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Arndt et al.

[11] **3,902,937**

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[54] **METHOD OF MAKING CONTROLLED BUOYANCY ELECTRICAL STRAND**

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[21] Appl. No.: **330,336**

Related U.S. Application Data

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[52] **U.S. Cl.** **156/51;** 156/79; 156/315; 427/119

[51] **Int. Cl.²** **H01B 7/02;** H01B 13/16

[58] **Field of Search** ..... 174/70 R, 101.5, 110 F, 174/113 R, 111, 115, 120 C, 116; 156/48, 51, 79, 244, 315; 117/232, 231; 161/DIG. 5

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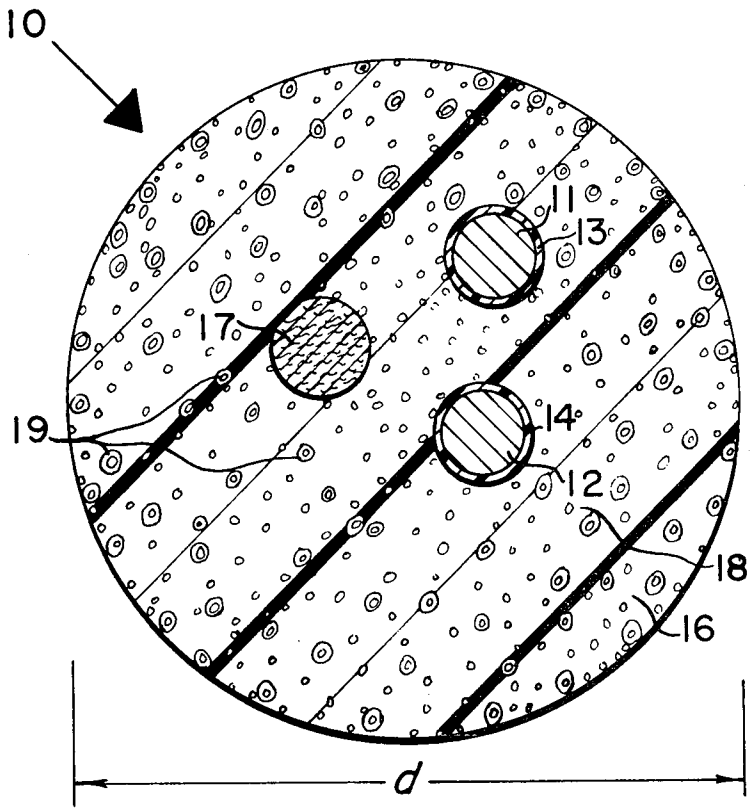
[57] **ABSTRACT**

A fine expendable wire strand with a slow, predetermined sinking rate in sea water is formed of enamel-film insulated conductors covered, along with a tensile strand, by a polymeric foam, interspersed with glass bubbles.

