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2,887,604

SPARK DISCHARGE SOUND GENERATOR

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FIG. 1

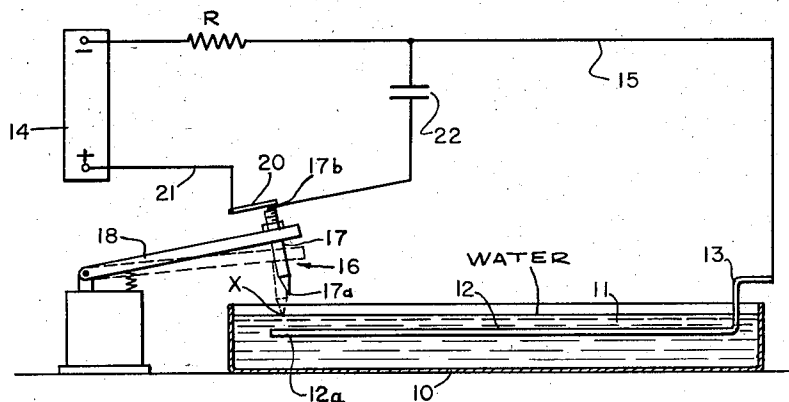


FIG. 4

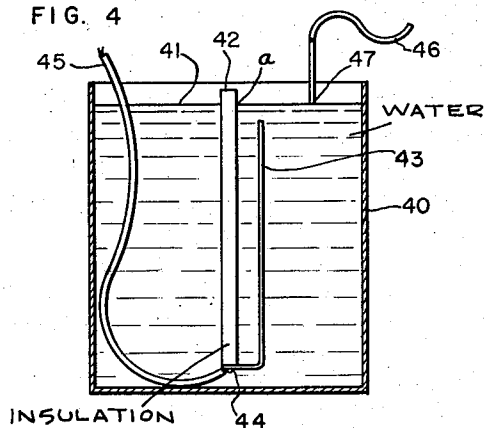


FIG. 5

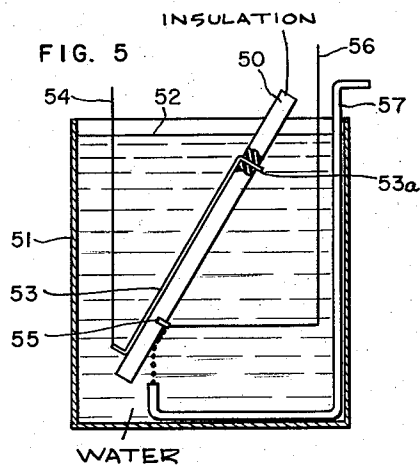


FIG. 2

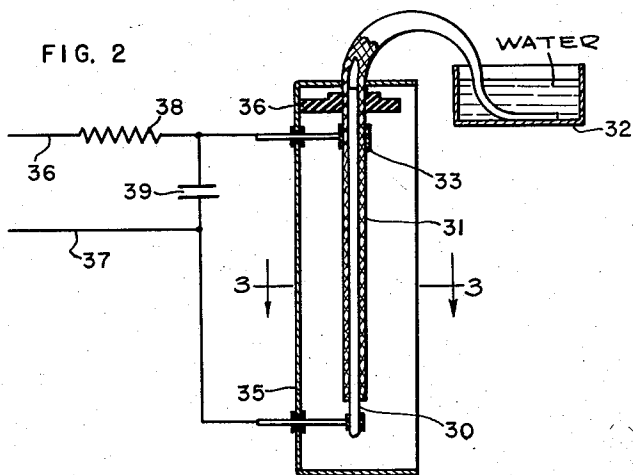
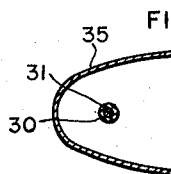


FIG. 3



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SPARK DISCHARGE SOUND GENERATOR

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9 Claims. (Cl. 313—232)

This invention relates generally to spark discharge sound generators, and a primary object of the invention is the provision of a high power spark sound unit for such a generator.

