LIGHTGUIDE CABLE PLACING

UNDERGROUND

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I. GENERAL

1.01 This practice covers the recommended methods of placing optical cable in underground plant. Optical cable is installed in a ductliner that has been installed in a standard duct in advance of the optical cable placing operation. Ductliner provides an efficient use of conduit space. In case of future growth and maintenance conditions, up to three ductliners can be placed in a 4-inch conduit. Refer to Section 628-200-215 for ductliner placing methods.

1.02 This practice is reissued to incorporate changes in optical cable placing procedures. A brief description of the different core designs for optical cable is provided. Recommendation for winch line type, types of lubrication, and lubrication procedures is also provided. Because of extensive rewriting the revision arrows are omitted.

1.03 This section may contain references to specific tools and materials in order to demonstrate a particular method. Such references are in no way intended as a product endorsement.

1.04 Typical optical cable has two basic strength member sheath designs; steel reinforced and nonmetallic fiberglass reinforced. Strength members have a direct relationship to allowable cable pulling tensions.

1.05 Optical Cable is available in two basic core designs; ribbon-type and stranded-type.

RIBBON-TYPE cable consists of a linear array of 12 fibers sandwiched between 2 adhesive layers of tape to form a ribbon. The number of ribbons stacked within the cable core makes up the fiber count.

STRANDED-TYPE core design consists of individual fibers usually contained in a buffer tube surrounding a inner strength member.

1.06 Optical cables are ordered in specific lengths. The lengths are determined by measuring between splice locations, including allowances for racking in all manholes plus a minimum of 12 feet of excess. Maximum cable lengths are limited by reel capacities. Reel capacities for AT&T Technologies stranded cable are given in Table A. After the cable is installed, the excess is coiled in the splice manhole.

1.07 Ribbon core optical cable can be shipped from the factory either with factory-installed connectors or without connectors. Stranded core optical cable must be spliced in the field.

1.08 Lubrication should be used for all optical cable pulls. Both the winch line (KEXLON rope)* and the cable should be lubricated. The cable lubricant should be applied as the winch line and cable are pulled into the ductliner. **Warning: Liquid detergents shall not be used as lubricants for placing optical cable. Most detergents will promote stress cracks when used on polyethylene.** The recommended cable lubricants for optical cable placing are POLYWATER,† types A and C, or HYDRALUBE BLUE.‡ Pour or pump the lubricant into the raised end of the ductliner ahead of the swivel connector so the swivel connector distributes the lubricant as the winch line is pulled in. Use approximately 1 quart of lubricant for each 300 feet of pull (approximately 4 gallons for 2400 feet of cable). If the ductliner is open at intermediate manholes, the appropriate proportion of lubricant should be applied at each manhole. Follow the same procedure when placing the optical cable.

2. PRECAUTIONS

2.01 Before starting any underground cable placing operations, all personnel must be thoroughly familiar with the practices in the 620 Division. The practices covering the following should be given special emphasis:

(a) Guarding and protecting work areas

(b) Testing and ventilating manholes

(c) Occupational exposure to lead dust

*Trademark of Samson Ocean Systems, Inc.

†Registered trademark of American Polywater Corporation.
‡Registered trademark of Arnco.

(d) Precautions pertaining to smoking or use of open flames around manholes

(e) Removing and replacing manhole covers

(f) Signals used in outside plant construction work.

2.02 When working in manholes, precautions must be taken to limit the amount of exposure to lead. Lead dust is released into the atmosphere any time the sheath of **older** lead sheath cable is disturbed. Inhalation of lead dust; transfer of lead dust from the hands to the nose or mouth; and ingestion of lead from food, drink, and tobacco products that have been exposed to lead dust can have adverse effects on the health. To effectively remove potential hazards, the lead handling procedures covered in Section 620-100-010 must be strictly observed.

2.03 All personnel involved in placing underground cable must be trained in the operation of the equipment and construction apparatus that will be used.

2.04 Adequate communications must be established and maintained between the cable feeding location, the pulling equipment, and all manned intermediate manholes during all pulling operations.

2.05 Practice good housekeeping. Arrange material in the vicinity of the manhole so it will not fall into the manhole or unnecessarily interfere with pedestrian or vehicular traffic.

2.06 Inspect manhole ladders before using and replace defective ladders promptly when found in a deteriorated condition. When the bottom of the ladder is in water or otherwise invisible, remove the ladder for inspection.

2.07 Before using pulling irons, inspect for significant corrosion and make sure they are securely anchored in the wall.

2.08 If work is done with a truck not equipped with an overhead exhaust and the truck is stationed near a manhole, position the truck so the exhaust gas will not blow into the manhole or be picked up by the manhole blower.

2.09 Position gasoline- and propane-driven generators, blowers, pumps, etc., so the exhaust fumes will not blow into the manhole.

2.10 Exercise caution when entering and leaving a manhole, particularly those located on traveled thoroughfares. Always use a ladder when entering or leaving a manhole. When ascending from the manhole, always face oncoming traffic. Keep hands free of materials or tools when ascending or descending a ladder. **Never use a cable, coil case, or apparatus case as a step.**

2.11 When working in a manhole, exercise care to prevent damage to cables.

2.12 Employees normally should not enter a manhole or remain in a manhole during the placing or removing of any cable. A worker can be in a manhole when an optical cable is being pulled in if the person stays out of the angle made by the pulling apparatus. Some necessary duties are:

- To provide manual assist in pull-through manholes.
- To observe alignment of equipment. The employee should remain clear of the equipment.
- To assist in alignment at the feed (trailing) end of the pull.

