

[54] METHOD FOR CONTROL OF MARINE FOULING

[76] Inventor: Andrew S. Yeiser, 302 Cleveland Dr., Huntington Beach, Calif.

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[51] Int. Cl. C23f 13/00

[58] Field of Search..... 204/147, 148, 196, 204/197

[56] References Cited

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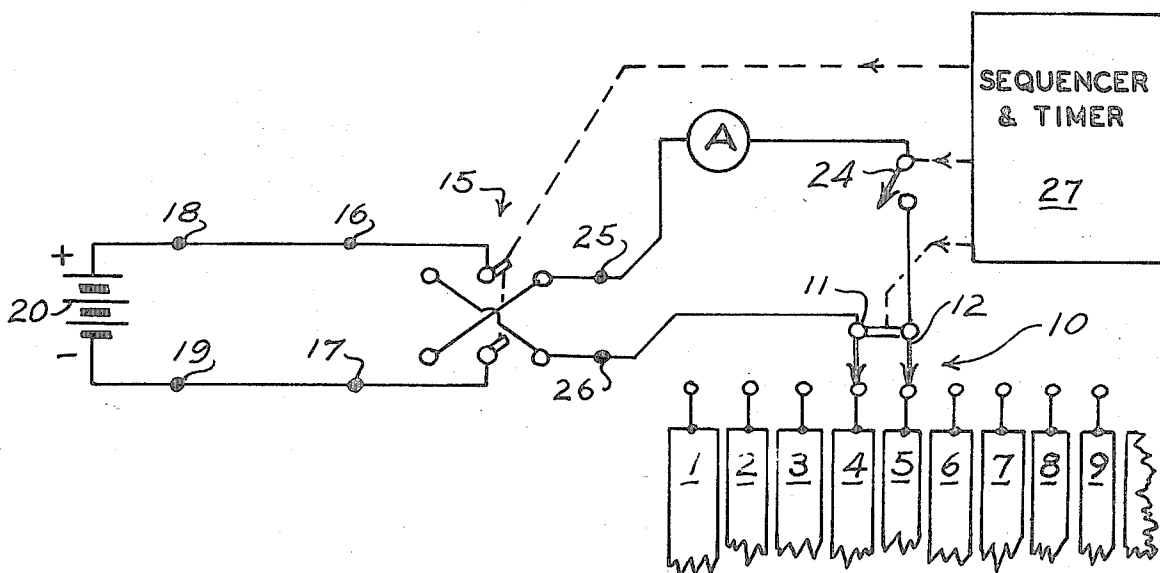
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Primary Examiner—T. Tung
Attorney—Lawrence Fleming

[57] ABSTRACT

An electrical apparatus and method for eliminating the fouling of boat bottoms and the like by marine growth. The underwater surface is sheathed with strips of a metal such as stainless steel. An electric current is passed between adjacent strips or areas, preferably for short periods of time on a regular "maintenance" schedule, e.g., 30 amperes per square foot for a few seconds every two days. The sheathing may be of 0.020" stainless steel in 3-inch wide strips spaced 0.1" apart. Test panels in sea water are found to remain clean and bright after six months immersion when so energized, while identical panels to which no current is applied become heavily fouled. Ions produced by electrolysis close to the sheathed surface move at relatively high velocities, and are found to kill the small organisms that settle on the surface. No persistent toxic chemicals such as mercury compounds are released into the water, and only minute quantities of dead organic matter are released at any one time.

