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[54] **WEATHER RESISTANT SEGMENTED FAIRING FOR A TOW CABLE**

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[51] **Int. Cl.**[2] **B63B 21/10**

[58] **Field of Search** ..... 254/135 R, 190 R; 114/235 F

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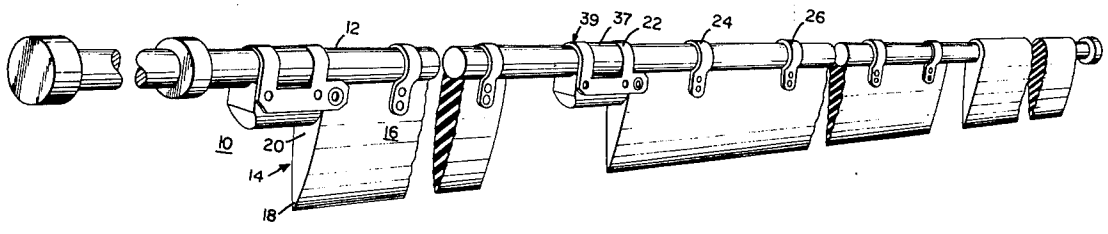
[57] **ABSTRACT**

A weather- and ozone-resistant elastomeric fairing for a tow cable comprising a plurality of sections using butyl synthetic rubber (Butyl-035) as the base polymer. Each section of the fairing is independently suspended and attached to the tow cable by fairing support rings and yokes by means of clips. The material for the fairing sections is fabricated with Butyl-035 as a base polymer and using different amounts of Elastopar, SAF black, zinc oxide, stearic acid, dioctyl sebacate, sulfur, methyl tuads, and captax to give the fairing sections weather resistant properties.