3. PRESURVEY

3.01 The presurvey of an optical cable route is an integral part of the engineering for the route. Presurvey begins with route selection and continues through the installation of the ductliner. Any problem areas encountered or special requirements determined during ductliner planning and placing must be considered during planning for the cable placing operation.

4. TOOLS AND MATERIALS

4.01 For setups in the pulling and feed manholes, the sheaves, pulling frame, etc., are the same as those normally used for all underground cable placing. Refer to Section 628-200-208 for an example of tools and equipment. Some tools and materials required for placing underground optical cable are described in the following list.

ITEM	DESCRIPTION
B Innerduct/Cable Slitter (AT-8959) (Fig. 1)	Similar to the B cable sheath slitter. Used for slitting innerduct longitudinally (Section 081-241-101).
B Innerduct Coupling (AT-8963) (Fig. 2)	Used to join sections of innerduct to form a continuous duct through an intermediate manhole, to extend an innterduct in a manhole, and to repair innerduct.
Winch	The winch should incorporate a tension control that can be adjusted in the field so the maximum allowable pulling tension will not be exceeded. The winch must also be capable of maintaining tension on the winch line when not taking up cable.
D Lightguide Cable Feeder (AT-8990) (Fig. 3)	Used to guide the winch line and optical cable into the ductliner. One end of the feeder is flared and the other end is belled to fit over the end of the ductliner.
Flexible Pulling Eye	The flexible pulling eye is installed on AT&T Technologies ribbon core optical cables. It is used for attaching winch lines when placing the cable and to protect the factory-prepared cable ends.
Innerduct Cutter (Fig. 4)	Used to ring cut innerduct.
Cable Grip	Cable grips are flexible wire mesh holding devices used to pull optical cable. These grips are used whenever the cable does not have a factory pulling eye installed.
Optical Cable Bending Shoe (Fig. 5)	Used to protect and rack optical cables where needed. Made from 1-1/2 inch polyvinyl chloride (PVC) pipe, split to allow for installation. Available in straight sections or 90 degree bends. Secure halves with cable ties or clips made from rings cut from 1-1/2 inch PVC pipe.
Optical Cable Storage Form (AT-8960) (Fig. 6)	Used to wind excess cable into a coil for storage in the manhole. The form is equipped with a hinge device to reduce the diameter of the form so the coiled optical cable can be removed from the form.
Pulling Line	The recommended winch line for pulling lightguide cable is 1/4-inch KEXLON rope.
Swivel Connector (Fig. 7)	The Pengo-Miller model A-13L swivel, or equivalent, will swivel when under tension to relieve any torsional imbalance between optical cable and winch line.

4.02 The tools and materials required for preparing ductliner seals are a rubber stopper, which fits inside the ductliner, a 7/16-inch cork borer or other similar tool for cutting a 7/16-inch diameter hole through the stopper, a 1-3/4 inch C sealing clamp, C cement, and splicer's scissors.

5. DUCTLINER

5.01 Ductliner is plastic pipe or tubing that provides a high quality path for optical cable. It is also used to subdivide conduit and make space available for additional cables. Up to three ductliners may be placed in one 4-inch conduit. Cable pulling tensions increase with the number of ductliners. Some ductliners can be purchased with a fish line or measuring tape already installed.

5.02 In manholes where the ductliner is interrupted, the ends of the ductliner may be joined to provide a continuous path through the manhole. The ducts can be joined with a B innerduct coupling (AT-8963) or equivalent.

5.03 The B innerduct coupling (Fig. 2) is fabricated from aluminum tubing. The coupling is 3 inches long and is threaded internally with a right-hand thread in one end and a left-hand thread in the other end. The end with the right-hand thread is marked with an

arrow to indicate the direction of rotation for installing the coupling. A slot in the center of the coupling provides a means to check whether the ends of the innerducts are butted in the coupling.

5.04 To install the coupling, first cut the ends of the innerduct with an innerduct cutter (Fig. 4), being sure the ends are square and smooth. Position the coupling on one innerduct end and turn it by hand until the threads have started. Insert the other innerduct end into the coupling and turn the coupling by hand until the threads have started on that end. Use channel lock pliers, a pipe wrench, or a strap wrench to turn the coupling until the ends of the innerduct are firmly butted against each other.

5.05 Table B shows the number of ductliners recommended to be placed in a conduit and the maximum cable diameter to be placed in a given size ductliner.

6. PLACING THE WINCH LINE

6.01 If more than one ductliner enters the manhole, identify into which one the optical cable will be placed. When the rodding line has been identified, tie it off, recap any spare ductliners, and tie the spares out of the way.

6.02 Position the truck or portable equipment with a winch at the pulling manhole. A typical example of a capstan winch set up for pulling cable is shown in Fig. 8. The description and operation of this capstan winch is covered in the practices of the 649 Division. The operation of other lightguide placing winches is available from the manufacturer. Set up at the pull manhole so the winch line can be fed by hand into the ductliner, snatch blocks or pulling frame. The winch should be in its final pulling position. Place an optical cable feeder on the end of the ductliner so it exits the duct in a straight line. Secure the ductliner with temporary ties so it will remain straight and will not creep into the main duct when placing the winch line or out of the main duct when pulling the cable. Secure the rodding line to the winch line rope. It is possible to set some winches to the various allowable maximum pulling loads for optical cable. Where this is not possible, it is necessary to use a dynamometer to avoid excessive pulling loads.

