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Fairing Stops for Plastic-Jacketed Underwater Tow Cable

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Foreword

When an underwater vehicle is to be towed by a surface craft at speeds greater than 1 or 2 knots, the tow cable designer faces several major problems. Included are overcoming the drag and lift forces that can limit tow vehicle depth and eliminating cable strumming, which causes fatigue failures.

The usual solution is to add segments of fairing to the tow cable to change its hydrodynamic characteristics. However, this is normally a costly, time-consuming effort, especially on tow cable that does not have metallic armor. This report describes a method that greatly simplifies one part of the fairing installation procedure and is especially useful on plastic jacketed cable.

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Executive summary

The construction and installation details of mechanical stops for use with fairing segments on plastic jacketed underwater tow cables are explained. Installation is easy, consumes about one man-minute per stop, and requires no tools. The parts do not have to be threaded onto the tow cable from one end, they are very inexpensive, and are available off the shelf. Slight modification of the off-the-shelf parts is generally necessary.

The technique does not require the resistance to crush, which is usually available only with metallic armored cable. It has been used successfully on electromechanical cable that contained a braided Kevlar tension member within a polyurethane jacket.

Acknowledgments

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Fairing stops for plastic-jacketed underwater tow cable

I. Introduction

When an underwater vehicle is to be towed by a surface craft at speeds greater than 1 or 2 knots, the designer of the tow cable must cope with several difficult problems. If bare cable with a round cross section were to be used, the drag and lift forces on the cable could place an unsatisfactory depth limitation or an unreasonably high scope-to-depth ratio on the tow cable. In addition the cable would strum, and the risk of a mechanical fatigue failure would be high.

The usual solution to these problems is to add material to the exterior of the tow cable to change its hydrodynamic characteristics. The least expensive and least troublesome modifications involve the addition of threads or ribbons to the periphery of the cable. These modifications usually greatly reduce strumming and significantly reduce drag, but still permit use of conventional winch drums and sheaves. However, even at moderate tow speeds, the cable drag forces can remain large enough to overwhelm the other forces on the tow system, and the towed vehicle is often limited to unsuitably shallow depths. To solve this problem, segments of fairing with a streamlined cross section can be mounted on the tow cable (see Fig. 1). The drag force on such faired cable is then much lower than otherwise, but at considerable cost for fairing hardware, installation labor, and special handling gear.

The fairing segments must be free to rotate with respect to the tow cable to align themselves in the direction of travel during towing. They must be constrained, however, to maintain approximate position on the cable rather than to slide en masse to the lowest position possible. If the segments are too low, rotation is inhibited and the cable, the fairing, or both would be damaged during bending on the sheave or winch drum.

The usual way to maintain approximate fairing position on the tow cable is to fasten mechanical stops to the cable approximately 3 m apart. The fairing segments are installed between the stops with appropriate spacing and are thereby severely limited in the distance they can slide. Also, the fairing forces tangential to the cable are never accumulated in the fairings for more than 3 m before being transmitted to the tow cable. This desirable feature defines the thrust bearing requirement on the stop, however. Several designs have been proven for fairing stops on metallic armored cable; it is possible to grip the armor tightly without deforming the conductors within.

If streamlined fairing is to be used on electromechanical cable without metallic armor, the possibility of damage to conductors inside the cable must be considered when designing cable stops. Also, if the cable contains Kevlar, a material spectacular in strength but poor in resistance to abrasion damage, the design of the stop is further constrained. An effort to learn of prior solutions to these problems produced only one invention disclosure,[1] which describes a technique for molding stops on a special overbraid—a time-consuming process. A better method was sought, but no other user of streamlined fairing on nonmetallic armored cable was found. The fairing manufacturer chose to limit his participation to production and shipment of the fairing.

The technique to be described was developed to place fairing stops quickly and inexpensively on any electromechanical cable that has no metallic armor. The construction details of the tow cable used to test the technique are shown in Figure 2. The faired cable has been used on two deployments, during which several days of towing time were accumulated at speeds up to 9 knots. In addition, the cable system has been exposed to the elements for 13 months while stored on its handling winch. So far no deterioration is apparent.