2 Claims, 2 Drawing Figures



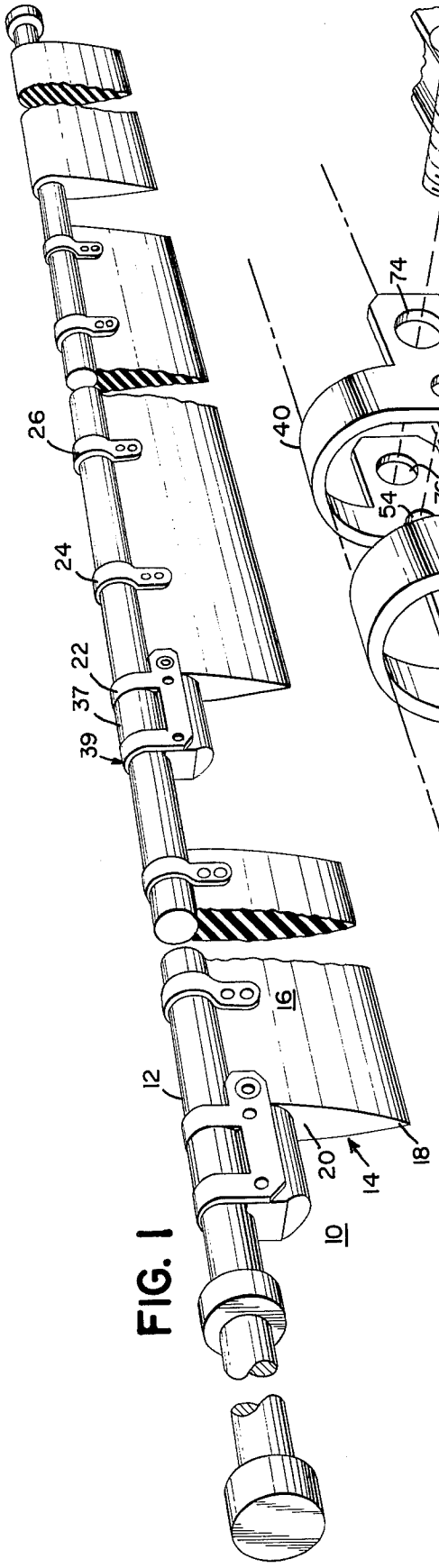

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FIG. 1

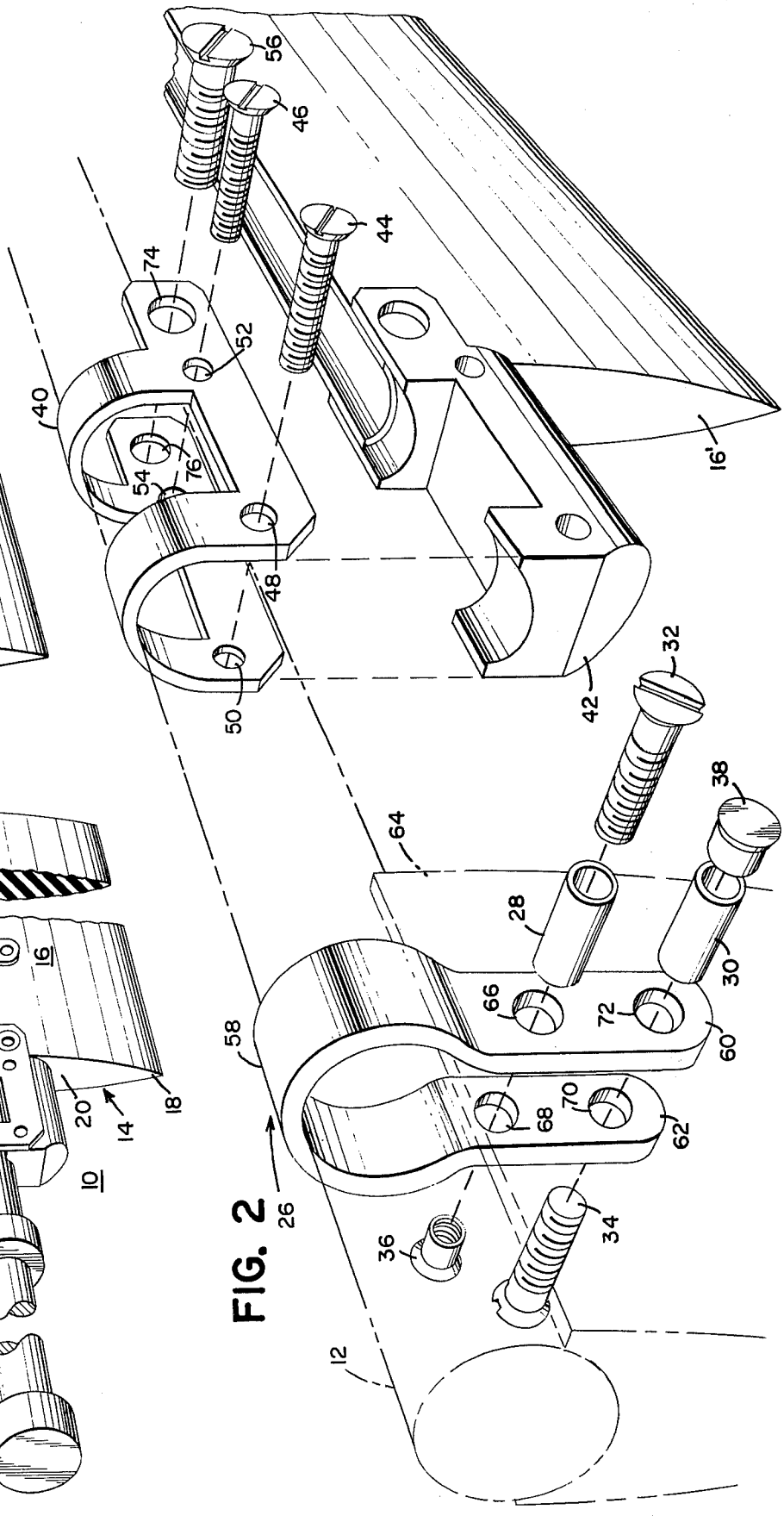
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FIG. 2

WEATHER RESISTANT SEGMENTED FAIRING FOR A TOW CABLE

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates to faired cables adapted for use in guiding both towed and self-propelled or maneuverable submerged devices and more particularly to a weather resistant segmented fairing for a tow cable for a variable depth sonar system and the like.