6.03 The ductliner in intermediate manholes may be continuous through the manhole or may be interrupted. **In either case, the ductliner must be positioned in a relatively straight path from entry duct to exit duct.**

(1) If the ductliner is continuous, and has been temporarily racked, work ductliner excess slack toward adjacent manholes. If necessary, slack can be cut out using the innerduct slitter and cutter. Temporarily tie the ductliner to keep it from creeping into the main duct during winch rope and cable placing and to keep ductliner ends aligned.

(2) If the ductliner is not continous and the entry and exit ducts are aligned, the ductliner may be joined with a coupling to make the ductliner continuous. If the ductliner ends are not long enough to join, a short section of ductliner may be spliced in using two couplings. To place a ductliner coupling and to splice in a section, cut and thread the rodding line through the coupling and ductliner section. Join the ends of the rodding line securely.

(3) If the ductliner is not continous and will not be joined and the entry and exit ducts are aligned, place an optical cable feeder on each of the ductliner ends after cutting a sufficient length from each end to allow for alignment. Align the ends and tie them in place to maintain alignment and to prevent the ductliner from creeping into or out of the main duct during winch line and cable placing. The rodding line ends must be connected according to the manufacturer's recommendation if the winch rope will be pulled through the manhole.

(4) If the entry and exit ducts are offset by a ratio greater than 3/10 (e.g., 3-foot offset between entry and exit ducts in a manhole 10 feet long), sheaves can be rigged in the manhole, or if the ductliner is continous it can be tied off to form a gradual sweep. When using sheaves (or blocks) they should be at least 12 inches in diameter. Cut off the ends of the ductliner to provide ample clearance, consistent with racking requirements, between ductliner ends and the sheaves. The sheaves must be tied in position because pulling tensions usually are not sufficient to stabilize the sheaves. The ductliner must be secured to prevent creeping.

6.04 Technicians may remain in pull-through manholes rigged with sheaves during powered pulling operations as long as they remain out of the angle made by the pulling apparatus. Set up the feed manhole with a snatch block, cable sheave, or tie off the ductliner to create a gradual sweep. so the rodding line exits the main duct in a straight line. When using sheaves or blocks arrange the ductliner so its end will

be at least 12 inches from the block or sheave. The ductliner may stretch during winch rope placing and will catch in the block or sheave if the distance between ductliner end and the block or sheave is too short at the beginning of the placing operation. Place an optical cable feeder on the end of the ductliner and temporarily secure the ductliner so it will not creep during winch rope placing. Pull the winch rope into the ductliner. **The reel used to take up the rodding line should have a solid hub. The constricting forces developed as plastic rope builds up on the reel can break a collapsible reel.**

7. PLACING THE CABLE

7.01 Air core optical cable is shipped pressurized. A valve stem should be provided at each end of each cable section. The cable pressure should be checked before and after placing. Cable pressurization is a means of excluding water from air core cable and ensuring the integrity of the cable sheath. If cable pressure is less than 5 psi before the cable is placed, repressurize the cable to 10 psi and check for leaks at the termination hardware and flexible pulling eye. If leaks are found, they must be repaired.

7.02 After the cable has been placed, recheck the pressure. If there is a pressure drop, recheck the terminating hardware and pulling eye for leaks and repair leaks. If there is a pressure drop and no leaks are found at the terminating hardware or pulling eye, cable damage is indicated. If pressure after placing is less than 8 psi, repressurize to 10 psi. Filled optical cable should be visually checked for sheath damage while hand feeding at feed and intermediate manhole locations.

FEED MANHOLE

7.03 Position the cable reel adjacent to the manhole so the cable can be hand-fed into the manhole during the placing operation. Remove the snatch block or cable sheave if used during the placing of the winch rope. Attach the winch rope to the optical cable with a Pengo-Miller A-13L swivel connector (Fig. 7) or equivalent, and a cable grip if there is no factory installed pulling eye. Tape the connector at the pulling eye so the connector will not turn crosswise in the duct. Be sure the connector swivels freely.

7.04 When the pull starts, pay out the cable by hand-maintaining a slack bight that will not snag on cable racks, hooks, ladders, etc., and will not permit slack loops to form on the cable reel. Proper hand assist at the reel greatly reduces pulling tensions.

PULL MANHOLE

7.05 The pull manhole can be set up with a snatch block or cable sheave so the winch rope exits the main duct in a straight line or by sweeping the ductline from the main duct to the manhole opening (Fig. 9). Secure the ductliner with temporary ties so it will not creep out of the main duct as the cable is pulled. The end of the ductliner must be at least 12 inches from a snatch block or sheave.

7.06 If high pulling tensions are encountered, placing crews must be prepared to provide assistance in intermediate manholes. If the pulling tension required is greater than the maximum recommended by the manufacturer (see Tables C, D, E, and F for typical pulling tensions), assistance must be provided. If assistance is anticipated, those persons should be in position in the intermediate manholes with positive communication to the pulling vehicle before the pull starts.

7.07 Start the pull by gradually engaging the winch at slow speed, until the winch line begins to move. After the pulling eye enters the ductliner at the feed manhole, speed may be increased. Monitor the tension to be sure tension does not exceed the maximum recommended by the manufacturer. Where assistance is required in intermediate manholes, sufficient ductliner must be removed to provide at least a 3-foot gap for working space.

