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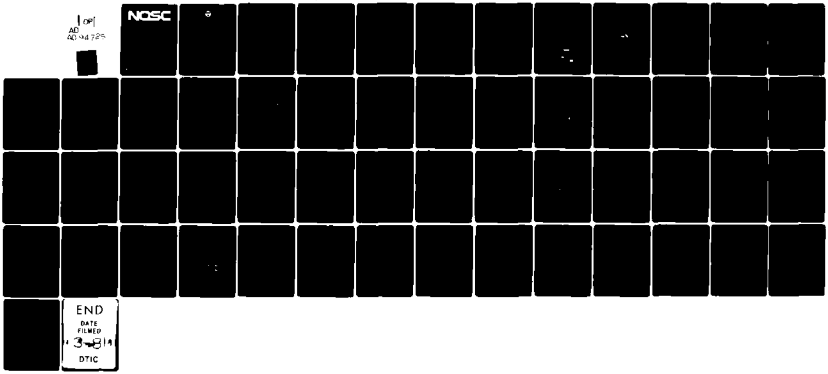

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Technical Document 394

REMOTE UNMANNED WORK SYSTEM VEHICLE TETHER CABLE TERMINATION AND POTTING PROCEDURES

Robert S. Stark

December 1980

Final Report: 1978–1980

Prepared for
Naval Sea Systems Command

Approved for public release; distribution unlimited

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Commander

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Technical Director

ADMINISTRATIVE INFORMATION

This document presents information concerning the methods and materials considered most effective in field termination and potting of the tether cable for the Remote Unmanned Work System (RUWS). It is based on an earlier document, NUC TN 1681, by H. L. Mummery and G. A. Wilkins, and reflects refinements of the procedures reported in that document. NOSC (formerly NUC) TNs are informal documents intended chiefly for internal use. This document is intended to assist those individuals who will be working with the cable at sea and in the field.

This work was performed at the Naval Ocean Systems Center Hawaii Laboratory as a part of the Deep Ocean Technology (DOT) program.

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The procedures for potting and terminating the strength and electrical portions of the tether cable of the Remote Unmanned Work System (RUWS) are described. Also included are lists of tools and materials to be used in the process.

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CONTENTS

ILLUSTRATIONS

INTRODUCTION

This document describes the procedures for potting and terminating the strength and electrical portions of the vehicle tether cable of the Remote Unmanned Work System (RUWS). Also included are lists of tools and materials to be used in the process (reference 1).

DESCRIPTIONS

REMOTE UNMANNED WORK SYSTEM

The RUWS is a major element of the Navy's Deep Ocean Technology project. An unmanned, cable-tethered work system, RUWS is designed to perform a variety of engineering and scientific tasks at ocean depths to 6,100 metres (20,000 feet). It was designed for air transport and operation from specified ships of opportunity. The system includes advanced capabilities for high-accuracy, deep-ocean navigation and local-area bottom search.

Missions that can be accomplished with the basic RUWS include limited search, inspection, recovery, repair, emplantment, documentation and data gathering. Spare communication channels and power are provided in the initial system configuration to facilitate future expansion.

RUWS equipment on the support ship consists of a control/navigation (CON/NAV) center, power generation units, and the motion compensating deck handling system (MCDHS). Submerged elements include the primary cable termination (PCT), the remote vehicle, and deep-ocean transponders for navigation. A cable system, consisting of the primary cable between the surface ship and the PCT, and a buoyant vehicle tether from the PCT to the vehicle, completes the major RUWS elements (references 2, 3, 4, 5 and 6).

All signals and power are multiplexed on the single coaxial core of the primary cable. Figure 1 illustrates the system.

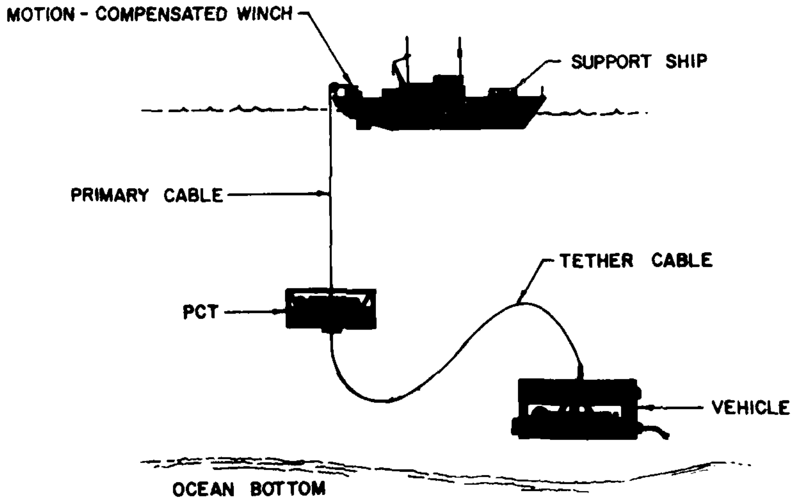

Figure 1. The Remote Unmanned Work System concept.

VEHICLE TETHER

The RUWS cable system is advancing the state of the art in electromechanical cable and handling gear. The tether for the RUWS vehicle, shown as figure 2, is a multiple-conductor cable with a Kevlar strength member, and is designed to be positively buoyant at 6,100 metres (20,000 feet). This 2.2-cm (0.86-inch) diameter cable has a breaking strength of 7,020 kg (15,000 pounds).

The tether cable is 260 metres (850 feet) long and permits free movement by the vehicle (reference 1).

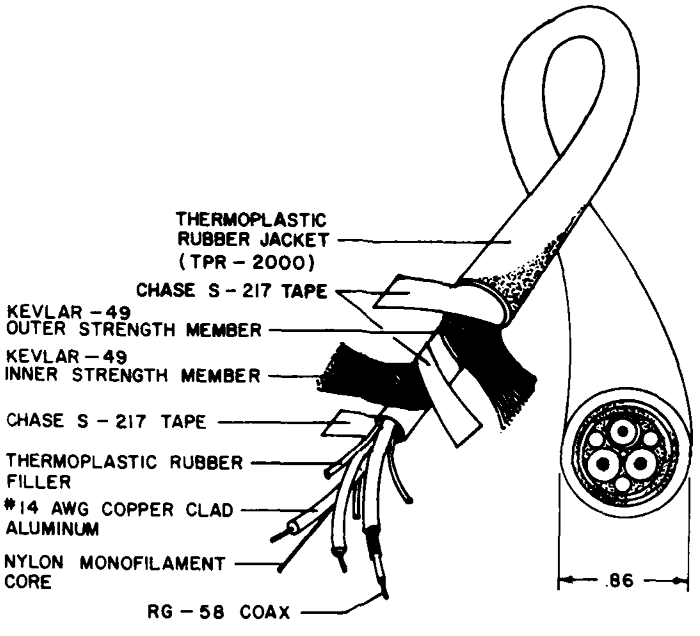

Figure 2. Cross section of the RUWS tether cable.

KEVLAR

Kevlar-49, formerly known as PRD-49, is a recent development of duPont. This new synthetic, high strength/weight material is used as the strength member for the tether cable. The basic fiber is supplied in a multiple filament yarn and is twisted in a polyurethane matrix into strength members which correspond to the individual steel wires in a conventional electromechanical cable.

These new strength members have shown outstanding resistance to flexure fatigue, load cycling and pressurization. Samples have been submitted to over 2,000,000 flexure cycles (20-percent loading) without degradation of tensile strength. Other samples have been soaked and pressure cycled to 10,000 psi (703 kg/cm^2) hydrostatic pressure in salt water without loss of strength, and with no measurable water absorption. The material showed little or no degradation during 12 months of ocean exposure.

ELECTRICAL COMPONENTS

The electrical portion of the tether cable contains three conductors: one a coaxial line, and two power conductors.

COAXIAL LINE

The coaxial line consists of a center conductor, dielectric, and an outer conductor and is similar in size to RG-58.

Center Conductor

Around a nylon monofilament axial wire are wrapped six strands of copper alloy wire served on with a 15-degree left hand lay, resulting in a lay length of 0.167 inch. Finally, twelve strands of copper alloy wire are served on with a 15-degree right hand lay, resulting in a lay length of 0.333 inch. The stranding is void-filled with Vistanex polyisobutylene.

Dielectric

The dielectric is submarine cable grade solid high-density polyethylene (HDPE).

Outer Conductor

The outer conductor consists of a single braid of 112 copper-clad aluminum wires which are 12 percent copper by volume. The braid has eight carriers for each lay direction, with seven wires per carrier. The braid is void-filled with Vistanex polyisobutylene.

POWER CONDUCTORS

The two power conductors each consist of a conductor surrounded by an insulation jacket.

Conductors

Around a nylon monofilament axial line are wrapped six strands of copper-clad aluminum wire, 12 percent copper by volume, served on with a 15-degree left hand lay, resulting in a lay length of 0.333 inch. Next are 12 strands of copper-clad aluminum wire, 12 percent copper by volume, served on with a right hand lay, resulting in a lay length of 0.667 inch. Voids are filled with Vistanex polyisobutylene.

Insulation Jacket

The insulation jackets for the conductors are submarine cable grade solid high-density polyethylene (HDPE).

TETHER CABLE TERMINATIONS

The terminations described in this document provide the means by which the tether cable is connected to the RUWS vehicle and to the PCT. These terminations consist of both strength and electrical terminations at both ends of the cable. While the strength terminations are similar at both ends, the electrical terminations differ. Figure 3 shows the completed terminations at both ends of the vehicle tether cable. Figure 4 shows a mechanical view of the tether cable mated to the RUWS vehicle.

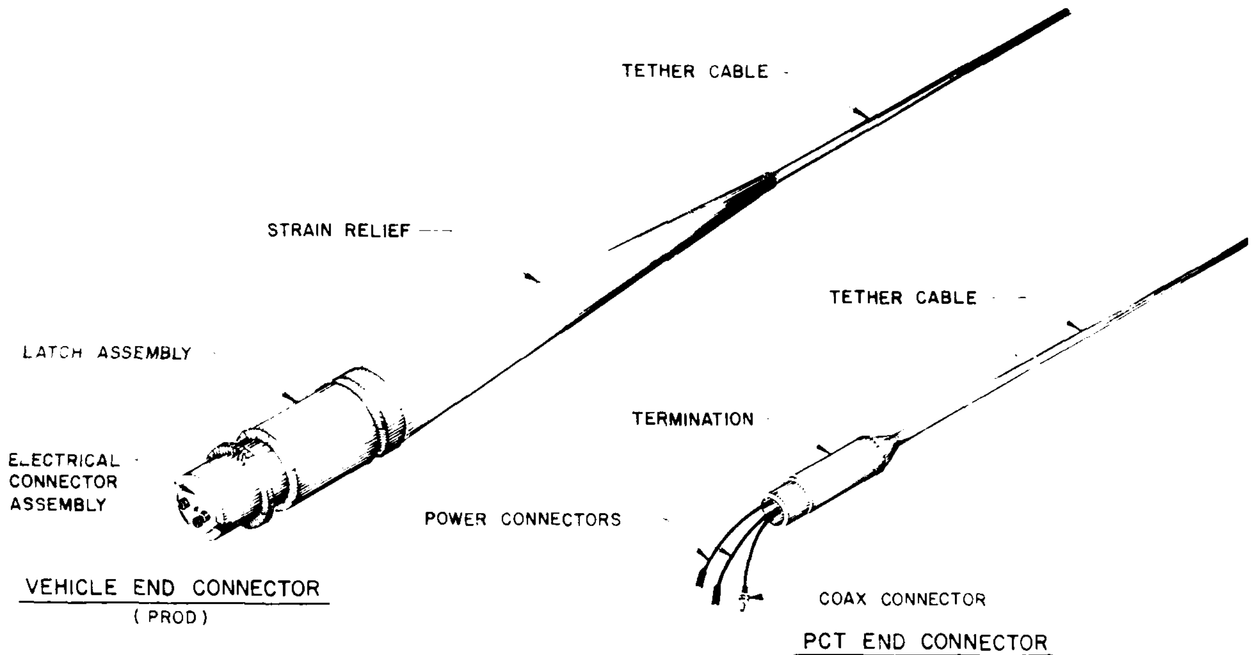

Figure 3. Completed terminations on the RUWS tether cable.

In the strength terminations, the Kevlar fibers are enmashed, by a prescribed pattern, in a urethane casing which is poured during the termination process described in the next section. In the electrical terminations, the termination at the vehicle end is accomplished first. The vehicle-end electrical termination consists of a valox connector insulator plug, into which the two power connectors and the coaxial connector are potted. At the PCT end, the two power conductors are terminated to a Brantner connector, and the coaxial conductor is terminated to a contact pin which is contained within a connector housing.