A variable depth sonar is used to achieve sonar transducer at variable depths in water depending upon water conditions in order to achieve greater ranges of operation. Furthermore, quenching is eliminated and the sonar transducer can deliver much greater power to the water. In order to maintain the position of a variable depth sonar, hereinafter referred as VDS, at a preselected depth, towed variable depth sonar devices have been developed which may be towed behind a ship by means of a tow cable. The tow cable provides a mechanical connection with the ship as well as electrical connections to the sonar transducers. Such tow cables are normally circular in cross-section and they cause considerable turbulence when drawn through water, causing cable drag and consequent loss of depth of the VDS. One way to overcome this turbulence is to change the shape of the cable by attaching a fairing which streamlines the overall shape of the cable. Continuous fairings have been used for this purpose. However, if such tow cables are canted at an angle to the towing direction, a lateral thrust is developed which causes excessive motion of the towed VDS in the form of side-to-side oscillations or changes in depth of the VDS. Sectional plastic fairing which is streamlined has also been tried wherein individual pieces are held in proper position by aligner rods. However, in service, sectional plastic fairings are subject to column action, i.e., the towing forces cause the fairing sections to stack one against the other which prevents them to rotate freely around the tow cable and align themselves directly behind the tow cable. This column action causes the tow line to kite either to the port or starboard side and prevents the VDS from staying directly behind the ship as required by service conditions. In addition, the serviceability of the tow line has been poor due to frequent breakage of aligner rods and sectional plastic tail pieces, especially when the tow line is used at high sea states. Thus it is desirable to have a reliable tow cable which will maintain the VDS at desired depths without frequent breakdowns in the service.

SUMMARY OF THE INVENTION

The weather- and ozone-resistant, segmented butyl rubber fairing for a tow cable of the present invention comprises a plurality of sectional pieces fabricated from Butyl-035 as the base polymer and different amounts of Elastopar, SAF black, zinc oxide, stearic acid, dioctyl sebacate, sulfur, methyl tuads, and captax to give them ozone- and weather-resistant properties. It is to be noted that Butyl-035 is a specific type of rubber, made by a number of manufacturers, wherein 035 refers to the specific amount of unsaturation for curing.

Each of the sectional pieces is hung from a yoke which is supported by a nylon thrust washer resting on a fairing support ring. Each support ring is vulcanized to the tow cable. The remainder of the fairing is held in proper position behind the tow cable by evenly spaced rings or clips. The yoke and the clips have sufficient clearance around the tow cable to allow the yoke and the entire length of the fairing to swivel freely around the tow cable. This ability of the fairing to swivel and hence to align itself helps the faired tow line to be non-kiting in service. The rubber fairing sections are in the form of a streamlined shape, each section comprising an elastomeric section of a medium hardness leading edge and a soft trailing edge, a Dacron reinforced strength member, and an antichaffing ply.

One object of this invention is to have a faired cable for maintaining a VDS at a desired depth.

Another object of this invention is to have a faired tow cable which is non-kiting in service.

Still another object of this invention is to have a segmented flexible fairing for a tow cable in short supported sections rather than of one continuous length to avoid bunching and buckling of the tow cable.

Still another object of this invention is to have a plurality of flexible fairing sections which are individually suspended and are not articulated to prevent contact.

Still another object of this invention is to have a plurality of fairing sections wherein each section is free to seek its own position in the free stream behind the tow cable.

Still another object of this invention is to make a segmented flexible fairing which is ozone-and weather-resistant.

Still another object of this invention is to have a plurality of flexible sectional fairing pieces wherein each section has leading and trailing edges made of butyl rubber compounds which are tail-light in sea water so that the fairing into which the compounds are vulcanized floats up behind the tow cable.

Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the following drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a tow cable having a segmented flexible fairing; and

FIG. **2** is a magnified view of a tow cable having a segmented fairing showing details of a yoke and a ring or clip used for securing a fairing section to the tow cable.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to the drawings wherein like reference characters designate identical or corresponding parts in various figures, and more particularly to FIG. **1** thereof, numeral **10** shows a perspective view of a weather-and ozone-resistant segmented fairing. A tow cable **12** has a plurality of fairing sections such as **14** attached to it. Fairing section **14** comprises a streamlined fairing piece **16** having a relatively soft trailing edge **18** and a tough, medium hardness leading edge **20.** The trailing edge **18** has low specific gravity which is lower than that of sea water (i.e., less than 1.025), low shore durometer A hardness, low modulus at 100 percent elongation, high tensile and high tear strength, low volume swell in water, good low temperature flexibility, and

good weather aging resistance. These requirements for the fairing sections reduce the buckling effect resulting from the cable catenary during towing and help to have the neutral axis of the fairing positioned so that the fairing tends to right itself on the cable. Leading edge **20** is of medium durometer hardness. Each fairing section is connected to tow cable **12** by means of a yoke **22** and a plurality of rings or clips such as **24** and **26.** Each fairing section is independent of the motion of other fairing sections attached to the tow cable.

