

CONNECTING

GENERAL

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2. GENERAL

2.1 Scope

2.11 This section covers the general requirements and methods when cutting, skinning and otherwise preparing wire ends. Also covered is specific connecting information when making connections to dormant and live feeders, switches and fuses. The section covers the permanent insulation of wire ends not terminated in a connecting device and it covers the installation of dummy fuses.

2.12 In general, installing new offices or adding to existing offices falls within the coverage of "Connecting" paragraphs in this section. When the work involves changes in existing offices this is considered transition work and principal coverage is Power Transition Handbook 22.

In either case when making connections to live circuits reference shall be made to Handbook 22.

2.13 Other sections in the 7 series cover dress of power wire (7B), fastening solder type and solderless type lugs and connectors to wire ends (7C and 7D), and securing these connectors to bus bars, studs, etc., (7E). Verification is covered in Section (7V) and now contains specific instructions for checking ac branch circuits after they are fused and working.

2.2 Precautions

2.21 When a fuse is removed or switch is opened in a live circuit in order to work on the circuit, it is advisable to attach clean canvas to, or otherwise insulate the fuse clips, or secure the switch in an open position in order to prevent the circuit from being accidentally

closed while being worked on. In addition to these measures a warning tag, ID-1270-A should be placed on the fuse or switch, and only removed by the person responsible for the operation. See Figure 1.

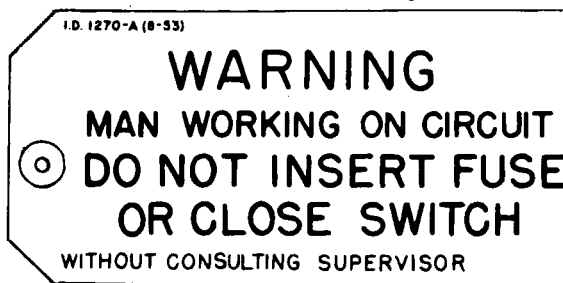


FIG. 1 ID-1270-A - WARNING TAG (RED TAG - BLACK LETTERS) (PAR. 2.21)

2.22 The fuse should be replaced, or the switch closed by the person responsible for the operation after it is determined that it is safe to do so.

2.23 When a fuse panel is first made alive hang a Warning Tag, ID-1270 (Figure 2) on the panel, and if the panel is located in such a way as to subject the equipment on the panel to danger of short circuit, erect sufficient protection around the panel to safeguard the live equipment from passing ladders, etc.

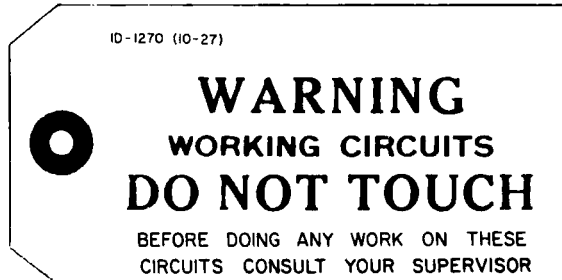


FIG. 2 ID-1270 WARNING TAG (WHITE TAG - RED LETTERS) (PAR. 2.23)

2.24 Cover tools such as screwdrivers and wrenches with tape or other approved insulating material in such a way as to reduce likelihood of short circuits to a minimum.

2.25 Tape R-3134 propane cylinder when used near electrically alive equipment or when splicing live leads. Apply tape to bottom and extend up side of cylinder to safety valve. Do not tape over safety valve.

2.26 A rubber mat may be used to advantage as a means of protection against hazards of electrical shock on concrete or damp floors while performing work on or near live equipment.

2.27 The cable duct in the base of universal duct type bays shall not be left exposed when it contains live power wires. If the guard rail covers are removed, temporary covers shall be provided.

3. INSTALLING EQUIPMENT

3.1 The tools, supplies and test apparatus required for operations covered in the 7 series are given in Paragraphs 3.11, 3.12 and 3.13.

3.11 Tools

Code	Description	Kit
R-2628	Brush, Wire	3
R-1748	Clamp, C, 3"	3,4,42,49,102
R-1455	Clamp, C, 6"	3,4,32,32A,42,49,102,145
R-2733	Copper, Soldering	32,32A,49
R-2912	Cutter, Armor	3,49
R-3134	Cylinder, Propane	3,21
ID-813	(These Tags Required	
GN-813	When Shipping Propane Cylinder)	
R-1789	Drill, .437"(7/16")	3,32,32A,102
R-1482	Files Flat, Combination, H-Type, 8"	3,5,21,32,32A,102,145,268
79B	Gauge, Gram,Tension	3,47,52,53,56,187
R-3162	Holder,Abrasive Paper	3
R-2761	Knife, Skinning	3,32,32A
R-2559	Lamp, Test, Power	3,32,32A,102
R-2137	Lighter, Flint	3,21,42,166
R-1616	Pin, Clothes	40,137,138,171,172
R-7890	Pliers, Gas, 10"	3,4,55
R-2120	Pliers, Long Nose	32,32A,102
R-2195	Pliers, Side Cutting, 8"	3,49
R-2666	Pliers, Thermo Grip	
or		
R-2666A		
R-2281	Saw Frame, Hack, 10" and 12"	3,4,5,32,32A,55,102,145
R-1514	Shears, Cable	32,32A,42,55
R-3154	Sheeting,Protective	
R-1516	Snips, Tinnners, 14"	4,42,49,55
R-2115	Stripper, Cable, Lead Covered	
R-2884	Stripper, Power Wire	3,49
R-2165	Stripper, Power Wire	3,49
R-3105	Torch, Propane	3,21
R-1543	Wrench, Adjustable	3,4,5,49,55
R-2670	Wrench,Allen,3/32"	3,32,32A,45,51,52,53,56,102
R-2671	Wrench,Allen,1/8"	3,15,32,32A,52,53,56,102
R-2485	Wrench,Allen,5/32"	3,24,32,32A,52,53,56,102
R-2485	Wrench,Allen,5/32"	3,24,32,32A,52,53,56,102,148,R-3103
R-3028	Wrench,Allen,3/16"	3,32,32A,102
R-2672	Wrench,Allen,1/4"	3,32,32A,102
R-2865	Wrench,Allen,1/4", Special	3
R-2486	Wrench,Allen,5/16"	3,32,32A,56,102
R-2673	Wrench,Allen,3/8"	3,32,32A,56,102

Code	Description	Kit
R-2718	Wrench, Plier	3, 5, 49, 55
R-3253	Wrench, Wire Nut	3

3.12 Supplies

Code	Description
RM-626122	Canvas, Flameproofed
RM-641204	Cement, Neoprene
R-3126	Compound, Silicone
R-3045	Connector, Wire
R-3046	Connector, Wire
RM-646317	Enamel, Gray Acid Resistant
Obtain	Fiberboard
Locally	
RM-591862	Fiber Sheet, Gray, 1/64"
RM-669152	Gloves, Cotton (In Kit 3)
Obtain	Mat, Rubber
Locally	
RM-646317	Enamel, Gray Acid Resistant
R-3163	Paper, Abrasive (In Kit 3)
625.373	Pencil, Yellow
RM-647651	Petrolatum
Obtain	Sheet Rock
Locally	
RM-641552	Soldering Stick, Allen's
RM-531817	Solder, Strip
RM-591127	Tape, Friction, 3/4"
RM-591102	Tape, Rubber
R-2916	Twine, No. 12
RM-647622	Varnish, Clear
→ RM-646482	Varnish, Shellac, Orange
ID-1270-A	Warning Tag, Man Working on Circuit
ID-1270	Warning Tag, Working Circuit

