

[54] **ELECTROSTATIC DISCHARGING SYSTEM**

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Related U.S. Application Data

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abandoned.

[52] **U.S. Cl.** **317/2 D, 317/2 R**
[51] **Int. Cl.** **H05f 3/00**
[58] **Field of Search** **317/2 R, 2 E, 4**

References Cited

UNITED STATES PATENTS

3,164,747	1/1965	Yahnke.....	317/2 R
3,260,893	7/1966	De La Cierva et al.....	317/2 E
3,427,504	2/1969	De La Cierva et al.....	317/2 E
3,600,632	8/1971	Bright et al.....	317/4

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[57] **ABSTRACT**

The electrostatic environment inside an oil carrier tank is measured through a sensor which produces an alternating current output signal which is fed separately to two power units, one of which produces a signal if the polarity of the field sensed is positive and the other of which produces a signal if the polarity of the field sensed is negative, each circuit amplifying its specific signal to a predetermined level. The parallel circuits are connected to a high voltage circuit which produces an electrostatic field having a predetermined polarity and a magnitude which is proportional to the electrostatic field sensed. The generated electrostatic field is applied to an ionizer nozzle through which water is sprayed into the tank. The water is electrostatically charged by the nozzle to have a polarity opposite to the polarity sensed by the sensor and effectively neutralizes the electrostatic charge within the tank.