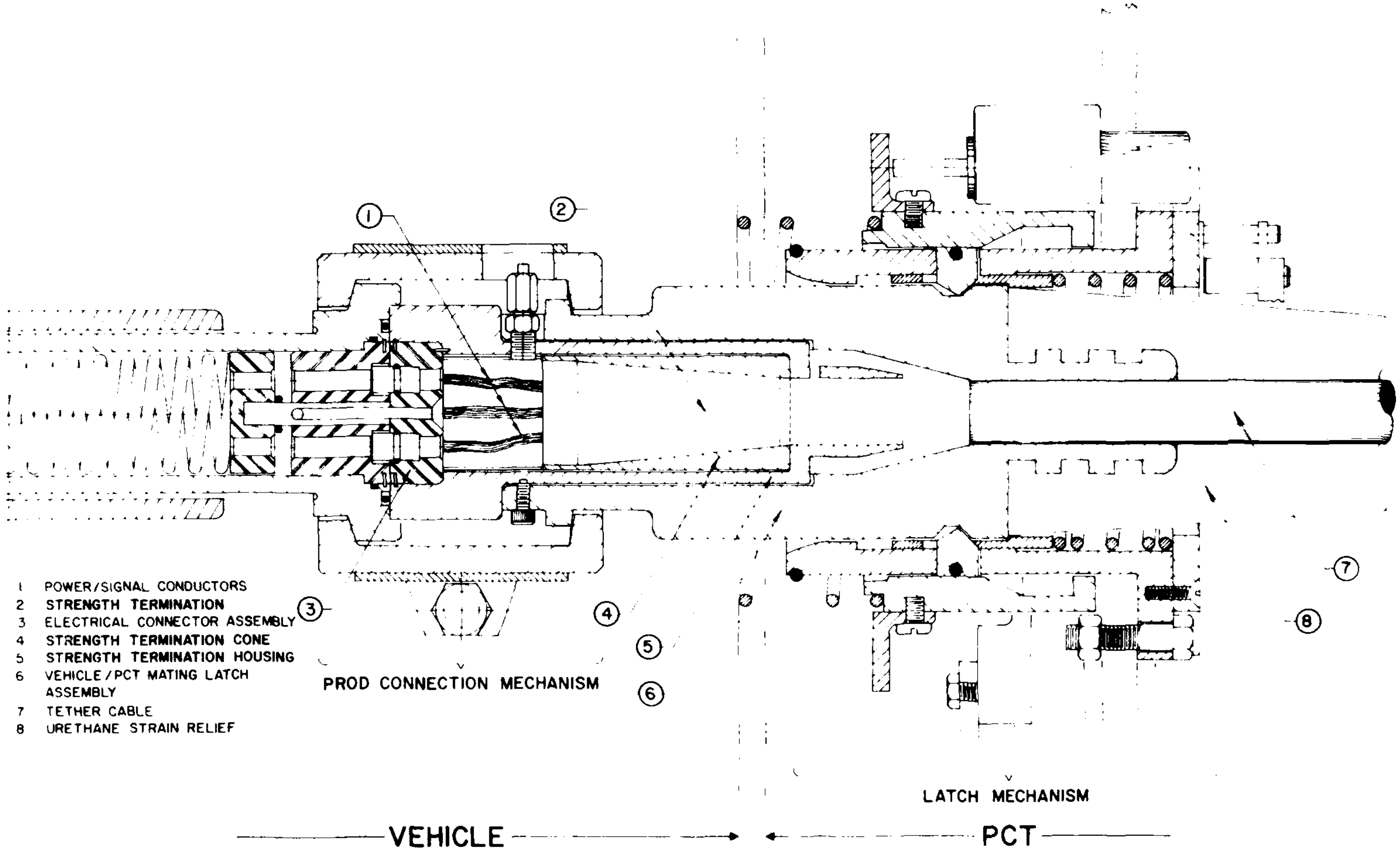

Figure 4. Mechanical view of the tether cable mated to the RUWS Vehicle.

PROCEDURES

This section contains a step-by-step description of the procedures to be followed in the strength and electrical connector termination and potting of the RUWS vehicle tether cable. These procedures result in four terminations. As was stated earlier, each end of the vehicle tether cable has a strength, as well as an electrical termination. All four terminations are essential.

Refer to appendices A through H for parts, materials, tools and the preparation and use of chemical mixtures.

MATING PROD AND STRAIN RELIEF ASSEMBLY

Before the actual terminations are begun, the mating prod (the male connector at the vehicle end of the tether cable) and strain relief assembly must be prepared (see figure 5). This operation, performed on the vehicle end of the tether cable, consists of molding the strain relief to the la assembly. First, the latch and prod must be cleaned and sandblasted, after which the appropriate surfaces are primed. The strain relief mold is cleaned and prepared. The prod is then assembled into the mold, and urethane is mixed and poured, forming the strain relief. The instructions for this procedure follow.

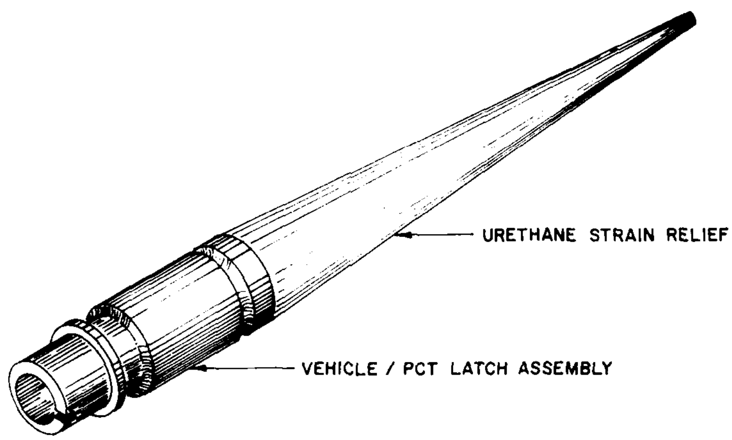

Figure 5. Vehicle/PCT mating prod and strain relief.

PREPARATION

1. Mask all areas not to be potted, as illustrated in figure 6.

2. Sandblast all the exposed surfaces (see figure 6).

3. Using Freon TE-35 or trichloroethylene as a solvent, thoroughly clean the assembly to remove all grease, oil and dirt. (Refer to appendix D.)

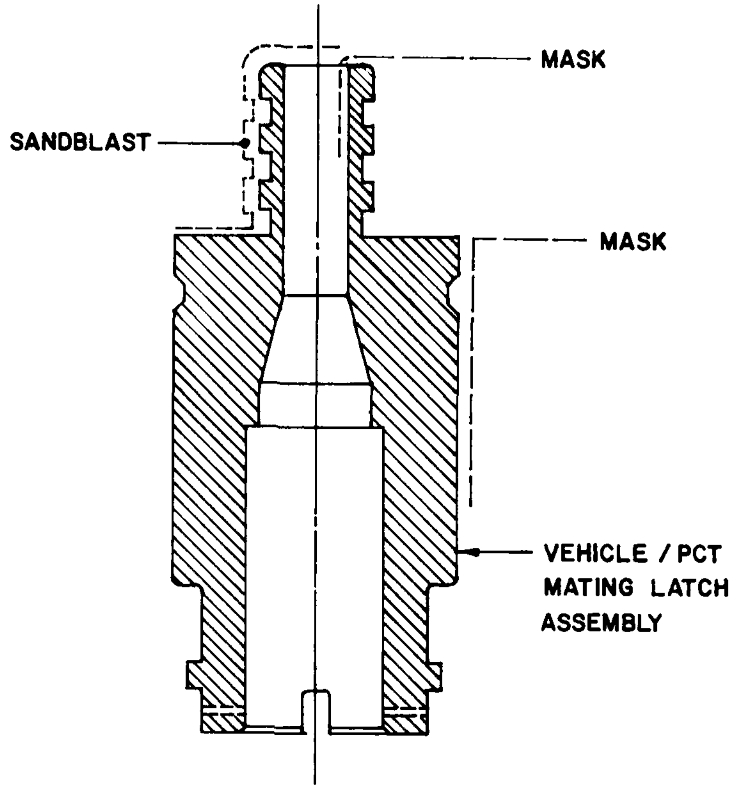

Figure 6. Masking and sandblasting the mating latch assembly.

POTTING PROCEDURE

1. Mix the primer required to bond the urethane to the metal prod, in accordance with the instructions in appendix E.

2. Apply primer to the sandblasted surfaces.

3. The strain relief mold is shown in figure 7. Separate the two halves of the mold and clean the inside surface with a solvent in accordance with appendix D.

4. Wipe the inside of the strain relief mold with silicone grease as a mold release.

5. Grease the polypropylene tubing and insert it approximately 2 inches into the mating latch assembly from the sandblasted end, as shown in figure 8.

CAUTION

Do not allow grease to get on primed surfaces.

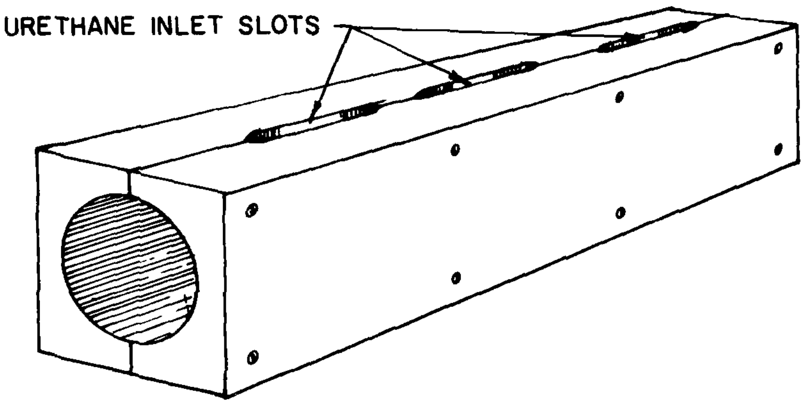

Figure 7. Strain relief mold.

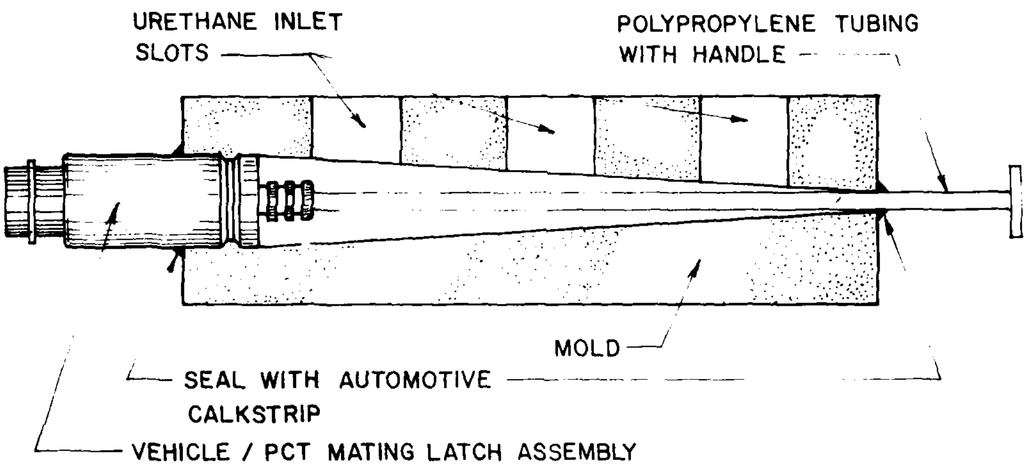

Figure 8. Strain relief potting assembly.

6. Assemble the prod and strain relief mold, placing the prod groove in the mold (see figure 8)

7. Install six heating elements, connecting them to the temperature control.

8. Set the temperature control for 150 degrees F.

9. Place one fire brick under each end of the mold, as shown in figure 9, to reduce heat loss.

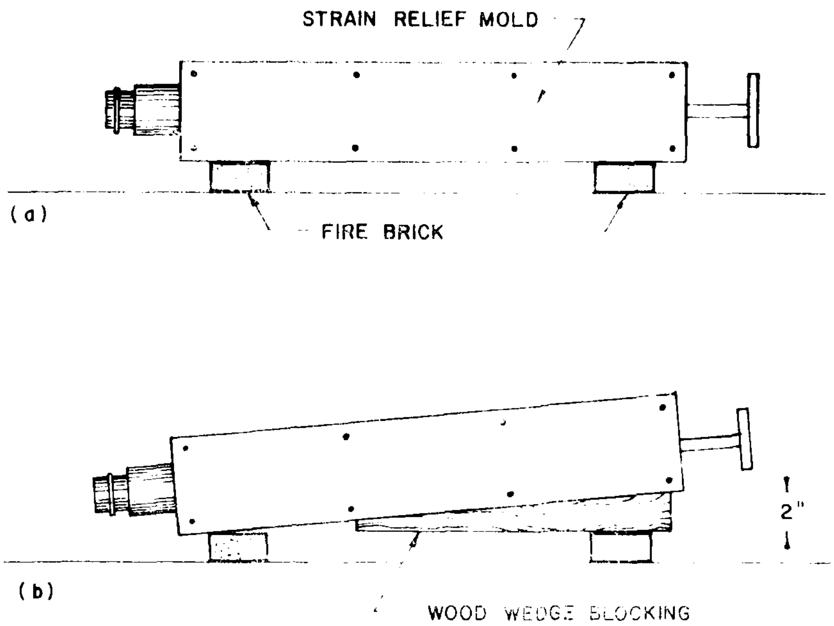

Figure 9. Chocking the mold for pouring.

10. Raise the mold end opposite the prod approximately two inches, as shown in figure 9, chocking it with a wedge. This will prevent an air trap forming within the mold.

11. Mix approximately 650 ml of PRC-1590 urethane in accordance with the instructions in appendix H.

12. Degas the urethane in a vacuum jar.

13. While the urethane is being degassed, turn the mold heater on. This will preheat the mold and make filling easier.

14. Begin pouring urethane into the slot hole at the prod end of the mold. Watch the urethane level through the hole as pouring progresses, gradually lowering the mold to a level position so as to avoid spilling urethane, yet still preventing an air pocket forming at the prod end of the mold. Fill the mold with urethane to the top of the slot holes. At the end of the pouring, the mold should be level.

15. Cure the mold for approximately eight hours at 150 degrees F.

16. To facilitate removal, demold the fixture while it is still hot.

17. Trim as necessary.

18. Remove the polypropylene tubing from the fixture. To accomplish this, first separate the urethane from the tubing by holding the handle and twisting the urethane back and forth. Then, while holding the prod, simultaneously twist and pull the tubing from the prod.

19. Visually inspect the strain relief. Eliminate any voids or large bubbles with a syringe and needle. No curing process is required.

