United States Patent [19]

Schramm et al.

[11] **3,782,704**

[45] **Jan. 1, 1974**

[54] **APPARATUS AND METHOD FOR PRODUCING AIR BUBBLES IN A BODY OF LIQUID**

[75] Inventors: **Harold J. Schramm; John R. McCullough,** both of West Chester, Pa.

[73] Assignee: **Schramm, Inc.,** Westchester, Pa.

[22] Filed: **Jan. 15, 1973**

[21] Appl. No.: **323,623**

Related U.S. Application Data

[63] Continuation of Ser. No. 83,026, Oct. 22, 1970, abandoned.

[52] **U.S. Cl.** **261/124,** 138/112, 285/156, 285/423, 239/450, 239/547

[51] **Int. Cl.** **B01f 3/04**

[58] **Field of Search** ..... 138/111, 112, 137; 285/137 R, 156, 423; 261/30, 124; 239/212, 450, 547

[56] **References Cited**

UNITED STATES PATENTS

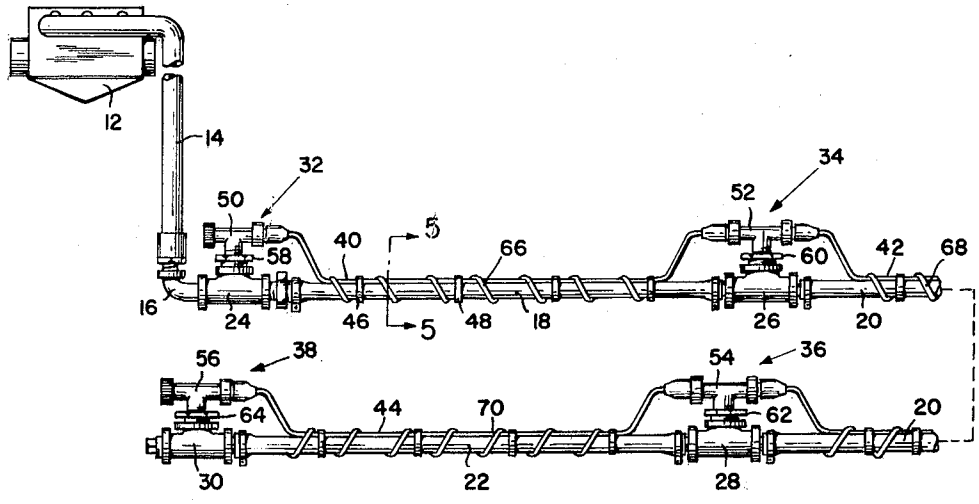
2,757,965	8/1956	Andrews	239/450
3,547,355	12/1970	Salazar	239/547
3,587,972	6/1971	Weeth	239/450
3,672,571	6/1972	Goodricke	239/450

Primary Examiner—Tim R. Miles
Assistant Examiner—Steven H. Markowitz
Attorney—George A. Smith, Jr.

[57] **ABSTRACT**

Uniformity, and therefore the effectiveness, of air barriers for confining surface water pollutants is accomplished by improving the uniformity of the air pressure in a perforated bubbling hose. This is achieved by the use of an auxiliary distributing conductor carrying air under high pressure, with a number of spaced interconnections with the bubbling hose having restrictions for dropping the pressure from the high level in the distributing conductor to a relatively low level in the bubbling hose.