3.13 Test Apparatus

Code	Description
ITE-4040	Adjusting Set, D.C.
R-2816	Box, Test (for Electrical Appliances)
ITE-4137	Continuity Test Set - AC
→ ITE-4503A	Hook-On Ammeter
Obtain	Lamp 120 Volt, 50 or 60 Watt
Locally	
ITE-4175	Socket, Weatherproof

4. CUTTING AND SKINNING OF WIRE

4.1 Cutting

4.11 Form wires to their final desired shape, place the end of the wire in close proximity to the connecting point and mark the insulation. Allow sufficient length for fitting the skinned end into the connecting device. Bending or forming wires after cutting usually causes separate conductors of a stranded wire to become uneven at the cut end and therefore, will not permit all of the strands to bottom evenly in the connecting device.

4.12 R-2195 8" side cutting pliers can be used to cut wire sizes No. 6 AWG and smaller

4.13 The R-1514 cable shears were standardized for cutting switch-board cable, however, they may be used to cut No. 2 AWG power wire and smaller.

4.14 Power wire larger than No. 2 AWG should be cut with the R-2281 hand hack saw. The R-3148 reciprocating saw may be used on unconnected leads where there is not enough room for the hand hack saw. Use a fine blade with either saw, and for ease of cutting, a small amount of petrolatum on the blade will prevent drag from the rubber covering.

4.15 The extra flexible type wire on large charging generator sets may be cut with R-1514 shears. This procedure results in a clean cut which does not disturb the strands or cause them to fan out. Where the wires are considered too large for cutting with cable shears they should be taped tightly over the point to be cut. Use fine toothed hack saw being careful not to disturb the strands sufficiently to cause difficulty when fitting the wire into lugs.

4.2 Skinning Wire

4.21 General

4.211 Exercise care so as not to nick or cut strands when skinning stranded wire.

4.22 Using R-2884 Stripper

4.221 To remove insulation with the R-2884 power wire stripper proceed as follows: See Figure 3.

4.222 Retract the cutting blade by rotating the knurled knob for blade depth adjustments. Fit the wire in the "V" shaped saddle and close down the clamping lever. Adjust the tool to fit the wire by means of the adjusting screw on the end of the main tool body until all side movement of the tool is reduced, but not so tight as to prevent free movement or cause binding.

4.223 Lift the clamping lever and remove the tool from the wire. Set the cutting blade parallel with the tool for a circular cut, then adjust the blade to a thickness of the insulation using the end of the wire for judging the depth. Care should be taken in making this adjustment so as not to score the conductor strands.

4.224 Replace and clamp the tool on the wire with the cutting blade at the mark where the cut is to be made. Swing the tool in a complete circle making a circular cut. Repeat for second cut if fitting a parallel or crosstap type of connector.

NOTE: If the cut is not a true circle, that is, tends to spiral, the cutting blade alignment detail should be rotated slightly to correct the condition.

4.225 Rotate blade through 90° so that it is parallel to the wire when the tool is replaced on the wire. This

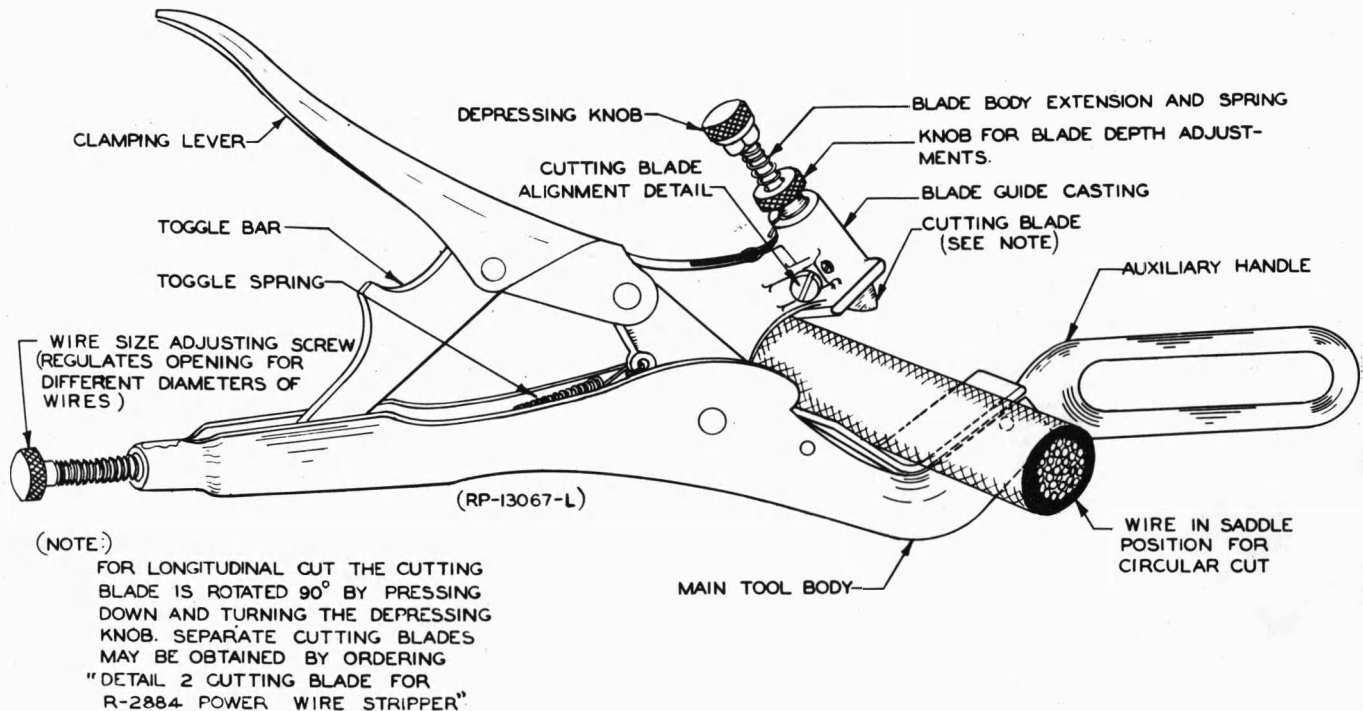


FIG. 3 REMOVING INSULATION WITH R-2884 POWER WIRE STRIPPER (PAR. 4.221)

is effected by depressing the blade body extension and rotating the blade to the position desired. Clamp the tool in place so that the cutting edge is at the circular cut and slide the tool along the wire between the circular cuts or to wire end. Remove the insulation with long nose pliers, R-2120.

4.226 The wires should be clean but if any particles of rubber adhere to the strands they may be removed with the R-2761 skinning knife.

4.23 Using the R-2761 Knife

4.231 When the insulation cannot be readily removed with the R-2884 stripper, as in close locations, use the R-2761 knife. See Figure 4 and proceed as follows:

4.232 Make a circular cut with the knife as shown in Figure 5 through all of the insulation at the place marked. Then make a second cut lengthwise from the circular cut to the end of the wire, following the twist in the strands. (See Figure 6). Two circular cuts are made for parallel and crosstap connectors in which case the insulation is cut lengthwise between the two circular cuts. Remove the insulation with the R-2120 long nose pliers. The wire should be clean, but if any particles of rubber adhere to the strands they may be removed with the knife.