TERMINATION CONES AND HOUSING

Each end of the tether must be terminated. At the vehicle end, the strength termination cone, when completed, is inserted into the termination cone housing. At the PCT end there is no housing. The two strength termination cones and the termination cone housing for the vehicle end are shown in figure 10.

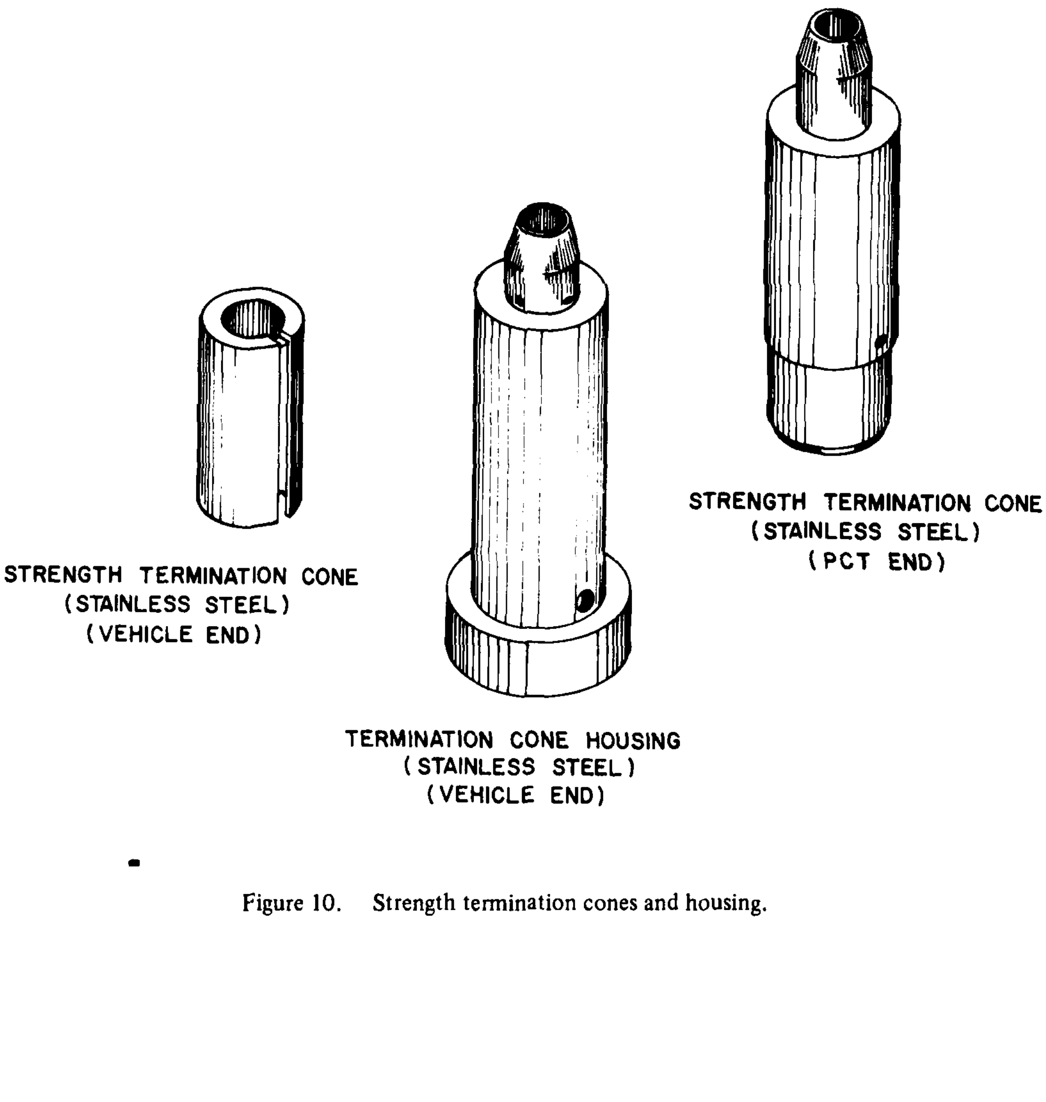

Figure 10. Strength termination cones and housing.

VEHICLE END

TETHER STRENGTH TERMINATION

This section presents instructions for the strength termination at the vehicle end of the tether cable. It should be noted, however, that the strength termination at the PCT end of the vehicle tether cable is identical to that for the vehicle end. It will be simpler in the field to perform both the strength and electrical terminations on the vehicle end first; then proceed to the PCT end.

The cone and housing are cleaned and sandblasted, and the termination potting fixture is assembled. The cable is stripped back and the strength members separated. The strength members are cleaned and dried; then wrapped to protect them while the cable, conductors and strength members are fed into the termination cone. The cable and cone are then installed in the termination fixture and the strength elements separated and secured in the fixture top plate. Epoxy then is poured into the cone, degassed and cured. Finally, the termination cone is removed from the fixture.

Potting of the termination cone and housing is the final step in this portion of the process. The cone and housing are cleaned and primed, and the cone is installed in the housing. The housing is then installed in the mold, and urethane is poured into the mold. After degassing and curing, the last step is to fill any voids which have developed during the process.

The instructions for this entire procedure are listed below.

1. Mask all areas not to be potted, as illustrated in figure 11.

2. Sandblast all the exposed surface of the cone and housing, as shown in figure 11.

3. Remove all masking tape.

4. Using Freon TE-35 or trichloroethylene as a solvent, thoroughly clean the cone and housing to remove all grease, oil and dirt (refer to appendix D).

5. Following the formula in appendix E, mix the metal primer required for urethane.

6. Prime all sandblasted areas in the interior of the termination cone and housing (see figure 11).

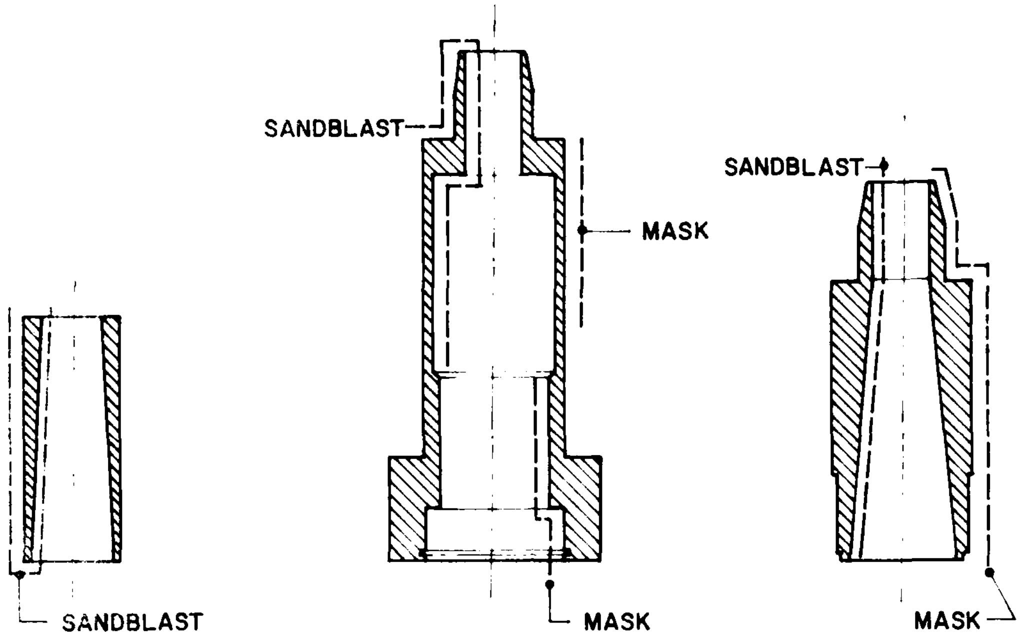

Figure 11. Masking and sandblasting the strength termination cone and housing for the vehicle end.

Assembling the Termination Potting Fixture

Assemble the termination potting fixture in accordance with figures 12, 13 and 14.

Strength Member Termination

1. Place the prod on the cable prior to installing the termination housing.

CAUTION

Be certain not to damage the prod or termination housing during the procedures which follow.

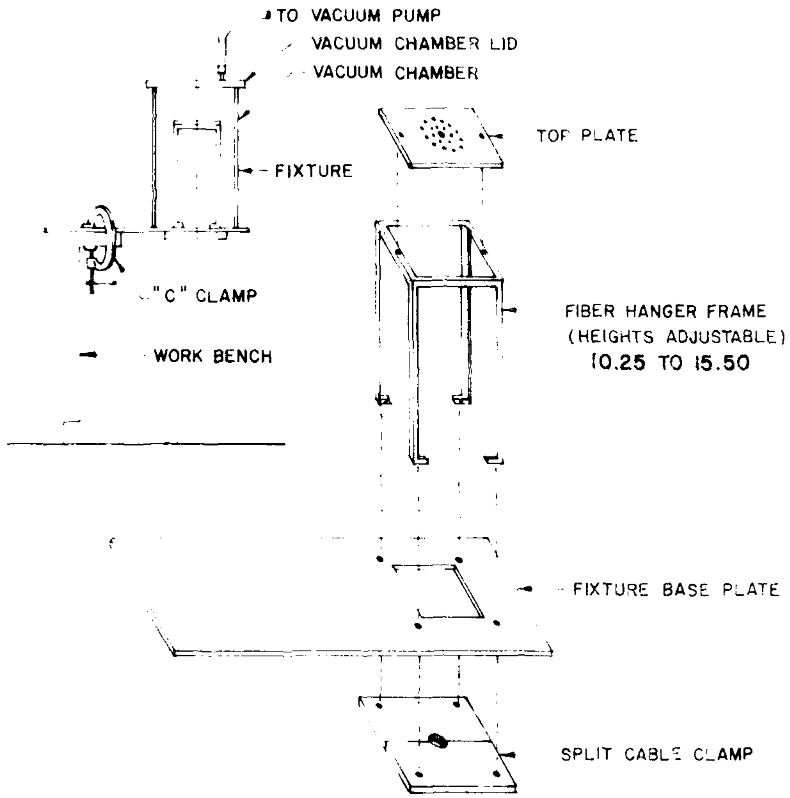

Figure 12. Assembly of the termination potting fixture.

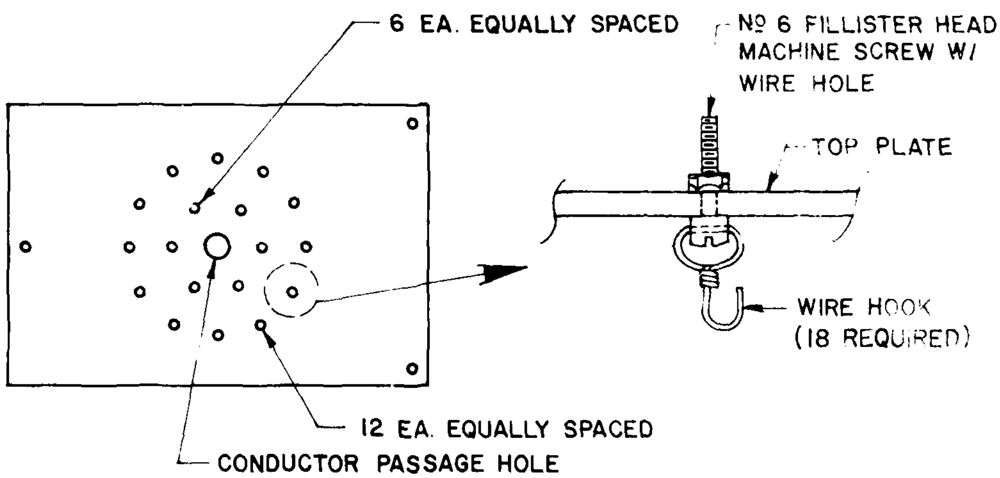

Figure 13. Fixture top plate.

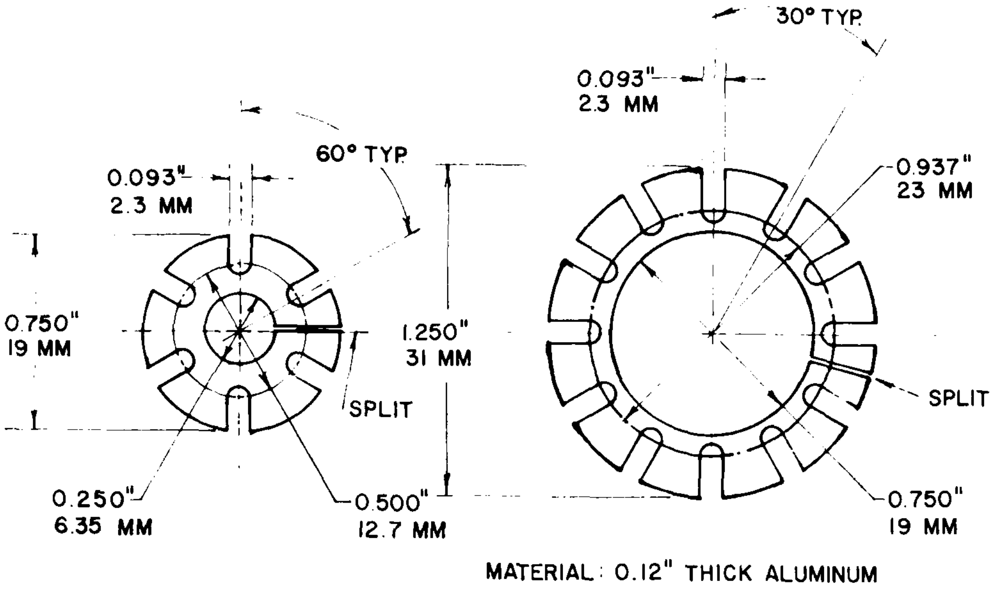

Figure 14. Strength member element separator ring.