11 Claims, 10 Drawing Figures

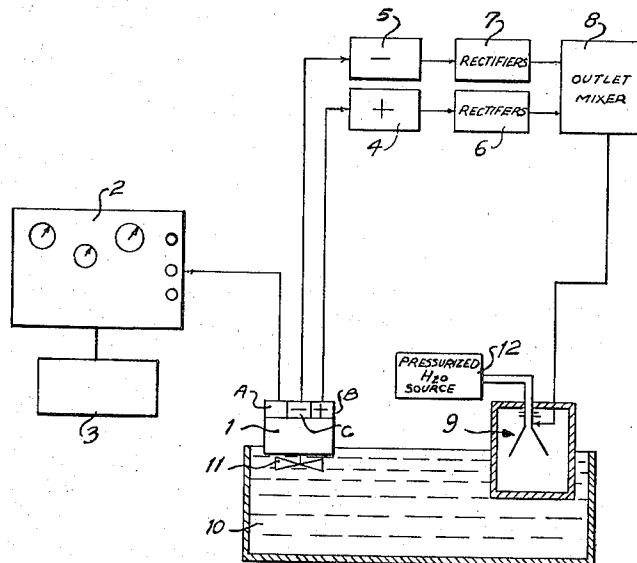


FIG. 1

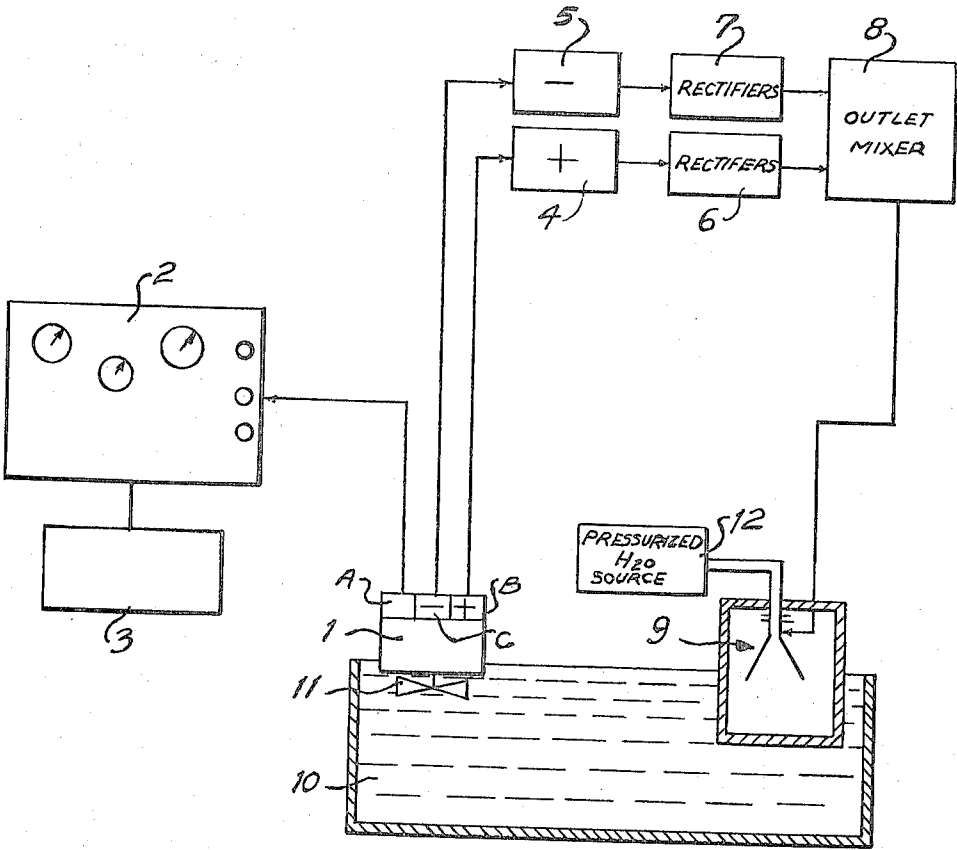


FIG. 2

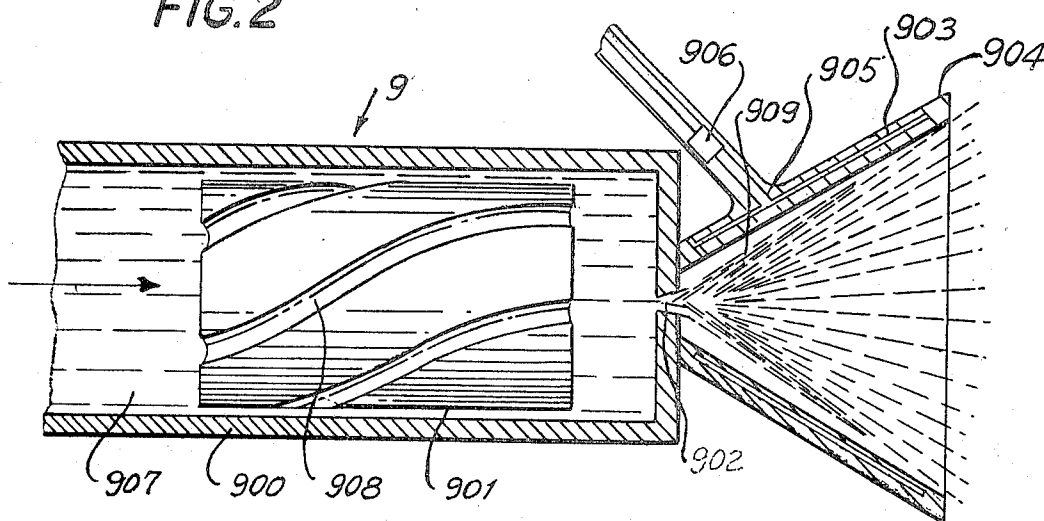
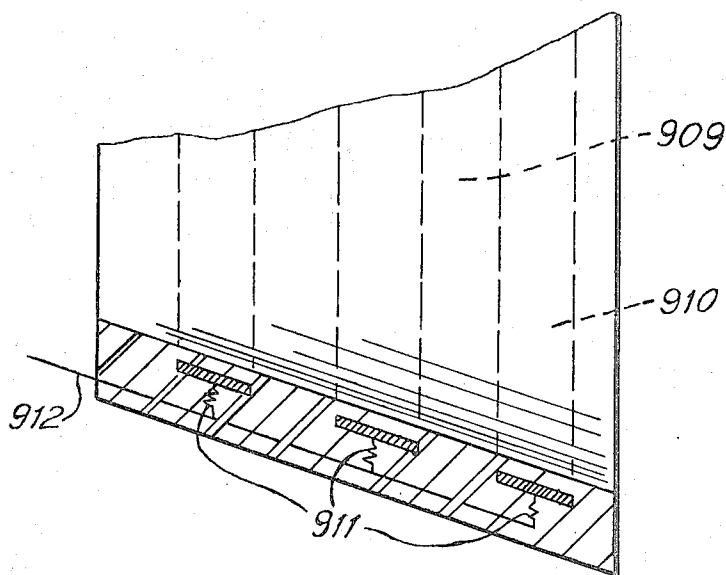