8 Claims, 5 Drawing Figures



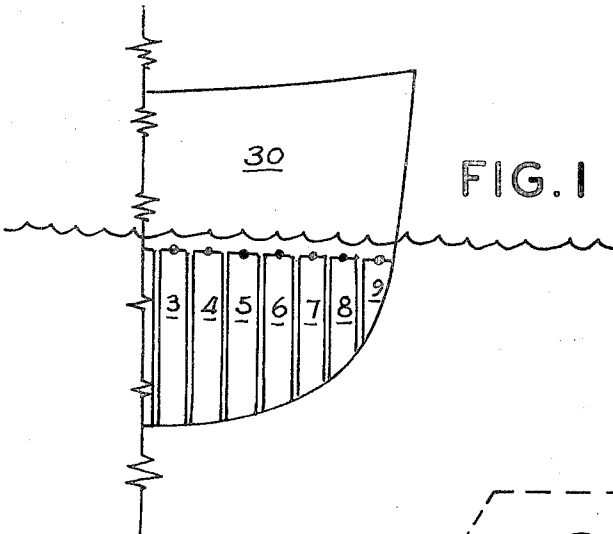


FIG. 1

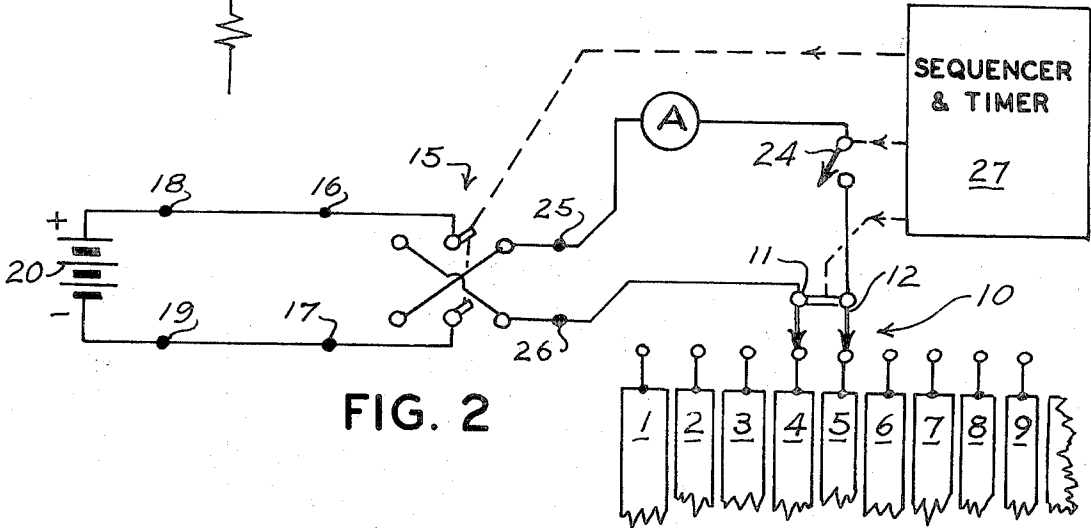


FIG. 2

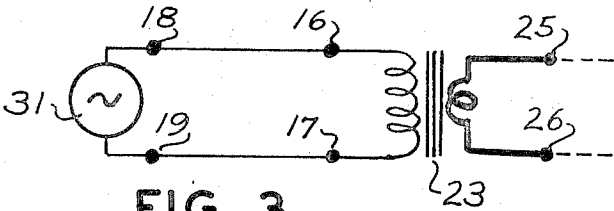


FIG. 3

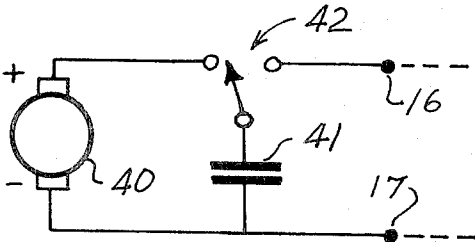


FIG. 4

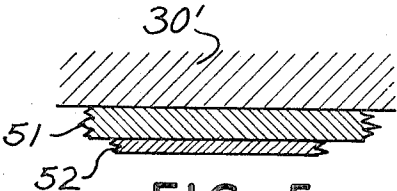


FIG. 5

INVENTOR
ANDREW S. YEISER

BY *Lawrence Fleming*
AGENT

METHOD FOR CONTROL OF MARINE FOULING

BACKGROUND OF THE INVENTION

The fouling of ship and boat bottoms, piling, and other underwater structures is an age-old problem. Continuous sheathings of copper have been used, which produce toxic copper compounds by slow solution. Anti-fouling paints are used, which release toxic copper or mercury compounds. Electrolytic schemes are known wherein ions and bubbles are generated by continuous electrolysis at relatively low current densities, one or more of the electrodes being located at some distance from the surface to be protected. Such methods have disadvantages. Paints and the like which release toxic metallic compounds have limited life and cause pollution. The most common anti-fouling procedure is still mechanical scraping.