II. Fabrication

A. Components

The components required are shown in Figure 3. The modified fairing nose was bandsaw cut perpendicular to and parallel with its cable hole to clear the installed stop. The manufacturer's label for the friction tape is shown in Figure 4. Figure 5 contains a generic view and dated price list of the assortment of type 5 "Nyliner" bearings suitable as fairing stops. The part tested was No. 16L16. The bearing flanges were trimmed on a lathe to 1¼-inch diameter so that they would not protrude radially beyond the fairing noses. The slits were widened with shears so that the bearings could be collapsed onto the tow cable, which was slightly smaller than the 1-inch shaft for which the bearings were intended. One hundred bearings were modified by a machinist in approximately 2 hours.

B. Installation

The installation procedure is described by Figures 6–10.

III. Safety line

The technology to terminate special electromechanical tow cables, such as the one described in Figure 2, is not mature. The manufacturer reneged on a verbal commitment to terminate this particular cable and ignored a "standing" company policy to terminate any cable if the customer requested termination. This reluctance is a result of the inability of Kevlar fibers to stretch and accommodate misalignment or other stress raisers where the Kevlar makes the transition from jacketed cable strength members to termination component. Tales of failure of Kevlar terminations are not uncommon, and they add an extra measure of discomfort to the normal concerns of the towed system designer. The use of streamlined fairing presents an opportunity, not only to remove this discomfort, but also to reduce the risk of loss of towed hardware due to other kinds of mechanical failures in series with the tow cable.

The aft portions of the fairing segments can be used to house a strength member in parallel with the tow cable. A very convenient strength member is double-braided nylon rope. This kind of rope is better known for the benign manner in which it parts when overloaded, in contrast to the deadly swift contraction of stranded nylon rope. However, the double-braid construction is also soft enough to be shaped to conform to the passages between fairing segments and to be shortened by hand. Shortening by hand is possible by grasping the relaxed rope with both hands a short distance apart. The short segment of rope between the hands can be compressed, which causes the segment to become still shorter as the diameter increases. By repeating this process, a relaxed length of rope nominally 3.2 m long can easily be shortened to 3.0 m and installed in the fairing segments between two fairing stops, as shown in Figure 11. When the faired tow cable assembly is stored on a winch, as in Figure 12, or is passed through a sheave, the compressed rope extends nearly to its original nominal length because it must take a greater radius of curvature than the adjacent tow cable. When it is straightened later, it apparently recompresses within the fairing segments because rope installed in this manner has been deployed and recovered many times without causing handling problems. The rope is terminated according to the manufacturer's recommendations on the winch and the towed vehicle. It remains unloaded as long as the tow cable and the tow cable terminations do not fail.

IV. Reference

1. Deeds, G. W. (1984). *NCSC Invention Disclosure, Fairing Support Ring for Kevlar Strengthened Tow Lines.* U.S. Naval Coastal Systems Center, Panama City, Florida.