FIG. 2a



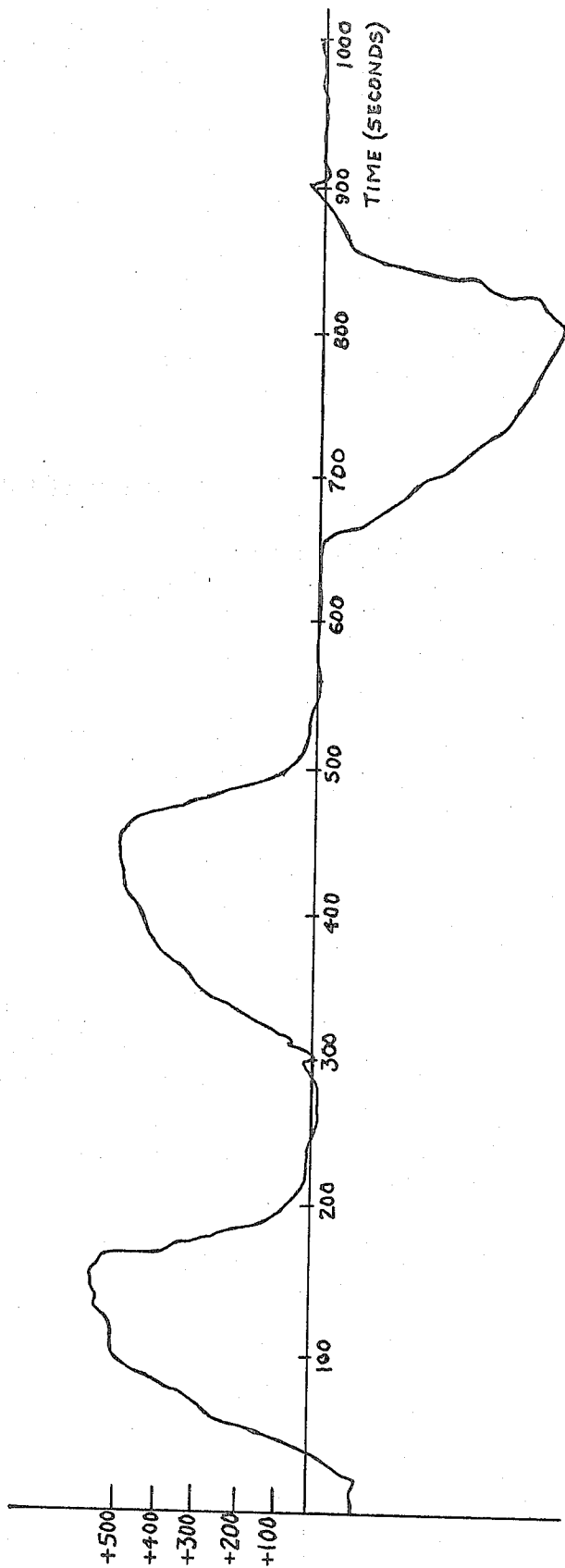


FIG. 3

FIG. 4

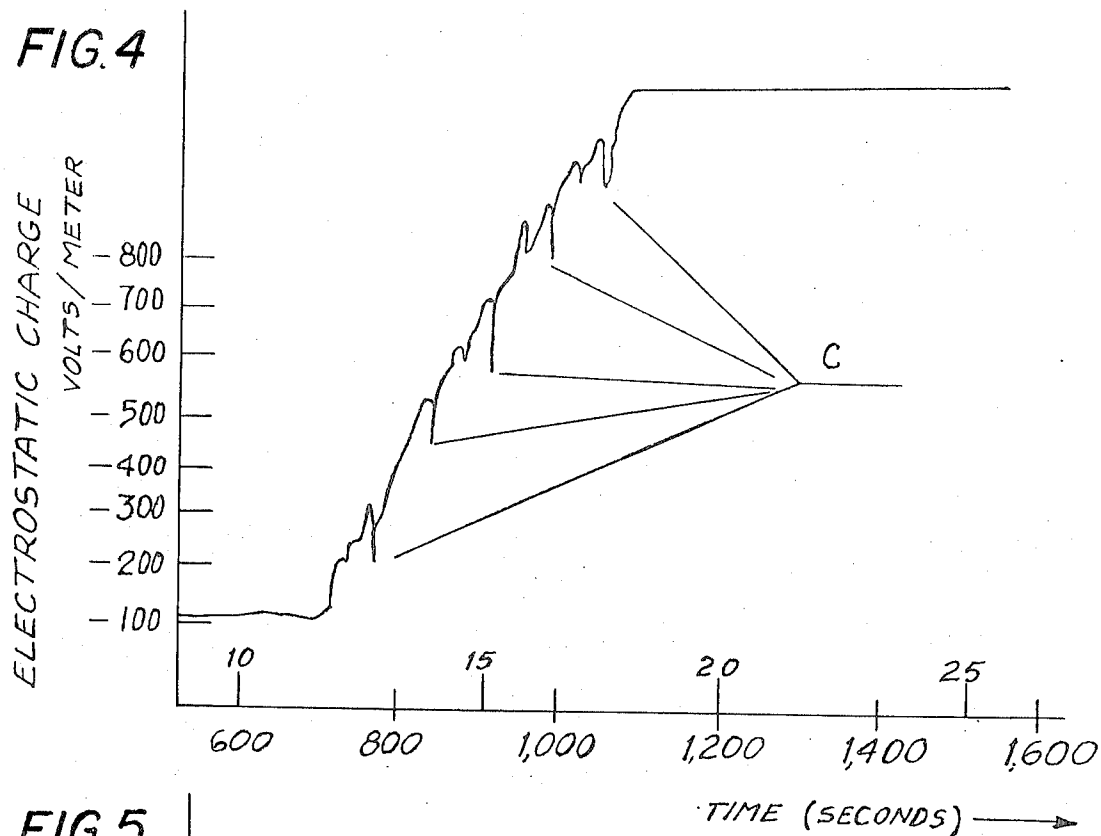


FIG. 5

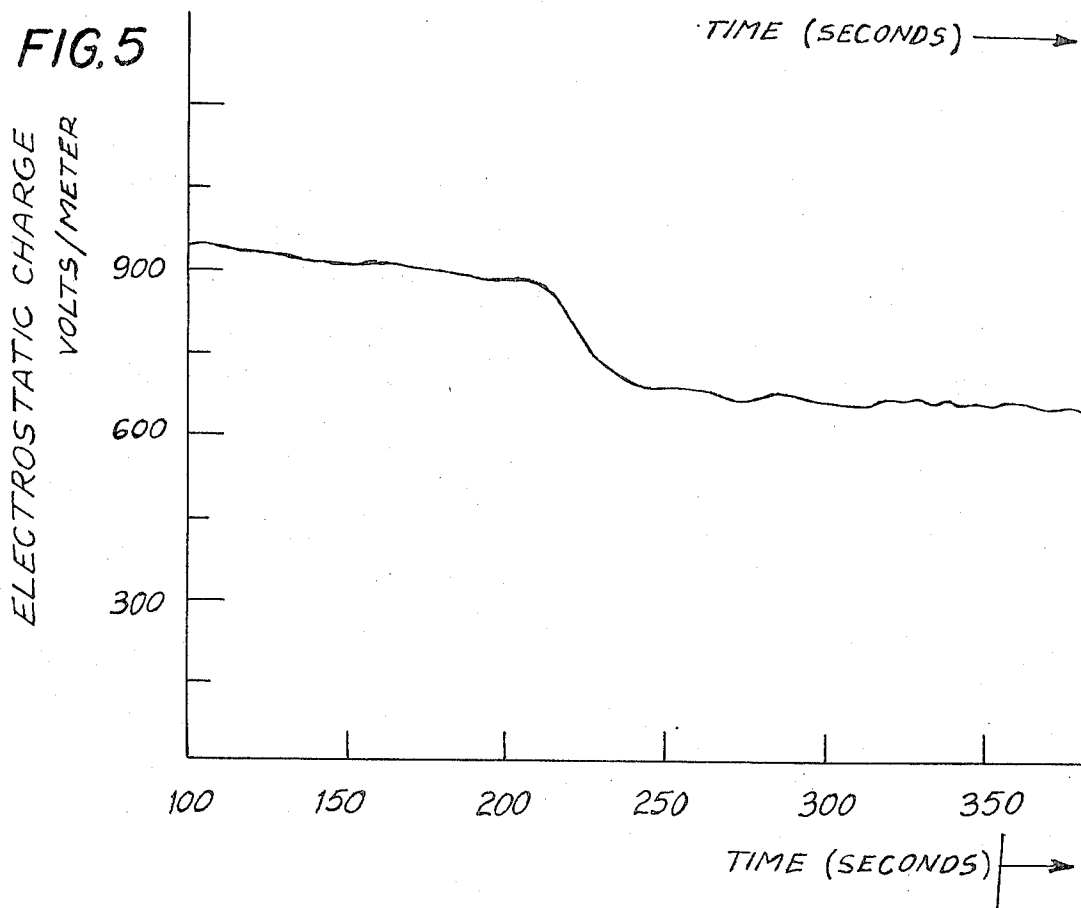