4.233 Caution: When using the skinning knife, cut in such a direction that the blade will not endanger any part of the body, if it should slip.

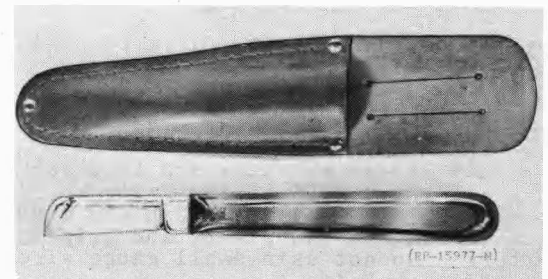


FIG. 4 R-2761 SKINNING KNIFE AND SHEATH (PAR. 4.231)

4.24 Using R-2165 Stripper

4.241 The R-2165 wire stripper is designed for use on No. 18 through No. 10 power wire and may be furnished per Model "A" or Model "B" as shown in Figures 7 and 8.

4.242 Hold the stripper, with the gripper jaws away from end of the wire. Insert wire in the proper size notch in the blade and so placed as to strip not more than $\frac{3}{4}$ " of insulation in one operation. Close handles to cut the insulation and strip. On Model "B" partially release handles to permit removal of wire and further release automatically resets the tool. On Model "A" release handles and remove wire. Squeeze handles and release once again to reset the tool. The sequence of operations are shown in Figures 7 and 8.

4.243 Power wire strippers should be kept clean and all insulation refuse removed frequently.

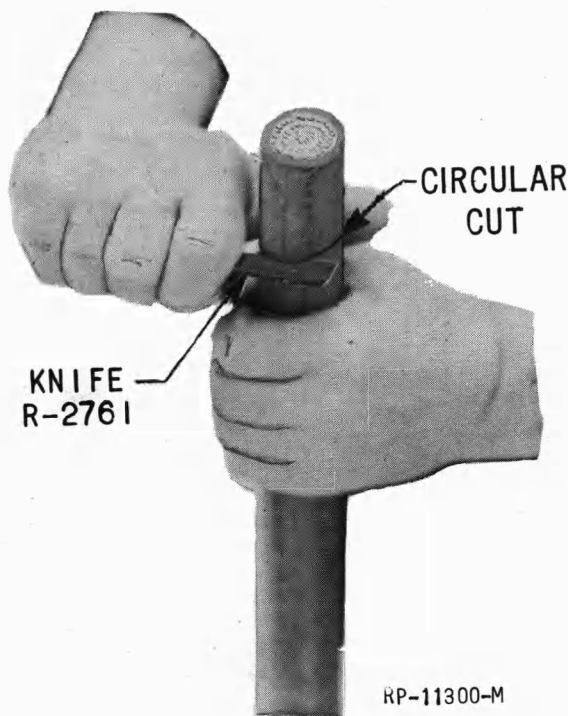


FIG. 5 CIRCULAR CUT WITH KNIFE (PAR. 4.232)

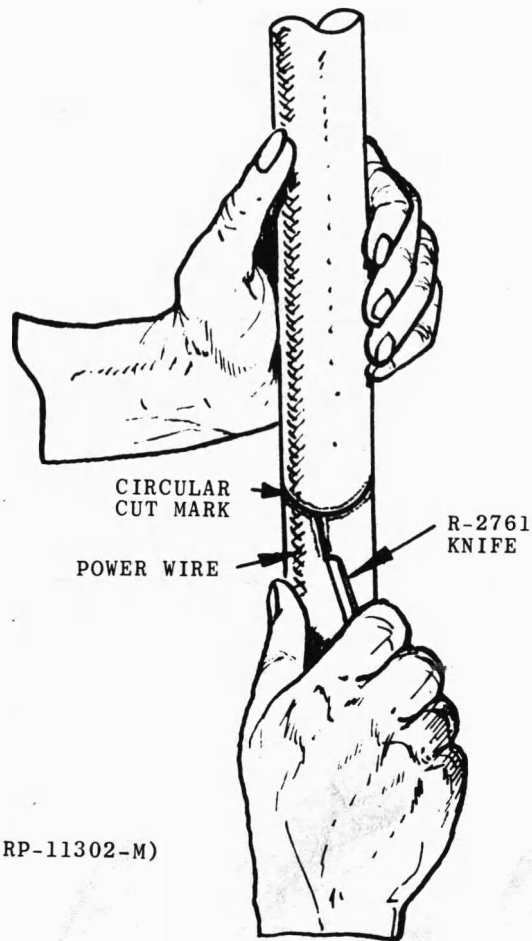


FIG. 6 LENGTHWISE CUT WITH KNIFE (PAR. 4.232)

4.25 Using R-2120 or R-2291 Pliers and R-6433 Cutters

4.251 As an alternate to using the R-2165 stripper for No. 10 power wire and smaller, crush the insulation with the smooth jaw pliers and trim with the cutters. Do not skin small gauge wire with the skinning knife.

5. ARMORED WIRE AND CABLE

5.1 Caution

5.11 Remove the armor as soon as practicable after cables have been run in at power or fuse boards to avoid possible contact of grounded metallic armor with live conductors. Coil up the wires from which armor has been removed, pending their permanent forming and connecting.

5.2 Removing Armor From Small Armored Cable

5.21 Use the armor cutter R-2912 (Figure 9) to remove armor from 2- and 3- conductor No. 12 and No. 14 armored cable (KS-5497). This tool is constructed with two pivoting points. Proceed as follows:

5.211 Mark the armor coil where it is to be cut. Open the handles to the extreme position. Place the cable in

the gripping jaws, at approximately 30°, with the overlapping edge of the armor toward the handle and the armor butt mark just ahead of the cutting blade. Close the handles to the extent permitted by the outer pivot to grip the cable. Check to see that the point of the cutting blade will enter the armor under the overlapping edge, and continue closing the handles as permitted by the inner pivot forcing the blade through the armor.

5.22 Pull the armor off the end of the cable. If difficulty is experienced, remove the armor in short sections. If the armor is tightly wrapped hold one end of the section to be removed and twist the other end forcing the spiral larger. Retain the twist while pulling the armor off.

5.23 Cut the bonding wire about 4 inches from the armor butt and fold it back over the cut in the armor. Insert the antishort bushing over the paper and under the bonding wire and armor. Place it so the split in the antishort bushing does not fall at the cut in the armor. To aid in placing the antishort bushing it may be necessary to twist the armor open or remove the Kraft paper as shown in Figure 10.

