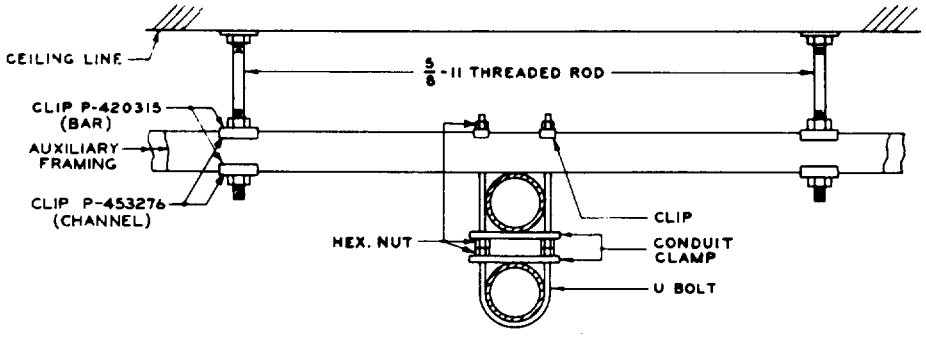
8.09 Conduit from fitting to fitting or outlet to outlet shall contain no more than four quarter bends or the equivalent. If more are required, insert pull boxes. (See 8.16.)

8.10 Make bends of rigid or flexible conduit so that the conduit will not be injured or the internal diameter appreciably reduced. The radius of the curve of the inner edge of any field bend shall be not less than six times the nominal internal diameter where rubber-covered cables are used, and not less than ten times the nominal internal diameter where lead-covered cables are used.

Conduit Terminations

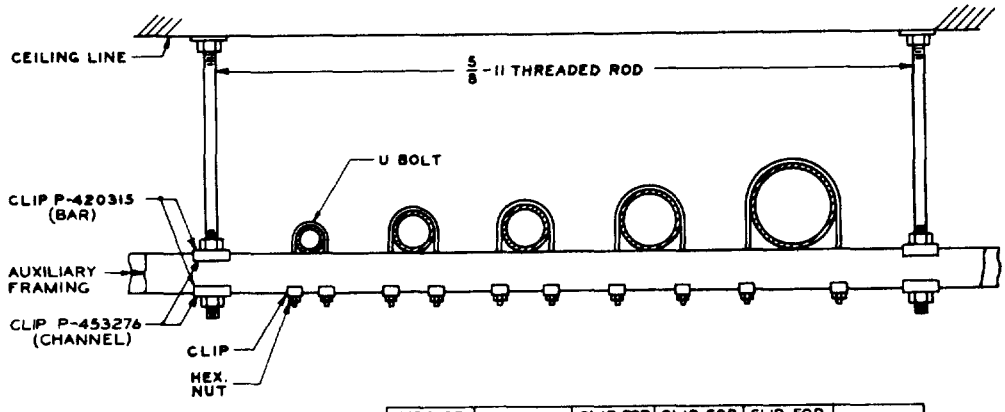
8.11 Terminate conduits as follows.

(a) Ream or otherwise smooth the ends of cut conduit to remove rough edges.



SIZE OF CONDUIT	U BOLT	CONDUIT CLAMP	CLIP FOR 3/8 BAR	CLIP FOR 1/2 BAR	CLIP FOR CHANNEL	HEX. NUT
1/2	P-160046	P-160056	P-420317	P-160067	P-374681	P-401452
3/4	P-160047	P-160057				
1	P-160048	P-160058				
1 1/4	P-160049	P-160059				
1 1/2	P-160050	P-160060				
2	P-160051	P-160061	P-420306	P-160068	P-453278	P-125614
2 1/2	P-160052	P-160062				
3	P-160053	P-160063				
3 1/2	P-160054	P-160064				
4	P-160055	P-160065				

Fig. 22 — Conduit Support for Two Tiers of Conduit



SIZE OF CONDUIT	U BOLT	CLIP FOR 3/8 BAR	CLIP FOR 1/2 BAR	CLIP FOR CHANNEL	HEX. NUT
1/2	P-160038	P-420317	P-160068	P-374681	P-94442
3/4	P-160037				
1	P-160038				
1 1/4	P-160039				
1 1/2	P-160040				
2	P-160041	P-420306	P-160067	P-453278	P-401452
2 1/2	P-160042				
3	P-160043				
3 1/2	P-160044				
4	P-160045				

Fig. 23 — Conduit Support for One Tier of Conduit

(b) Where tapped holes are provided in cabinets, starters, boxes, etc, screw joints up tight.

(c) Where threaded conduit terminates in untapped holes in cabinets, boxes, etc, use locknut on outside and metal bushing or bushing of insulating material with a locknut on the inside of box.

(d) With threadless fittings used on the conduit use the shoulder of the fitting or a locknut on the outside and a nut on the inside.