3 Claims, 2 Drawing Figures



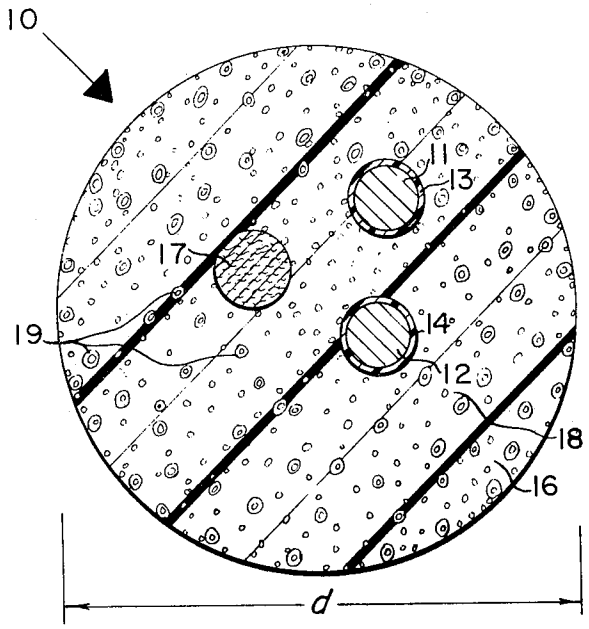


Fig. 1

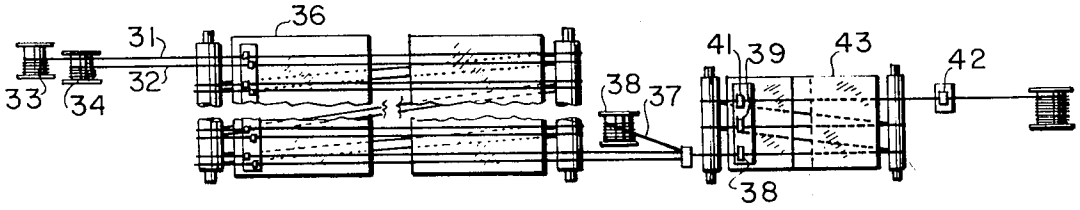


Fig. 2

METHOD OF MAKING CONTROLLED BUOYANCY ELECTRICAL STRAND

This is a division of application Ser. No. 215,858, filed Jan. 6, 1972, now U.S. Pat. No. 3,740,454.

BACKGROUND OF THE INVENTION

The present invention is directed to an improved wire strand or fine cable of the type that is deposited in long lengths from a moving vessel for the purpose of making measurements of the environment at sea. It is desired of such strand that it should have the smallest possible diameter, consistant with adequate tensile strength and it should be very rapidly depositable, while at the same time retaining such electrical properties as good conductance, high insulation resistance between conductors and between the conductors and sea water, and low capacitance between conductors and the conductors and sea water. It would be desirable that the strand not sink too rapidly upon being deposited in the sea, but, on the other hand, it should sink to the bottom within a reasonable time and not remain floating after it has been discarded. It should be possible to manufacture the strand on available wire insulating equipment, in large quantities, at reasonable cost.

SUMMARY

We have invented a controlled buoyancy strand which satisfies the hitherto unobtainable combination of desiderata comprising at least one, and preferably, in parallel, two, or more, elongated electrical conductors, such as copper wires, insulated with enamel film, such as polyurethane film. Our strand preferably also comprises at least one tensile member, parallel to the conductors. Buoyancy is supplied to our strand by an element, such, preferably as an elongated encasement, comprising a polymeric foam and at least 4 weight percent and, preferably, no greater than 20 weight percent of glass bubbles dispersed in the foam. Preferably our encasement will have a circular section, will have a diameter no greater than 0.04 inches, and will have a composite density only slightly exceeding the density of sea water. We have found plasticized polyvinyl chloride is particularly suitable for the foam of our strand and that the glass bubbles may advantageously have an average particle density that does not exceed about 0.35 grams per cubic centimeter.

In our new method of making a controlled buoyancy strand we film-coat at least one electrical conductor wire with magnet wire enamel. We blend a mixture comprising 75–96 parts by weight of a polymeric organosol, 4–25 parts by weight of glass bubbles, and 0.1–2.0 parts by weight of blowing agent. We continuously pass the conductor, coated with the enamel, along with at least one tensile member, through an enameling applicator and therein cover the member and the wire with a layer of the mixture. Then we pass the strand through a heating zone, therein activating the blowing agent and forming the organosol. Preferably several applications of the mixture will be applied, followed each time by passage through the heating zone. We may also apply coatings of the polyvinyl organosol free from blowing agent but comprising the dispersion of glass bubbles, preferably before and after the application of organosol and glass bubbles comprising blowing agent.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a section of a strand of our invention.

FIG. 2 shows a plan of the steps of the method of our invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

A two conductor embodiment of our strand is indicated generally by the numeral **10** of FIG. **1.** Two fine copper wires **11, 12** are insulated respectively with films **13, 14** of polyurethane enamel. We have preferred the use of polyurethane because it bonds particularly well to a polyvinyl encasement **16,** but other enamels, known as magnet wire enamels such as polyvinyl formal, polyester, polyimide-amide, polyimide, epoxy, nylon, polyacrylic and polyolefin are well suited for use in our invention. The thickness of the enamel films **13, 14** will be no greater than that required for a desired degree of insulation resistance, since the film, being non-porous and solid in section, will have a higher density than the encasement **16.** Typical thickness of the films **13, 14** in the illustrated embodiment will approximate 0.1 mil on Awg 39 (0.0035 inch) wire.