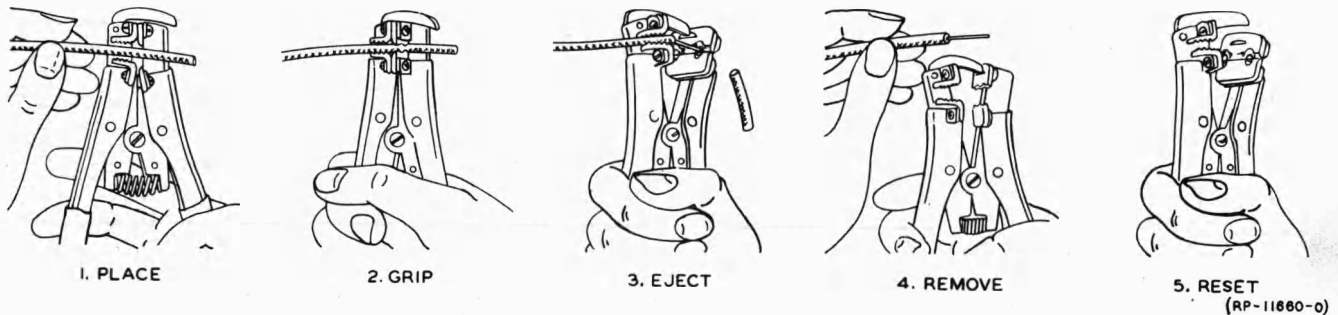


FIG. 7 OPERATION SCHEMATIC OF R-2165 POWER WIRE STRIPPER - MODEL A (PAR. 4.241, 4.242)

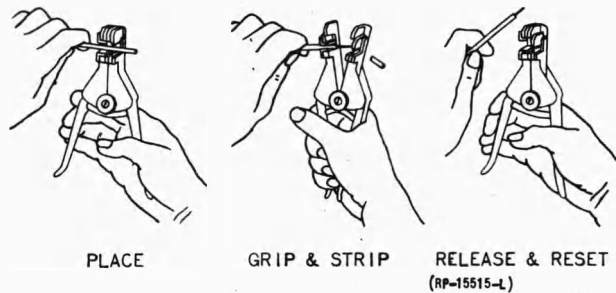


FIG. 8 OPERATION SCHEMATIC OF R-2165 POWER WIRE STRIPPER - MODEL B (PARS. 4.241, 4.242)

5.3 Removing Armor From Large Armored Cable

5.31 Follow the same procedure as covered in Paragraph 5.2 for small armored cable except that it is necessary to make a diagonal cut through one turn of the armor using a hack saw. Always tilt the back of the hack saw frame toward the person. In event the blade should slip it will then skid away from the person. Dress the edge of the armor. Install the antishort bushing as shown in Figure 10 and 11.

5.4 Terminating Armor on Armored Wire and Cable

NOTE: Cutting holes in cabinets, panels, boxes, and removal of knock-outs for termination of the armor on armored covered wire and cable is similar to preparation for terminating conduit and is covered in Section 9C.

5.41 Connectors are furnished in unit packages which are marked with the KS and list number. Some of these connectors have the same basic dimensions but are listed differently when supplemented with different size fillers which adapt them to the armor specified. Retain these fittings in the carton until ready for use to assist in identification and to insure the proper connector or combination being applied to the armor for which it is intended. Lists 10, 11, 12, 14, 60, 61, 62 and 64 are supplied with fillers. See Figure 11.

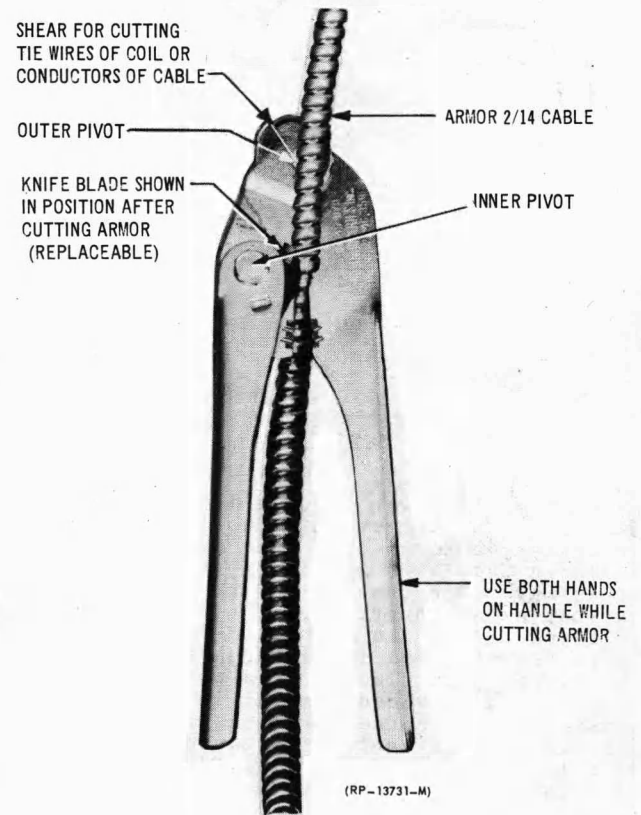
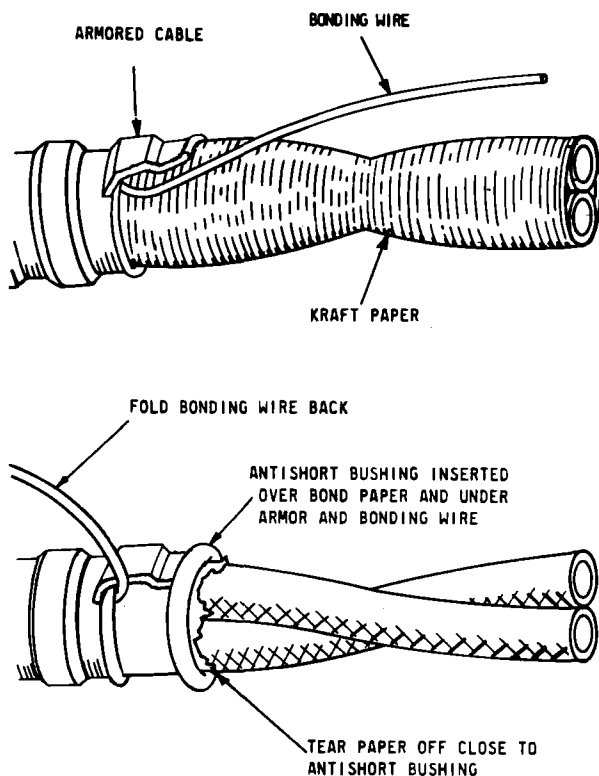


FIG. 9 REMOVING ARMOR WITH R-2912 CUTTER (PAR. 5.21)

5.42 At cabinets, starters, raceways, boxes, etc., use a straight or a 90° wire and cable connector as shown and listed in Figure 11. Place connector on cable and fully engage armor. Arrange connector so the bonding wire will be clamped between the armor and the body of the connector or connector clamp. Tighten screws securely and bend protruding end of bonding wire back and forth until it breaks off short at the connector.



RP-11281

→ FIG. 10 INSTALLING ANTISHORT BUSHING AND REMOVING PAPER COVERING (PAR. 5.23, 5.31)

5.43 If power service leads of Number 4 or larger enter cabinets, starters, raceways, boxes, etc., the connector must have an insulated surface at the opening. This may be in the form of an insulated throat as an inherent part of the connector (Figure 11), or an insulated bushing, otherwise, substantial insulating material shall be fastened in place. If a wholly insulated bushing is provided a metal locknut for fastening the connector is required, however, the locknut may not be required if a metallic type insulated bushing (Figure 12) is furnished and this securely fastens the connector.