9 Claims, 14 Drawing Figures



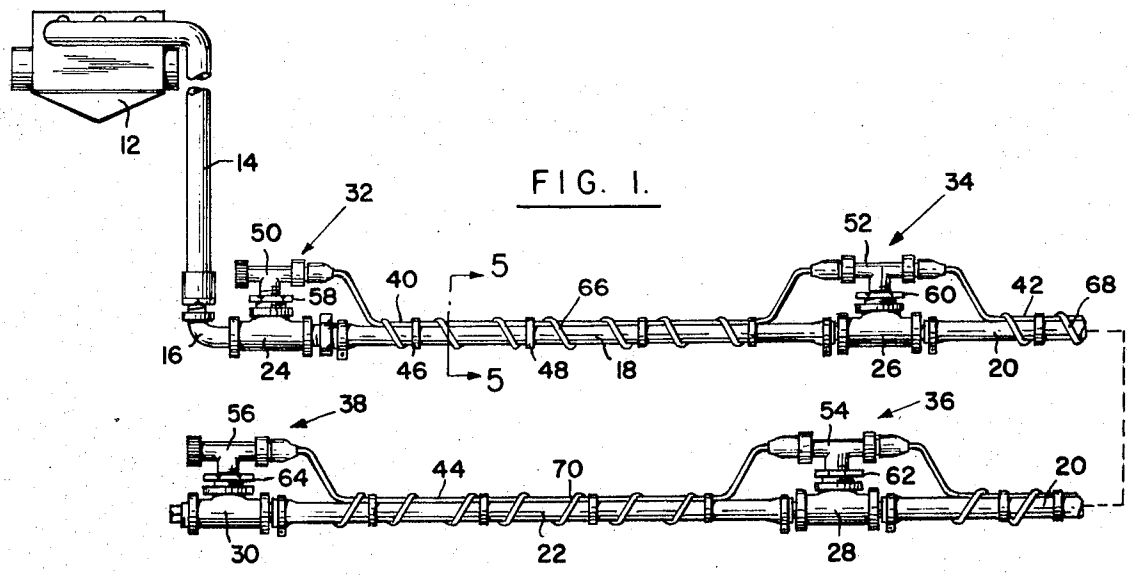


FIG. 1.

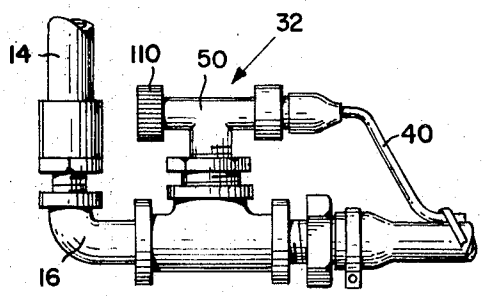


FIG. 2.

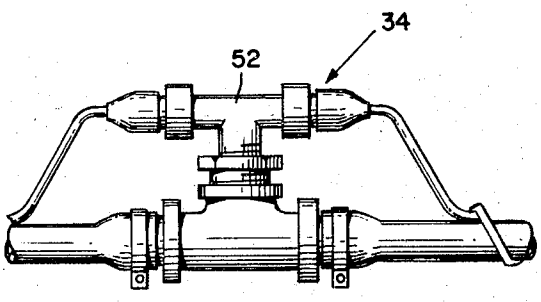


FIG. 3.

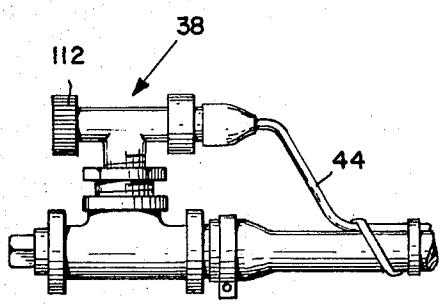


FIG. 4.

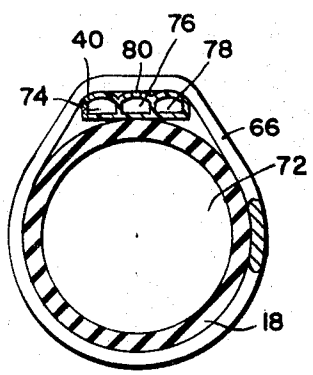


FIG. 5.

INVENTORS
HAROLD J. SCHRAMM &
JOHN R. McCULLOUGH
BY
Smith Harding Earley & Follmer
ATTORNEYS

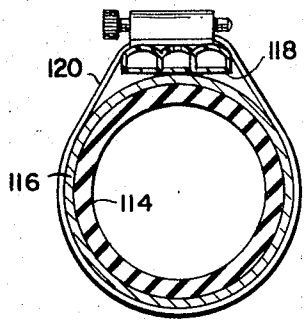


FIG. 6.

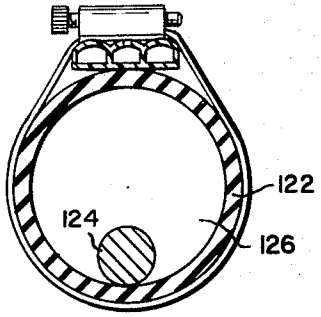


FIG. 7.

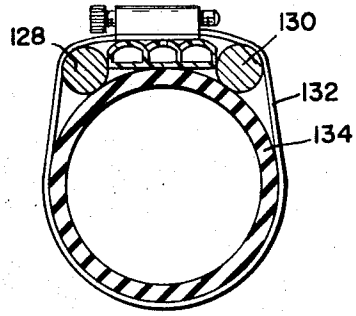


FIG. 8.