2. Thread the prod and termination housing down the cable approximately 15 feet for easy handling of the cable during termination.

NOTE

> Plant pruning shears are recommended for the next step because, unlike normal shears, they have only one cutting blade. The second is a flat surface against which the material being cut is forced. For this application, such shears have been found to be ideal, not only because they are usually sharper, but because they provide more leverage.

3. Cut off the damaged end of the cable, using a turning motion around the cable to cut all layers evenly rather than attempting to make a single cut through the layers.

4. Measure 10 inches from the end of the cable; then make a mark around the cable at that point using a tubing cutter with slight pressure.

5. Bend the cable slightly at the mark to improve visibility of the work area; then remove the outer jacket with a razor, being careful not to cut the inner elements.

6. Unwind, cut and remove the chase tape 0.250 inch from the outer jacket.

7. Unwind the strength member carefully.

8. Unwind, cut and remove the inner chase tape as was done in step 6.

9. Cut and remove the thermoplastic rubber fillers and nylon monofilament core (see figure 2).

CAUTION

Do not nick the conductor insulation.

10. Without bending the conductors or the coax sharply, tape the conductors back along the cable, as shown in figure 15.

11. Fill a beaker with approximately 600 ml of Freon TE-35 or trichloroethylene solvent (refer to appendix D).

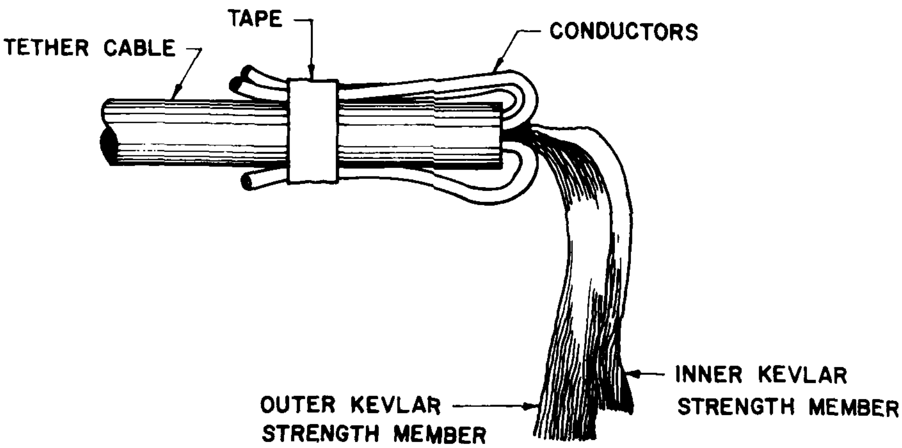

Figure 15. Taping the conductors along the cable.

12. Clean the Kevlar strength members in the beaker by suspending the cable from an overhead and hanging the member in the solvent as shown in figure 16.

13. Allow the members to soak for approximately 15 minutes; then agitate the elements with up and down and lateral motions.

14. Change the solvent and repeat step 13.

15. Remove the elements and press them dry with lint-free paper towels.

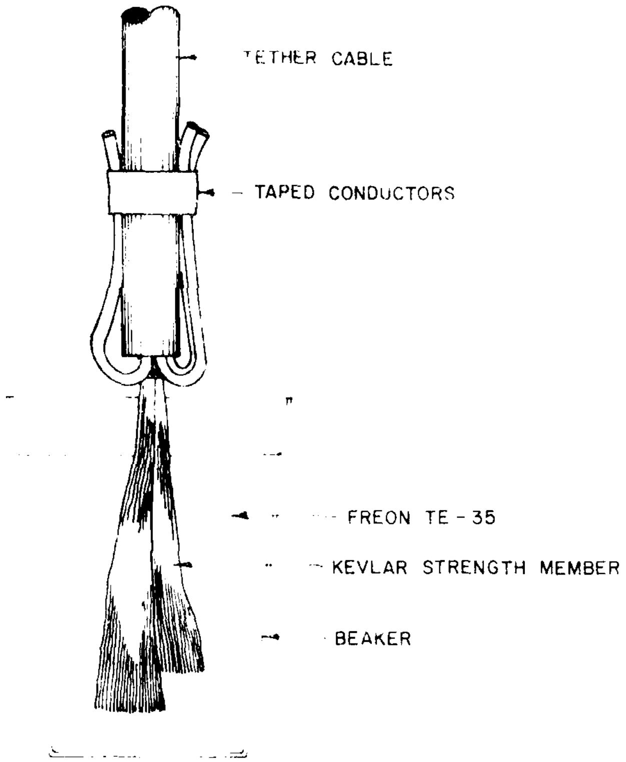

Figure 16. Cleaning the strength member elements.

16. Allow the elements to air dry for a minimum of two hours.

CAUTION

Protect the elements from contamination during air drying.

17. To further protect the outer strength member elements from contamination, wrap them with an 8"x11" sheet of paper, as shown in figure 17.

18. Check the fiber wrap coming out from the side of the cable. Avoiding a possible cross, divide the fibers as shown in figure 18.

19. Divide the inner fiber into three equal parts; then further divide each of the three parts in half, so that there is a total of six equal parts.

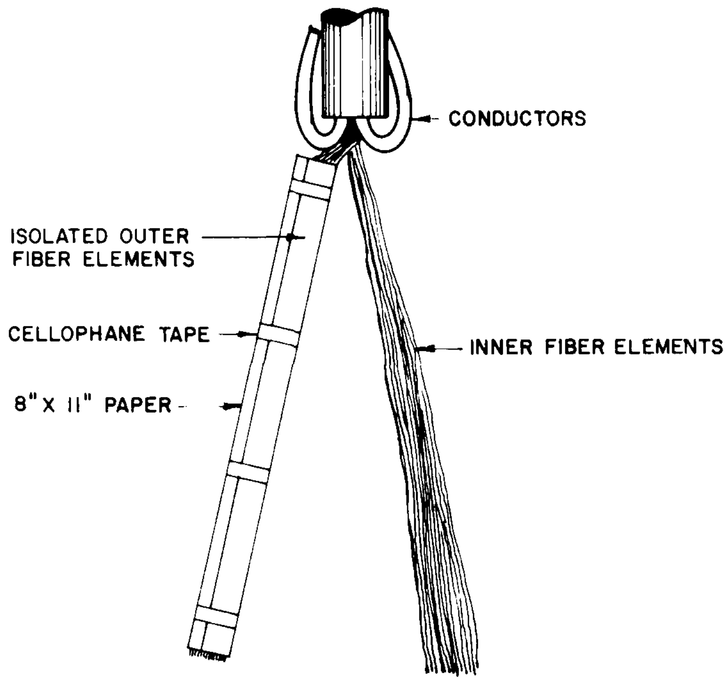

Figure 17. Isolation of the elements.

20. Wrap the end of each part with small gauge soldering lead.

21. Using cellophane tape, number the six parts I-1 through I-6.

22. To protect the inner strength member elements from contamination, wrap them with an 8"x11" sheet of paper as shown in figure 17.

23. Remove the paper wrapping from the outer elements; then divide them into 12 equal parts, as was done for the inner elements in step 19.

24. Wrap the end of each part with small gauge soldering lead.

25. Using cellophane tape, number the 12 parts O-1 through O-12.

26. To protect the outer strength member elements from contamination, wrap them with an 8"x11" sheet of paper, as shown in figure 17.

27. Remove the conductors from the cable.

28. Pass the conductors, elements and cable into the strength termination code, as shown in figure 19.

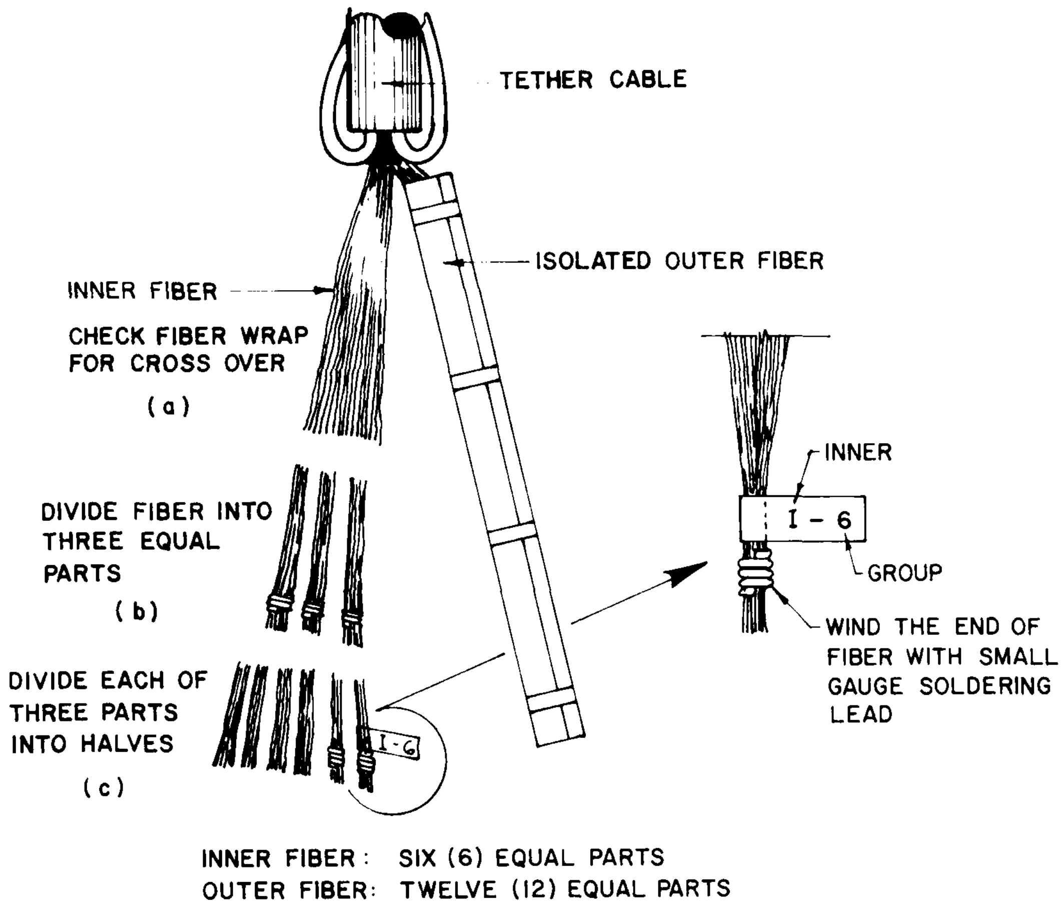

Figure 18. Dividing the elements.

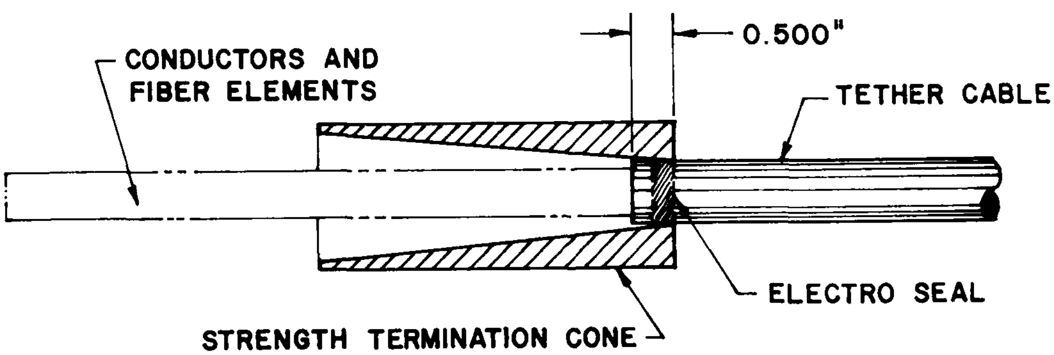

Figure 19. Sealing the termination cone and cable.

29. Apply a 0.250-inch-wide band of electro seal around the cable jacket at the location between 0.250 inch and 0.50 inch from the end of the jacket (see figure 19).

30. Pull the cable back into the strength termination cone until approximately 0.50 inch of the cable jacket portion remains in the cone. Apply a twisting motion between the cone and the cable to achieve a good seal.

31. Wipe excess electro seal from the portion of cable jacket which is outside the strength termination cone.

CAUTION

Handle the cable with extreme caution during the following steps. The cable end in the strength termination cone is easily damaged at this point in the operation.

32. Pass the strength termination cone and cable end up through the base plate of the termination fixture assembly.

33. Install half of the split clamp on the underside of the square hole in the base plate.

34. Place the cable in the split clamp and install the other half of the split clamp, leaving approximately 1 inch between the bottom of the cone and the split clamp.

35. Insert two pieces of 1-inch blocking material between the strength termination cone and the split clamp, one on each side of the cable, as shown in figure 20.

36. Recheck the strength termination cone and cable, especially the outside deal, to be certain they have not been loosened.

37. Tighten the split clamp.

38. Bind the three conductors together with three rubber bands. One band should be placed just above the top of the strength termination cone; one at a point halfway between the strength termination cone and the top plate; and the third just below the top plate (see figure 21).