5.44 Connector locknuts in the small sizes are satisfactorily secured in position by using the R-2718 wrench. This is applicable to the locknuts of the armored cable fittings on the crossbar frame appliance outlet bases, and connectors at the flush mounted device boxes on the end of crossbar frame lineups. Locknuts of the larger sizes (1" and over) may be secured with suitable wrenches.

5.45 At 803-C ringing machine tables the armor on all armored wire and cable except line driven motor leads shall

be removed from a point just below the table top and the ends of the armor shall be protected with fiber antishort bushings. Place the fiber antishort bushing between the leads and sheath and use friction tape (RM-591127) around the outside to hold the bushing in place and guard outside rough edges. Apply one coat of RM-646482 shellac.

5.46 At open type power boards, switchboards and locations similar, to the extent that the armored cable does not pass through an enclosure surface, 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. At the above locations removal of long sections of armor and paper is common. To facilitate the removal of paper grasp the small wire under the paper and rip out and up toward the butt of the armor. In the absence of this small wire the paper may be removed by pulling apart the separate conductors. If the conductors are twisted, however, it is not necessary to untwist them except as required for termination. Use a fiber antishort bushing between the leads and sheath. If an armored cable connector with individually bushed holes is not furnished use RM-591127 friction tape around the outside to hold the fiber bushing in place and guard outside rough edges. Apply one coat of RM-646482 shellac.

5.47 Some enclosed type ac power service cabinets and switchboards such as KS-15697 and KS-15699 are equipped with split panels. One panel is used to terminate armored wire and cable and the other shall be left blank so as to provide access for subsequent running and terminating operations. Typical of this arrangement is drawing ED-81414-01.

6. REMOVING SHIELDING FROM SHIELDED WIRE

6.1 To remove the shielding from shielded wire proceed in accordance with the Wiring and Connecting Handbook.

7. STRIPPING AND BUTTING LEAD COVERED WIRE

7.1 Remove the lead sheathing from wire or cable as shown in Figure 13.

7.2 Lead covered leads shall have the lead stripped to the edge of the power board or fuse board 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. Butt lead sheath 1-1/2" from nearest point of connection at lugs, etc.

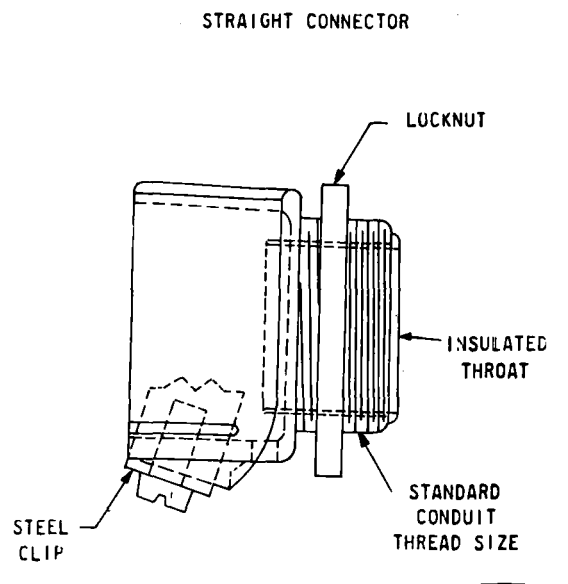
7.3 Leads which have a braided insulation under the lead covering need not be painted. Leads which have spiral tape insulation under the lead covering shall be taped with one layer of friction tape and given one coat of shellac.

8. GENERAL CONNECTING METHODS

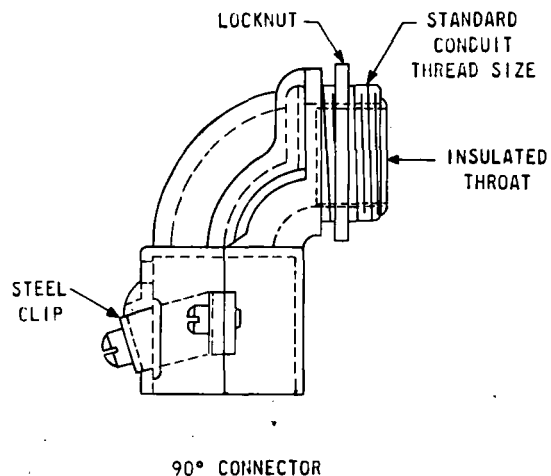
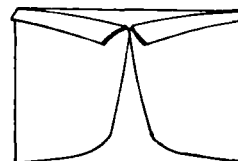
8.1 Connecting

8.101 Verify all power wires, previously run and tagged, by buzzing with ITE-4137 prior to making any connection. Color coded wires within a tagged cable need not be verified individually.

CONDUCTORS		LIST NUMBER			CONDUIT SIZE
SIZE	NO.	STRT. CONN.	90° CONN.	FIBER BUSHINGS	
14	2	02	52	101	1/2
	3	02	52	101	
	4	02	52	102	
12	2	02	52	101	1/2
	3	02	52	102	
	4	02	52	103	
10	1	02	52	108	1/2
	2	02	52	102	
	3	03	53	102	
	4	04	54	103	
8	1	02	52	108	1/2
	2	05	55	103	
	3	05	55	103	
	4	06	56	104	
6	1	02	52	101	1/2
	2	05	55	104	
	3	06	56	104	
	4	07	57	105	
4	1	02	52	101	1/2
	2	07	57	105	
	3	07	57	105	
	4	07	57	106	
2	1	03	53	102	1/2
	2	07	57	106	
	3	08	58	106	
	4	08	58	112	
1	1	04	54	103	1/2
	2	08	58	112	
	3	09	59	112	
	4	10	60	112	
0	1	06	56	103	3/4
	2	09	59	112	
	3	10	60	112	
	4	10	60	114	
00	1	06	56	104	3/4
	2	10	60	112	
	3	10	60	114	
	4	11	61	114	
000	1	06	56	104	3/4
	2	10	60	114	
	3	11	61	114	
	4	12	62	116	
0000	1	07	57	105	1
	2	11	61	114	
	3	12	62	116	
	4	12	62	116	
300,000 CM	1	07	57	106	1
	2	12	62	116	
	3	13	66	116	
	4	14	64	118	
400,000 CM	1	08	58	106	1-1/4
	2	13	66	116	
	3	14	64	118	
	4	14	64	118	
500,000 CM	1	08	58	112	1-1/4
	2	14	64	118	
	3	14	64	118	



FIBER ANTI-SHORT BUSHING



(RP-178C6)

FIG. 11 KS-5497-01 ARMORED WIRE AND CABLE CONNECTOR, LIST NUMBERS, AND SIZES
(PARS. 5.31, 5.41, 5.42, 5.43)

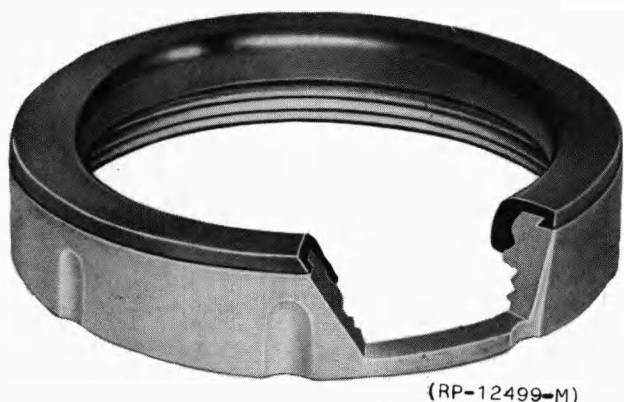


FIG. 12 INSULATED BUSHING (PAR. 5.43)