FIG. **2** shows attachment of a yoke such as shown in FIG. **1** by numeral **22** and a plurality of rings or clips, preferably evenly spaced on the tow cable, such as shown by numerals **24** and **26** in FIG. **1.** Cable **12** is shown in FIG. **2** by fathom lines. Clip **26,** its sleeves **28** and **30,** screws **32** and **34,** and corresponding nuts **36** and **38** are preferably made of No. 316 stainless steel. However, other similar materials may be substituted for stainless steel in the fabrication of these parts and the subsequent parts without deviating from the teachings of the subject invention. Yoke **22** is supported on a nylon thrust washer resting on a fairing support ring **37.** The yoke is designed to straddle the support ring **37** in region **39.** The support ring **37** is preferably made of No. 18 gage, No. 316 stainless steel strip about 2 inches by 5 inches, and is vulcanized to the tow cable by a Nitrile Rubber layer having composition as discussed below.

For vulcanizing one of the support rings to the tow cable, a portion of the tow cable of width slightly greater than the width of the support ring is wire brushed; degreased by means of a solvent such as xylene or acetone; dried with cold air, painted with a phosphoric acid mixture (80 percent by volume) for about one minute, rinsed with water and dried with cold air thereafter. The cleaned work area on the tow cable is then painted with a smooth coat of an adhesive such as Thixon P-4 or the like and allowed to dry for at least half an hour. The uncured Nitrile Rubber is then slipped inside the pre-cleaned support ring and any rubber extending the surface of the support ring is removed. The support ring with the rubber is then slipped over the already prepared section of the tow cable and squeezed thereon. The tow cable and the support ring are then treated in a mold preheated to 307°F and a pressure of 24,000 pounds is applied for 10 minutes. The excess rubber flashing is then removed and the seam of the support ring is carefully tack welded without burning a hole therein. The weld is ground to match the surface of the support ring.

The support rings are positioned along the tow cable to ensure a nominal 4-inch clearance between the lower end of one fairing section and the upper end of the adjoining fairing section. Each support ring is tested to withstand a shear load of 1,000 pounds applied for a period of 1 minute. Yoke portion **40** of yoke **22** is attached to its insert **42** by two screws **44** and **46** which are preferably two No. 10-32 flat head screws passing through respective pairs of holes **48, 50** and **52, 54** provided with mating nuts which come flush with the yoke surfaces. Yoke portion **40** is attached to the fairing piece **16'** by means of screw **56,** preferably a No. ⅜-24 flat head screw provided with a matching nut, so that there is adequate clearance between the fairing and the tow cable when the inner leading edge of the yoke is bearing against the tow cable. Clip or ring **26** has its upper portion **58** mated with the tow cable **12** with its lower ears **60** and **62** in contact with opposite sides of the fairing section **64.** Screws **32** and **34,** together with the respective sleeves **28** and **30** and the respective nuts **36** and **38,** are used to connect lower ears **60** and **62** of ring or clip **26** with fairing section **64.** Sleeve **28** is inserted through holes **66** and **68** in ring or clip **26** and screw **32** is passed through the sleeve **28** and is used together with nut **36** to fasten the ring or clip **26** to the fairing section **64.** Likewise, sleeve **30** is inserted through holes **70** and **72** in ring or clip **26** and the fairing section **64.** Screw **34** and nut **38** are then used to attach securely ring or clip **26** to fairing section **64.** FIG. **2** also shows a magnified view of yoke **22** to be attached to tow cable **12.** Yoke portion **40** of yoke **22** is placed in position over tow cable **12.** Insert **42** is attached to the fairing piece **16'.** Holes **48** and **50** in yoke portion **40** are lined up with the respective holes in insert **42,** holes **52** and **54,** and **74** and **76** in yoke portion **40** are lined with the respective holes in insert **42.** Screws **44, 46,** and **56** are used together with their matching nuts to tie fairing piece **16'** to yoke portion **40** and tow cable **12.** It should be noted that each fairing section has a yoke and insert section attaching the fairing section to the tow cable and a series of rings or clips, preferably evenly spaced, attaching the fairing section to the tow cable. There is enough clearance between the tow cable and the yoke and rings which enables the fairing to rotate about the tow cable freely.