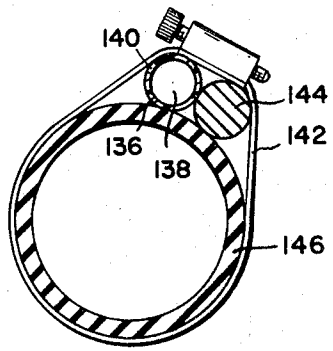


FIG. 9.

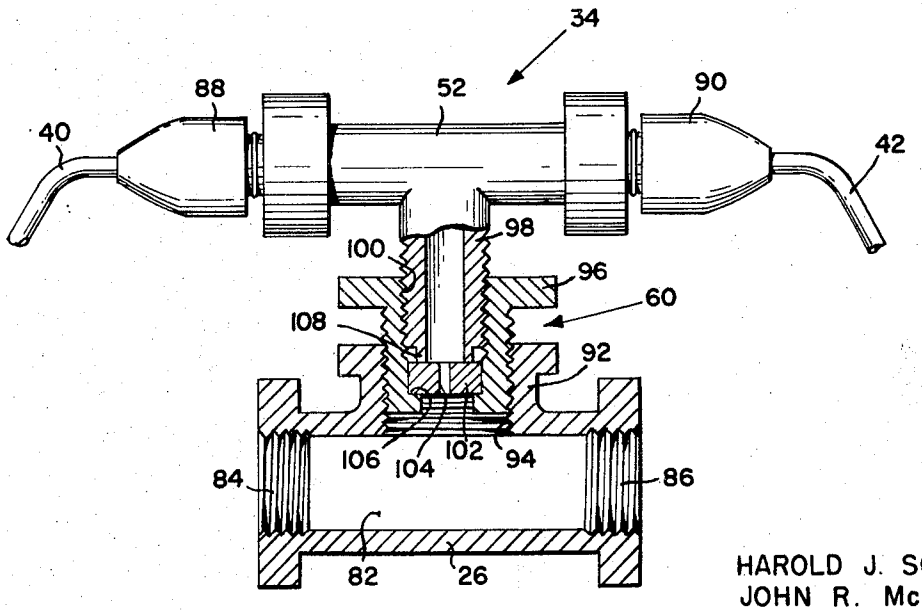


FIG. 10.

INVENTORS
HAROLD J. SCHRAMM &
JOHN R. McCULLOUGH
BY
Smith, Harding, Earley & Follmer
ATTORNEYS

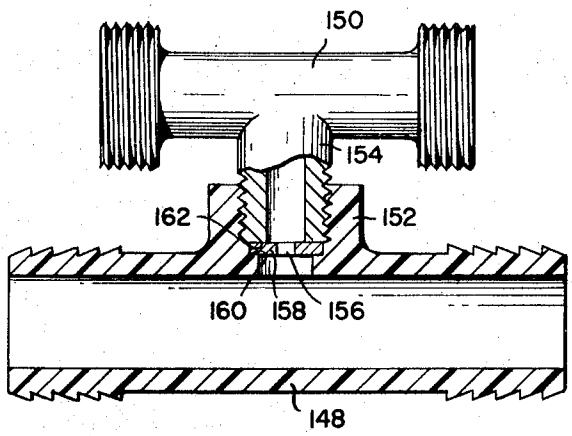


FIG. 11.

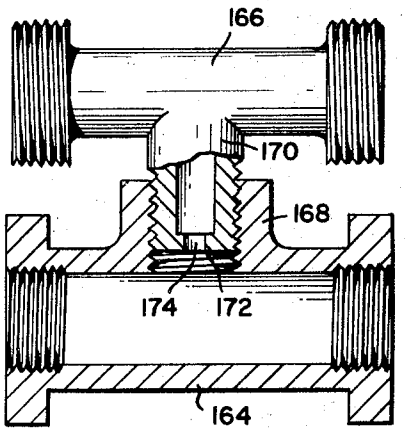


FIG. 12.

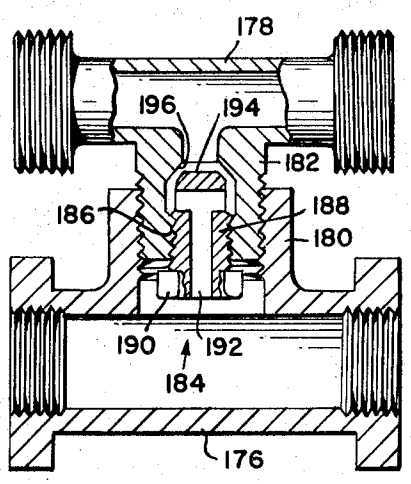


FIG. 13.