FIG. 6

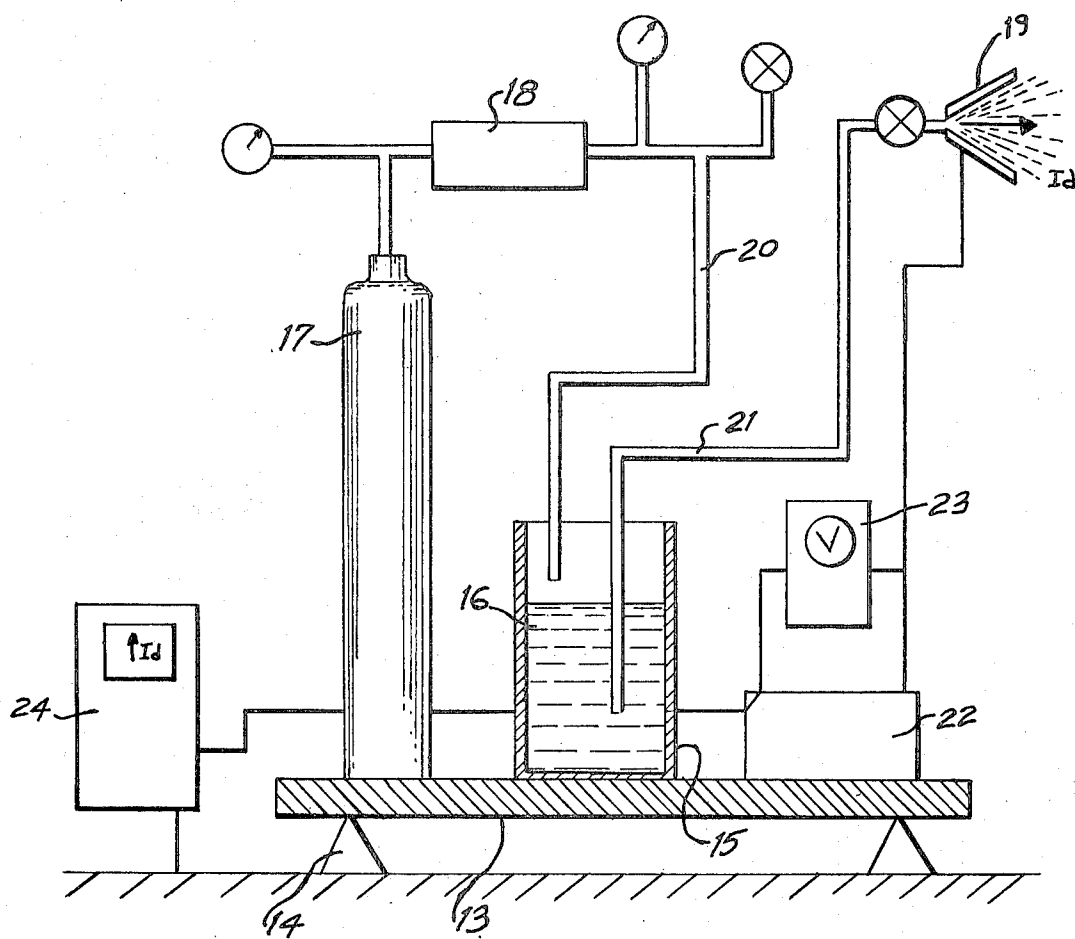


FIG. 7

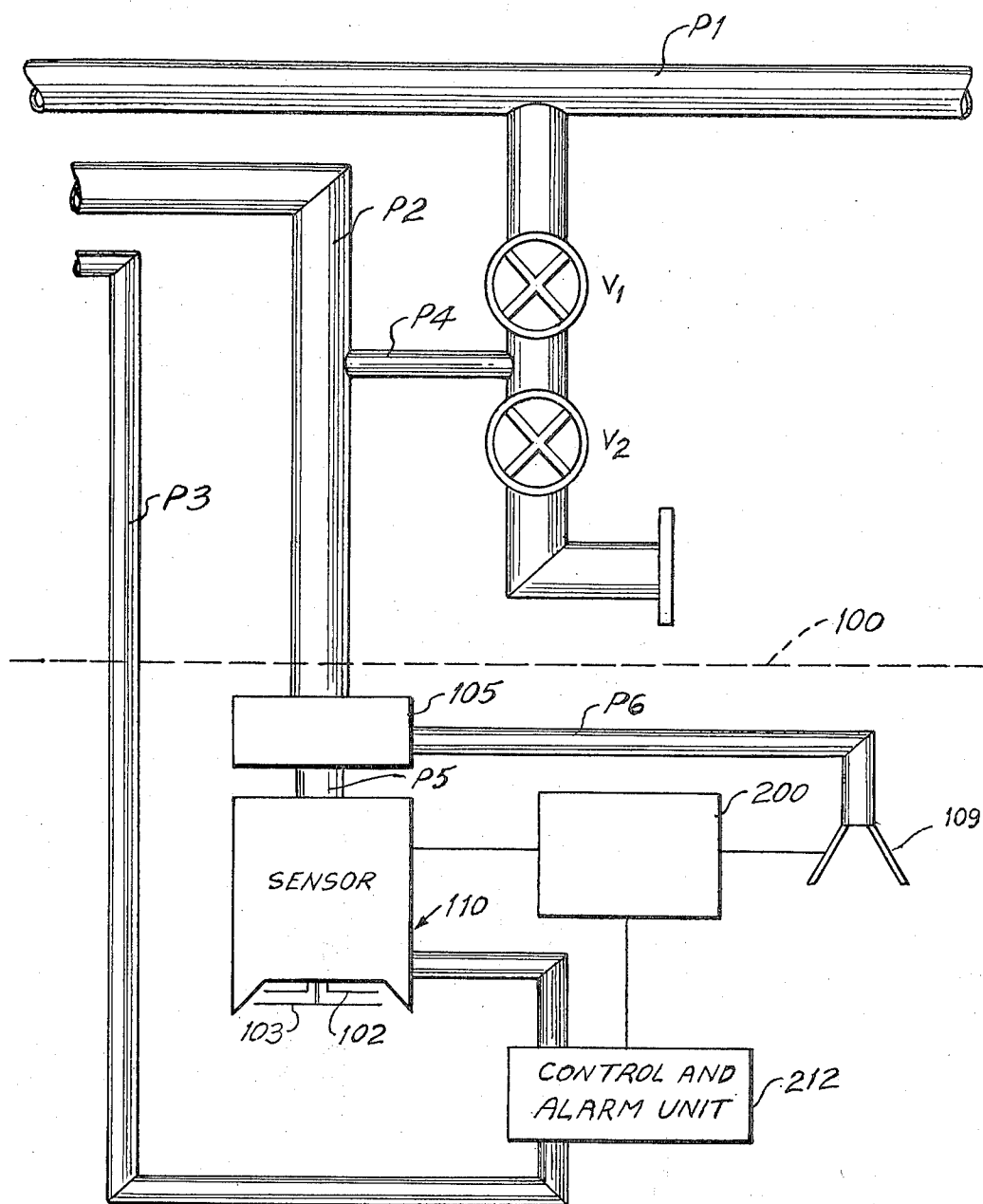


FIG. 8

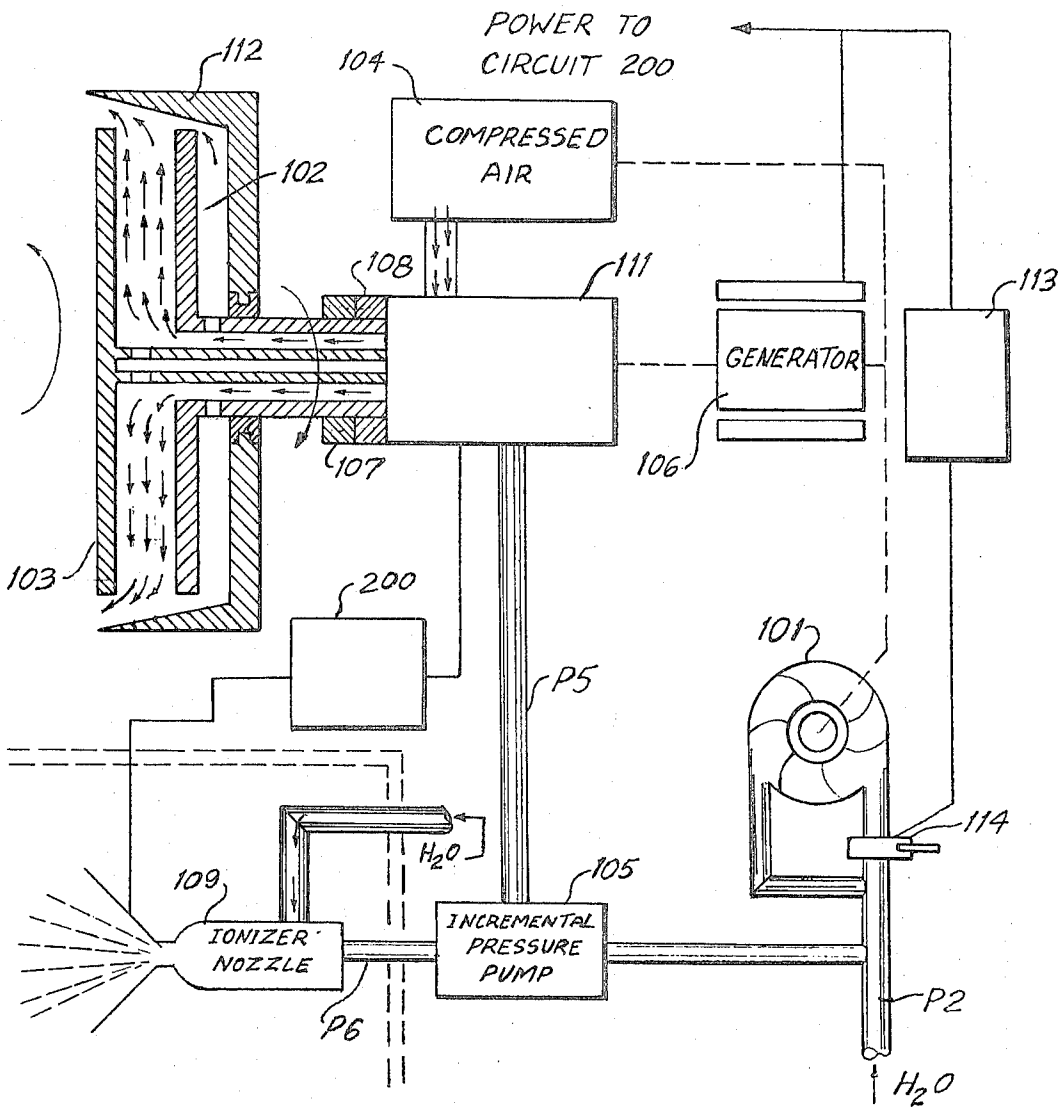