8.102 Attach only one lead to a punching, lug or connector that is designed to accommodate one lead.

8.103 No splices are permitted within conduits. Make splices only in authorized boxes, fittings, wireways, etc.

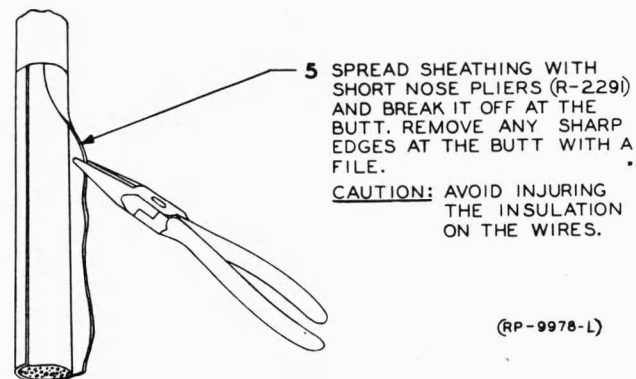
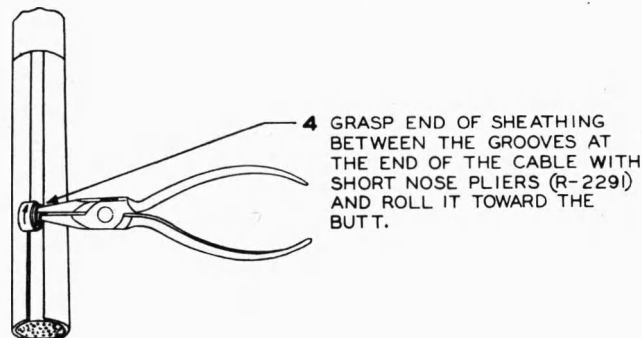
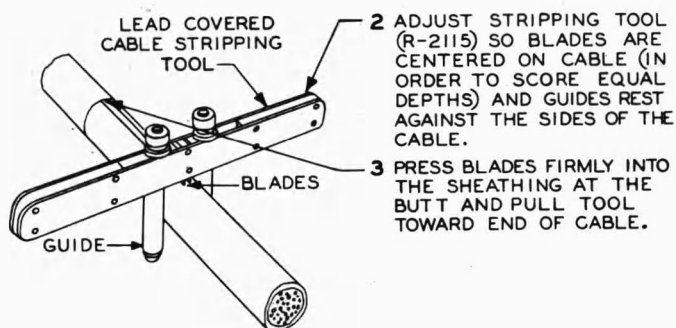
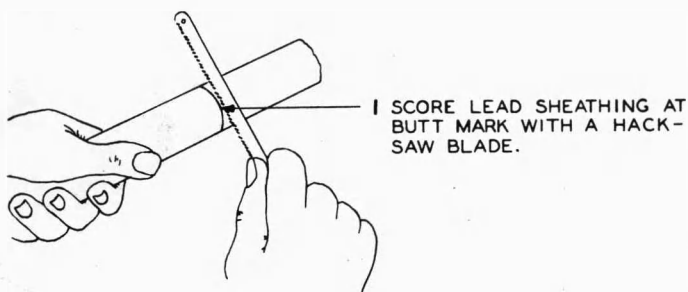
8.104 Where two battery feeders are used in a lineup of frames, connect the frame feeders to the lineup feeders as indicated on standard drawings. In No. 5 offices the two feeders are used to increase

load capacity. Standard drawings indicate the frame feeders (not necessarily each frame; some frames have more than one feeder) connected alternately except some frames having two feeders must have both connected to the same lineup feeder. In this case the next similar frame has both frame feeders connected to the other lineup feeder. In No. 4A offices the two power feeders serve the additional function of limiting service interruption due to damage to a power feeder. In No. 4A offices the feeders are designated A and B and the identity of each feeder must be carefully retained from the power room to the frame fuses.

8.105 On Battery Distributing Fuse Boards and Power Boards all alarm wiring for power fuses and associated alarm fuses shall be connected initially whether the locations are to be fused or to be made spare.

8.106 When wiring transformers associated with KS-5396-01 ringing machines on 803-C power plants, terminate wires at leads which are not taped. After factory tests on the ringing machine the manufacturer tapes all transformer leads not to be used and leaves untaped those leads which are to be connected by the installer. Refer to the note on the T-80686 drawing, specified for the job which covers transformer leads.

8.107 Connections which are a part of an approved manufacturer's product need not be modified on the job.



(RP-9978-L)

FIG. 13 BUTTING AND STRIPPING LEAD COVERED POWER WIRE (PAR. 7.1)

8.108 On most plugs and receptacles the circuit ground terminal is identified by being nickel plated or white metal. On Twist Lock plugs and bodies the circuit ground is identified by being copper plated and therefore is darker than the live terminal. The frame ground is always identified as green. Standard drawings shall be followed regardless of color or material of terminal. Typical drawings showing this information are: ED-63616-30, -31, -34, for toll and ED-91181-10 and T-81126-11 for common systems.

8.109 After all wiring operations are completed remove and discard temporary wiring tags. Tags attached to apparatus containing permanent instructions, such as lubrication tags, shall be left in place.

8.110 Solderless connections are made up the same for both ac and dc circuits, that is, as far as cleaning and the use of protective compound is concerned.

8.2 Testing AC Circuits

8.21 Each branch of all ac service circuits shall be tested after it has been fused and loaded as described in Paragraph 10.62 and covered in Section 7V.

8.3 Test Lamps

8.31 The R-2559 neon test lamp is an excellent indicator of potentials from 100 to 550 volts. It may also be used for continuity tests of fuses. It is not dependable for continuity tests of wiring because it may light on leakage currents. See Figure 14.

8.32 The ITE-4175 lamp socket fitted with a 25 to 60 watt lamp is completely trustworthy for continuity tests. It can be used, however, only with circuits operating between 20 and 150 volts.

8.33 Tests at fuse boxes, switch boxes, service cabinets, etc., should be made with extra care. The circuits are usually tested with the R-2559 lamp.

CAUTION: Do not use the ITE-4175 lamp set on potential over 150 volts.

9. CONNECTING TO DORMANT FEEDERS

9.1 Just before working on a battery or ac feeder believed to be open, or on a ground feeder, use an ITE-4175 or R-2559 test lamp depending on the voltage of the circuits involved, to confirm the absence of a potential. Prior to making any test, place the lamp across a known source of the potential to be connected and ground to determine the brightness of the lamp at this potential. Determine if a difference of potential exists between a conductor about to be connected and the point to which it is to be connected by means of the lamp.