The wires **11, 12** are laid parallel in the strand **10.** This has the advantages that no wire twisting step is required with attendant expense and possible damage, particularly to such fine wire, that the capacitance can be lowered by separating the two wires, and that no problem is presented of uniform distribution of the encasement **16** into interstices of a twisted strand. Voids at the interstices of twisted wires would result in undesirable variations of density. Where these advantages are relatively unimportant, however, which may be the case with larger conductors, twisted wires may be used within the scope of our invention. A tensile member **17** is laid parallel to the wires **11, 12** to prevent them from elongating due to the stresses of dereeling, and of any water drag that may occur. We prefer to use a cotton-polyester thread having a breaking strength in excess of 2 pounds for the member **17.** Other fibers such as pure cotton or polyester, rayon, linen, and silk may be used as may also glass or metals such as stainless steel, but these latter have the disadvantage that increased encasement volume is required to compensate for their weight and the steel would detract from electrical properties.

The novel structure of the encasement **16** constitutes an essential feature of our invention. This comprises a polymeric foam portion **18** within which are dispersed a large plurality of very small glass bubbles **19.** Organosols suitable for the portion **18** are commercially available. An organosol is described in the Condensed Chemical Dictionary published by Reinhold Publishing Corporation as "a colloidal dispersion of any insoluble material in an organic liquid, but more specifically, the finely divided dispersion of a synthetic resin in plasticizer, with or without solvents or other materials." "Organosol" in this application refers to the more specific definition. The organosol of foam **18** is polyvinyl chloride and it is made to foam by the inclusion of a blowing agent, of which a number of types are commercially available. We have preferred to use N,N dinitroso-N,N-dimethyl terephthalamide because of the fine structure of the foam created and its low release temperature (90°–105°C). It is important that the blowing agent selected should produce a closed cell structure. The poly-

meric foam would, in itself, be capable of imparting buoyancy to the strand **10** but we have discovered that the dispersion of glass bubbles within the foam structure not only enables us to control the strand density within fine limits, but unexpectedly results in a much smoother strand surface. Smoothness is important to strand handling both in production operations and deposition at sea.

By glass bubbles we refer herein to very small hollow glass spheres such as those sold as Micro balloons IC 101 by Emerson & Cuming Inc., Canton, Mass., and sold as glass bubbles by the 3M Company of St. Paul, Minn. Glass bubbles are available in nominal average densities from 0.20 to 0.37 grams per cubic centimeter. The higher densities are due to greater glass wall thicknesses that may be required to withstand high pressures. We have employed glass bubbles of 0.20 grams per cubic centimeter average density and prefer to keep the density to 0.35 grams per cubic centimeter for reasons of economy and lower strand diameter. We have found that glass bubbles passing through a 170 inch screen should be used in the encasement **16** and that about 8% by weight of the bubbles based on the weight of foam is optimum. Fewer than 4% will not suffice to afford the advantages of glass bubble addition and higher percentages, such as, in particular, percentages over 20 are not properly supported in a foam matrix.

The strand **10** has no outer jacket and the encasement **16** is in direct contact with sea water after the strand has been deposited possibly except for a very thin surface wiped coating of silicone oil lubricant such as Dow Corning 510* Silicone. By this means the diameter *d* is minimised and the eventual collapse of the foam, once the strand has sunk to sufficient depths, removes any change of resurfacing.

*Trademark registered by Dow Corning Corp.

Method of Manufacture

The preferred method of manufacturing the strand of our invention is well illustrated by the method used for the strand of EXAMPLE III, above. A composition A was prepared by screening B 22A glass bubbles, supplied by 3M Company and discarding all bubbles that were retained on a standard 170 mesh screen. A mixture was then prepared of a polyvinyl chloride organosol having a viscosity of 1900–1950 cps at 20°C, a Shore Durometer hardness (after cure) of D 49, a cured tensile strength at 25°C of 2250 psi and an elongation of 227%; and 8% of the weight of the organosol of the separated fine glass bubbles. Composition B was prepared, as above, but with 7.9% of glass bubbles and 0.7% of blowing agent (Nitrosan, supplied and trademark registered by E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.). Composition C was prepared, identical to composition A but with 5.5% of the bubbles. Two Awg No. 39 copper wires **31, 32** insulated with polyurethane film by paying them from spools **33, 34** through a known type of enamelling machine **36,** (commercial standard Single Analac Wire supplied and trademark registered by Anaconda Wire and Cable Co.), and a thread of Polyspun 100 **37** supplied by the Standard Coosa-Thatcher Co. of Chattanooga, Tenn., from a spool **38,** were pulled in parallel through an 0.028 inch steel ball enamelling die, **38** and coated with composition A to a diameter of 0.020 inch, after curing. The strand was then passed through an 0.034 inch ball die **39** and coated with composition B to a cured diameter of 0.028 inch after curing, finally the strand was passed through an 0.036 ball die **41** and coated with composition C to a diameter of 0.032 inch and, after curing, wiped with silicone oil by means of felt applicator **42** (DC-510 supplied and trademark registered by Dow Corning Corp. of Midland, Mich.). Coating