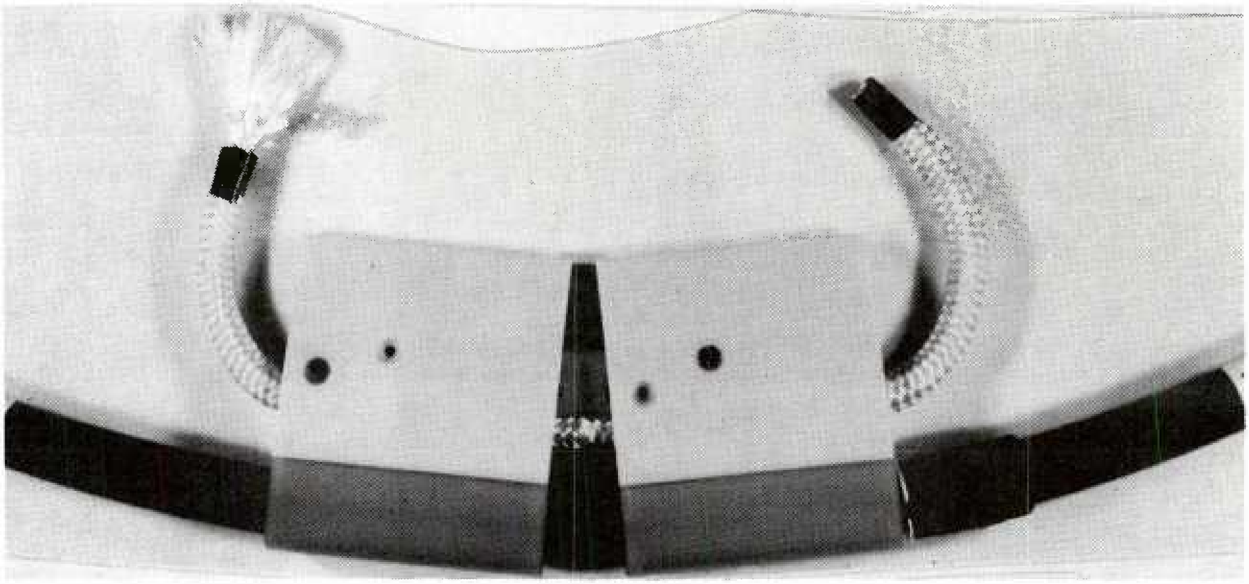
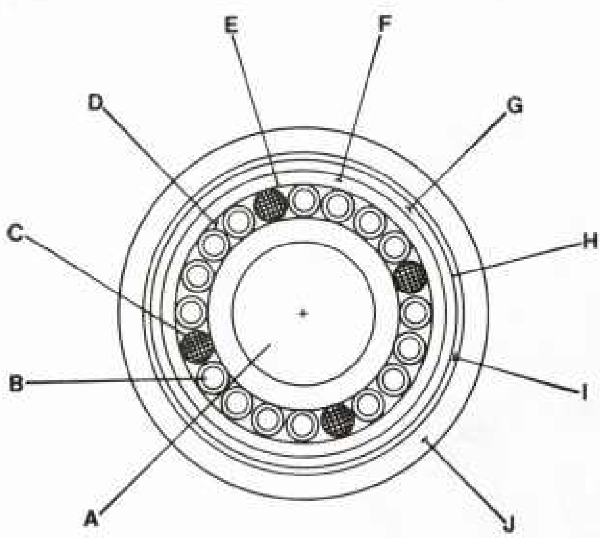


Figure 1. Components of a typical faired tow cable.



	DESCRIPTION	O.D. (INCHES)
A.	NYLON HOSE	
	Nominal I.D. 0.375 Minimum I.D. 0.357	0.500
B.	SINGLE CONDUCTORS - 16 UNITS	
	AWG No. 16 (19/29) T/C wires	(0.058)
	Insulation - polypropylene	(0.088)
C.	SINGLE CONDUCTORS SHIELDED - 4 UNITS	
	AWG No. 20 (19/32) T/C wires	(0.040)
	Insulation - polypropylene	(0.070)
	Shield - AWG No. 36 T/C wires spiral wrap	(0.080)
	Jacket - heat sealed - mylar	(0.088)
D.	WATER BLOCKING COMPOUND	
E.	ADHESIVE MYLAR TAPE	0.691
F.	JACKET	
	L.D. polyethylene	0.751
G.	STRENGTH MEMBER - KEVLAR	
	64 ends #49/7100 Denier braided	0.800
H.	SEPARATOR TAPE	0.810
I.	BEDDING BRAID - DACRON	
	50% coverage	0.830
J.	JACKET	
	Polyurethane	0.974

BREAKING STRENGTH = NLT 12,000 POUNDS

MINIMUM BEND DIAMETER = NGT 25 INCHES

WEIGHT IN AIR = NGT 500 LBS PER 1000 FEET

WEIGHT IN WATER = NGT 200 LBS PER 1000 FEET

Figure 2. Tow cable construction.