9.2 Remove the frame or unit main fuses and their associated alarm fuses from all equipment bays. Select the identified leads to be connected and make the

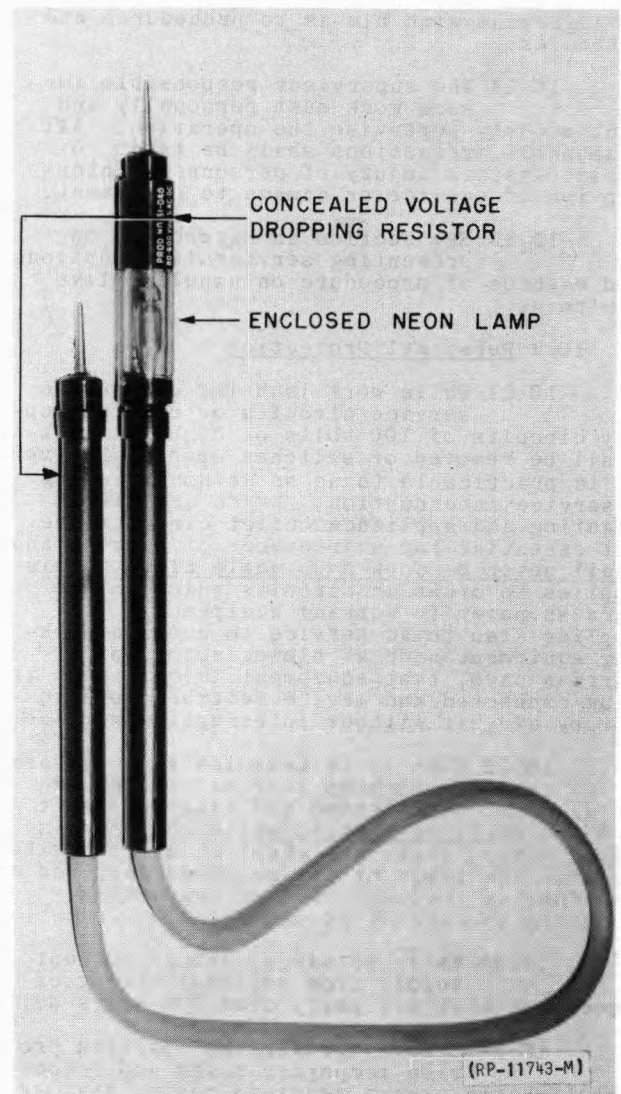


FIG. 14 R-2559 NEON TEST LAMP (PAR. 8.31)

connections starting at the equipment end and working toward the source of supply end. Make a final buzzer test prior to connecting and compare with the tag designations to insure against polarity reversals.

10. CONNECTING TO LIVE FEEDERS

10.1 Planning

10.11 Handbook 22 titled "Power Transitions" shall be referred to before doing any work on live feeders and equipment.

10.12 On power plant modification jobs where transition work may affect service follow any procedures covered in the job papers. Information regarding conductor sizes, battery capacities, fuse capacities and other engineering information should be obtained from the Equipment Engineers (or telephone company on telephone company engineered jobs).

10.13 Make no changes on live working power equipment in an operating office, except at such time as designated by the telephone company representative and in agreement with him as to procedures and schedules.

10.14 The supervisor responsible for such work must personally and continuously supervise the operation. All reasonable precautions shall be taken to avoid physical injury of personnel, interruption of service or damage to equipment.

10.15 See section in Handbook 0 on preventing service interruptions and methods of procedure on handling live equipment.

10.2 Personnel Protection

10.21 While work is being done on ac service circuits or ringing supply circuits of 100 volts or higher, fuses shall be removed or switches opened wherever it is practicable to do so without causing a service interruption. Frame and aisle lighting and appliance outlet circuits are not essential for maintenance of service and shall never be worked on while alive. This applies to other ac circuits which do not furnish power to working equipment. It applies also to ac service to certain working equipment such as blower motors of carrier bays, test equipment, etc., which is plug connected and may be switched to a temporary circuit without interrupting service.

10.22 When it is unavoidably necessary to work on live ac service or adjacent to unprotected and live equipment, two men shall be present while the work is being done. These men shall be aware of the hazards involved, of the measures required to avoid an accident, and of the action required in case of an emergency.

10.23 Where possible, remove current supply from adjacent wiring or equipment that may carry over 100 volts dc.

10.24 Before opening the circuits provide temporary power and temporary lighting, where required, using standard installation tools and procedures as covered in Handbook 0.

10.25 Remove fuse or open switch or circuit breaker to disconnect power from the circuit on which work is to be done, protect and tag the fuse mounting, switch or circuit breaker as described in a previous paragraph on precautions to avoid accidental reclosing, and test the circuit at the work location to be sure power has been removed. The test may be made by observing lamps in the circuit or by means of test lamps or a voltmeter. On ac service circuits, when preparing to cut or open grounds and neutrals, the voltmeter test does not indicate when the conductor is carrying current. Therefore, it is essential to visually inspect and determine that no other live circuit is completed over this return path through an error in wiring. If visual inspection is not feasible the ground wire may be cut with the person insulated from the wire or otherwise insulated from grounded objects. Once cut, each wire end shall be checked for absence of a potential.

10.3 Equipment Safety

10.31 Wrap live bus bars and cover live terminals and lugs near equipment being worked on with sheets of R-3154 protective sheeting. It is available in 3' 3" x 4' pieces which, because of inherent characteristics, can be used to tuck in small spaces giving more adequate protection than might otherwise be obtainable. When the protective sheeting is likely to be touched or disturbed it should be tied securely in place. Tie the protective sheeting without puncturing. When work is being done above live bus bars or studs, protect them with fiber board to catch falling solder or tools. Fiberboard can usually be obtained by cutting pieces from the outer covering of cable reels or from packing cases made of this material. Remove nails, etc.

10.32 Remove the frame or unit main fuse and the associated alarm fuse from the equipment bay or unit before connecting the power feeder to a live power feeder. Make a final buzzer test of added wiring prior to connecting and compare with the tag designations to insure against polarity reversals.

10.4 Making Connections

10.41 All connections to added equipment shall be completed before the connection to the live feeders are made. Trace by hand to the identified source the working lead to which a connection is to be made.

10.42 Prior to making any connection determine the polarity of each side of a proposed connection by placing a test lamp across known battery or ac and ground, in turn, and each connecting point. Then place the lamp across the points to be connected. If the lamp glows dimly, as compared to the initial check with known battery or ac, or does not light, the connection may be completed.

10.43 A momentary glow at full brilliance for the voltage being connected indicates the presence of an electrolytic capacitor. The lamp should be kept in place until almost the instant of connection so the capacitor will remain charged. A persistent glow may indicate an electrolytic capacitor forming. Allow the lamp to remain in position for several minutes and make the connection when the lamp begins to dim.

10.44 If the lamp stays lighted indicating a difference of potential do not make the connection until the trouble is cleared.

10.45 After connections are made, verify the polarity and potential of the power wire connections at each bay, frame shelf and ac service outlet.

10.5 Relocation of Live Feeders

10.51 If it is not possible to remove the current supply from a wire, one end of which is being relocated, or disconnected at the equipment, tape the open end for protection while forming.

10.6 Frame and Aisle Lighting

10.61 When adding branch circuits from the distributing box or extending existing circuits, before connecting to the live circuit verify that no continuity exists between the added neutral (white wire) and the equipment ground. To check for absence of continuity first ascertain that no potential exists between the white wire and the equipment ground and then check with an ohmmeter. Once it is determined the added neutral is not inadvertently grounded it may then be connected to the existing neutral or the circuit ground bus in the distribution cabinet.

10.611 This requirement agrees with the N.E.C. which allows the neutral wire to be grounded only where the service enters the building.