The above are intended to provide tight metallic joints between conduit and box to insure a low resistance to fault currents so overload protection will be operated. Additional provisions apply in certain cases as follows.

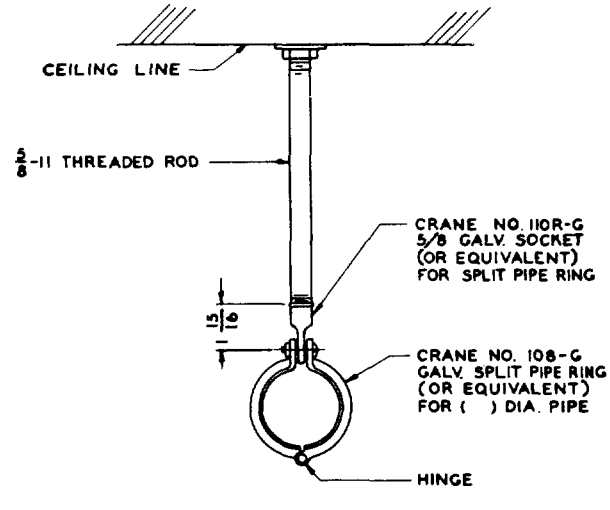
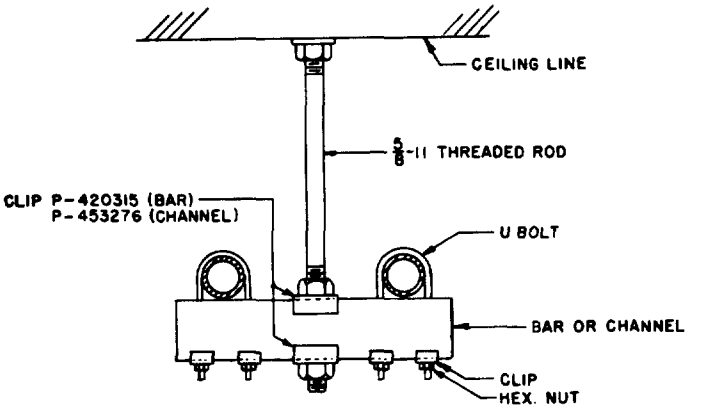


Fig. 24 — Conduit Support for Single Conduit Where Auxiliary Framing is Not Used



SIZE OF CONDUIT	U BOLT	CLIP FOR ⅜ BAR	CLIP FOR CHANNEL	HEX. NUT
½	P-160036	P-420317	P-374681	P-94442
¾	P-160037			
1	P-160038			
1¼	P-160039			
1½	P-160040			
2	P-160041	P-420306	P-453278	P-401452
2½	P-160042			
3	P-160043			
3½	P-160044			
4	P-160045			

Fig. 25 — Conduit Support for Two Conduits Where Auxiliary Framing Is Not Used

8.12 Where ungrounded conductors No. 4 or larger, carrying commercial power service, enter a cabinet or a raceway, a substantial bushing providing a smoothly rounded insulating surface must be provided to guard against possible damage to the wire insulation which might result in grounding. This insulation under conditions such as those covered in 8.11 may be as follows.

Condition (a): A substantial insulating insert held firmly in place.

Condition (b): If the bushing is of the metal type not providing insulation, add an insulating insert held firmly in place.

Condition (c): Add an insulating bushing or an insulating insert held firmly in place. Insulating bushings may be of metal with molded-in insulating material at rim, or may be made entirely of insulating material. If a metal bushing clamps tightly against the inside wall of the cabinet or box, the inside locknut normally used under condition (c) may be omitted.

8.13 At power boards, switchboards, and similar protected locations, use an insulating bushing on the end of the conduit.

8.14 At power boards the height of the conduit fitting should be:

At top of board—bottom of fitting even with top of board.

At bottom of board—top of fitting 4 inches above floor.

Sealing Ends of Sleeves and Conduits Not Terminating in Cabinets or Fittings

8.15 The ends of sleeves or conduits carrying power wire alone or with switchboard-type cable, which terminate upward or horizontally, shall be sealed by packing first with oakum and then sealing with RM-641575 compound. For sleeves or conduits all openings of which are in the same room or enclosure, no ends need be packed and sealed unless they turn upward or are located in open-type battery rooms where all openings are packed and sealed. See Section 800-614-153 on sheathing for cable openings.

Use of Flexible Conduit as a Pull Box

8.16 In straight runs of rigid conduit or at bends, where some form of pull box is required, flexible conduit approximately the length of a standard elbow if at bends (1 foot 6 inches if in a straight run) may be used between the two sections of rigid conduit. If there are four or more medium-size conduits or a conduit larger than 3 inches in a run, a pull box usually is preferable. Flexible sections may be used in an offset in rigid conduit where it rises or drops from one level to another.