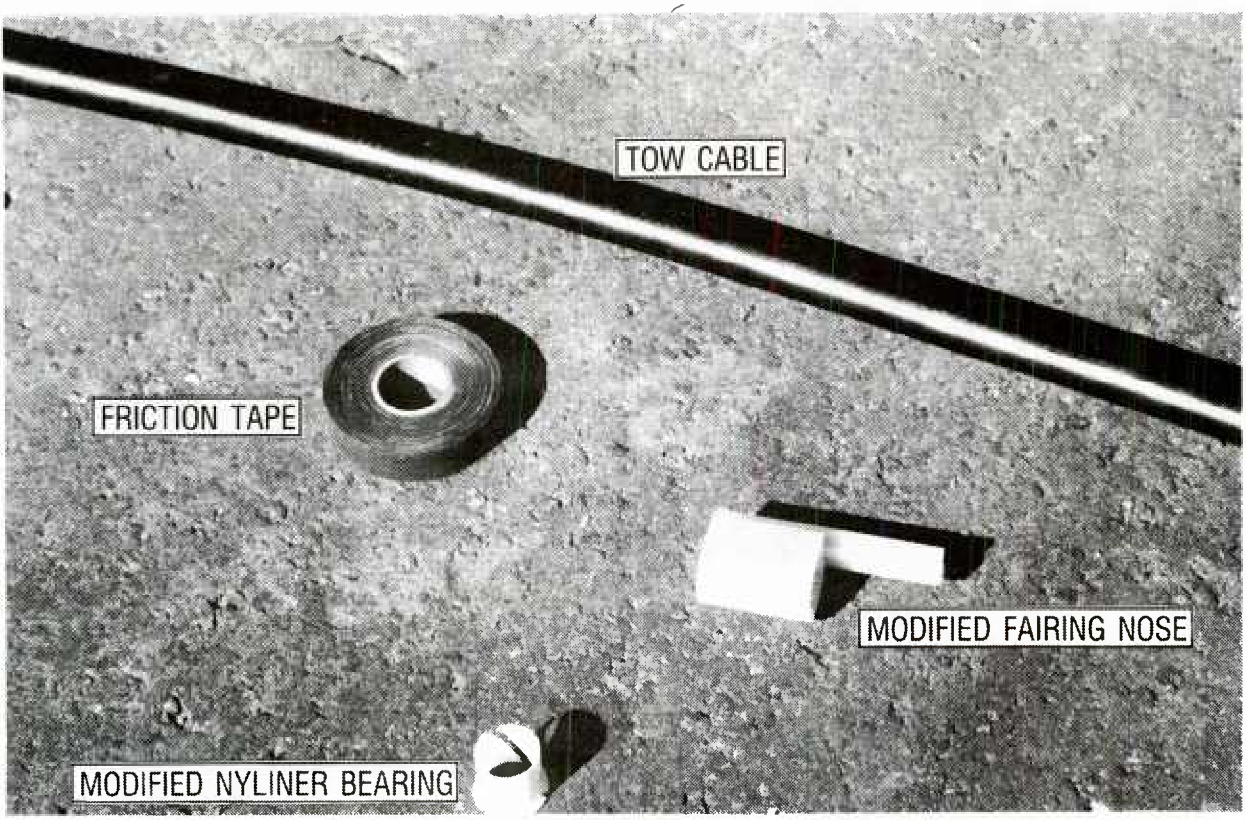


Figure 3. Components required for fairing stop.

Figure 4. Manufacturer's label on friction tape.

		PRICE EACH ($)					PRICE PER THOUSAND ($)		
Bearing No.	Nominal I.D.	1-9	10-49	50-249	250-499	500-999	1000-1999	2000-4999	5000-9999
TYPES 5 & 6 Use suffix "FK" if key is desired.									
3L3-F&FK	3/16"	1.00	64	.36	26	.20	134.38	86.46	51.38
4L4-F&FK	1/4"	1.00	.64	.36	.29	.23	141.37	89.92	53.08
5L5-F&FK	5/16"	1.00	64	36	.29	.23	143.10	91 64	56 52
5L7-F&FK	5/16"	1.00	64	.36	.29	.23	143.10	91.64	56.52
5L10-F&FK	5/16"	1 00	64	36	.29	.23	143.10	91.64	56.52
6L6-F&FK	3/8"	1.00	.64	38	33	.24	144 85	95.09	58.22
6L11-F&FK	3/8"	1.00	64	38	.33	.24	144.85	95 09	58.22
7L7-F&FK	7/16"	1.00	.64	38	.33	.24	155.32	105.46	68.51
8L3-1/2-F&FK	1/2"	1.00	.64	38	35	24	165.81	117.56	83.93
8L5-1/2-F&FK	1/2"	1.00	64	38	.35	.24	165.81	117.56	83.93
8L8-F&FK	1/2"	1 00	64	38	35	.24	165 81	117 56	83 93
8L12-F&FK	1/2"	1 00	64	38	35	.24	165 81	117 56	83.93
10L5-1/2-F&FK	5/8"	1 00	64	38	.36	.26	176.26	129 67	90 78
10L7-F&FK	5/8"	1 00	64	38	36	26	176.26	129 67	90 78
10L10-F&FK	5/8"	1 00	64	.38	36	26	176 26	129 67	90 78
10L14-F&FK	5/8"	1 00	64	38	36	26	176.26	129 67	90.78
10L18-F&FK	5/8"	1 00	64	.38	36	26	176.26	129 67	90 78
12L12-F&FK	3/4"	1 00	.71	49	.38	29	188 49	140 05	104 46
12L18-F&FK	3/4"	1 00	71	49	38	29	188 49	140.05	104 46
14L7-1/2-F&FK	7/8"	1 00	83	59	42	32	218 16	162.51	121.59
14L14-F&FK	7/8"	1 00	83	59	42	32	218 16	162 51	121 59
✓16L16-F~~&FK~~	1"	1 10	83	61	46	.34	249 58	195.37	150.70
18L18-F&FK	1-1/8"	1 10	83	65	48	36	279 25	221 29	171.24
20L20-F&FK	1-1/4"	1 10	83	66	49	.38	305 41	247.24	196 94
24L24-F&FK	1-1/2"	1 21	99	70	61	45	397 90	345 78	299 69