7.08 Some manufacturers pulling-eye assembly must not be pulled over any block or sheave regardless of sheave diameter. When this type pulling eye reaches the pull manhole or any intermediate manhole where blocks or sheaves have been used, stop the pull before the pulling eye reaches the snatch block or sheave. Assist the cable or reposition the block or sheave behind the pulling eye and continue the pull. The optical cable may be pulled over a sheave or quadrant blocks as long as the minimum bending radius and the maximum pulling tension is not exceeded. The minimum bending radius for optical cable is 10 times the cable diameter for a no-load condition and 20 times the cable diameter if the cable is under load. An example of maximum pulling tensions for various cable types are listed in Tables C, D, E, and F. Always check with the manufacturer for the maximum pulling tension of the particular optical cable.

8. BACKFEEDING - INTERMEDIATE MANHOLE

8.01 The backfeed method is another way of increasing the placing distances between splices of optical cable. Adequate work space is required at an intermediate manhole to implement this procedure.

8.02 Set up the optical cable reel at the manhole designated as the midfeed point. Remove any cable sheaves or snatch blocks if used during the placing of the winch line. Attach the winch line to the optical cable and position the reel in the same manner as described in paragraph 7.03.

8.03 Follow the procedures outlined in paragraphs 7.05 through 7.08.

8.04 When sufficient cable has been stored in the pull manhole, reposition the pulling winch at the next pull manhole.

8.05 At the intermediate manhole back off the optical cable remaining on the reel by hand. The cable must be laid out in a large figure eight configuration close to the manhole opening. The figure eight configuration will allow the optical cable to be hand fed into the manhole without kinks or twists.

8.06 Pull in the winch line from the new pull manhole to the midfeed point where the cable is laid out.

8.07 Attach the winch line to the optical cable as in paragraph 7.03.

8.08 Pull the optical cable as in paragraph 7.04.

9. DUAL REEL METHOD

9.01 In locations where the conventional backfeed method cannot be used due to traffic or other problems, the dual reel method should be considered.

9.02 The dual reel method requires a modified cable reel and two winches to pull optical cable in different directions from a midpoint feed manhole.

9.03 A cable reel modification is required to separate and temporarily terminate the bight of the optical cable on the dual feed reel. A typical reel modification is shown in Fig. 10. A slave reel is also required in this procedure.

9.04 Place a reliable footage counter between the factory cable reel and the slave reel. Place the cable through the footage counter and wind **the shorter of the two sections** onto the slave reel (Fig. 11). Place a marker tape on the cable when the required footage is reached. This marker represents the center of the feed manhole (Fig. 12). Reposition the slave reel next to the factory reel. Place the bight of the cable (marker tape) at the center of the dual reel and fasten with plastic cable ties (Fig. 13).

9.05 Place the footage counter on the cable (long section) coming from the factory reel and begin winding both cables onto the dual reel. Stop the winding operation when the end of the cable on the slave reel is reached. Place a marker tape representing this end on the cable coming from the factory reel. This mark represents the end of the short section (Fig. 12). Tie the short section of cable to the dual reel and continue winding until the correct footage is reached on the long section. Mark the end of this section with a specified colored marker. This will identify the long section of cable which must be placed first (Fig. 12). Tie the cable end to the dual reel.

10. PLACING THE CABLE - DUAL REEL

10.01 Procedures for placing the winch rope are the same as for the single reel operation. Position the dual reel adjacent to the manhole designated as the midfeed point. Remove any cable sheaves or snatch blocks used during the placing of the winch rope. Attach the winch rope to the long cable section identified by the marking tape, using the same procedures as for single cable placing. The short section of cable remains tied to the cable reel.

10.02 A pulling eye is required at each end of double pull cable. The ribbon-core cable design is normally shipped from the factory with flexible pulling eyes attached. Stranded core cables are normally shipped from the factory without pulling eyes attached. Pulling eyes must be attached to the cable before it can be placed.

10.03 Pull the long section of cable until the tape marker is close to the feed tube on the ductliner. Stop the pulling operation and disconnect the end of the short section from the reel. Hand-feed one or two wraps until the end of the cable is aligned with the tape marker on the long cable section. Connect the winch rope from the short section to the pulling eye.

10.04 Resume the pull of both winches and communicate to the winch operator the desired speeds of either winch to coordinate identical pulling rates. Stop the pull when there are a few wraps remaining on the

reel. Hand remove the cable and remove the radius cable ties from the reel. Resume the pull at a slow rate of speed while feeding the bight of the cable into the manhole. The tape marker should be centered in the manhole and the cable racked as in a normal pull-through manhole.

11. RACKING OPTICAL CABLE AND DUCTLINER

11.01 Racking should begin in the centermost manhole and proceed manhole by manhole toward each end. The preferred method of obtaining racking slack is by hand with intermediate assist, where necessary. Mechanical assistance is not recommended.

11.02 In the pull manhole, if the back half of the splice case is in place, position the cable so the end of the plastic sheath extends into the splice case 3 inches. Secure the end of the cable in this position with plastic cable ties. **When handling the cable, be sure the minimum bending radius is not exceeded.**

11.03 If the back half of the splice case is not in place and the cables have factory installed connectors and pulling eyes, place a wrap of plastic tape on the flexible pulling eye 9 inches from the end of the plastic sheath of the cable. Position the flexible pulling eye in the splice location so the tape falls on the center line of the splicing bay. Use plastic cable ties to hold the flexible pulling eyes, each end of the cable should overlap the center of the splice location 40 inches.