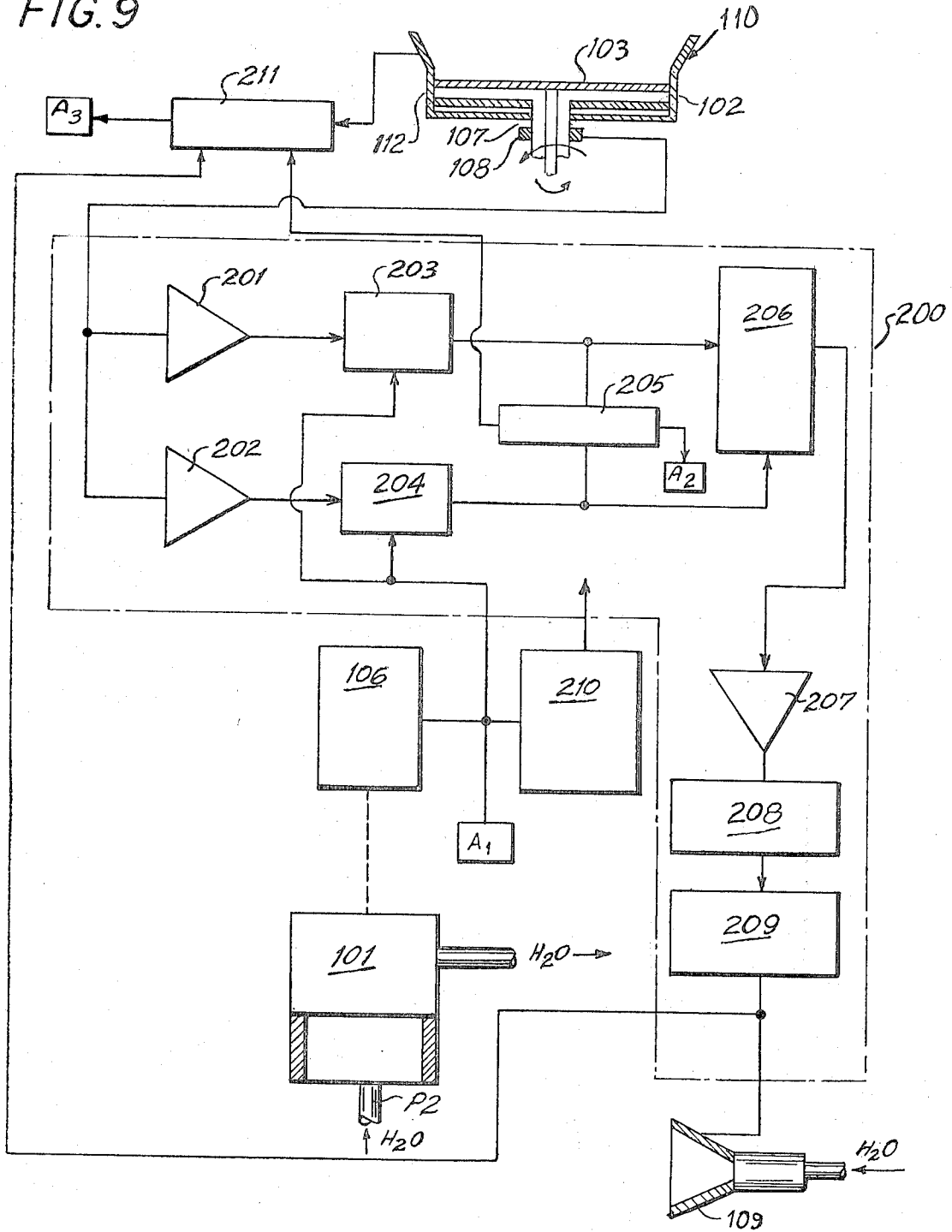


FIG. 9



ELECTROSTATIC DISCHARGING SYSTEM

This is a continuation of application Ser. No. 239,567, filed Mar. 30, 1972, now abandoned.