BRIEF SUMMARY

This invention is an electrolytic means and method for the control of marine fouling, wherein substantially the entire surface to be kept free from fouling is sheathed or covered with relatively thin strips (or areas of other suitable shape) of non-corrosive conducting material such as stainless steel. The metal should be one that does not appreciably dissolve and release any substantial number of metallic ions (as copper does). Relatively narrow spaces or gaps are left between adjacent strips or areas, and separate electrical connections are made to individual strips or areas, or to suitable groups of them. An electric current is passed between adjacent strips or areas, preferably for a very small percentage of time, e.g., about 0.001 per cent or 2 seconds every two days. A suitable current density or area density is 30 amperes per square foot.

Test panels immersed continuously in sea water for six months have been found to remain clean when supplied with electrical defouling current on the above time schedule and at the above current density. Identical panels not fed with current became fouled to a depth of over 2 inches. The test panels were sheathed with 3-inch wide strips of 0.020 inch thick stainless steel, spaced about one-eighth inch apart.

Electrolysis of sea water produces many different kinds of ions, including unstable and metastable ones; it is thought that the efficacy of the present means and method depends substantially on the direct impingement on small marine organisms of ions which are moving at relatively high velocities, the velocities being high because the ions are formed close to the organisms (or even inside them) at relatively high current density. It is also believed that the gas bubbles generated by the electrolysis assist in scrubbing the dead organisms off of the surface.

According to the invention, pairs or groups of the conductive strips or areas of the sheathing may be electrically energized in succession to reduce the electric current demand. For this purpose, suitable sequential switching apparatus may be employed. The defouling current may be d-c or a-c. A preferred current supply is d-c, reversed in polarity once during each application. Another suitable heavy-current supply is a discharge from a large electrolytic capacitor. A preferred sheathing material is sheet copper of the order of 0.01 inch thick clad with stainless steel of the order of 0.002 inch-0.02 inch thick. The stainless steel cladding faces

outward; the copper is provided for high electrical conductivity.

While heavy currents are often required, the duty cycle is so low that the average electrical energy requirement is relatively low, e.g., 2.5 kwh per month for 1,000 square feet of surface.

IN THE DRAWING

FIG. 1 is a diagrammatic view of the bow portion of a boat hull whose underwater portion is sheathed with metal strips according to the invention;

FIG. 2 is a simplified circuit diagram, partly in block form, of an electrical circuit suitable for supplying and routing the defouling current according to the invention;

FIG. 3 is a circuit diagram of an alternative detail of FIG. 2;

FIG. 4 is a diagram of another alternative detail of FIG. 2;

FIG. 5 is a diagrammatic sectional view of a small portion of sheathing according to the invention.

DETAILED DESCRIPTION

In FIG. 1, a portion of a boat hull or the like is indicated at 30, having its underwater portion sheathed or covered with strips of conducting material 3-9. Contiguous areas of other shapes may obviously be used instead of strips, but strips of the order of 3 inches wide, with spaces in between of roughly one-eighth inch, are one preferred shape. Dots at the ends of each strip 3-9 indicate electrical connections. Strips 3, 5, 7, and 9 may be connected together and strips 4, 6, and 8 also together, and current applied between these two groups. To reduce the current demand, the current may alternatively be applied first between strips 3 and 4, then to 4 and 5, and so on in succession. The terms "contiguous" and "adjacent" are used herein to refer to strips or areas having a relatively narrow space between them, and not actually touching each other.

FIG. 2 indicates some suitable circuitry for energizing such strips, which are therein shown at 1-9. As many as needed would be used. Here, a selector switch 10 may be used, with one stationary contact connected to each of the strips or areas 1-9. The switch 10 may have two movable contacts or sliders 11, 12 mechanically (but not electrically) connected together, so that in one position the sliders would connect to strips 1 and 2, in the next to 2 and 3, and so on. The circuit may contain an off-on switch 24, which in turn is connected, optionally through an ammeter A, to a reversing switch 15 and thence to a power source indicated as a battery 20. A suitable sequencing and timing device is indicated as a block 27, arranged to control switches 10, 15, and 24 by known means. In operation, d-c from source 20 would be applied in one polarity for, say 1 second, between strips 1 and 2; then the sequencer 27 would operate reversing switch 15, leaving switch 24 on for 1 more second, then turn it off. The unit 27 would then move selector switch 10 to connect to strips 2 and 3, repeat the process, and so on.