11.04 Set up the ductliner from the main duct in the same manner as any plastic sheathed cable. The ductliner should extend slightly beyond the first rack where it can be securely tied in place. If the ductliner does not end at a vertical rack where it can be securely tied, it can be cut back to the nearest point of support. If the ductliner will not reach the first rack, use split plastic bends to support the cable. The cable alone may be supported across splicing bays using plastic cable ties.

11.05 In intermediate manholes, it is not recommended that an attempt be made to develop slack for racking ductliner. Slack for racking the optical cable may come from either the feed or the pulling end of the cable, depending on which end is closer and the amount of excess cable. If the ductliner is continuous in intermediate manholes, cut it. Form the ductliner to the final racking position and secure it in position with plastic cable ties. The ends should extend beyond the first vertical rack so they can be tied at that point. It is often desirable to secure the ductliner to an existing, racked cable rather than attempt to cut the ductliner so it terminates at a specific point beyond the first rack. Support the cable that is not enclosed in the ductliner with plastic cable ties. Where necessary, the cable should be protected and/or supported with straight sections of split 1-1/2 inch PVC pipe.

11.06 In the feed manhole, excess cable can be coiled on the optical cable storage form. The cable is coiled on the form by starting with the terminated end of the cable. When placing cables equipped with factory installed pulling eyes, **do not wrap the flexible pulling eye on the storage form.** Secure the sheath end of the flexible pulling eye to the storage form with a plastic cable tie and coil the cable by rolling it up on the form (Fig. 14). As the cable is coiled, lower the storage form through the manhole opening. Secure the coiled cable with plastic cable ties. Collapse the form and remove the coil of the cable. Support the coil temporarily. Rack the ductliner and the cable and tie securely.

11.07 The coil should be racked in a location where it will not be subjected to damage, preferably on the manhole wall behind in-place cables. Place the coil in its racked position and adjust the size of the loops in the coil to position any terminating hardware in the correct position in the splicing bay. Do not decrease the diameter of the coil. If the length beyond the coil is too short, remove one or more loops from the coil and then enlarge the coil to absorb any excess. Tie the coil securely in place with plastic cable ties.

12. SEALING DUCTS

12.01 All unused ductliners should be capped with 1-1/2 inch size B or C cable caps. The ductliners must be racked along the same path as the occupied ductliner. The occupied ductliner should be sealed with a rubber plug.

12.02 For the plug in the occupied ductliner, use a standard No. 5 rubber stopper with a 7/16-inch hole cut through the center. Split the stopper with scissors so it can be placed around the cable. Apply C cement to the cable, the inside and outside surfaces of the stopper, and the inside surface of the innerduct. Place the stopper around the cable and push the stopper into the ductliner until it is flush with the end. Secure the stopper in place with a 1-3/4 inch size C sealing clamp.

12.03 The conduit occupied by the ductliner also must be sealed. Where there is one ductliner seal the conduit with a standard split rubber conduit plug. Where more than one ductliner has been placed in a single conduit, seal the space between the ductliners and the conduit with B duct sealer or WATER-PLUG* sealer. Use the methods described in Section 628-220-204. Do not use plastic duct seal.

*Registered trademark of Standard Dry Wall Products.

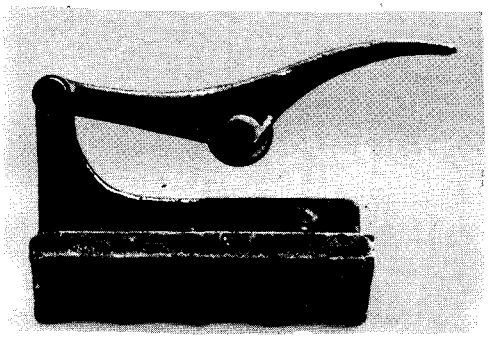


Fig. 1—Innerduct Slitter (AT-8959)

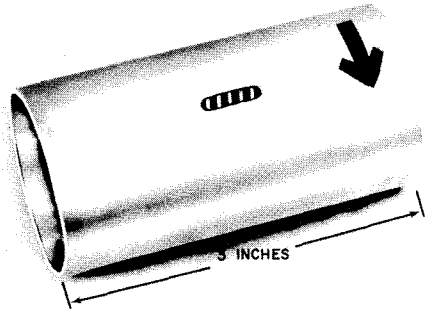


Fig. 2—Innerduct Coupling (AT-8963)

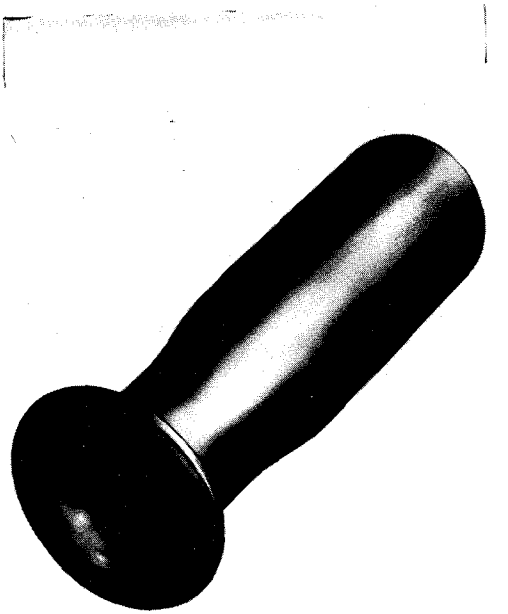
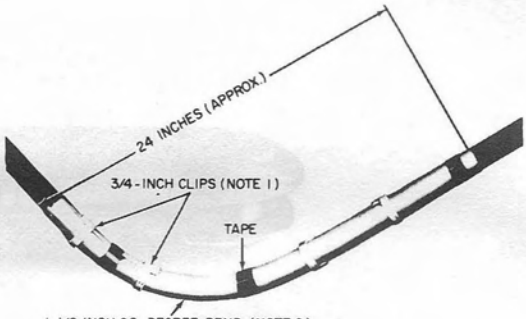


Fig. 3—D Optical Cable Feeder

Fig. 4—Innerduct Cutter



NOTES:
1. ALSO AVAILABLE IN 3-INCH WIDTH.
2. SPLIT, 1-1/2 INCH CONDUIT AVAILABLE IN 2,3, AND 5-FOOT LONG STRAIGHT SECTIONS.