10.62 After an ac branch circuit has been connected and fused it shall be tested to determine that no unbalance current is present. An unbalance in current indicates a split in current where all of the current in the line (hot) conductor does not return exclusively over its paired neutral. This prohibited condition contributes to noise in telephone circuits and is caused by connecting two or more circuits together (usually on the ground side) or grounding the circuit ground (white wire) to the iron work (specified only where the service enters the building.)

10.621 Place a load of 100 watts or more on the branch circuit under test. Determine that no unbalance exists by placing the ITE-4503A Hook-on ammeter around armored wire, conduit or any other paired ac service conductors starting as near the source as possible. If an unbalance is indicated by any reading on the clamp-on ammeter repeat readings beyond each "T" connection until no reading is indicated. The area of trouble will be located between the last two readings. Correct the fault and record this test in job verification records.

11. CONNECTIONS AT AC TRANSFER SWITCHES

11.1 Where two polyphase services are present at a load transfer switch they must be connected so that the phase rotation (phase sequence) is the same. The actual connections are determined by test rather than by the attached tags indicating individual phase identity.

11.2 The test with the R-3404 Phase Sequence Indicator and the action to be taken to meet this requirement is covered in Section 199B of Handbook 21.

11.3 These connections shall be verified for proper phase rotation and entered as part of verification records.

12. FUSING, SWITCHING AND CONNECTING TO LIVE CIRCUITS

12.1 Place fuses in the source end first, such as at the Main Control Board, distribution fuses second (B.D.F. Boards of End Guard Fuse Boxes) and the

individual fuse panels last. Use the test lamp across each fuse connection prior to inserting the fuse to determine if uncharged capacitors are in the circuit or if a false ground is present. Proceed as follows:

12.11 Place one leg of the test lamp on a known ground such as the framework or ground bar. Touch the other leg to the live side of the fuse stud. Observe if the lamp lights and note range of brightness. Then remove the lead from the ground and place on other fuse stud. If the lamp does not light insert the fuse. If the lamp glows to full brilliance for the voltage being tested, and then starts to dim, hold it until it glows dimly or goes out. This will indicate that any capacitors in the circuit have been charged. When the lamp begins to dim insert the fuse immediately while the capacitors are still charged.

12.12 If the lamp stays lighted indicating a difference of potential do not make the connection until the trouble is cleared.

12.2 After connections are made and the circuits are fused verify the circuit assignment, polarity and potential of all power wire connections of each bay, frame, shelf and ac service outlet.

13. POWER SERVICE LEADS - COLOR CODE AND POLARITY

13.1 The color code for power service wire is white, black, red, blue and yellow. White is reserved for circuit ground or neutral leads and these leads, if permanent, must always be white (white includes natural gray). Green is not in the color code but is used for frame or equipment grounds such as in cords for portable equipment. The other colors are used in sequence; white with black or white with red in ground return two-wire circuits; black and red in two-wire circuits without ground return; white with black and red in three-wire circuits with a ground lead; black, red and blue in three-wire circuits without a ground or neutral lead, (the blue is a white wire painted at the exposed ends - see Section 6D) and white with black, red and blue for three-phase, four-wire circuits with a ground or neutral lead. If a white wire is used as a live lead it must be painted at exposed ends either black or in accordance with the color code.

13.2 Wire No. 6 or smaller, shall be painted if necessary at exposed ends, to conform with the color code.

13.3 Wire No. 4 or larger, shall be painted if necessary at the exposed ends, so that the ground or neutral lead is natural gray or white and all remaining leads are black.

NOTE: See Section 6D for method of painting wire ends.

13.4 Information covering polarity connections for leads attached to receptacles or plug caps is covered on

standard drawings such as ED-91181-10. This drawing may be ordered if information is not available on the job drawing.

14. SPLICING BATTERY DISTRIBUTING AND POWER SERVICE LEADS

14.1 Battery Distributing Leads

14.11 Except when splicing long runs that cannot be furnished in one piece (discussed in Section 6B) and, unless job information differs, splicing and connecting No. 10, 12 and 14 AWG leads in protected locations shall be made with R-3045 or R-3046 wire connectors. These connections are covered in Section 7D.

14.111 A protected location is a position such that normal maintenance operations or pulling in future cables will not disturb the splice.

14.112 Examples of a protected location are in vertical channels, ducts, etc., on frame uprights, under racks, on racks or sections of rack reserved exclusively for power wires.

14.113 In unprotected locations the leads shall be soldered as covered in Section 7C. Other sections in the 7 series cover the method for installing the various connectors.

14.12 Taps and splices where the largest lead is No. 8 AWG or larger and the small lead not less than No. 14 AWG, shall be made using KS-5537 connectors.

14.13 Cross taps are made with Frankel No. 2632 cross tap.

14.14 When extending feeders an in-line connector Frankel 2560C is used. This type of straight through connection is used for improved appearance or where space is limited.

14.2 Power Service Leads

14.21 No. 12, 12 and 14 AWG leads are spliced at approved boxes, fittings, wireways, gutters, enclosures, etc., with R-3045 and R-3046 wire connectors.

→ Arrowed lines indicate new or changed information.

[Vertical lines at side of paragraphs indicates requirements.

14.22 Larger wire splices and connections are made with approved solderless connectors covered in Section 7D.

15. PROTECTION OF WIRE ENDS

15.1 Wire ends do not necessarily terminate in a connecting device. These free ends are sometimes left as permanent extensions through the last connector in such a manner that solderless splices can be used to extend to future equipment. When required, this arrangement will be covered on equipment drawings. Examples are in switchboard line-ups and at crossbar main and cross aisles where there is a possibility of growth.

15.2 Insulate the exposed ends of all connected power wires.

15.21 To insulate the ends of No. 10 AWG and larger first place a "clove hitch" 1/2" to 3/4" from the end with sewing twine and complete with a square knot. This knot is shown in Section 7D. Fig. 2 Cover with several turns of rubber tape and then fold tape back and forth across the end until end is covered. Repeat with friction tape extending it beyond the rubber tape. Except when taping in an enclosure, apply one coat of shellac to extend on to the wire insulation.

15.22 For leads No. 12 AWG and smaller, apply one or two turns of friction tape approximately 2" from the end. Fold the wire end over so the end comes in the middle of the tape and continue taping the end on itself. Except when taping in an enclosure, apply one coat of shellac to extend on to the wire insulation.

16. DUMMY FUSES

16.1 In enclosed locations dummy fuses need not be installed in power fuse clips except as necessary to retain fuse caps. In exposed locations dummy fuses shall be installed in all locations where regular power fuses are not installed and where regular power fuses are installed and not working.

R. W. HILLEGAS

Engineer of Installation

Reason for Reissue:

- (1) To describe method of removing tightly wrapped armor.
- (2) To detail method of terminating bonding wire under armor.
- (3) To correct RM number of orange shellac.
- (4) To require physical identification before connecting to working circuits.
- (5) To specify thickness of tape when taping is required.
- (6) To warn against cutting strands when skinning stranded wire.
- (7) To prohibit pulling splices into conduit.
- (8) To require that phase leads at transfer switch be checked for phase rotation when connected and entered in verification records.
- (9) To require verification of ac circuits for absence of grounds.
- (10) To require verification of ac circuits for absence of split pairs.

Replaces Section 7A dated 11-19-59.