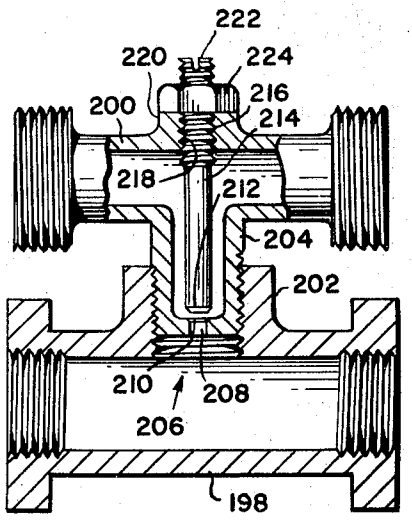


FIG. 14.

INVENTORS
HAROLD J. SCHRAMM &
JOHN R. McCULLOUGH
BY
Smith, Harding, Earley & Follmer
ATTORNEYS

APPARATUS AND METHOD FOR PRODUCING AIR BUBBLES IN A BODY OF LIQUID

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a continuation of our application Ser. No. 83,026, filed Oct. 22, 1970 and now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to bubbling apparatus, and particularly to an apparatus for effecting the continuous production of air bubbles in a body of water. Bubble producing devices have been used for many purposes. Among the more important uses are the aeration of lakes, the de-icing of channels and marinas, the oxidation and turnover of sewage lagoons and stagnant bodies of water, and the confining of water pollutants such as oil spills floating on the surface of a body of water. This invention, while useful in all of the above applications and capable of producing superior results therein, has particular utility in the confining of floating pollutants, in reservoir destratification, and wherever air distribution over long distances is involved in a bubbling apparatus. It will be described with particular reference to the confining of pollutants.

For some time, it has been known that floating pollutants such as oil spills, other floating chemicals, debris and flotsam and jetsam can be confined by the use of an "air barrier." An air barrier is a rising wall of water and bubbles which forms, above the surface of a body of water, a crest or a rolling mound of water and bubbles which is in an unstable condition. From the crest, water flows horizontally outwardly (usually in both directions unless some obstruction exists), and generally at a right angle to the rising wall of water and bubbles.

The bubbles rise, float to the surface, and their motion apparently induces some vertical upward flow of the water. More importantly, however, the mixture of bubbles and water has a lesser average density than the surrounding water, and therefore tends to accelerate upwardly toward the surface.

The vertical velocity of the water and the horizontal surface flow (which is dependent on the vertical velocity) are in turn dependent on the depth of the water through which the bubbles can create a vertical acceleration. At the surface, the air is released to the atmosphere, and the water forms the crest or mound, which is typically from ½ inch to 3 inches above the surface. The water in the crest is in an unstable condition, and naturally flows downhill toward either side of the barrier.

To produce an air barrier for confining oil spills and the like, a perforated hose is arranged on the bottom, or otherwise underneath the surface of the body of water in a configuration such that the wall of water produced by the rising bubbles will create a crest which contains a spill. The velocity of the water flowing from the crest opposes the movement of the oil or other pollutant across the barrier. The air barrier need not surround the oil spill entirely. Other barriers including natural barriers can form part of the boundary. The bubbling hose can be moved as desired, and the resulting movement of the air barrier will effect movement of the pollutant.

It is important that the crest of water be as high as possible, and most important that it be uniform and continuous in order to avoid eddies or openings which might allow or even hasten the passage of floating material through the barrier. The bubbling hoses which have been used heretofore have been connected to air compressors and have perforations distributed along their lengths, through which the air flows to produce bubbles. Except where relatively short lengths of such hose are used, the bubbling at the perforations nearest the air compressor is considerably more vigorous than the bubbling taking place at locations more remote from the compressor. Some compensation can be achieved by varying the sizes of the openings in the bubbling hose from small to large as the distance from the compressor increases. However, this expedient is not entirely satisfactory in installations involving long lengths of bubbling hose. Differences in bubbling activity can also result from depth variations. In either case, the air barrier is not uniform, and eddy currents are produced which allow the escape of floating material through the barrier. In some instances. The pressure in some parts of the hose can become so low that very few bubbles or no bubbles at all are produced. In that event, a discontinuity will exist in the barrier, allowing the escape of floating material. Without the benefit of the invention, in order to avoid such discontinuities in air barriers, very high pressures would have to be used involving a very wasteful use of air.