Fig. 5—Optical Cable Bending Shoe

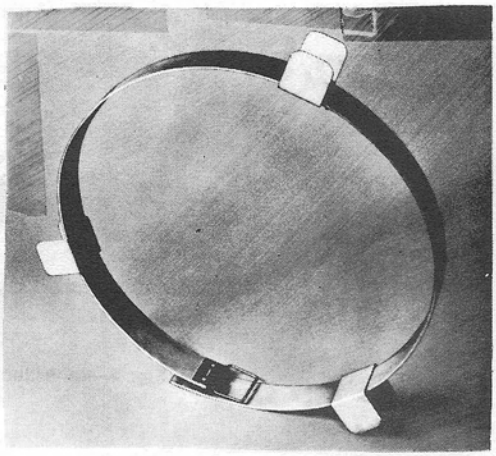


Fig. 6—Optical Cable Storage Form (AT-8960)

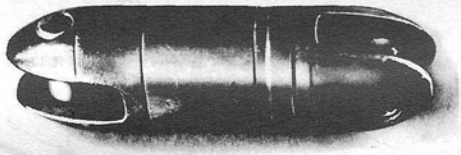


Fig. 7—Pengo-Miller A-13L Swivel Connector

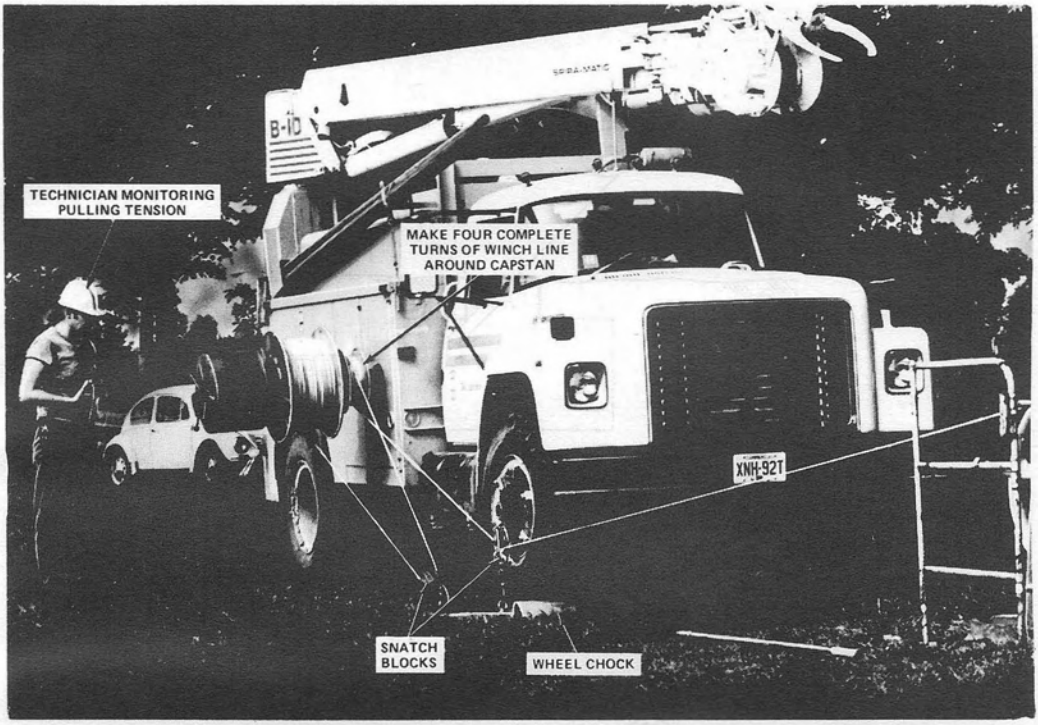
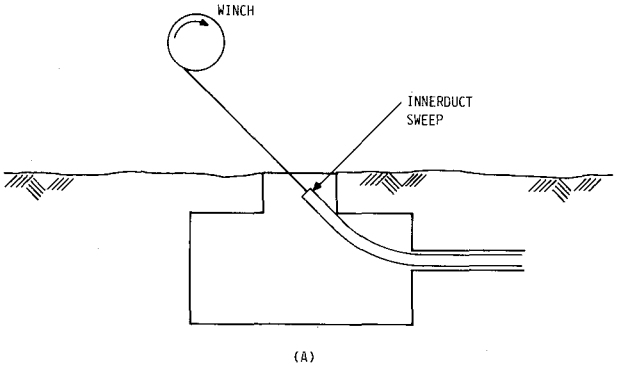