BACKGROUND OF THE INVENTION

The invention relates to an electrostatic discharging system for use in tanks which contain liquid fuel, and more particularly to a system for neutralizing the electrostatic charge in the tanks of oil carriers. The system disclosed herein is related in some respects to the discharging systems described in U.S. Pat. Nos. 3,260,893 and 3,427,504 of which the present application is a joint inventor.

It is necessary in the transportation and storage of liquid fuel products to ensure that no electrostatic discharges take place in the form of sparks in an explosive atmosphere. This is particularly true with regard to the tanks of oil carriers. In such oil carriers the storage departments are generally divided into several tanks by means of large bulkheads. On the return trip, after the tanks are emptied, the ship must carry a minimum of load in order to be able to sail so the removed oil is replaced by a salt water ballast stored in the same tank. At the shipping port, before being refilled with oil, the oil carrier's tanks are washed.

In practice the tanks are washed with water blasts under high pressure. The blasts of water are atomized and generally beat against the bulkheads. In so doing the water acquires an electrostatic charge and also introduces an electrostatic space charge to the tank. The electrostatic charge is generated as a consequence of the different functions of the atoms placed at the water breakup surfaces when the breaking particles are not homogeneous in saltiness, impurities, temperature and other factors.

The nature of this electrostatic charging process is such that it is almost impossible to predict its intensity or polarity. For example when tanks are washed with pure sea water they sometimes have a positive charge while when the same tanks are washed with fresh water the tanks may have a resultant negative charge. When the magnitude of the resulting electrostatic field within the tank surpasses the air's dielectrical strength, an electric arc results which is capable of causing an explosion of the mixture of hydrocarbon gases and air often found in such tanks.

At the present time the only practical method to prevent such explosions is to control concentration of the gaseous mixture within the tank. This is a complicated and time consuming process which interferes with the washing cycle.

SUMMARY OF THE INVENTION

The foregoing problems are overcome by the present invention of an automatic electrostatic discharging system for use in a liquid fuel container comprising means for sensing the magnitude and polarity of an electrostatic field within the container and for producing a first output signal representative of the magnitude and polarity of the electrostatic field sensed. A first circuit responsive to the first output signal produces a second output signal when the polarity of the field sensed is positive and a second circuit responsive to the first output signal produces a third output signal when the polarity of the field sensed is negative. A third circuit responsive to the second and the third output signals pro-

duces a high voltage, electrostatic potential proportional in magnitude to the electrostatic field sensed by the sensor and having a predetermined polarity. This high voltage, electrostatic potential is applied to water particles sprayed into the container to electrostatically charge the water particles with a polarity opposite to that sensed by the sensing means.

In a preferred embodiment the means for electrostatically charging the spray of water includes an ionizer nozzle which is cone shaped and which forms a cone shaped spray of water. An insulated electrode in the interior surface of the cone provides an electrostatic field which induces a surface charge on the atomized water particles through the dielectric insulation surrounding the electrode.

In one embodiment the sensing means includes a device mounted inside the tank having two vanes which are coaxial and which rotate in opposite directions. The vanes each have four, forty five degree segments. A first one of the vanes is grounded and continuously exposed to the field within the container. The second vane is periodically exposed to the electrostatic charge in the atmosphere surrounding the sensor by the first vane as the two vanes are counterrotated, thereby causing an alternating signal to be produced in the second vane. This alternating signal is representative in polarity and magnitude of the electrostatic field sensed. In one preferred embodiment the phase of the signal, when compared with a reference signal generated in synchronism with the counterrotation of the vanes, is the indication of the polarity of the electrostatic field sensed.

It is therefore an object of the present invention to provide a system for sensing the polarity and magnitude of an electrostatic charge within a petroleum tank and for neutralizing that charge by spraying in water particles which are electrostatically charged to the same magnitude but with a polarity opposite to that of the field within the tank.

It is still another object of the invention to provide a simplified water ionizing nozzle for use in discharging the electrostatic charge within a petroleum tank.

The foregoing and other objectives, features, and advantages of the invention will be more readily understood upon consideration of the following detailed description of certain preferred embodiments of the invention, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a discharging apparatus according to one simplified embodiment of the invention;

FIG. 2 is a partially schematic, longitudinal sectional view of an atomizing nozzle according to one embodiment of the invention;

FIG. 2A is a partially schematic, longitudinal sectional view of a modified nozzle according to another embodiment of the invention;

FIG. 3 is a graph illustrating the charging and discharging rates for an electrostatic field obtained in a laboratory test of one embodiment of the invention;

FIG. 4 is a graph illustrating the charging rate of an electrostatic field obtained in a test of one embodiment of the invention in an oil carrier tank;

FIG. 5 is a graph illustrating the discharging rate of an electrostatic field in the oil carrier tank referred to

in FIG. 4 using the same embodiment of the invention;

FIG. 6 is a schematic diagram of a test arrangement of the invention illustrating the fundamental principles of the invention;

FIG. 7 is a schematic diagram of an installation of one preferred embodiment of the invention aboard an oil carrier vessel;

FIG. 8 is a system diagram illustrating the structure of a portion of the embodiment of FIG. 7; and

FIG. 9 is a block diagram of the electronic sensing system of the embodiment depicted in FIGS. 7 and 8.

DESCRIPTION OF CERTAIN PREFERRED EMBODIMENTS

Referring now more particularly to FIG. 1 the fundamental aspects of a simplified embodiment of the invention will be described. An electrostatic field sensor 1 which is mounted in an oil carrier tank 10 has three output terminals designated A, B and C. At the terminal A the sensor produces a voltage proportional to the electrostatic field which is measured and this signal is fed to a unity of measurement and control circuit 2. The signal is further registered graphically on a recording voltmeter (eg. a chart recorder) 3.

Besides the signal observed at terminal A the sensor 1 also supplies alternating signals modulated at a frequency of 1.7 KHz. These two signals are produced at terminals B and C and are fed to two power units 4 and 5, respectively. As will be explained in greater detail further in the specification the sensor includes inner and outer coaxial vanes 11 which counterrotate with respect to each other. The inner vane is alternately exposed to and then shielded from the electrostatic field in the tank 10 by the outer vane. Each time the outer vane overlies the inner vane the vanes are said to "intercept" each other. Hence the vanes act as a chopper to convert the tank space charge into a current which is used to modulate the 1.7 KHz alternating signal. The sensor 1 is similar in its construction to the sensor disclosed in U.S. Pat. No. 3,427,504 referred to above.