SUMMARY OF THE INVENTION

In accordance with this invention, a continuous and uniform barrier is insured by providing an air distribution system which improves the uniformity of the air pressure in the perforated bubbling hose. Since, in many cases, considerable distances have to be covered by the air barrier between compressed air sources, or from a boat or shore-based compressor, an auxiliary air conductor is used to distribute air from the compressor under high pressure to various points along the bubbling hose. Interconnections are made at these various points, each interconnection having pressure dropping means such as a restricted orifice, so that the highest pressure in the bubbling hose is considerably below that in the distributing air conductor. As a result, a relatively uniform and locally controlled pressure is maintained throughout the bubbling hose.

The invention can also be used advantageously in the various other bubbling applications mentioned above, particularly since the system for distributing air into the bubbling hose insures that continuous bubbling will take place along the entire length of the hose.

The principal object of this invention is to provide a bubbling apparatus capable of producing an air barrier having a high degree of uniformity.

Another object of the invention is to provide a bubbling hose consisting of detachable sections which may be assembled easily to produce a bubbling hose of any desired length.

A further object of the invention is to provide a bubbling hose in which adjustments can be made for depth variations along the length of the hose in order to insure uniform bubbling.

A further object of the invention is to provide a bubbling hose having a high degree of flexibility.

A still further object of the invention is to provide a bubbling hose having a high pressure distribution system, all of which is capable of being wound onto spools for storage.

A still further object is to provide a weighted bubbling hose assembly having a simple construction and a high degree of flexibility.

A still further object of the invention is to provide a novel method for producing a uniform air barrier in a body of water.

Other objects will be apparent from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevation of an assembled bubbling hose and a distributing conductor consisting of a plurality of connected sections;

FIG. 2 is an elevation of an interconnection between the air distributing conductor and the bubbling hose at the compressor end of the system;

FIG. 3 is an elevation of an intermediate interconnection;

FIG. 4 is an elevation of an interconnection at the far end of the system remote from the compressor; FIG. 5 is a cross-section of the assembled bubbling hose taken on the plane 5—5 of FIG. 1;

FIG. 6 is a cross-section of a first modification of a bubbling hose assembly consisting of a bubbling hose and a lead sheathed distributing conductor;

FIG. 7 is a cross-section of a second modification of a bubbling hose and distributing conductor assembly wherein the distributing conductor has an internal strip of lead for weight;

FIG. 8 is a cross-section of a third modification of a bubbling hose and a distributing conductor assembly in which two external strips of lead are used as weights;

FIG. 9 is a cross-section of an assembly consisting of a distributing conductor, a circular bubbling hose, and a single external strip of lead weight;

FIG. 10 is a section of an H-connector for interconnecting the distributing conductor with the bubbling hose;

FIG. 11 is a section of an alternative H-connector;

FIG. 12 is a section of another alternative H-connector;

FIG. 13 is a section of another alternative H-connector having continuous adjusting means; and

FIG. 14 is a section of a still further alternative H-connector having continuous adjusting means.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows a compressor **12,** which may be of various types although preferably of the reciprocating type capable of delivering pressures of the order of 100 psi or greater. The high pressure outlet of the compressor is connected through a conduit **14** which extends downwardly to an L-connector **16** for connection of the high pressure air to the distributing conductor comprising large hose sections **18, 20,** and **22** as well as legs **24, 26, 28** and **30** of H fittings indicated respectively at **32, 34, 36** and **38.** Conduit **14** is preferably of sufficient length so that it can extend from the compressor, located on or above the surface of the body of water or on a shore point to fitting **32** resting on the bottom of the body of water.

Three sections of bubbling hose are indicated at **40, 42** and **44.** Each is associated with one of the distributing conductor sections, and attached in substantially parallel relation thereto by clamps such as clamps **46** and **48.** Various alternatives, such as a helically wound tape or cement may be used instead. The bubbling hoses deviate at their ends from parallel relation with the distributing conductors in order to reach the legs of the H fitting indicated at **50, 52, 54** and **56.**

Each H fitting has a cross-member connecting its respective legs, cross-members for the fittings **32–38,** being shown respectively at **58, 60, 62** and **64.**

In order to hold the assembly on the floor of the body of water in which it is used, each section is weighted down with a lead strip wound helically about the distributing conductor and the bubbling hose. Lead strips are indicated at **66, 68** and **70.** The helically wound lead strip not only provides weight, but also aids the clamps in fastening the bubbling hose to the distributing conductor. The helical configuration permits a certain degree of flexibility, allowing the assembly to be arranged in the desired configuration easily. The weight not only holds the bubbling assembly down, but also provides a certain degree of stiffness for resisting propeller wash, tidal currents and wave action.