39. Pass the conductors through the center hole of the top plate.

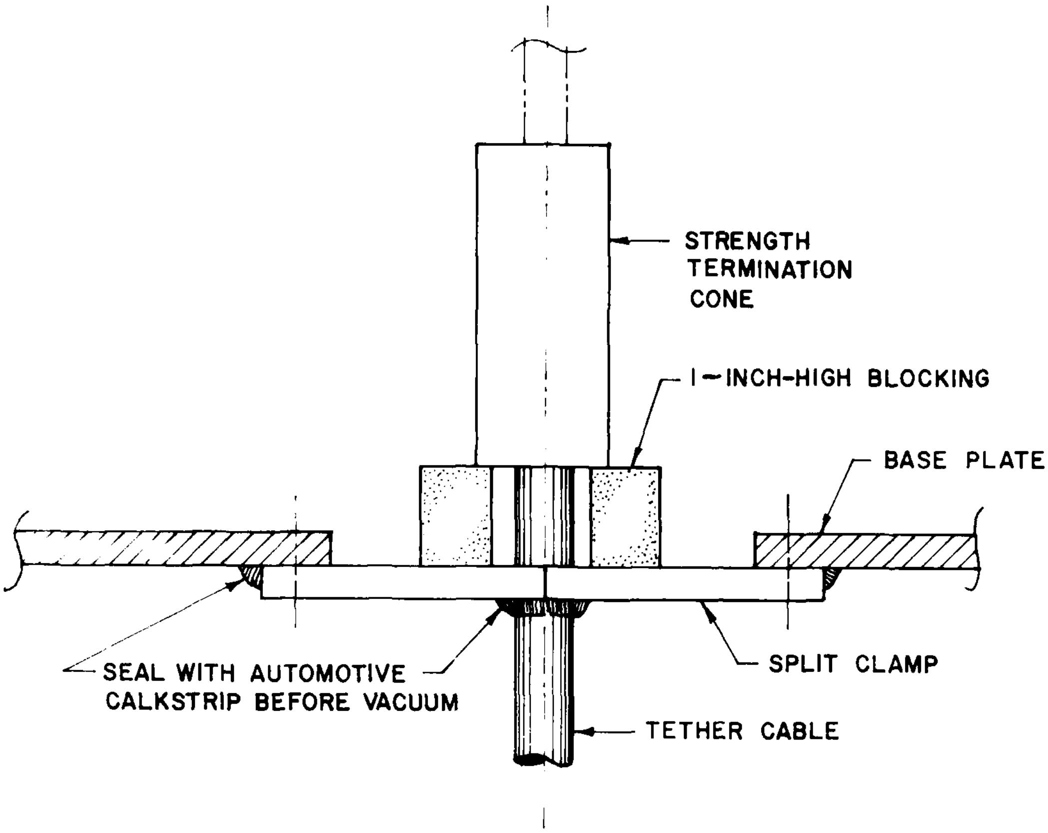

Figure 20. Installing the cable in the base plate.

40. Secure the conductors in the top plate by means of a rubber band and wedge pin, as shown in figure 21.

41. Remove the paper wrapping from the inner fiber elements.

42. Pull upward on the number six (6) element and turn the element 90 degrees to achieve crossover. Attach the element to the nearest hook as a starting point (see figure 22). Filament twist should be approximately one turn per inch.

43. Continue hooking up the elements, proceeding in inverse order and checking each time for the proper crossover.

44. Check the tension of each element. Tension may be tightened or loosened by adjusting the nuts at the top of each hook.

45. Cut and remove the excess from each element one inch from the rubber band.

46. Proceed to hook up the outer elements in the same manner as the inner elements, except that they should be hooked up in a clockwise direction.

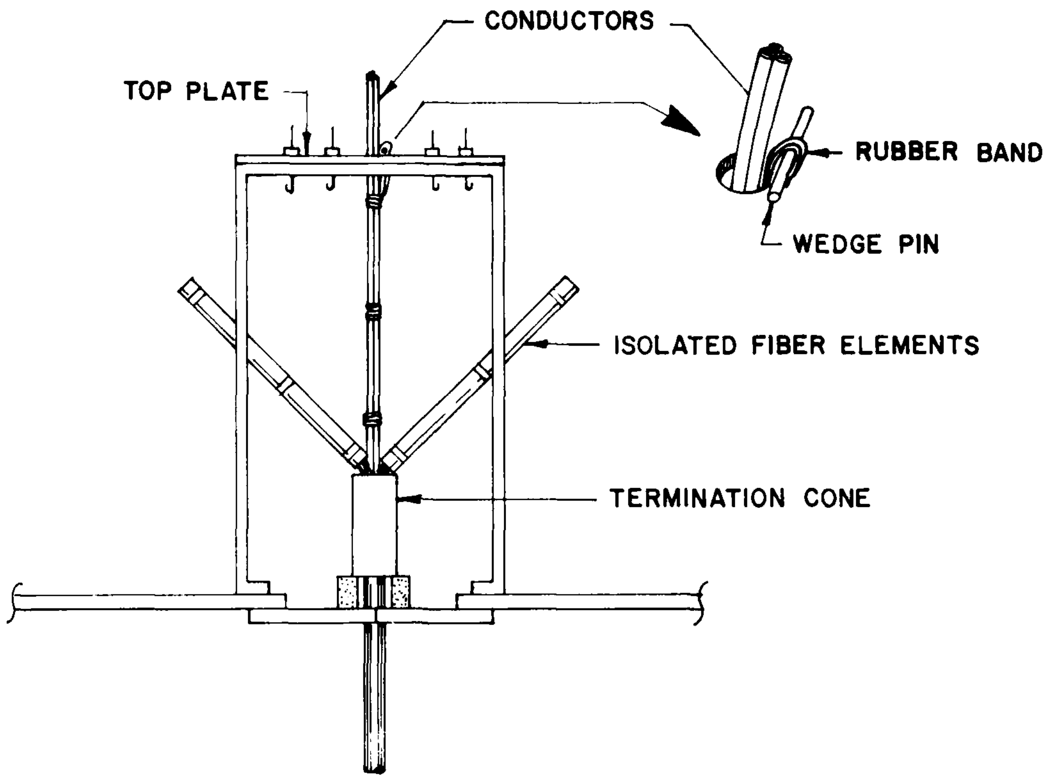

Figure 21. Stringing the conductors.

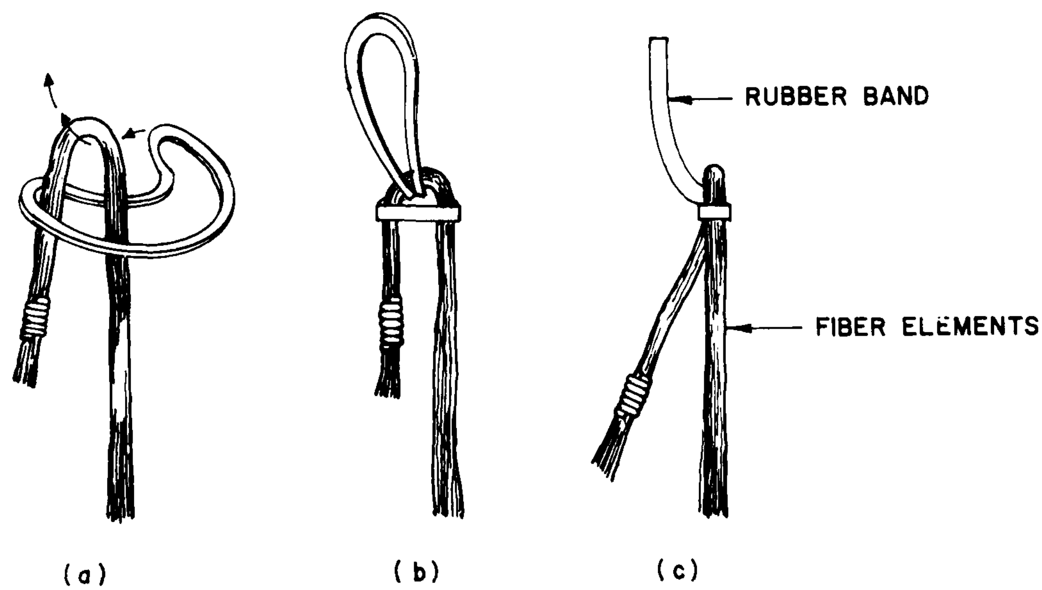

Figure 22. Rubber band attachment to the element.

47. Install the inner strength member element separator ring, opening the split section of the ring, passing it through the conductors to the center of the ring, and then bending the ring back to its original state. Place the elements in the separator grooves, as shown in figure 23.

48. Again check the elements for proper crossover.

49. Install the outer strength member element separator ring, as was done for the inner ring in step 47.

50. Position the separator rings so that the elements have the proper angle within the separator cone.

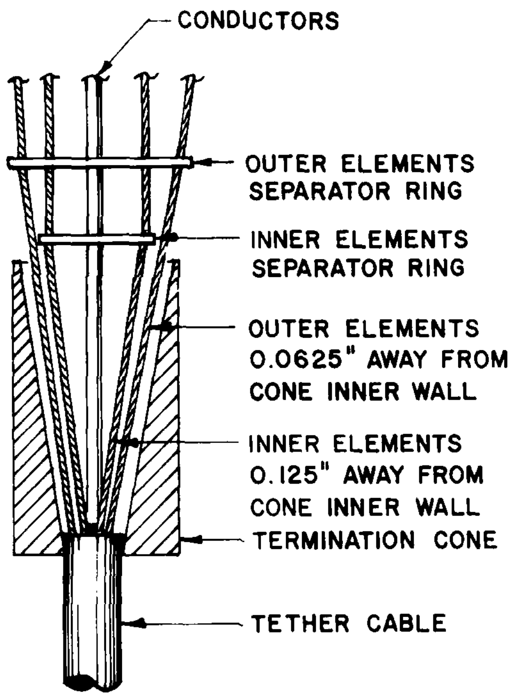

Figure 23. Positioning the element separator rings.

Pouring, Degassing and Curing Epoxy

1. Using automotive calkstrip, seal all joints in the split plates, cable, cable clamp and any thru-bolt holes (see figure 20).

2. Mix 100 ml of epoxy and degas it as described in appendix G.

3. Carefully pour the epoxy into the termination cone, filling it to a point just below the edge of the slots in the side of the cone.

4. Place the plastic vacuum chamber over the fixture, applying silicone grease to the sealing surfaces, as shown in figure 12.

5. Attach a vacuum line from the pump to the chamber.

6. Begin evacuating the fixture, watching for bubbles in the epoxy. If bubbles become excessive, causing the epoxy to spill, release the vacuum.

7. Check for leakage at the cone and cable; then cycle the vacuum several times, holding at a vacuum of 28.5 in/hg (724 mm/hg) for approximately five minutes in each cycle.

CAUTION

The vacuum may pull the cable into the fixture and loosen the elements. If this occurs, release the vacuum, loosen the cable clamp, and pull the cable back to its original position. To prevent such pulling and loosening, attach a weight (20 pounds maximum) to the cable, as shown in figure 24.

8. Remove the vacuum chamber and check the level of the epoxy to be certain the cone is full. If the cone is not full, add more epoxy.

9. Allow the epoxy to set for approximately two hours before applying heat.

10. Install two infrared lamps on either side of the fixture, 18 inches (46 cm) from the epoxy-filled cone. The heat may be controlled by augmenting the lamps with reflectors; then moving the lamps and reflectors as needed.

11. Place the tip of a dial thermometer on the surface of the epoxy so that it is just touching the surface.

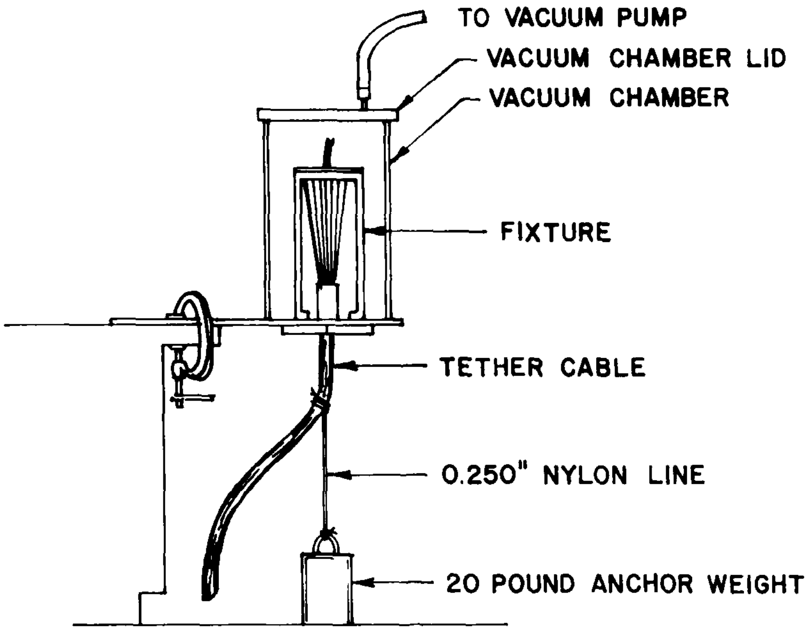

Figure 24. Fixture evacuation.

12. Tape the thermometer to the fixture.

CAUTION

Never exceed 175 degrees F (80 degrees C).
The conductor insulation jacket will soften
if it is overheated during the cure cycle.
Refer to appendix G for cure cycle instructions.

13. Remove the termination cone from the fixture.

14. Using caution not to damage the conductors, cut off all the elements at the top surface of the epoxy.

Potting the Termination Cone and Housing

1. Clean the cone, cable and conductors with Freon TE-35 trichloroethylene solvent. This is considered to be the most suitable solvent, since it will not damage the insulation.

2. Mix metal primer, as described in appendix E.

3. Prime all exterior surfaces of the termination cone except the channel groove.

4. Prime the nose of the termination housing.

5. Using Freon TE-35 or trichloroethylene solvent, clean the cable for a distance of three inches from the cone.

6. Prime the cable with nonmetallic primer, as described in appendix F.

7. Allow all primed surfaces to air dry.

8. Clean the termination housing potting mold, applying silicone grease as a mold release agent.

9. Gently push the termination cone into the housing.

10. Force a small amount of electro seal into the space between the cable and the nose of the housing to prevent leakage through to the termination cone (see figure 25).