Fig. 8—Pulling Truck Set Up at Manhole



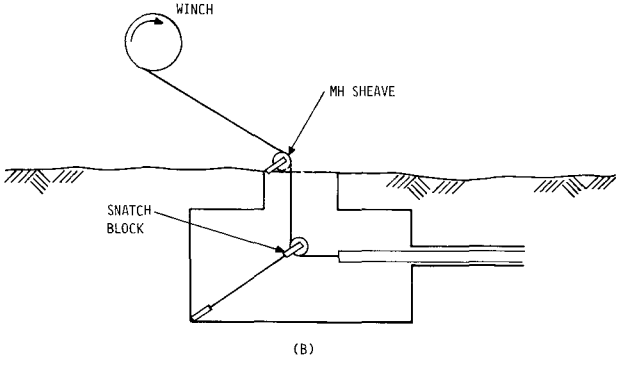


Fig. 9—Innerduct Sweep vs Blocks at the Pull Manhole

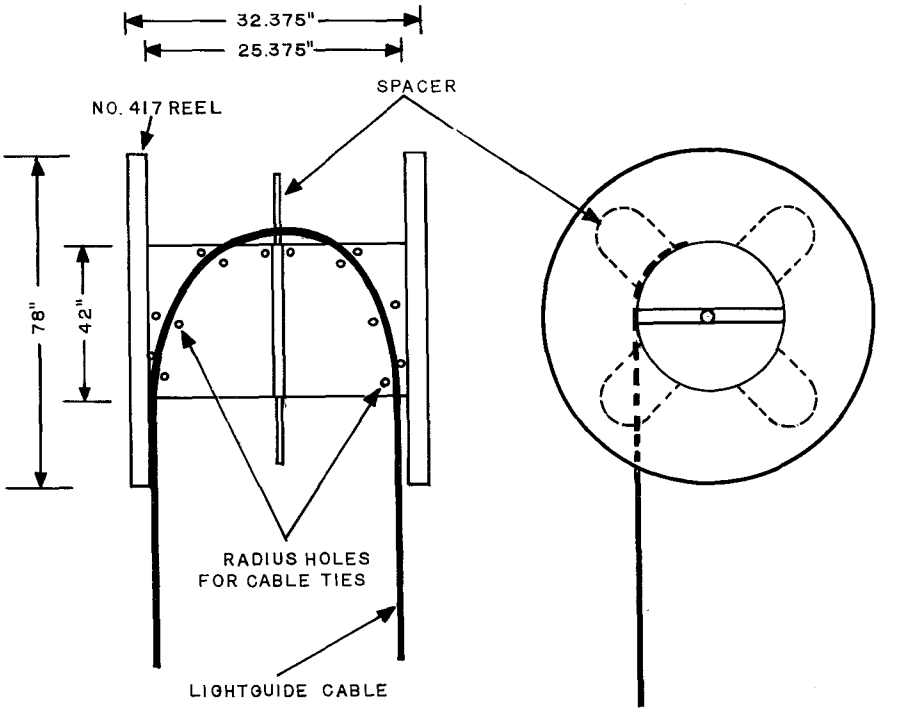


Fig. 10—Typical Reel Modification

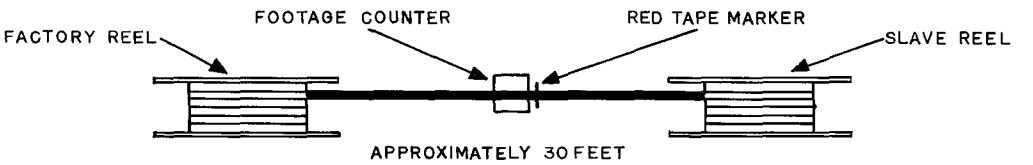


Fig. 11—Placing Short Section on Slave Reel

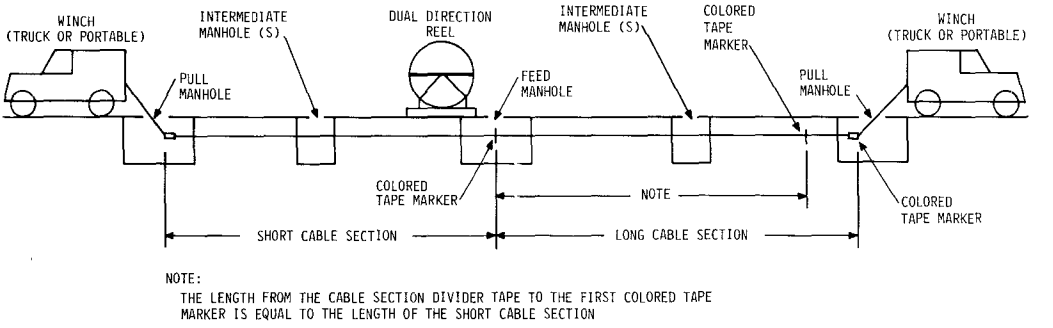


Fig. 12—Location of Cable Tape Markers

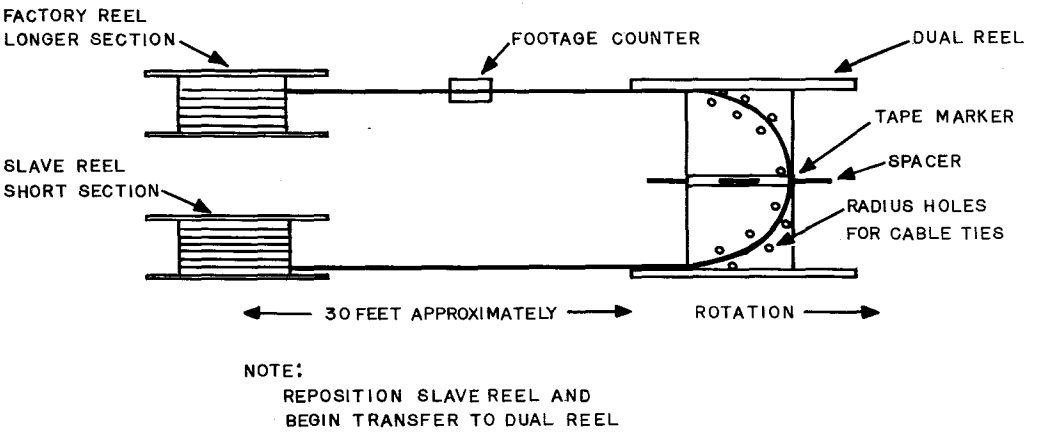


Fig. 13—Position of Reels for Take Up

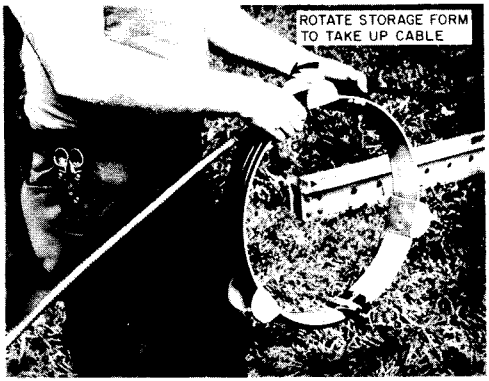


Fig. 14—Excess Cable Being Coiled on Storage Form

TABLE A

LIGHTGUIDE STRANDED CABLE SHIPPING REEL CAPACITIES (NOTE 1)

CABLE SIZE (UNITS)	CABLE DIAMETER (INCHES)	REEL SIZES (NOTE 2)				
		413	414	417	420	480
1	0.40	1.5	2.2	7.3	-	-
	0.65	0.5	0.8	2.7	5.3	1.0
3	0.65	0.5	0.8	2.7	5.3	1.0
	0.75	0.4	0.6	2.0	4.0	4.8
6	0.80	-	0.6	1.8	3.5	4.0
	0.90	-	0.4	1.4	2.8	3.1
	0.95	-	0.4	1.3	2.5	3.0

NOTE 1: REEL CAPACITIES STATED IN SHEATH KILOMETERS.

NOTE 2: ALL CAPACITY CALCULATIONS BASES ON 5-INCH BUTTERFLY ALLOWANCE FOR INSIDE END.

NOTE 3: KILOMETERS X 3281 = FEET

TABLE B

RECOMMENDED DUCTLINERS

MAXIMUM CABLE DIAMETER (INCHES)	DUCTLINER SIZE (INCHES) NOMINAL DIA.	MAXIMUM NUMBER OF DUCTLINERS PER CONDUIT (NOTES 1 AND 2)			
		4-INCH ROUND	4-INCH SQUARE	3-1/2 INCH ROUND	3-1/2 INCH SQUARE
5/8	1	3	4	3	3