Of course, it is not necessary that the assembly be held in the bottom of the body of water. Alternatively, it might be held in an intermediate position between the surface and the bottom of suitable devices such as anchors or floats. Where these are used, however, it may be necessary to insure that the assembly remains in a rigid condition so that parts do not sag in the water when they become filled with water.

FIG. 5 is a cross-section of the section comprising distributing conductor **18** and bubbling hose **40.** Conductor **18** is preferably a circular rubber hose, although other materials and configurations may be used. The cross-sectional area of its internal passage **72** is larger than the cross-section of the internal passage of the bubbling hose **40** so that the air flowing through passage **72** is relatively unrestricted. The large passage **72** is provided in order to avoid substantial pressure drop in the distributing conductor.

Bubbling hose **40** is in the form of an elongated conductor preferably of the polyvinyl chloride type having three parallel internal passages although other materials and configurations may be used. Passages are indicated at **74, 76** and **78.** An opening **80** is provided in the wall of one of the passages, and this opening allows the escape of air to produce bubbles. Openings can be provided at any desired positions along passage **76,** or they may be provided in the other passages **74** and **78,** or in any combination of the passages, depending on the bubbling characteristics desired.

The openings can be in the form of slits, preferably running lengthwise of the bubbling hose. These slits are self-cleaning, and tend to close and seal the hose when pressure is removed to prevent the entrance of sand and other matter. Alternatively, the openings can be drilled holes, machined orifices, self-closing check valves, or small inserts of porous material which allow air to pass when pressure is applied, and which allow water to flow back into the bubbling hose when pressure is turned off, but which keep all but the finest foreign matter from passing into the bubbling hose. External flaps or lips and seals over the openings can also be used.

FIG. 10 illustrates H-fitting **34** (which is identical to fitting **36**). Within leg **26** there exists a large-diameter passage **82** which is connected by means of threads **84** and **86** and threaded adapters, to sections **18** and **20** of

the distributing conductor, and itself, forms part of the distributing conductors. Air travels from passage **82** through a passage within cross-member **60** to the interior of leg **52** which connects to section **40** of the bubbling hose through fitting **88** and to section **42** of the bubbling hose through fitting **90.** Leg **26** is part of a T-connector having a leg **92** with internal threads **94.** A fitting **96** is threaded into threads **94,** and leg **98,** which is a leg of the T-connector of leg **52,** is threaded into internal threads **100** of fitting **96.** A metal plug **102** having a restricted orifice **104** rests on shoulder **106** within fitting **96,** and is tightly held in position on shoulder **106** by the end **108** of leg **98.** Orifice **104** is positioned so that all of the air flowing from the distributing conductor to the bubbling hose through cross-member **60** must pass through the orifice. The restriction produces a pressure drop so that the pressure within the bubbling hose is less than the pressure in the distributing conductor. Plug **102** can be replaced by removal of leg **98** from fitting **96,** and plugs having different orifices may be used to replace it, if desired, in order to effect different pressure drops.

All of the H-fittings **32-38** are substantially identical, the only difference being that the fittings at the near and far ends, shown respectively in FIGS. **2** and **4,** are provided with caps **110** and **112** instead of being connected to bubbling hose.

The restrictions need not be in the cross-members of the H-fittings, but may be in the legs which form part of the bubbling conductor. For example, plugs having restricted orifices might be mounted in either end of leg **52** of fitting **34.** As another alternative restriction can be provided by adjustable valves.

The entire assembly in FIG. **1** is sufficiently flexible that it can be wound on large spools for shipment or storage. The assembly can be paid out from shore, from the deck of a barge or boat, or even from aircraft by unwinding the spool. The spool can be conveniently mounted on a combination tractor-compressor so that it can be conveniently transported from place to place along with its air source. Alternatively, the assembly can be placed in the body of water section-by-section, interconnections being made at the H-fittings one after another.

With the assembly in place underneath the surface of the body of water, compressor **12** is operated, and bubbles rise uniformly from the apparatus producing uniform bubbling. Pressure will be lowest at the intermediate points in each bubbling hose section, but the sections are relatively short so that the pressure variations along their lengths are negligible. In addition, the pressure can be controlled in the various sections to compensate for differences in depth along the length of the apparatus and in order to produce varying bubbling characteristics where desired.

If desired, the assembly can be moved while in operation in order to effect movement of the pollutant or in order to effect a contraction of the area covered by the pollutant to facilitate its removal by skimming devices or absorbants.