Figure 5. Price list for "Nyliner" bearings. Type 5 is recommended. Part No. 16L16-F was tested. Manufacturer is Thomson Industries, Inc., Port Washington, NY. Prices effective January, 1985.

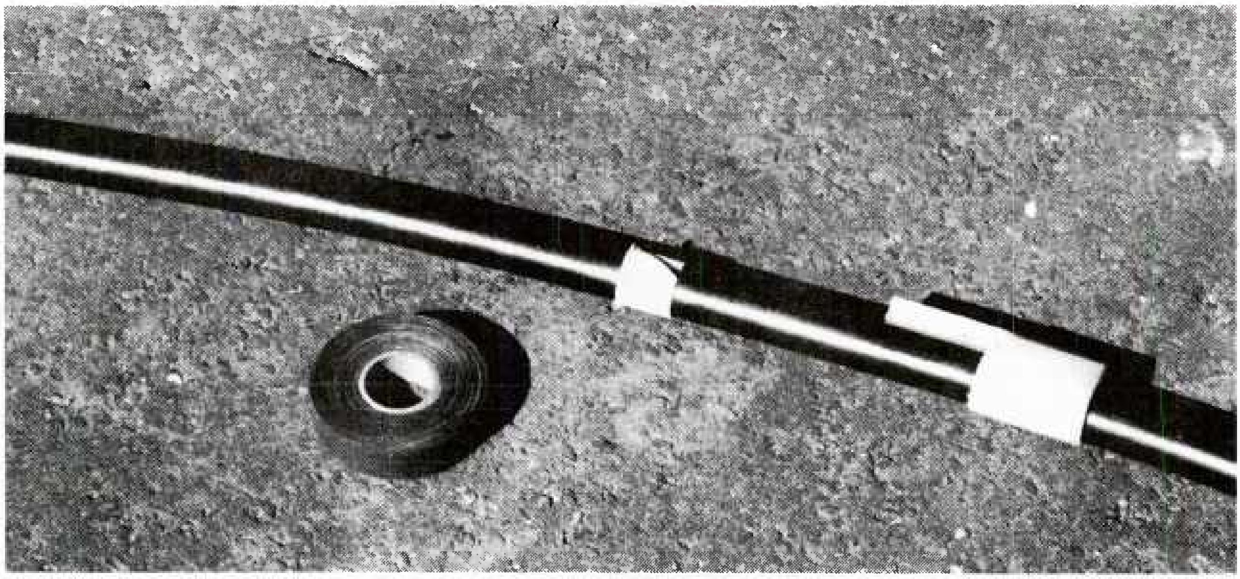


Figure 6. The Nyliner bearings and modified fairing nose are opened and installed on the cable.

Figure 7. Friction tape under hand tension is wrapped on the cable jacket and then on itself until the thickness of the layers of tape equals the bearing thickness.

Figure 8. The bearing is butted against the layers of friction tape, then the tape is spiral wrapped with hand tension over the bearing to the bearing flange.