13/16	1-1/4	2	3	1	2
1	1-1/2	1	2	1	1

NOTE 1: THE CONDUIT SYSTEM MUST BE KNOWN TO BE IN GOOD CONDITION BEFORE PLACING THE MAXIMUM NUMBER OF DUCTLINERS.

NOTE 2: THE MAXIMUM CABLE PULLING DISTANCES MAY BE REDUCED IN DUCTS CONTAINING MORE THAN ON DUCTLINER.

TABLE C

PHYSICAL CHARACTERISTICS SINGLE-UNIT CABLE CORE

SHEATH TYPE	CABLE DIAMETER (IN.)	WEIGHT (LB/FT)	MAXIMUM PULLING TENSION (LB)
STEEL REINFORCEMENT			
CROSSPLY	0.40	0.05	600
FIBERGLASS REINFORCEMENT			
SINGLEPLY	0.40	0.05	300
CROSSPLY	0.40	0.05	600

TABLE D

PHYSICAL CHARACTERISTICS 3-UNIT CABLE CORE

SHEATH TYPE	CABLE DIAMETER (IN.)	WEIGHT (LB/FT)	MAXIMUM PULLING TENSION (LB)
STEEL REINFORCEMENT			
SINGLEPLY	0.65	0.14	600
CROSSPLY	0.75	0.22	2000
FIBERGLASS REINFORCEMENT			
SINGLEPLY	0.65	0.14	600
CROSSPLY	0.75	0.18	2000

TABLE E

PHYSICAL CHARACTERISTICS 6-UNIT CABLE CORE

SHEATH TYPE	CABLE DIAMETER (IN.)	WEIGHT (LB/FT)	MAXIMUM PULLING TENSION (LB)
STEEL REINFORCEMENT			
SINGLEPLY	0.80	0.21	1000
CROSSPLY	0.90	0.33	4000
FIBERGLASS REINFORCEMENT			
SINGLEPLY	0.80	0.21	1000
CROSSPLY	0.90	0.28	2000

TABLE F

PHYSICAL CHARACTERISTICS RIBBON CABLE

SHEATH TYPE	CABLE DIAMETER (IN.)	WEIGHT (LB/FT)	MAXIMUM PULLING TENSION (LB)
CROSSPLY	0.48	0.08	600
CROSSPLY W/VAPOR BARRIER	0.48	0.08	600
DIELECTRIC			
300# STRENGTH	0.48	0.09	300
600# STRENGTH	0.48	0.10	600