The power unit 4 demodulates the alternating signal from the terminal B and produces an output signal when the charge sensed by the sensor 1 is positive in polarity. Similarly the power unit 5 demodulates the alternating signal from the terminal C and produces an output signal when the electrostatic field sensed is negative. The output signals from the power units 4 and 5 are fed to rectifying circuits 6 and 7, respectively. The rectifying circuits 6 and 7 produce high voltage signals representative of the output from the power units 4 and 5. The high voltage signals from the rectifying circuits 6 and 7 are fed to an outlet mixer 8 which combines the output signals and converts them into a single high voltage signal with a magnitude proportional to the magnitude of the electrostatic field measured by the sensor 1 and with a predetermined polarity. As will be explained further in the specification this predetermined polarity in the preferred embodiments of the invention is the same as the polarity of the field sensed by the sensor.

A single high voltage output signal from the outlet mixer 8 is connected to an ionizer nozzle 9. The ionizer nozzle 9 imparts a charge to the water particles sprayed into the tank through the nozzle from a high pressure source 12 which is opposite in polarity to the nozzle

charge to counteract the electrostatic field inside the tank 10.

Referring now more particularly to FIG. 2 the ionizer nozzle 9 has a body portion 900 in the inner space of which there is provided a core 901 having a snug fit with the interior of the body portion 900. The core 901 has a plurality of helical grooves 908, for example three grooves as shown in the FIG. 2. The body portion 900 is provided with an opening 902 at its downstream end. The outer portion of the opening 902 is encircled by a cone 904 of electrically insulating material, such as a fluorinated hydrocarbon, for example. A cone shaped electrode 903 made of an electrically conductive material is encased within the insulated cone 904. The electrode 903 is connected at a break 905 in the insulating material to an electrical conductor 906 which is connected to the outlet mixer 8.

Water from the source 12 being pressure forced into the upstream end 907 of the body 900 of the nozzle 9 has a rotating motion imparted to it by the helical grooves 908 and, upon being forced through the opening 902, forms a hollow cone of water 909. Since the water flow rate is uniform, but the diameter of the cone increases, the water cone 909 consequently breaks up into atomized water particles. This atomization of the water cone takes place within the zone of influence of the metal cone electrode 903 so that an electrostatic charge is imparted to the water particles which are then projected into the tank.

In FIG. 2A a modified form of the nozzle is illustrated having a cone of insulating material 909 in which a plurality of interconnected rings 910 of electrically conductive material are encased. The rings 910 are coaxial with the longitudinal axis of the cone and are spaced apart from each other. They are each interconnected by high value resistors 911 to the electrode 912 which is connected to the outlet mixer 8. The advantage of the modification is that when there is a local fault in the cone insulation the remainder of the cone is not rendered unusable but only the ring which is directly affected by the fault. Since very little current is required to electrostatically charge the water particles, the resistors 911 effectively insulate the ring in which the fault occurs from the remaining rings.

It is necessary that the electrodes of the nozzles in both of the embodiments of FIGS. 2 and 2A be insulated with a material having relatively high insulating properties not only so that a corona discharge does not take place which might cause an explosion but also because of the process by which water particles are charged. This process is termed condensive induction. In effect, the electrode of the nozzle acts as one plate of a condenser or capacitor and the water acts as the opposite plate with the insulation surrounding the electrode acting as the dielectric material. Thus when an electrical potential is applied to the ionizing electrode the exterior surface of the water in contact with the dielectric, insulating material becomes electrified by a superficial charge having a polarity opposite to that of the electrode. As the water is atomized, the superficial charge created in the water is retained in each of the atomized water particles which continue on their way to neutralize the space charge within the tank.

Referring now more particularly to FIG. 3 the results obtained during an experimental test of the system described above in regard to FIG. 1 are illustrated. A tank was first electrostatically charged by means of water

ionized through the nozzle 9 to simulate the tank washing procedure carried out in an oil carrier tank. The tank was then discharged through the same apparatus as described above. The space charge was increased from -100 volts per meter to +500 volts per meter while the nozzle was charged with a voltage of -350 volts per meter. The build up of the charge was accomplished in only slightly more than 75 seconds. The space charge was discharged by the apparatus as described above in approximately 70 seconds.

Starting from zero electrostatic potential the tank was recharged in 110 seconds to approximately +500 volts per meter and was then discharged in the manner described above in approximately 115 seconds. Finally, the process was repeated again in the last curve of FIG. 3. At this time the ionizer nozzle was placed under a voltage of approximately +150 volts per meter to produce a negative field in the tank. The tank was then discharged by the apparatus in approximately 75 seconds.

In FIG. 4 the results of placing the sensor 1 and the ionizer nozzle 9 in the tank of an actual oil carrier are graphically illustrated. The tank was electrostatically charged by washing it in the usual manner until the charge reached the level at which the sensor became saturated. Then the natural discharge of the tank was allowed to reduce the potential to just under the level of saturation of the sensor. In FIG. 5 the discharging affect of the apparatus in the same tank is illustrated and it is clear that from an electrostatic field potential of 900 volts per meter the system discharged it to 630 volts per meter in approximately 120 seconds. The field was not completely neutralized due to the high dimensions of the tank in relation to the prototype nozzle employed.

Referring now more particularly to FIG. 6 a test arrangement for the invention is illustrated wherein a table 13 which is completely electrically isolated from the ground by a pair of insulators 14 supports a metallic container 15 which is filled with water 16. A source of compressed gas 17 is connected to the tank 15 to pressurize the water. The pressure is regulated by an automatic valve 18 in the line 20 connecting the tank of gas 17 to the container 15. The tank 15 is connected to an ionizing nozzle 19 by a pipe 21 which carries the pressurized water to the nozzle.

The nozzle 19 is connected to a battery powered, high voltage generating source 22 mounted on the table 13. The voltage applied to the nozzle 19 is measured by a voltmeter 23. The discharge current generated in the nozzle 19 is measured with respect to the ground by a picoamperemeter 24 connected between the battery system 22 and the ground.