COMPOSITION OF TRAILING EDGE OF FAIRING SECTIONS

The requirements for the material to be used for preparing various sections of the fairing are such that it will reduce galloping of the tow line, i.e., mechanical and hydromechanical characteristics of a tow line make the tow cable to be unstable like a telephone wire strumming in wind; kiting, i.e., the tow line experiencing side forces which bring about a sideway motion of the tow line; and buckling, i.e., instability resulting from the fact that stresses developing in the trailing edge are greater than stresses developing in leading edge if the material out of which a fairing section is made is of uniform density. In order to reduce galloping, kiting and buckling, it was considered essential to prepare a special type rubber material using Butyl-035 as a base polymer and preparing materials of different characteristics for trailing edge and leading edge of each of the fairing sections. Special nitrile rubber is also made for vulcanizing support rings to the tow cable.

As pointed out above, it is considered essential that specific gravity of the material out of which trailing edge portion of each of the fairing sections is made should have specific gravity lower than that of sea water, i.e., 1.025, good weather-and ozone-resistant properties, low shore durometer A hardness, low modulus at 100 percent elongation, high tensile and high tear strength, low volume swell in water and good low temperature flexibility. In order to achieve these characteristics, a new material is developed, preferably using Butyl-035 as a base polymer and using a Super Abrasion Furnace black (i.e., SAF black) such as Philblack-E made by Phillips Petroleum, Rubber Chemical Division. SAF black is used as a reinforcing agent to give the material tensile properties for reinforcement and its opacity prevents deterioration of the material by sunlight. A peptizer such as Elastopar (i.e., 33.3 percent

dispersion of N-Methyl-N, 4-Dinitrosoaniline in some carrier such as Whitex Clay) is also used for dispersion and reinforcing of the material. Dioctyl sebacate, a plasticizer, is used to soften the material and to keep it flexible at low temperature. The curing system using sulfur, methyl tuads (i.e., Tetramethylthiuramdisulfide), and captax (i.e., 2-Mercaptobenzothiazole) is used. Zinc oxide and stearic acid are used as activators to assist in the vulcanization process. Composition of trailing edge compound satisfying above-mentioned properties is preferably chosen to be as follows:

Ingredients	Parts by weight
Butyl-035	100
Elastopar	1
Philblack-E (SAF)	15
Zinc Oxide	3
Stearic Acid	2
Dioctyl Sebacate	10
Sulfur	1.25
Methyl Tuads	1.5
Captax	1

COMPOSITION OF LEADING EDGE OF FAIRING SECTIONS

The requirements for the medium hard leading edge compound are found to be low specific gravity, medium shore A durometer hardness, high modulus at 100 percent elongation, high ultimate tensile strength, high tear strength, low volume swell in water, good low temperature flexibility, and good weather resistance. The composition of leading edge compound satisfying above-described properties is preferably found to have the following composition:

Ingredients	Parts by weight
Butyl-035	100
Elastopar	1
Philblack-E (SAF)	65
Zinc Oxide	5
Stearic Acid	3
Dioctyl Sebacate	15
Sulfur	1.5
Methyl Tuads	1.5
Captax	1

METHOD OF PREPARING FAIRING SECTIONS

Both trailing edge compound and leading edge compound are formulated by allowing curing time to be seventy minutes at 307°F. The following mixing procedure is developed for attaining trailing edge compound and leading edge compound having desirable properties.

1. Preheat Banbury type mixer to 300°F.
2. Add Butyl polymer and masticate it for ½ minute.
3. Add Elastopar and mix for ½ minute.
4. Add half the amount of SAF black (Philblack-E) and half the amount of stearic acid and mix for 2 minutes.
5. Add remainder of SAF black and stearic acid and zinc oxide and mix for 2 minutes.
6. Remove mixed stock from Banbury type mixer and mill it on a cold rubber mill until homogeneous.
7. Add dioctyl sebacate, sulfur, methyl tuads and captax in the order listed and mill it until homogeneous.
8. Refine six times on a cold mill with tight rolls and batch off.