Spark sources of sound are discussed in the standard acoustic text books. They have uses both as sources of sound, as such, and in various industrial processes where high amplitude sound waves are applied to effect or aid certain desired physical or chemical process steps. The present invention is characterized by a spark source which yields a greatly lengthened spark through a special air gap for a given impressed voltage. Generally speaking, the breakdown voltage for an air gap is about 20,000 volts per inch. We have discovered a novel air spark gap bounded by a water surface across which a very greatly lengthened spark may be obtained for a given impressed voltage, yielding greatly augmented sound power.

The invention may be best described by referring at once to the drawings, in which:

Fig. 1 shows diagrammatically a spark source set-up in accordance with the invention;

Fig. 2 shows a modification, equipped with a sound radiating reflector;

Fig. 3 is a section taken on line 3—3 of Fig. 2;

Fig. 4 is a diagrammatic illustration of a further embodiment; and

Fig. 5 is a diagrammatic illustration of still another embodiment.

In Fig. 1, numeral 10 designates a shallow pan, typically composed of stainless steel. This pan contains a body of water 11, and numeral 12 designates a linearly extended electrical conductor or electrode disposed in the pan substantially parallel to and typically from $\frac{1}{8}$ " to $\frac{1}{4}$ " below the surface of the water level. This conductor, electrode, or "antenna," which may be composed of a round wire, or a flat strap, has a submerged tip 12a, and a bent terminal portion 13 extending up out of the water at the opposite end of the pan.

A D.C. power supply of suitable voltage, typically 12,000 volts, is designated at 14, and one terminal thereof, for example, the grounded negative terminal, is connected by lead 15 to the exposed terminal portion 13 of electrode 12.

The opposite electrode 16, here shown to comprise a pointed pin 17 carried by a pivotally mounted switch arm 18, is disposed with its point 17a approximately over the electrode 12. The switch arm 18 is spring actuated to assume a normal or charging position such as shown in full lines, and may be depressed from such position to cause the electrode tip to approach the water level over the submerged electrode 12, as indicated in the dotted lines. In the uppermost position of the arm, a terminal 17b on the upper end of the electrode pin 17 makes contact with a switch contact arm 20, which is shown as connected by lead 21 to the positive terminal of the power supply unit. A large condenser 22, for example, 100 mF., is connected across lead 15 and terminal 17b; and it will be seen that when the switch arm 18 is in its upper

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or charging position, the condenser is connected across the power supply and therefore charged, while depression of the switch arm breaks the charging circuit, and impresses the voltage of the charged condenser across the electrodes 12 and 16. A resistor R may be included in the circuit to limit the rate of charge of the condenser to a reasonable value.

When the electrode 16 has sufficiently approached the water surface, a powerful spark discharge takes place from the electrode tip 17a to the surface of the water, and thence along the surface of the water, directly over the electrode 12, to the exposed terminal portion 13 of said electrode. With a 12,000 volt power supply, we have in this way obtained a spark of a length as great as 22". The gap jumped by the spark is thus through air from the electrode tip 17a to a point x at the water surface, located directly over the electrode 12, and thence through air but directly over and in close proximity to the surface of the water to the terminal 13. The spark obtained is whitish-blue in color, very intense, and is accompanied by a loud, sharp "crack." The condenser alternately charges and discharges as the switch arm 18 is elevated and depressed. Obviously, electronic switching can be substituted for the simple mechanical switch here shown for purpose of simple illustration.

We have found that the water used, if too electrically conductive, as for instance if salt be dissolved therein, will result in the spark diving to the submerged electrode 12. It may either do so at once, or may travel a distance toward the terminal 13 before penetrating the water and striking the electrode 12. We have found ordinary city tap water to be entirely operative. If too conductive in any given case, it may be mixed with distilled water until suitable dielectric properties are attained. We have reversed the polarity of the electrodes 12 and 16, and detected no difference in operation.