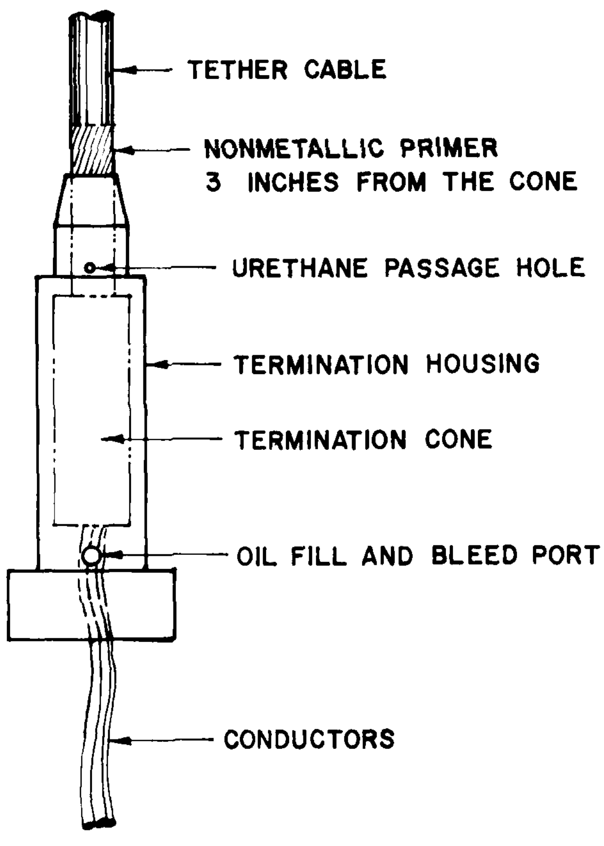

Figure 25. Termination housing and cone.

11. Install the housing in the mold, aligning one of the small intake holes with the cone channel slot.

12. Tighten the mold bolts and install the bridge clamp over the top of the housing.

13. Seal the mold and the housing joint with automotive calkstrip.

14. Tighten the bridge clamp evenly to force the housing to the bottom of the recess in the mold and keep it in place.

15. Suspend the mold from an overhead at a comfortable working height (see figure 26).

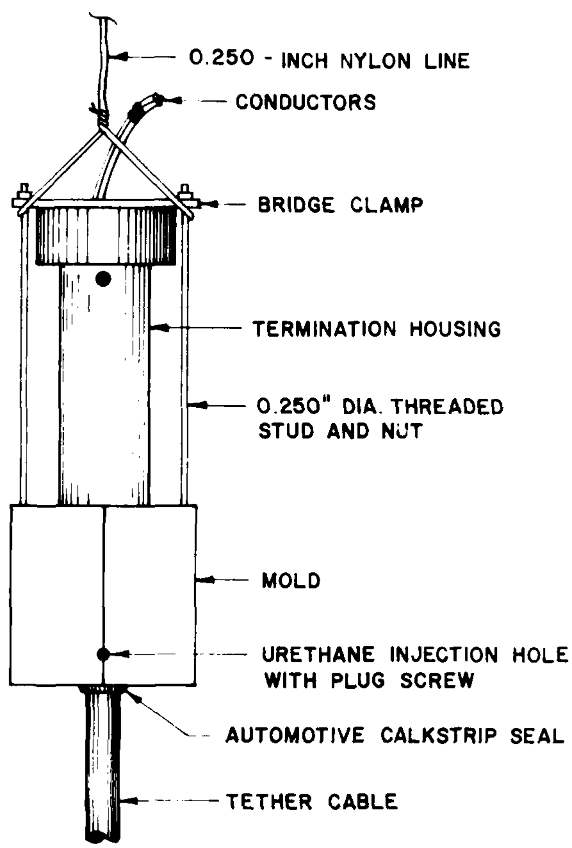

Figure 26. The potting setup.

16. Mix and degas approximately 150 ml of urethane, following the instructions in appendix H.

17. Pour the degassed urethane into injection gun tubes, being extremely careful not to trap any air bubbles in the tubes (see figure 27).

18. Install four cartridge heaters in the mold.

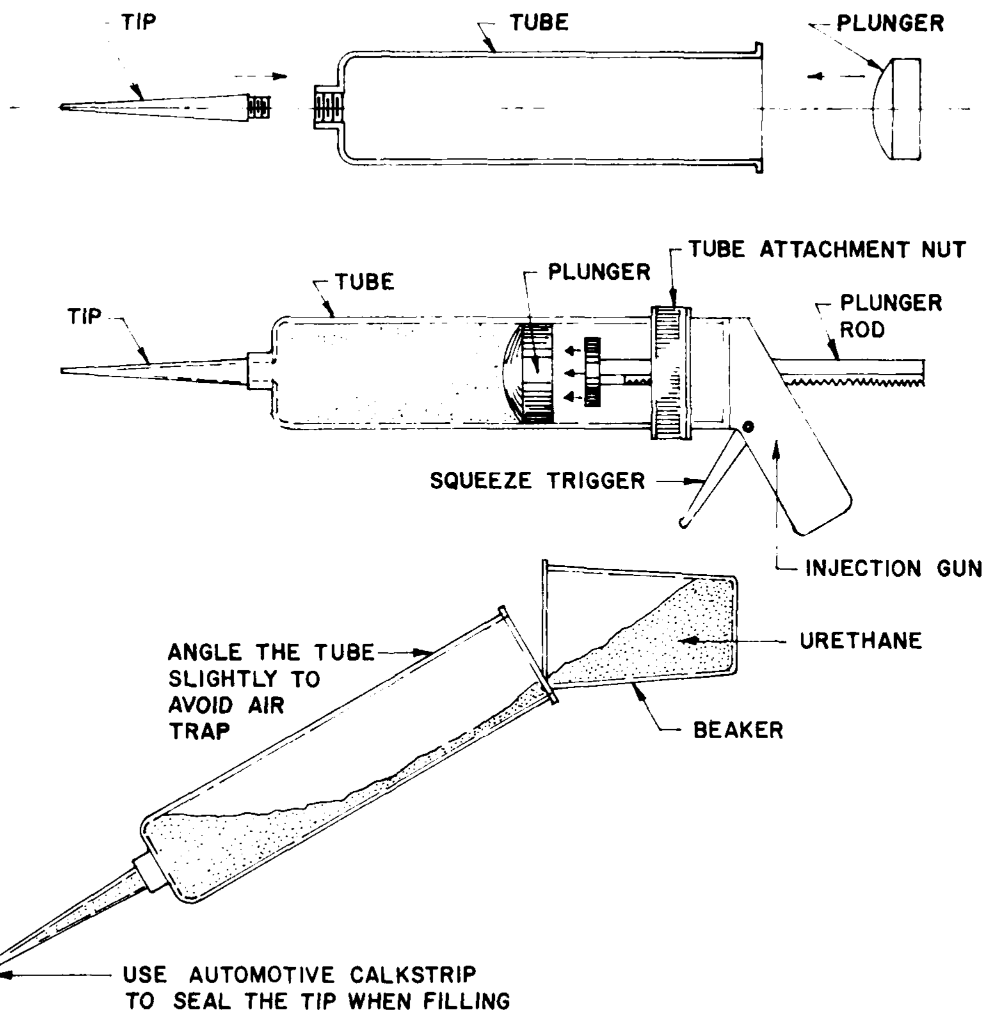

Figure 27. Injection tube and gun.

19. Install the controller sensor and hook up the wires in parallel, using wire nuts.

20. While the urethane is being degassed, turn the heater control on and set it for 150 degrees F (66 degrees C). This will preheat the mold and make the filling easier.

21. Inject the urethane through the injection hole located in the mold. Fill slowly until the urethane flows from the channel groove at the strength termination cone. Ensure that the cone is full to the top.

22. Check for leakage around the cable and mold.

23. When the mold is full and free of bubbles, install a screw as a plug in the injection hole.

24. Turn the controller off and remove the sensor and heaters.

25. Remove the completed termination assembly while the mold is still warm.

26. Remove the bridge clamp.

27. Remove the mold bolts and install them in the four threaded jacking holes.

28. Turn each jacking bolt 1/2 turn at a time until the mold separates into two halves.

29. Work the cable and housing gently until they come free of the mold.

30. Inspect the completed assembly for voids or bubbles.

31. Mix approximately 25 ml of urethane, in accordance with the instructions in appendix H.

32. Add 10 percent MEK (methylethylketone); then degas the mixture.

33. Check the mixture to see if it is thin enough to be used in a small syringe with a large needle. If it is too thick, add more MEK in small amounts until it reaches the desired consistency.

34. Fill the syringe with the mixture, install the largest needle, and puncture each bubble, filling the void with the urethane mixture. A temperature cure is not required.

TETHER ELECTRICAL TERMINATION

This section presents instructions for the electrical termination at the vehicle end of the tether cable. The operation is begun by cleaning the conductor cavity. The conductors then are cut back, the insulation stripped, shrinkable tubing installed, and power sockets crimped in place on the conductors. The center conductor is then inserted into the crimp barrel. The crimp support sleeve is installed, followed by the split teflon grommet. The terminated inner contact assembly is then inserted into the crimp support sleeve and the sleeve is crimped. The shrinkable tubing is shrunk into place, and the connectors are installed in the valox connector insulator plug. The insulator strips are installed in the housing and urethane is poured into the plug, degassed and cured. The plug is then installed in the housing. Finally, the termination housing is assembled to the prod. The instructions for this entire procedure are listed below.

1. Remove any urethane drips or spills.

2. Clean the conductor cavity thoroughly with Freon TE-35 or tricholoroethylene, taking care to move the conductors as little as possible.

3. See figure 28 for an illustrated breakdown of electrical termination parts.

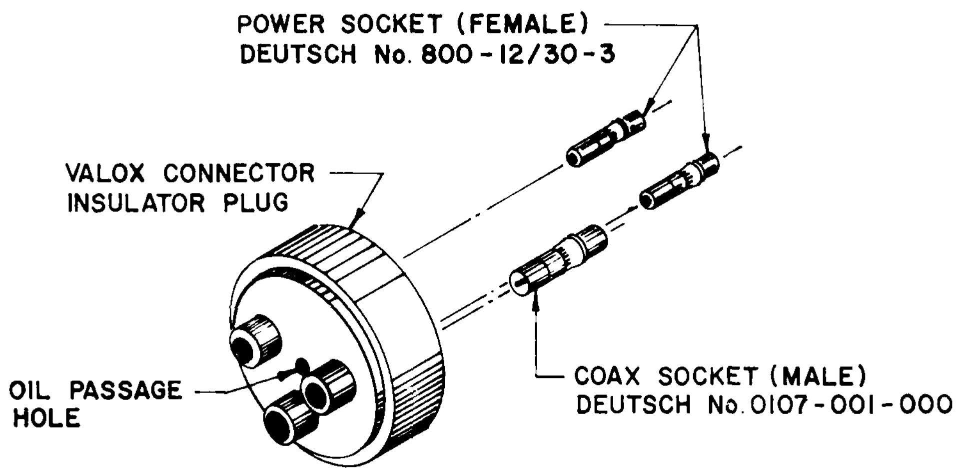

Figure 28. Electrical termination parts.

4. Measuring from the surface of the termination housing, cut the power and coaxial conductors to a length of 1.250 inches (25.4 cm).

5. Using a knife, cut around the insulation of the power conductor.

6. Strip the insulation from the conductor, leaving a minimum of 0.1875 inch and a maximum of 0.1288 inch of exposed wire, as shown in figure 29.

7. Using the Buchanan crimp tool M22520/1-01 with the 02 turret set for size 12 (yellow hole) and the wire gauge dial set for #14 AWG, install the shrinkable tubing on the power conductor.

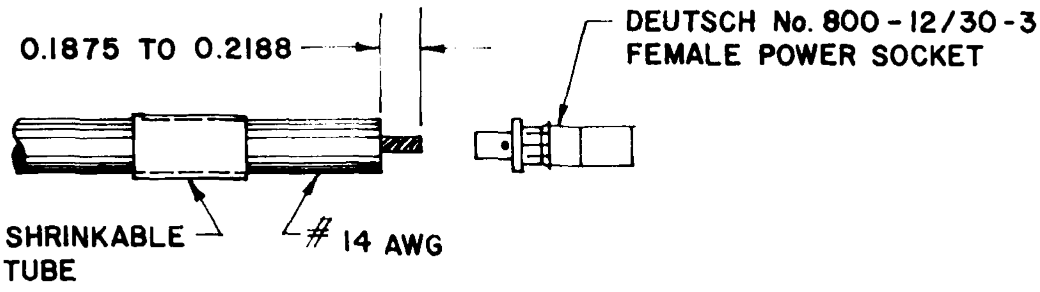

Figure 29. Power contact.

8. Insert the Deutsch #800-12/30-3 female power socket into the tool and crimp it onto the power conductor.

9. Using a knife, cut around the insulation of the coaxial conductor.

10. Strip the insulation from the coaxial conductor in accordance with figure 30.

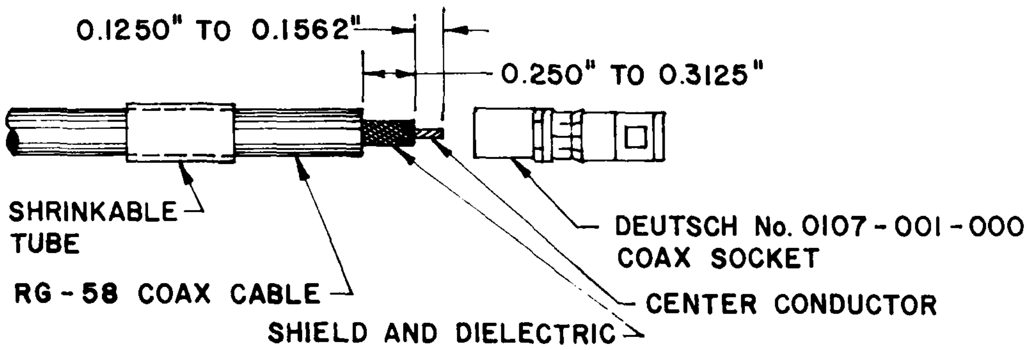

Figure 30. Stripping the coaxial conductor.