A segmented fairing blank is made of raw, i.e., uncured, pieces of the respective butyl-rubber compounds, a Dacron strength member along the leading edge and an antichaffing ply of nylon along the exterior portions of the leading edge. The blank measures a certain length depending upon the length of the mold cavity and is roughly shaped to conform to the cavity. The raw rubber blanks for fairing sections are so cut and arranged that the leading edge portion is preferably about one inch wide while the remaining trailing edge portion is preferably 4.5 inches wide. The strength member is composed of preferably six or more plies of Dacron reinforcement for a total width of at least 0.25 inch. It is positioned at and conforms to the leading edge of the fairing section and runs the entire length of the fairing section and is looped back on itself for 8 inches at each end to form an eye having a diameter of 9/16 inch. An antichaffing ply is attached over the leading edge and extends over both adjacent surfaces by about one inch and runs along the entire length of the fairing section. The entire raw length assembly is vulcanized in a mold under pressure of at least 600 per square inch (psi) mold surface area for 70 minutes at 307°F.

COMPOSITION AND FORMULATION OF NITRILE RUBBER

For vulcanizing support rings to the tow cable a material having sufficient adhesive strength and shear load bearing capacity is required. The Nitrile Rubber Compound which meets these requirements preferably uses Hycar 1042 (a specific polymer having generic name — Nitrile Butadiene-Rubber) as the base polymer and has the following composition:

Ingredients	Parts by weight
Hycar 1042	100
Philblack-A (FEF)	60
Zinc Oxide	5
Stearic Acid	1
Maglite-D	4
DOTG	0.5
Captax	1.5
Sulfur	2

The polymer is banded on the mill to form a rolling bank. Zinc oxide is added to about one-half the Philblack-A (FEF, i.e., Fine Extrusion Furnace) and is mill-mixed into the polymer. Stearic acid, maglite-D, and DOTG (Di-Ortho-Tolyl-Guanidine) are then added to the remaining half of Philblack-A (FEF) and are mill-mixed into the polymer. Captax (2-Mercaptobenzothiazole) and sulfur are then added and the stock is cut and refined on the mill and is sheet-off to a thickness of 3/16 inch. Curing time is 10 minutes at 307°F. The total mill-mixing time is about 25 minutes.

Briefly stated, leading edge compound and trailing edge compound are made out of materials using Butyl-035 as a base polymer and Nitrile Rubber for vulcanizing support rings to the tow cable is made using Hycar 1042 as the base polymer. Fairing sections are attached to the tow cable using a yoke-insert arrangement and a series of clips or rings. Each fairing section is independent of the other fairing sections attached to the ca-

ble. A tow cable having fairing sections attached thereto is free of galloping, kiting and buckling.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. As an example, the compositions of leading edge compound and trailing edge compound of fairing sections may vary. Furthermore, the number and design of yoke-insert systems and clips may vary. It is therefore understood that within the scope of appended claims the invention may be practiced otherwise than as specifically described.

We claim:

1. A towing system for a variable depth sonar comprising:

a substantially long tow cable:

means for securing a plurality of spaced fairing sections to said tow cable, said plurality of fairing sections having an axis of symmetry substantially normal to the longitudinal axis of said tow cable and having longitudinal axis substantially parallel to the longitudinal axis of said tow cable, each of said plurality of fairing sections having a leading edge and a trailing edge;

a plurality of support rings vulcanized to said tow cable along the longitudinal axis thereof;

a plurality of clips connected to said tow cable and to said plurality of fairing sections; and

the trailing edge of each of said plurality of fairing sections being made from a first butyl rubber compound essentially of the following ingredients:

Ingredients	Parts by weight
Butyl-035	100
Elastopar	1
Philblack-E (SAF)	15
Zinc Oxide	3
Stearic Acid	2
Dioctyl Sebacate	10
Sulfur	1.25
Methyl Tuads	1.5
Captax	1.

2. The towing system of claim 1 wherein said leading edge of each of said plurality of fairing sections is made from a second butyl rubber compound essentially consisting of the following ingredients:

Ingredients	Parts by weight
Butyl-035	100
Elastopar	1
Philblack-E (SAF)	65
Zinc Oxide	5
Stearic Acid	3
Dioctyl Sebacate	15
Sulfur	1.5
Methyl Tuads	1.5
Captax	1.

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