After extended study and laboratory experiment, we still find the underlying principle of operation of this spark source to be more or less obscure. A process of progressive ionization at the water surface is evidently involved. The water body is a source of negative ions which will evidently be attracted to the water surface by the positive ions from the air above. The electric field between the electrodes 16 and 12 is of very high voltage gradient adjacent the electrode tip 17a, suggesting ionization in the air space above the water as a mechanism by which the spark may be initiated. The initial striking of the spark between the electrode tip 17a and the water surface above the tip of electrode 12 may be accounted for either by such ionization of the air, by a reduced potential difference between the water level and the electrode tip 17a owing to an accumulation of negative ions at the water surface, or by the approach of the electrode 17a toward the submerged electrode 12, or some combination of such factors. In any event, the path through the water, which constitutes a slightly conductive dielectric layer in series with the air gap between the electrode tip 17a and the point x at the water level, is not penetrated by the spark in proper operation though the possibility of some conduction of current through the water is not excluded. Instead, the spark follows the path along the water surface from the point x to the terminal 13. The breakdown of this gap portion x to 13 along the water surface above the electrode 12 may tentatively be explained by the fact that the point of greatest electrical strain is initially above the tip of the electrode 12, and moves back along the electrode 12 as the electron avalanche started by this strain bridges the gap from the point 17a to x. The electron flow does not short through to the electrode 12 because of the dielectric strength of the water. As the point of greatest electrical strain recedes along the electrode 12 (following

initial striking from the electrode tip 17a) the gap portion x to 13 along the water surface progressively breaks down and is bridged by the electron avalanche.

Referring now to Figs. 2 and 3, there is shown a modified form of generator embodying the invention, characterized by employment of a wetted wick in place of the pan of water of the first described embodiment, and showing also the use of a parabolic sound wave reflector in combination with the spark source unit. The elongated electrode or antenna, corresponding to the electrode 12 of the first described embodiment, is here designated at 30, and is surrounded by a wick 31 whose upper end dips into a water filled container 32, so that the wick becomes saturated and surrounds the electrode with a layer of water. The opposite electrode comprises a conductive ring or band 33 surrounding the wetted wick 31 and the upper end portion of the antenna 30. A parabolic sound wave reflector 35 surrounds the source unit, its upper end wall being suitably apertured for passage of the wick, as clearly shown in Fig. 2. The wick 31 and electrode 30 may be supported by a suitable insulation mounting 36 suitably secured to the wall of the reflector.

One power lead 36 is connected to electrode 33, and the other power lead 37 is connected to the lower extremity of the electrode 30, a resistor 38 being shown in series with the power lead 36, and a condenser 39 being connected across the leads 36 and 37.

In operation, a voltage impressed across the leads 36 and 37 charges the condenser 39 through the resistor 38 until the voltage across the condenser reaches the breakdown level. As in the first embodiment, the spark does not strike from the electrode 33 through the water held by the wick directly to the electrode 30, but travels longitudinally along the exterior surface of the wetted wick between the electrode 33 and the exposed lower extremity of the electrode 30. Thus, as in the case of Fig. 1, there is a water layer between the extended electrode or antenna and the opposite electrode, and a spark is drawn from the latter along the exterior surface of this water layer or barrier parallel to the antenna to its exposed lower extremity. The spark extinguishes as soon as the condenser 39 is discharged, the resistance 38 being too great to maintain the heavy current flow. After the spark is extinguished this short circuit no longer exists, and the relatively small current through resistor 38 can then charge the condenser again, until breakdown, and thus the cycle is automatically repeated. This form of the invention does not require a switching mechanism because the cycle automatically repeats at a frequency determined by the power source across leads 36 and 37, the values of resistor 38 and condenser 39, and the breakdown voltage of the spark. It is a relaxation oscillator. This relaxation oscillator is usable with many species of the invention.