11. Install the shrinkable tubing on the coaxial conductor.

12. Insert the Deutsch #107-001-000 male coaxial socket into the tool and crimp it onto the coaxial conductor.

13. Place the inner contact pin in the Daniels crimp tool MH-800. Set the tool at selection number 3.

14. Insert the center conductor into the contact crimp barrel, ensuring that no wires remain outside the crimp barrel. The dielectric will be against the end of the contact. The inner conductor will be visible in the contact inspection hole if the cable preparation and termination are properly done.

15. Place the crimp support sleeve over the dielectric and under the outer shield braid, as shown in figure 31.

16. Separate the two halves of the split teflon grommet.

17. Install one half of the grommet into the support sleeve bore, pushing the grommet half into the bore until it snaps behind the contact shoulder.

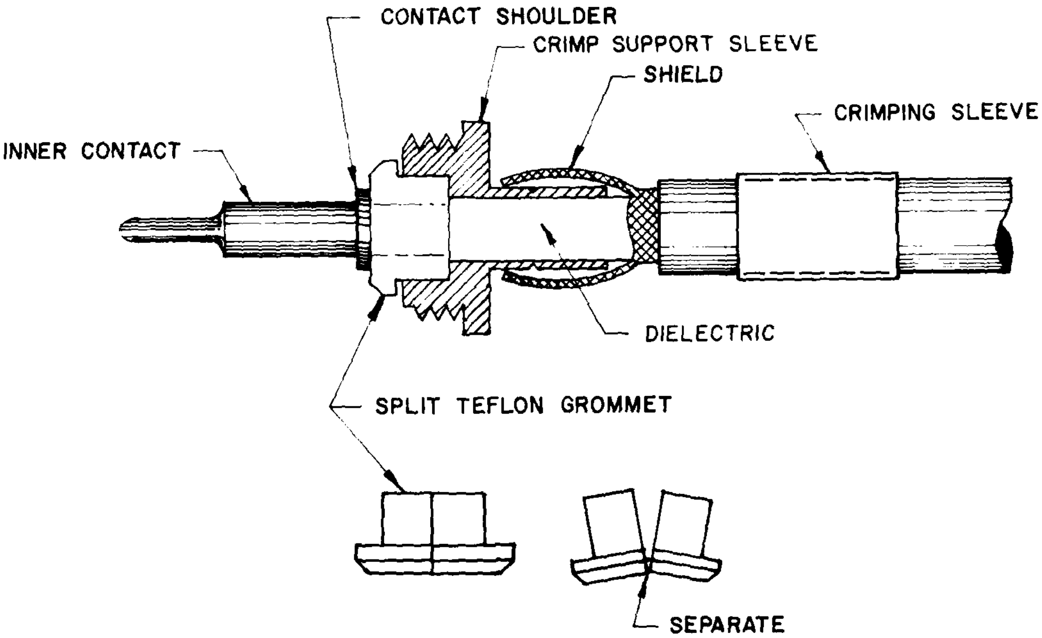

Figure 31. Coaxial contact assembly.

18. Install the remaining grommet half in the same manner.

CAUTION

After both grommet halves are installed, the contact shoulder must be fully exposed forward of the grommet halves.

19. Using a 13/64 open-end wrench to hold the support sleeve, insert the terminated inner contact assembly into the crimp support sleeve to a 6-inch-pound maximum torque.

CAUTION

Do not turn the crimp support sleeve on the cable during this assembly.

20. Using the Buchanan hexagonal crimp tool M22910/7-1 with die number MS22910/7-17, push the crimping sleeve over the exposed outer shield braid and butt it against the crimp support sleeve shoulder.

21. Insert the assembly into the upper die "B" at the crimp sleeve and crimp it.

22. Trim excess from the shield braid wires, if necessary. The shield braid wires should not extend onto the shoulder of the outer body.

23. Slide the shrinkable tubing over the sleeve of the contact. (For the power contact, slide the tubing over the crimp barrel.)

24. Carefully shrink the tubing in place.

25. Install the connectors in the valox connector insulator plug, pushing them in until they snap into place. They should be flush on the face side, as shown in figure 28.

26. Install the insulator strips in the housing. They should fit snugly and not protrude above the insulator step.

27. Suspend the termination housing from an overhead, as shown in figure 32.

28. Mix approximately 25 ml of urethane, following the instructions in appendix II.

29. Pour the degassed urethane into the valox connector insulator plug, using a mixing rod or screwdriver to transfer the urethane to the plug, a little at a time.

30. Install two infrared lamps on either side of the valox connector plug, approximately 18 inches (46 mm) from the urethane-filled plug. Control the temperature by moving the lamps as necessary.

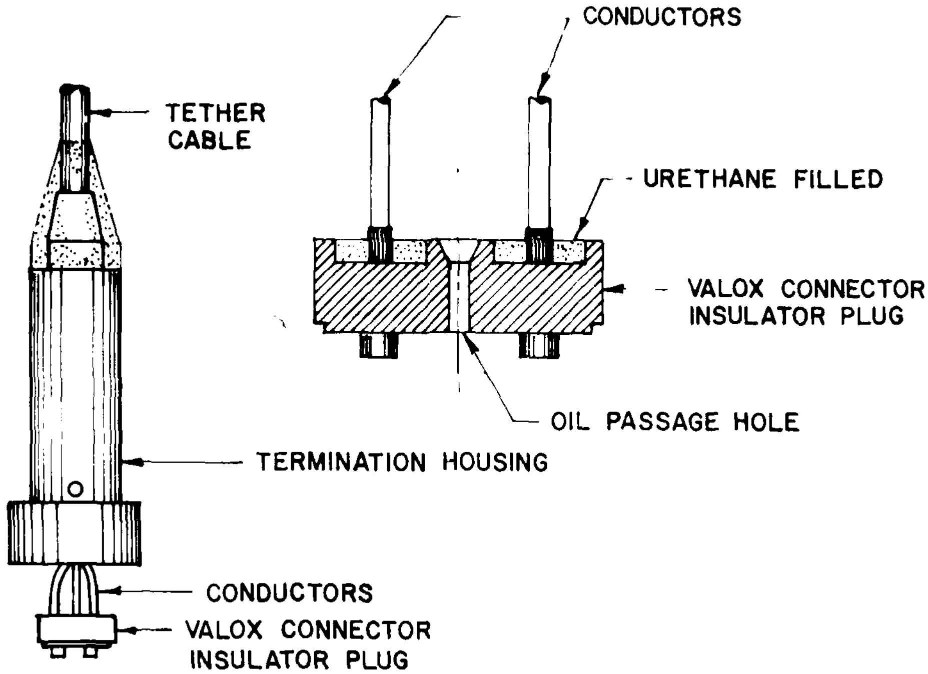

Figure 32. Valox connector insulator plug potting.

31. Install the valox connector insulator plug in the housing.

32. Rotate the insulator and conductor 360 degrees while inserting them in the housing.

CAUTION

Do not use excessive force. The turning should form the conductors into a service loop behind the insulator in the cavity. Ensure that the insulator seats on the alignment pin in the housing.

33. Install the retaining snapring.

34. Slide the termination housing into the prod and rotate it until the threaded fill port is visible through the access hole.

35. Install the sealing screw. The termination must be filled with oil when it is installed on the vehicle.

PCT END

When the termination is complete at the PCT end, the tether cable connector is inserted through a holddown clamp and secured to the reel by means of the transition tubing, as shown in figure 33. The specific termination instructions are contained in the following paragraphs.

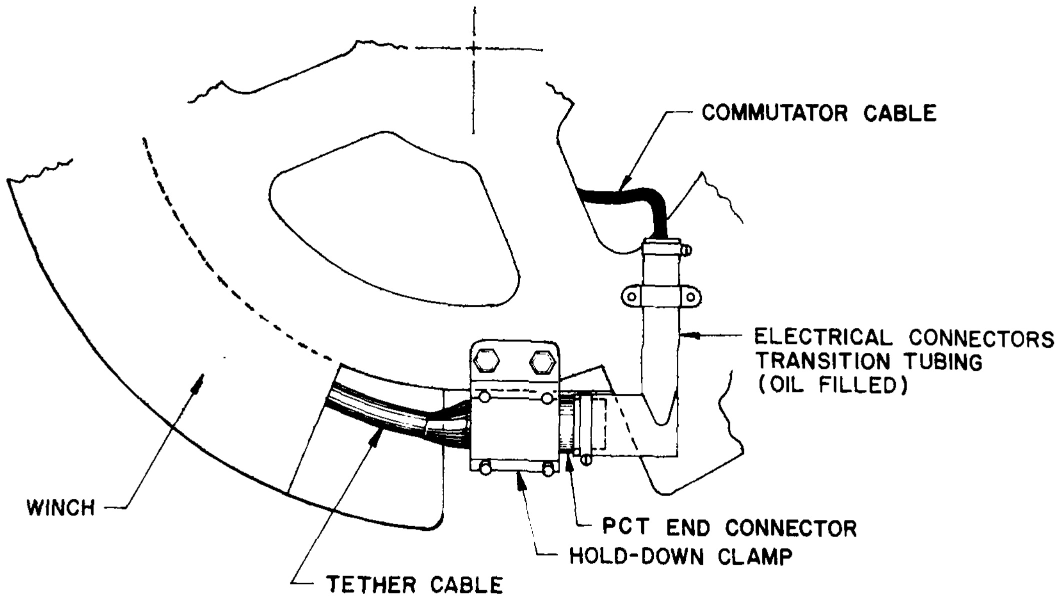

Figure 33. Cable connected to the PCT.

TETHER STRENGTH TERMINATION

The strength termination for the PCT end is the same as for the vehicle end. Therefore, the step-by-step procedures followed for the strength termination at the vehicle end should be followed here.

TETHER ELECTRICAL TERMINATION

This section presents instructions for the electrical termination at the PCT end of the tether cable. Figure 34 illustrates the completed termination. To achieve this, first the conductors are cut and insulation stripped back. Shrinkable tubing is installed, the pins are inserted, and the cable connector is assembled as shown in figure 35. The step-by-step instructions for this procedure are listed below.

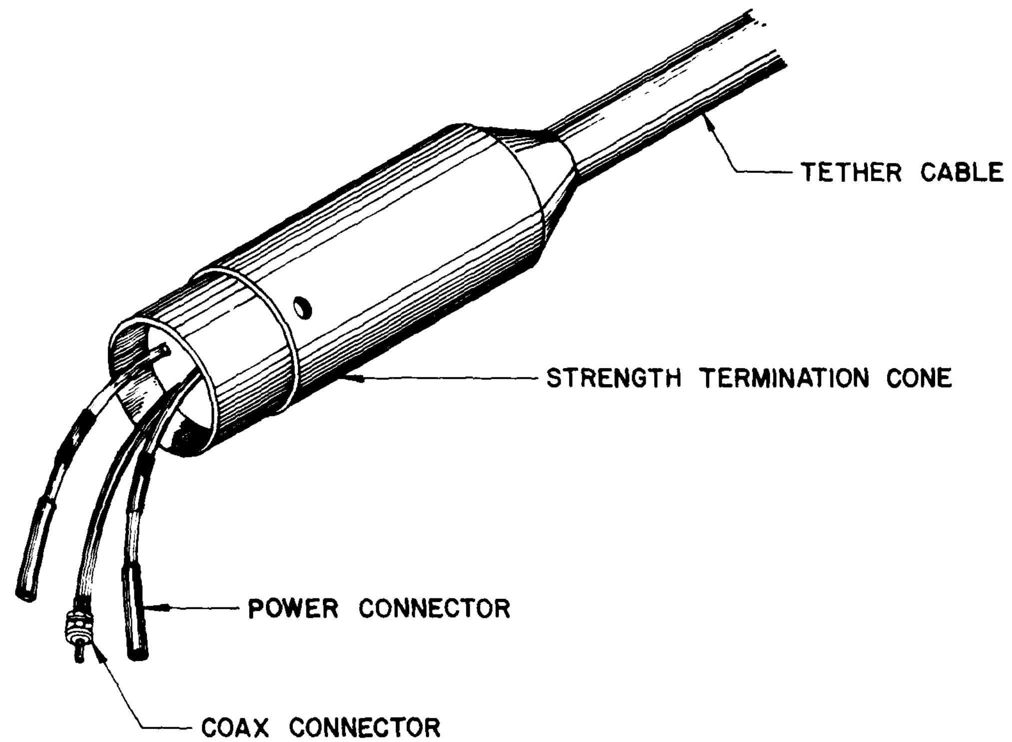

Figure 34. Completed termination, PCT end.

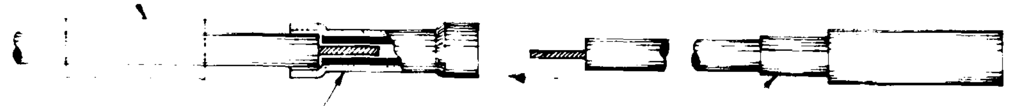

Figure 35. Power connector termination at the PCT end.