In the event that certain parts of the body of water are substantially deeper than others so that some parts of the bubbling assembly will be lower than others and subject to high external pressures, it may be necessary to compensate for the depth differences. This can be accomplished by having less restriction in those parts of the assembly lying on deeper parts of the floor of the body of water.

Under some circumstances, not all of the interconnections are required to have restrictions. For example, if there are only two interconnections, and an adequate pressure drop exists along the distributing conductor, only the interconnection nearest the compressor needs to have a restricted orifice.

Various structural modifications can be made in the bubbling hose assembly particularly with regard to the configuration of the weights. Various heavy materials other than lead may be used for weight.

Since many high pressure air hoses are lead encased during their manufacture, while the rubber is vulcanized at high temperatures, it is convenient to leave the lead casing in place rather than to strip it off to expose the finished hose surface. The finished distributing conductor in FIG. **6** is of such a construction. It consists of a circular rubber hose **114** completely covered by a lead sheath **116.** The lead sheath provides sufficient ballast to hold the entire assembly under water, while allowing a high degree of flexibility. The bubbling hose **118** is held in place by clamps, one of which is shown at **120** although various alternatives, for example, helically-wound tape or cement might be used instead. The lead sheath is particularly advantageous because it adds a great deal of weight to the high-pressure hose without taking up much space.

As an alternative, a lead strip extending lengthwise within the interior of the distributing conductor can be used as a weight, as shown in FIG. **7.** The distributing conductor **122** has a lead strip **124** within the interior passage **126.** Strip **124** is of sufficient size to hold the entire assembly under water, but does not substantially affect the flow of air in passage **126.** Each section of the distributing conductor is preferably provided with a separate lead strip.

As shown in FIG. **8,** lengthwise lead strips **128** and **130** can be clamped by means of a clamp **132** on the outside of a distributing conductor **134.**

FIG. **9** shows a different form of bubbling hose **136,** having a single circular passage **138** and transverse openings, one of which is shown at **140.** A clamp **142** clamps hose **136** and a lengthwise lead strip **144** to a distributing conductor **146.** The interconnections are similar to those shown in FIGS. **2, 3** and **4.**

FIG. **11** shows an alternative interconnecting means comprising a pair of T-connectors **148** and **150** having respectively legs **152** and **154** threaded together to provide a passage for the flow of air from the distributing conductor to the bubbling conductor. A restriction effecting a pressure drop is provided by opening **156** in plug **158,** which is clamped to shoulder **160** by the end **162** of leg **154.**

FIG. **12** shows an interconnecting H-fitting made up of T-connectors **164** and **166** respectively having legs **168** and **170** threaded together and forming an interconnecting passage for the flow of air from the distributing conductor to the bubbling conductor. Unlike the fittings in FIGS. **10** and **11,** this fitting does not have a separate plug with a restricted orifice. Rather, the end **172** of leg **170** has a built-in restricted orifice **174.**

FIG. **13** shows an alternative H-fitting comprising T-connectors **176** and **178** respectively having legs **180** and **182** threaded together to provide a passage **184** for the flow of air from the distributing conductor to the bubbling conductor. Leg **182** is provided with internal

threads **186** in which is threaded a valve member **188** having a bolt-like head **190** for wrench operation. Valve member **188** has a T-shaped internal passage **192** allowing the flow of air. The end **194** of member **188** opposite head **190** cooperates with a valve seat **196** to provide an adjustable restriction. Where this fitting is used, adjustments can easily be made to compensate for depth variations to produce uniform bubbling activity.

FIG. **14** shows a still further alternative H-fitting comprising T-connectors **198** and **200** respectively having legs **202** and **204** threaded together to provide a passage **206** for the flow of air from the distributing conductor to the bubbling conductor. The end of the leg **204** has a built-in restriction **208** for producing a pressure drop. The upper end of the restriction is bevelled at **210** to form a valve seat which cooperates with end **212** of valve stem **214.** Valve stem **214** is provided with threads **216** which cooperate with internat threads **218** in boss **220** projecting outwardly from the wall of T-connector **200** opposite leg **204.** A notch **222** is provided in the outer end of stem **214** for adjustment of the valve seating by a screwdriver. A locking nut is indicated at **224.** With this H-fitting, continuous adjustments of pressure drop and therefore of bubbling activity can be made by a diver while the bubbling apparatus is in operation.

It will be apparent that various other modifications can be made to the bubbling apparatus in accordance with the invention, and that its utility is not limited to the production of air barriers. While the distributing conductor is desirably flexible, in some installations non-flexible metal or plastic pipe might be used.