Reference is next directed to Fig. 4, showing another embodiment of spark source. Numeral 40 designates a container filled with water to the level 41. Numeral 42 designates an insulation (acrylic resin) bar extending down into the water. An elongated electrode rod or antenna 43 is placed substantially parallel to the bar 42 and its lower terminal portion is attached to the lower end thereof as at 44. One power lead 45 is attached to the electrode terminal at 44. The other power lead 46 is touched down to the water surface at 47, using any suitable switching device. In this case, a spark travels over the surface of the water from 47 to a point a where the acrylic bar 42 emerges from the water, and then travels down the surface of the bar 42, parallel to the electrode 43, to the terminal 44 at the bottom. This form of the invention suggests either that a water-air interface is not necessary, or else that a sufficient film of air clings to the surface of the bar 42.

A still further under-water spark source in accordance with the invention is shown in Fig. 5. In this case, an

acrylic or other insulation bar 50 is mounted so as to extend downwardly into a container 51 holding a body of water whose surface is at 52. Preferably, for a reason which will appear presently, the bar 50 is inclined somewhat from vertical. Along the uppermost edge of the bar 50 is placed an elongated electrode rod or strap 53. The upper end portion 53a of the electrode strap 53 extends transversely through an opening in the upper end portion of the bar 50 so as to protrude somewhat from member 50. A power lead 54 is connected to the lower end of strap 53. The opposite electrode comprises a conductive terminal element 55 set into the lower portion of bar 50 on the opposite side from the strap 53, and to this terminal member or electrode 55 is connected the opposite power lead 56. The spark gap then consists of a path along the surface of the insulation member 50 between the electrode element 55 and the protruding extremity 53a of the elongated electrode member 53. An air supply hose 57 supplies air to a point near the lower end of the inclined bar 50, so as to rise through the water along the surface of the bar 50 between the two spark terminals. Application of a sufficient voltage across the leads 54 and 56 results in a spark traveling along the gap between elements 53a and 55, the gap being the interface region between the water and the bar 50.

It will be understood that for sound wave generation, the spark sources above described may be furnished with suitable sound wave reflectors, as in Figs. 2 and 3; or may be used without such reflectors. The embodiment of Fig. 5 is particularly suited to under-water generation to sound waves for promotion of various industrial processes.

The foregoing illustrative examples demonstrate several of numerous ways in which the invention may be practiced, and it will be understood that the examples given are merely illustrative and not exhaustive of the forms which the invention may take in practice. The characteristic feature is a water surface bounding a spark gap, with an elongated electrode substantially parallel to but separated by a dielectric substance from the water surface. In some forms, the water surface is a water-air interface between bodies of water and air. In others, the water surface is bounded by a solid dielectric medium. All such modifications, and others, are within the broad scope of the invention as defined by the appended claims.

We claim:

1. A spark impulse source unit for a sound wave generator comprising a linearly-extended electrode having a terminal portion at one end, a relatively thin layer of liquid of low conductivity laying alongside said linearly-extended electrode along the length thereof, said layer having on its side facing away from said electrode a spark guiding surface generally paralleling said linearly-extended electrode and intersecting said terminal portion thereof, a discharge electrode for initiating a spark discharge to said spark guiding surface of said liquid layer positioned at a point located opposite said linearly-extended electrode and a substantial distance from said terminal portion, and means for impressing across said electrodes a high tension voltage pulse so as to create a sudden spark discharge of short duration between said discharge electrode and said terminal portion of said linearly-extended electrode at the point of intersection of said spark guiding surface therewith in a path along said spark guiding surface of said liquid layer.

2. A spark impulse source unit for a sound wave generator comprising a linearly-extended electrode having a terminal portion at one end, a relatively thin layer of liquid of low conductivity laying alongside said linearly-extended electrode along the length thereof, said layer having on its side facing away from said electrode a spark guiding surface generally paralleling said linearly-extended electrode and intersecting said terminal portion thereof, a discharge electrode for initiating a spark dis-

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charge to said spark guiding surface of said liquid layer positioned at a point located opposite said linearly-extended electrode and a substantial distance from said terminal portion, and means for periodically impressing a high tension voltage pulse across said electrodes so as to create a succession of spark discharges of short duration between said discharge electrode and said terminal portion of said linearly-extended electrode at the point of intersection of said spark guiding surface therewith in a path along said spark guiding surface of said liquid layer.