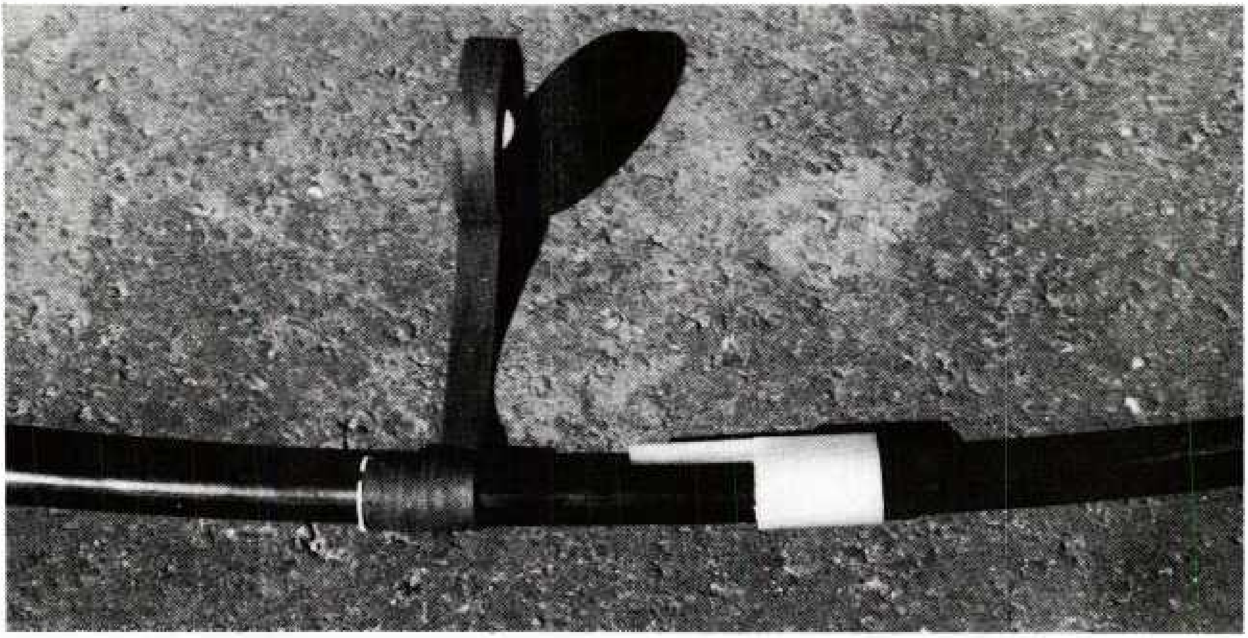


Figure 9. The direction of spiral wrapping of the tape under hand tension is reversed until the tape is again atop the first built-up layers.

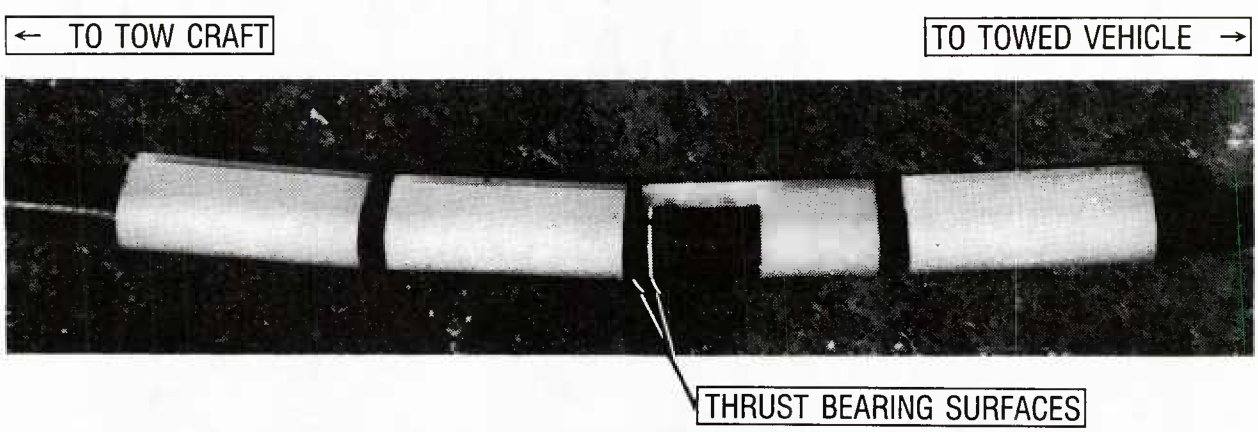


Figure 10. The tape is cut and the remainder of the fairing assembly is installed according to the manufacturer's instructions.

Figure 11. Installation of foreshortened 0.5-inch, double-braided nylon safety line within fairing.

Figure 12. Temporary work station for installation of tow cable stops, fairing, and safety line before loading the finished cable on its winch.