We claim:

1. Interconnecting means for delivering air from a distributing conductor to an elongated air conductor having an internal passage and a plurality of openings distributed along its length for allowing outward flow of air to produce bubbles in a body of liquid comprising:

a pair of mating conductors, one adapted to connect to said distributing conductor, and the other adapted to connect to said elongated air conductor so that together they form an interconnecting passage,

threaded means for detachably fastening said mating conductors together in mating relationship,

a plug having a restricted orifice for producing a pressure drop across the interconnection between said distributing conductor and said air conductor, and

means for removably fastening said plug within the interconnecting passage.

2. Interconnecting means according to claim **1** wherein said mating conductors are the legs of separate T-connectors.

3. Apparatus adapted to be connected to a compressor for producing air bubbles in a body of liquid comprising:

at least one elongated air conductor having an internal passage and a plurality of openings distributed along its length for allowing air to flow outwardly from its internal passage to produce bubbles,

an additional conductor having an opening adapted to be connected to a compressor, and an internal passage communicating with said opening and adapted to conduct air from said compressor under high pressure,

means interconnecting the internal passage of said elongated air conductor with the internal passage of said additional conductor at at least two separate locations both remote from said compressor, and

means for producing a pressure drop across the interconnection nearest said opening,

said elongated air conductor comprising at least two detachable sections and said additional conductor comprising at least two detachable sections, each section of said elongated conductor being attached to a section of said additional conductor, and including a first fitting having three ports, two of which connect a pair of said sections of said elongated conductor, and a second fitting having three ports, two of which connect a pair of said sections of said additional conductor, the remaining ports of said fittings being interconnected to provide said interconnecting means.

4. Apparatus adapted to be connected to a compressor for producing air bubbles in a body of liquid comprising:

a first elongated air conductor having an internal passage continuous at all times throughout its length,

a plurality of openings spaced longitudinally along the length of said conductor for allowing air to flow outwardly from its internal passage to produce bubbles,

a second elongated air conductor fastened in substantially parallel relation to said elongated air conductor and adapted to conduct air from a compressor under high pressure,

a plurality of restricted interconnecting means connecting the passages of said conductors and having a longitudinal spacing greater than the longitudinal spacing of said openings,

whereby the air within said first conductor is maintained at a substantially uniform pressure, and

in which the first air conductor comprises a plurality of detachable sections, and the second air conductor also comprises a plurality of detachable sections, each section of said first conductor being fastened in substantially parallel relation to a section of said second conductor, and having H fittings connecting the adjoining ends of corresponding sections of said air conductors, the restricted interconnecting means being located in said H fittings.

5. Apparatus for releasing air bubbles into a body of liquid comprising:

an elongated air distributing conductor adapted to conduct air from a compressor under high pressure, said distributing conductor comprising a plurality of flexible, interconnected detachable sections,

a flexible bubbling hose comprising a plurality of flexible interconnected, detachable sections, each section of bubbling hose being fastened to one of said flexible, interconnected conductor sections in substantially parallel relationship and close proximity thereto, to form a flexible two-conductor bubbler adapted to be wound onto spools, each end of each bubbling hose section being located adjacent a different end of the flexible, interconnected section to which it is fastened, and each of said bubbling hose sections having openings spaced longitudinally along its length for allowing air to flow outwardly from its internal passage to release bubbles,

a fitting located at each interconnection of the elongated air distributing conductor, said fitting including: means for interconnecting the adjacent ends of the distributing conductor sections and providing open communication between said sections, and restricted interconnecting means for interconnecting the interior of the distributing conductor with the bubbling hose on the interconnected section of the air distributing conductor whereby the air within the bubbling hose may be maintained at a substantially more uniform pressure.

6. Apparatus according to claim **5** in which each said restricted interconnecting means comprises a pair of separable mating conductors, forming an interconnecting passage and a plug having a restricted orifice removably secured within said interconnecting passage.

7. Apparatus according to claim **5** in which each said restricted interconnecting means comprises a pair of separable mating conductors forming an interconnecting passage and a plug having a restricted orifice located within said interconnecting passage and clamped between seats formed on said mating conductors.

8. Apparatus according to claim **5** in which each said restricted interconnecting means comprises a pair of separable mating conductors threaded together to form an interconnecting passage and a plug having a restricted orifice located within said interconnecting passage and clamped between seats formed on said mating conductors.

9. Apparatus according to claim **5** including continuously adjustable means for adjusting the restriction in said restricted interconnecting means.

* * * * *