3. A spark impulse source for a sound wave generator comprising means providing an air-liquid interface with a liquid body of relatively low conductivity, a liquid-immersed linearly-extended electrode closely spaced from and generally paralleling said interface, said linearly-extended electrode having a terminal portion at one end and a tip portion at the other, one of which intersects said air-liquid interface, a discharge electrode positioned in proximity to said air-liquid interface at a point spaced along said linearly-extended electrode from the portion of the latter which intersects said air-liquid interface, and means for impressing across said electrodes a high tension voltage pulse so as to create a sudden spark discharge of short duration in a path extending along said air-liquid interface between said discharge electrode and said intersecting portion of said linearly-extended electrode.

4. A spark impulse source for a sound wave generator comprising a pan containing a body of liquid of low conductivity, a linearly-extended electrode positioned a relatively short distance below and generally parallel to the upper surface of said body of liquid, said electrode having a submerged tip at one end and a terminal portion at the other extending upwards through the liquid surface, a discharge electrode positioned above the liquid surface over said linearly-extended electrode at a point substantially spaced from said terminal portion, and means for impressing across said electrodes a high tension voltage pulse so as to create a sudden spark discharge of short duration between said discharge electrode and said terminal portion of said linearly-extended electrode in a path including the air space between said discharge electrode and a point of the liquid surface immediately thereunder, and continued by the liquid surface between said point and said terminal portion of said linearly-extended electrode at the point of intersection of said liquid surface therewith.

5. The subject matter of claim 3, including means for depressing said discharge electrode toward the surface of said liquid body.

6. A spark impulse source for a sound generator comprising spark terminals and a spark gap therebetween, a body of liquid of relatively low conductivity having a surface paralleling and bounding said gap for a substantial distance, a linearly-extended electrode connected to one

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of said terminals immersed within said body of liquid and relatively close-spaced from and substantially paralleling said liquid surface, and means for impressing across said terminals a high tension voltage pulse so as to cause a sudden spark discharge of short duration across said gap adjacent said bounding liquid surface.

7. A spark impulse source for a sound generator comprising spark terminals and a spark gap therebetween, a body of liquid of relatively low conductivity, and air forming an air-liquid interface paralleling and bounding said gap for a substantial distance, a linearly-extended electrode connected to one of said terminals relatively closely-spaced from and substantially paralleling said interface, and means for impressing across said terminals a high tension voltage pulse so as to cause a sudden spark discharge of short duration across said gap adjacent said bounding air-liquid interface.

8. A spark impulse source for a sound generator comprising a container holding a body of liquid of relatively low conductivity, an insulation body in said body of liquid having an extended surface in contact with said liquid, a pair of spark terminals positioned in proximity to the plane of said extended surface and spaced a substantial distance apart so as to form a spark gap, a substantial extended length of which is along said plane, at least one of said terminals being substantially in said plane, a linearly-extended electrode connected to one of said spark terminals and extending generally parallel to said surface in relatively close-spaced relation thereto, and means for impressing a high tension voltage pulse across said terminals to create a sudden spark discharge of short duration in a path along said surface in parallelism to said linearly-extended electrode.

9. A spark impulse source for a sound generator comprising a container holding a body of liquid of relatively low conductivity, an insulation body in said body of liquid having two opposite and generally parallel extended surfaces, at least one of which is in contact with said body of liquid, a pair of spark terminals positioned substantially in the plane of said last-mentioned surface, so as to form an extended spark gap therebetween along said surface, a linearly-extended electrode connected to one of said terminals and extending along the other of said surfaces of said insulation body in general parallelism to said spark gap, and means for impressing a high tension voltage pulse between said terminals to create a sudden spark discharge of short duration along said spark gap.

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