In FIG. 2, power terminals are indicated at 16-19. The connections between terminals 16 and 18, and between 17 and 19, may be in a cable running from the boat to the dock. The apparatus to the right of terminals 16, 17, FIG. 2, may be located on board, and the d-c power source may be 20 located ashore.

FIG. 3 shows an a-c supply for the defouling current. A-c source 31 may be a commercial power line on shore, connected via a cable between terminals 16-19 (as before) to a stepdown transformer 23 which may be located on a boat. A low-voltage, high-current secondary winding goes to terminals 25, 26, from which the remainder of the wiring may proceed as from the corresponding terminals or points 25, 26 in FIG. 2.

FIG. 4 shows the essentials of a simple capacitor-discharge circuit for supplying pulses of defouling current. A large capacitor 41 may be charged by connecting it across a dc power source such as a generator 40, via switch 42, which may then be switched over to connect to terminal 16. Terminals 16 and 17 may be connected to the circuitry shown to the right of terminals 16, 17 in FIG. 2. Alternatively, terminals 16, 17 in FIG. 4 may be connected to a relatively large number of pairs of strips or areas simultaneously in a group, if capacitor 41 is of very large capacitance such as 1 farad. Electrolytic capacitors of this value have been manufactured in moderate physical sizes. A 1-farad capacitor, for example, discharged from 30 volts at constant current, would provide 30 amperes for 1 second, or 30,000 amperes for 1 millisecond.

FIG. 5 shows diagrammatically a small portion of a boat hull or the like 30' with a small portion of a preferred kind of metallic sheathing 51, 52 attached thereon, as by epoxy glue. Layer 51 is copper or other high-conductivity metal. The outer layer 52 is preferably of stainless steel, or other material which is relatively non-corrosive and does not dissolve and release substantial numbers of metallic ions (as, say copper does) when electric current passes between it and the water.

To illustrate the magnitudes involved in a practical example, assume that the invention is applied to a 50-foot boat which has a bottom area of 1,000 square feet, and displaces 12 tons. Stainless steel sheathing 0.015 inch thick would weigh approximately 650 pounds, or 2.6 percent of the weight of the boat. The electrical power required for defouling on a "preventive maintenance" basis, at 10 volts and 30 amperes per square foot, would be 300 kw during the periods that the current is applied (such as 2 seconds every 2 days). The average energy consumption would be 0.083 kilowatt-hour per day, or about 30 kwh per year.

The electrical connections to the strips or the like 1-9, etc. may be made by any of the suitable through-the-hull or other known means.

It will be understood that the invention is not restricted to specific values of current density and application time, the above examples being given for the purpose of illustration.

It will be seen that the practice of the invention does not introduce any foreign substances into the water, but operates merely to break down chemically certain substances that are already there. In addition, the amount of organic matter removed by each individual application of current is so small as to be substantially invisible; thus there is no need to dispose of large quantities of decaying organic debris in a short time, as there is when an accumulation of fouling is mechanically scraped off the bottom of a boat.

I claim:

1. A method for maintaining an underwater surface free from fouling by marine growth, comprising the following steps:

covering substantially all of said surface with a sheath in the form of a plurality of electrically separated adjacent electrode areas of the same electrically conductive material, said material having exposed surface portions substantially insoluble in sea water and incapable of producing substantial quantities of toxic ions of said material, and

applying an electric current between at least one adjoining pair of said electrode areas at a current density of about 30 amperes per square foot for periods of about 2 seconds for every 2 days,

said current producing ions of substances in the water but substantially no ions of said conductive material, said ions moving at relatively high velocities and killing said marine growth.

2. The method of claim 1, wherein all said electrode areas are in the form of parallel strips of sheet metal.

3. The method of claim 2, wherein alternate strips are electrically connected together to form two groups, and said current is applied between said groups.

4. The method of claim 1, wherein all said electrode areas are in the form of parallel strips of sheet stainless steel.

5. The method of claim 1, wherein all said electrode areas are in the form of parallel strips of sheet copper having a layer of stainless steel on their exposed outer surfaces.

6. The method of claim 1, comprising the following additional step:

applying said current between the succeeding adjoining pairs of said electrode areas in sequence.

7. The method of claim 1, comprising the additional step of connecting a capacitor, to said electrode areas to provide current pulses.

8. The method of claim 1, wherein said current is applied in successive pulses of opposite polarity.

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