1. Cut the two power conductors off 1 inch from the cone.

2. Cut the coaxial conductor off 4 inches from the cone.

3. Strip the insulation back from the ends a distance of 0.3125 inch, being careful not to damage the conductor wires during the stripping (see figure 35).

4. Slide a 1.50-inch length of shrinkable tubing over the conductor, as shown in figure 35; then insert the wire into a solderless butt connector and crimp it.

5. Cut 3 inches from the connector end of a Brantner RMA-FP connector.

6. Repeat steps 3 and 4 above.

7. Install the parts on the coaxial cable as shown in figure 36.

8. Slide the shield back approximately 0.750 inch.

9. Strip the dielectric 0.0938 inch from the end.

10. Tin the wires with soldering lead.

11. Insert the pin into the teflon insulator.

12. Insert the wire portion into the pin soldering chamber and apply heat to the tip side of the pin to solder the pin and the wire.

13. Assemble the connector as shown in figure 36.

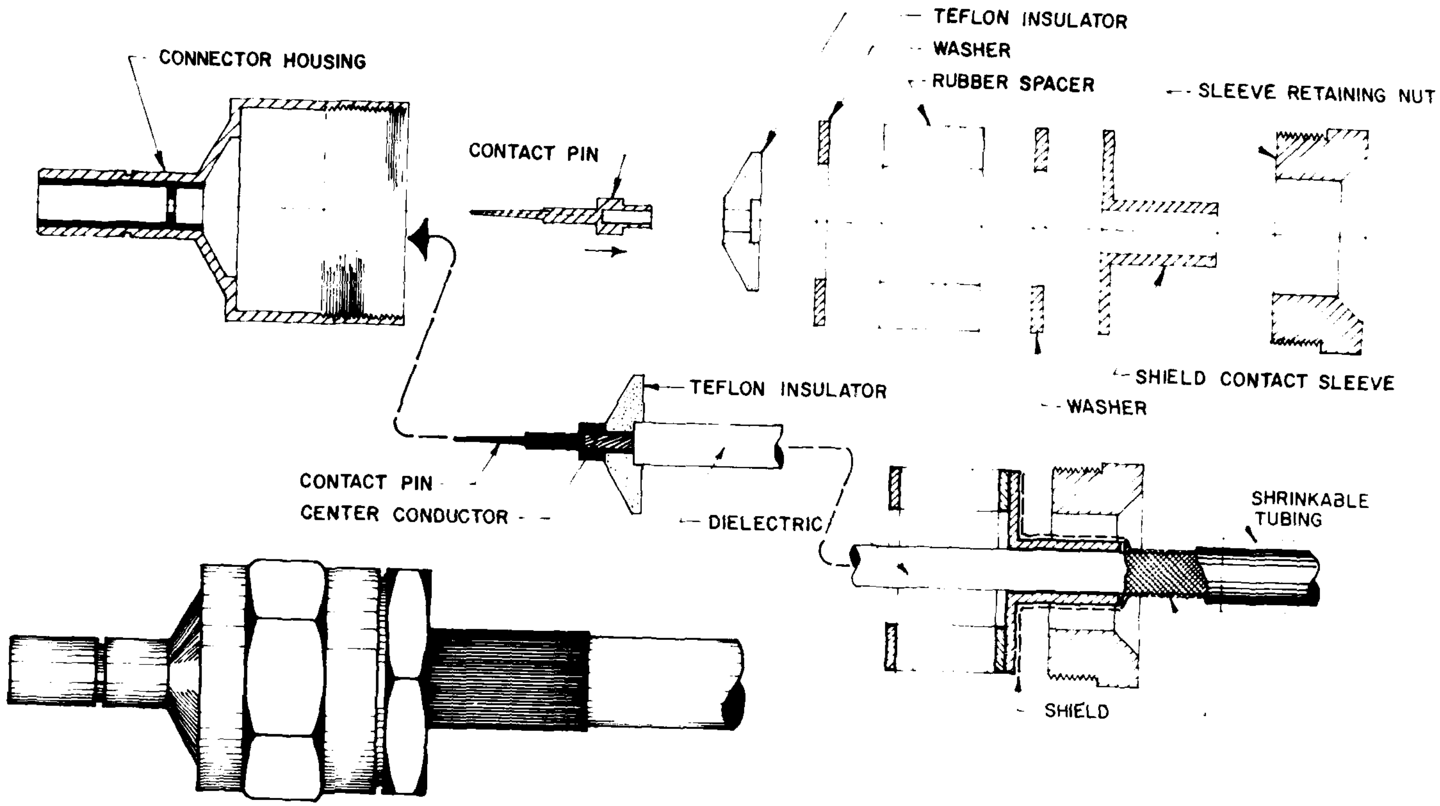

Figure 36. Illustrated breakdown of termination at PCT end.

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1. Mummery, H. L. and G. A. Wilkins, Procedures for the Termination and Potting of the RUWS Vehicle Tether Cable, NUC TN 1681, March 1976.

2. Gibson, P. T., F. G. White, G. L. Thomas, H. A. Cress and G. A. Wilkins, Evaluation of KEVLAR-Strengthened Electromechanical Cable, Proceedings of the Marine Technology Society 10th Annual Conference, p. 170, September 1974.

3. Wilkins, G. A., Performance Characteristics of KEVLAR-49 Tension Members, Proceedings of the International Conference on Composite Materials, Geneva, Switzerland, April 7-11, and Boston, Massachusetts, April 14-18, 1975.

4. Wilkins, G. A., Designs for Neutrally Buoyant Multiconductor Cables, Proceedings of MTS-IEEE OCEAN '75 Symposium, p. 121, September 1975.

5. Wilkins, G. A., J. D. Hightower and D. M. Rosencrantz, Lightweight Cables for Deep Tethered Vehicles, Proceedings of MTS-IEEE OCEAN '75 Symposium, p. 138, September 1975.

6. Wilkins, G. A., P. T. Gibson and G. L. Thomas, Production and Performance of a KEVLAR-Armored Deep Sea Cable, Proceedings of MTS-IEEE OCEAN '76 Symposium, p. 9A, September 1976.

APPENDIX A: TERMINATION PARTS

The parts listed here are required in order to complete successfully the procedures outlined in this document.

1. Prod and strain relief assembly.

2. Termination cone (vehicle and PCT).

3. Termination housing.

4. Insulation strip.

5. Valox connector insulator plug.

6. Female contact Deutsch #800-12/30-3 (2 required).

7. Coaxial contact Deutsch #0107-001-000 (1 required).

8. Snapring (insulator plug retainer).

9. 22-18 (red) insulated solderless butt connector (2 required).

10. Brantner RMA-FP connector (1 required).

APPENDIX B: LIST OF MATERIALS

The materials listed here are required to complete successfully the procedures outlined in this document.

1. Urethane, PRC-1590 or PRC-1592.

2. Primers for urethane:

   a. Metal primer, PR-420

   b. Plastic primer, PR-1543.

3. Trichloroethane.

4. Freon TE-35.

5. Methylethylketone (MEK).

6. Silicone grease (mold release).

7. Beakers (50, 400 and 600 ml).

8. Lint-free paper towels.

9. Acid brushes.

10. Electroseal.

11. Automotive calkstrip.

12. Epoxy:

    a. Resin: Reichold Chemical, Inc. 37-137

    b. Hardener: Reichold Chemical, Inc. 37-620.

13. Masking tape.

14. Cellophane tape: Scotch.

15. Rubber bands.

APPENDIX C: LIST OF FIXTURES AND TOOLS

The fixtures and tools listed here are required to complete successfully the procedures outlined in this document.

1. Workbench.
2. Strength termination fixtures:
   a. Base plate
   b. Fiber hanger frame
   c. Top plate
   d. Split clamp
   e. Element separator rings.
3. "C" clamps.
4. Bell jar: plexiglass tube.
5. Bell jar: top plate.
6. Vacuum pump with 1/4-inch (6.35-mm) ID tygon tubing.
7. Heater.
8. Heater elements.
9. Thermometer.
10. Mixing rods.
11. Molds:
    a. Strain relief
    b. Termination housing.
12. Injection mold gun with cartridge, cap and tips.
13. Syringe and needles.

14. Crimp tools:

a. Buchanan crimp tool M22520/1-01

b. Daniels crimp tool MH800

c. Buchanan hexagonal crimp tool M22910/7-17.

APPENDIX D: SOLVENTS AND THEIR USES

Freon TE-35 is used to soak the urethane from the strength member elements. In addition, it is used for cleaning in situations where a stronger solvent would cause damage.

Trichloroethane (chlorethane NU or trichloroethylene) is used to remove the void filler compound and some urethane from the strength member elements. Also, it is used for cleaning and degassing. However, caution must be exercised in the latter cases since damage to the conductor insulation can result.

MEK (methylethylketone) is used for cleaning metal parts before the primer is applied. Its primary use is for thinning the urethane to be used in filling the bubbles.

Acetone is used for cleaning metal parts before the primer is applied. It may be substituted for MEK for cleaning purposes only.

NOTE

Do not use acetone as a thinner for filling bubbles.

APPENDIX E: URETHANE METAL PRIMER MIXING INSTRUCTIONS

Material: PR-420 (Products Research and Chemical Corporation).

Thoroughly mix one part of Part A with six parts of Part B by volume. Do not mix more than can be used within a four-hour period.

Brush a thin film of mixed PR-420 on all inside surfaces of connectors and on wire, but not on the insulation. Let the primer dry for one hour at 75 degrees F (22 degrees C).

If the primer becomes contaminated, reclean the primed surface lightly with methylethylketone (MEK) and dry. Stripping the primer from the connector and repriming is not necessary.

APPENDIX F: USE OF NONMETALLIC PRIMER

Material: PRC-1543 (Products Research and Chemical Corporation).

To obtain good adhesion, the surface should be made tacky with methylethylketone (MEK). Apply a thin coat of PR-1543 to the tackified surface by brush and allow to dry for 30 minutes at room temperature. If primed surfaces become contaminated before potting or molding, buff the primed surface with a suitable abrasive and reapply a thin coat of PR-1543.

APPENDIX G: EPOXY MIXING, DEGASSING AND CURE CYCLE

Materials: Reichold Chemical, Inc. 37-127 Resin
Reichold Chemical, Inc. 37-620 Hardener

Mix the resin and hardener, using a ratio of 100 parts resin to 50 parts hardener.

Pour the mix into a beaker having at least twice the capacity of the amount of epoxy mixed.

Place the beaker in the vacuum bell jar and evacuate until the mixture begins to bubble. This cycle may have to be repeated several times.

NOTE

> Do not allow the mixture to overflow the beaker. It may be necessary to close off the pump with a valve and allow air to flow back into the bell jar to stop violent bubbling.

When it is possible to maintain a full vacuum on the bell jar and only a few small bubbles remain, the epoxy is outgassed and is ready to be poured into the termination cone.

Epoxy may be cured at 77 degrees F (22 degrees C) for 15 hours, or for 4 hours at 170 degrees F (68 degrees C).

APPENDIX H: URETHANE MIXING, DEGASSING AND CURE CYCLE

Material: PRC-1590 or 1592 (Products Research and Chemical Corporation).

HEALTH PRECAUTIONS

PRC-1590 has proven to be a safe material to handle when reasonable care is observed. Ordinary hygienic principles, such as washing the compound from the hands before eating or smoking, should be observed. Hands should be washed with a waterless cleaner, followed by soap and water. Avoid breathing vapors, prolonged contact with the skin, contact with open breaks in the skin, and ingestion.

MIXING INSTRUCTIONS

NOTE

Do not open containers until ready to use.

Part B solidifies when it is kept at temperatures below 65 degrees F (19 degrees C) for prolonged periods. Whenever this condition is encountered, loosen the lid and warm Part B to 120 ± 50 degrees F (44.5 ± 6 degrees C). When warming the material, use a thermometer to determine the actual material temperature. Liquefaction is complete when the material loses all of its opaqueness and becomes clear. Stirring is essential during liquefaction to provide a uniform material and to hasten melting. After liquefaction, Part B will remain liquid at room temperature.

Part A may solidify partially when stored for prolonged periods below 65 degrees F (19 degrees C). Whenever this condition is found, loosen the lid and warm Part A to 220 ± 10 degrees F (102 ± 6 degrees C). Do not heat over 230 degrees F (110 degrees C). When warming the material, use a thermometer to determine the actual material temperature. Liquefaction is complete when the material becomes smooth and uniform in appearance and loses all signs of graininess. Stirring is essential during liquefaction to provide a uniform material and to hasten melting.

DEGASSING INSTRUCTIONS

Pour mixed urethane into a beaker or beakers having two-thirds greater capacity than the amount of urethane mixed. Place the beaker in the bell jar and evacuate it to a maximum of 28.5 in/Hg (274 mm/Hg). Allow the mixture to foam up and collapse; then continue evacuating until most of the small bubbles have disappeared from the surface of the urethane.

NOTE

Do not allow the mixture to overflow the beaker. It may be necessary to close off the pump with a valve, allowing air to flow back into the bell jar to stop violent bubbling.

When most of the small bubbles have been removed, the mixture is ready to be poured into the injection gun tubes.

NOTE

Care should be taken to avoid trapping any air bubbles when pouring the mixture into the injection gun tubes.

CURE CYCLE INSTRUCTIONS

The urethane must be cured at 175 degrees F (80 degrees C) for 16 hours. Do not cure at a higher temperature, or damage to some materials in the mixture may result.

PHYSICAL PROPERTIES AFTER 16-HOUR CURE (PR-1590)

Hardness, Shore "A"	75
Specific Gravity	1.08
Volume Shrinkage (Percent)	4
Tensile Strength	3500 psi (247 kg/cm^2)
Ultimate Elongation, Die "C"	500 percent

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