Routing of Conduits

8.17 Do not route conduits through foundation piers, columns, beams, stairways, elevator shafts, or any other building structure. Avoid boiler rooms or hot locations. Route conduits through cable vaults only when exceptional conditions make it necessary, and then only with the telephone company's approval.

8.18 Conduits shall not be extended over batteries at such a height as to interfere with maintenance of the batteries.

8.19 All exposed runs of conduit shall be run parallel with or at right angles to the walls of the building as far as possible.

8.20 All concealed runs of conduit shall, in general, be as short as possible, irrespective of crosses and bends in the run. No part of the conduit or coupling concealed in a cement floor shall come closer than 1-1/2 inches to the finished floor except where it emerges.

Location of Conduit With Respect to Other Pipes

8.21 Minimum clearances shall be as follows.

(a) At least 1 inch from the water-cooled sections of engine exhaust pipes.

(b) Insulated exhaust pipes or silencers, conduit at right angles: 1 inch when conduit is under or at side, 3 inches if conduit crosses above.

(c) Insulated exhaust pipes or silencers, conduit parallel: 1 inch when conduit is under or at side, 12 inches if conduit runs above.

(d) Uninsulated exhaust pipes or silencers, conduit at right angles: 12 inches when conduit is under or at side, 3 feet 0 inch when conduit crosses above except that the 3 feet 0 inch may be reduced to 12 inches if conduit or exhaust is insulated at the point of crossing for a distance of at least 12 inches beyond the uninsulated pipe or conduit.

(e) Uninsulated exhaust pipes or silencers, conduit parallel: 12 inches when conduit is under or at side, 3 feet 0 inch when conduit runs above.

(f) ***Steam Pipes:*** 1 inch from covered pipes, 6 inches from uncovered pipes.

9. COMMON CHARGE AND DISCHARGE LEADS

9.01 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.

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

9.03 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.

9.04 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 H).

9.05 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.

10. OPEN-CELL BATTERY ROOMS

10.01 Open-type storage cells in glass were replaced as standard by the enclosed, sealed type in 1927, and lead-lined tank cells were superseded by the enclosed tank type in 1940. The additional information for open-type cells has been removed from the rest of this section and collected here for use on additions or rearrangements.

Supports

10.02 When aluminum bus bars are added to existing aluminum installations in open-cell battery rooms, insulators with alloy inserts and aluminum and aluminum-alloy sleeves, clips, bolts, nuts, rods, framing bars, etc, are used (see Fig. 1 through 9).

Connections

10.03 Standard alloy caps and stud bolts shall be used at the reinforced bars of open-tank cells for connecting copper bus bars. Put NO-OX-ID or Alcoa No. 2 in the alloy caps. Bolted joints are used for copper bus bars in open-cell battery rooms.

10.04 In open-cell battery rooms, aluminum alloy clamps, with aluminum alloy bolts, nuts, and washers shall be used with aluminum bus bars.

10.05 Aluminum contact surfaces should be cleaned (dry) with sandpaper or abrasive cloth to remove dirt, grease, etc, and to break down hard oxide. Then apply a coat of petrolatum and use a wire brush to break up any soft oxide that has re-formed. Clamp the connections together (within 5 minutes if possible) without removing the petrolatum.

Permissible Loads

10.06 Aluminum bus bars are supported as in 6.05, except that when aluminum framing bars are used, reduce the load to the following.

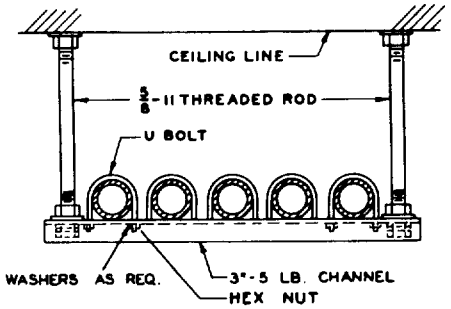
FRAMING BARS — (ONE PAIR, 2- BY 3/8-INCH ALUMINUM) SPAN BETWEEN SUPPORTS	LOAD POUNDS
Up to 2 feet 0 inch	1000
2 feet 0 inch to 3 feet 0 inch	600
3 feet 0 inch to 5 feet 0 inch	400

Conduit Supports

10.07 Support conduits in open-cell battery rooms as in Fig. 26.

Conduit Termination

10.08 Conduits terminating in open-cell battery rooms shall not be secured to the floor, but shall be braced or fastened to the stands with iron bar details or U-bolts. All openings in conduits or sleeves in open-type battery rooms shall be sealed as covered in 8.15.



SIZE OF CONDUIT	U BOLT	HEX. NUT
1/2	P-160036	P-94442
3/4	P-160037	
1	P-160038	
1 1/4	P-160039	
1 1/2	P-160040	
2	P-160041	P-401452
2 1/2	P-160042	
3	P-160043	
3 1/2	P-160044	
4	P-160045	

Fig. 26 — Conduit Support in Open-cell Battery Rooms