	EXAMPLE I	II	III	IV
Organosol	PVC	PVC	PVC	PVC
% glass	13	abt. 7	5.5–8	10
glass density, g/cc	0.33	0.28	0.20	0.20
tensile member	none	cotton-nylon	cotton-polyester	glass
conductor size Awg	39	39	39	39
No. of conductors	2	2	2	2
conductor insulation	epoxy nylon*	poly-ure-thane	poly-ure-thane	poly-ure-thane
No. of coats of organosol	5	4	3	3
strand O.D., inch	.036	.036	.032	.035
breaking load, lbs.	.45	2.6	2.7	6.8
copper elongation, %	27	6.5-11	6–19	5.6
sinking rate, in salt water**				
initially, ft/min	0.4	0.4	1.0	0.9
24 hrs. ft/min	3.4	3.0	0.5	0.9
IR wire to wire 20 ft. samples, thousand megohm in air	200	35	200+	200+
salt water** initial	30	35	200	200
" 8 hrs	10	2.5	10	15-20
" 72 hrs	10	0.3	10	15-20
capacitance/ft at 1 KHz pf, wire to wire in air	49.2	41.0	28.5	17.7
	57.8	54.8	36.5	26.3
Diss. factor, wire to wire at 1 KHz, 1 ft., % in air	12.6	16.3	10.1	9.2
in salt water**	12.7	15.3	6.7	7.5

*described in patent 3,408,867

**Na Cl in water, sp. gr. 1.027 at 25°C

speed was 30 feet per minute and after each coat the strand passed through a 5-foot horizontal muffle oven 43 maintained at 210°C for the first 2 feet and 230°C for the last 3 feet of oven space. A cured specimen taken after the first coat exhibited a descent rate of 7.5 feet per minute in the 1.027 gravity salt water. A specimen after the second coat exhibited a descent rate of 2.4 feet per minute.

The foregoing description has been exemplary rather than definitive of our invention for which we desire an award of Letters Patent as defined in the following claims.

We claim:

1. The method of making a controlled buoyancy strand comprising the steps of:

A. film coating at least one electrical conductor wire with magnet wire enamel,

B. blending a liquid mixture comprising:

a. 75–96 parts by weight of polymeric organosol,

b. 4–25 parts by weight of glass bubbles,

c. 0.1–2.0 parts by weight of blowing agent,

C. continuously passing said conductor wire coated with said enamel, along with at least one tensile member, through an applicator suitable for applying liquid magnet wire enamel and therein covering said member, together with said wire, with a layer of said mixture,

D. continuously passing said wire and said member while covered with said mixture, through a heating zone and therein activating said blowing agent and foaming said organosol.

2. The method of claim **1** comprising the additional steps of blending a liquid mixture comprising 75–96 parts by weight of said polymeric organosol and 4–25 parts by weight of said polymeric organosol and 4–25 parts by weight of glass bubbles and free of blowing agent and, after foaming said organosol comprising blowing agent, continuously passing said strand through an applicator suitable for applying liquid magnet wire enamel and therein coating said strand with said mixture free of blowing agent.

3. The method of claim **2** comprising the additional steps of continuously passing said conductor wire coated with said enamel, along with said tensile member, through an applicator suitable for applying liquid wire enamel and therein covering said member, together with said wire with said mixture free of blowing agent, and heating said mixture free of blowing agent, prior to covering said strand with said mixture comprising blowing agent.

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