A preferred embodiment of the invention for actual use in each tank 100 of an oil carrier is illustrated in FIGS. 7, 8 and 9. The tank 100 is cleaned with water supplied by a pipe P1 through a first wash valve V1 and a second wash V2 (FIG. 7). Between the wash valves V1 and V2 a pipe P4 connects the flow in pipe P1 to a feed pipeline P2 which supplies pressurized fluid to an incremental pressure pump 105 and to a hydraulic turbine 101 (FIG. 8). When the valve V1 is opened the presence of hydraulic pressure in the pipeline P2 causes the system's release for operation. Thereafter the second wash valve V2 is opened to allow wash water into the tank 100.

The incremental pressure pump 105 increases the pressure of the fluid and supplies the high pressure fluid

through a pipe P5 to the sensor unit generally designated 110. The water supplied from the incremental pressure pump 105 to the pipe P5 is used to help clean any oil residue from the vanes 102 and 103.

The pressurized fluid supplied through the line P2 drives the hydraulic turbine 101. The turbine 101 is mechanically linked to a generator or alternator 106, to the driving mechanism 111 of the sensor 110, and to a compressed air pump 104. The compressed air pump 104 supplies a source of compressed air through the hollow drive shafts of the vanes 102 and 103 which blows between vanes and thus purges them of contaminated water. This purging process is done periodically during the washing cycle to ensure the accuracy of the readings of the sensor 110.

The incremental pressure pump also supplies a high pressure output flow through a pipe P6 to an ionizing nozzle 109. The nozzle 109 is preferably of a construction substantially identical to the construction of the embodiment depicted in FIG. 2A.

The sensor unit 110 has two coaxial vanes; vane 102 which is an internal vane and vane 103 which is an external vane. As indicated by the directional arrows in FIG. 8, the vanes 102 and 103 rotate in opposite directions. The vanes in one preferred embodiment of the invention each comprise four equally spaced octants, thus each vane is in the shape of four 45° segments. The vanes rotate at the same speed but in opposite directions and the rotational speed of each reaches approximately 2,400 revolutions per minute. The vanes are typically constructed of a noncorrodible metal such as stainless steel, for example.

The external vane 103 is electrically connected to the ground of the circuit. The internal vane 102 has a coil 107 wound about the outer surface of its shaft and coaxial with it. The coil 107 rotates with the shaft and has one of its leads connected to the shaft through an integrated amplifier also mounted on the shaft (but now shown). The other lead of the coil 107 is grounded. A second coil 108, which is fixed and nonrotating, is also mounted coaxial with the shaft of the vane 102 and adjacent to the coil 107 and is magnetically coupled to the coil 107 to receive the signals from the vane 102. The amplifier for the coil 107 may be powered by an alternating signal applied through the same or different coils which is then rectified. As will be described in reference to FIG. 9 the coil 108 is connected to a control system 200 which produces a high voltage output signal to charge the ionizer nozzle 109.

A cup-shaped housing 112 surrounds the backsides of the vanes 102 and 103 to not only protect the vanes from damage but also to allow an electrostatic charge to be placed upon the vanes during testing of the system. The outer edges of the housing 112 are tapered to facilitate the application of this electrostatic charge.

The electrical output from the generator 106 is fed to the control system 200 and is also fed to a valve control system 113. When the voltage output from the generator 106 exceeds a predetermined value, the valve control 113 feeds an output signal to a restriction valve 114 between the pipe P2 and the turbine 101 to reduce the flow of pressurized fluid to the turbine and thereby to decrease its speed and also to reduce the rotational speed of the generator 106. The decrease in the rotational speed of the generator 106 consequently reduces the output voltage and the system is stabilized.

The generator 106 is of the type which has a permanent magnet rotor. The frequency of the signal produced by the generator and the number of poles of the generator must be double the interception frequency of the internal and external vanes 102 and 103, respectively. For example in the case of a sensor, such as in the preferred embodiment, having four vanes interception takes place eight times per complete revolution of each vane and therefore the generator must produce four cycles in its alternating signal per revolution of each vane.

The system is initially adjusted such that when the vanes are intercepting (overlying) the generator will go through an instantaneous voltage of zero volts. This relationship is then made fixed so that the phase of the alternating signal produced by the generator is an indication of the relative position of the electrostatic vanes.

By way of example, when the internal vane 102 is exposed by the external vane 103 to a positively charged electrostatic field within the tank then a chopped signal is produced by the sensor 110. After each interception of the vanes (i.e., when the alternating generator voltage is zero) the sensor output voltage will be positive going. This signal is later compared in the phase by the circuit 200 with the generator alternating voltage as will be explained in more detail with regard to FIG. 9 to give an indication of the polarity and magnitude of the electrostatic field within the tank.

Referring now more particularly to FIG. 9 the control system 200 for the sensor comprises a pair of amplifiers 201 and 202 which have their inputs connected to the coil 108 mounted about the shaft of the internal vane 102. The signal produced in the vane 102 is magnetically coupled through the coils 107 and 108 and is thereby separately transmitted through the amplifiers 201 and 202 to a pair of phase comparators 203 and 204, respectively.

The alternating signal from the generator 106 is also connected to each of the phase comparators 203 and 204. The phase comparators demodulate the signals from the amplifiers 201 and 202 to determine whether the signal is positive going or negative going with respect to the alternating signal from the generator 106. The relative phase of these signals from the amplifiers 201 and 202 with respect to the generator signal are indicative of the polarity of the electrostatic field sensed by the sensor 110.

The output from the phase comparators 203 and 204 are coupled to a servo compensation network 206. If the polarity of the field sensed by the sensor 110 is positive the phase comparator 203 will provide a signal to the servo compensation network 206 which will then produce a corresponding output signal indicative of the positive field. If the polarity of the field sensed by the sensor 110 is negative the phase comparator 204 will provide a signal to the servo compensation network 206 which will then produce a corresponding output signal indicative of the negative field.

It should be noted that if no electrostatic field is sensed by the sensor 110 the phase comparators 203 and 204 will give identical output signals and the servo compensation network 206 will produce no output signal. The servo compensation network contains circuitry to ensure stability and damping in the system and thus it does not respond to all signals from the phase comparators 203 and 204 but only to such signals when

they exceed a predetermined magnitude and time response.

The output signal from the servo compensation network 206 is amplified by an amplifier 207 and fed to a high voltage rectifying circuit 208 which produces a voltage comparable in magnitude to the voltage sensed by the sensor 110 and of the same polarity. The voltage from the high voltage rectifier 208 is applied to the ionizing nozzle 109 through a high impedance 209 which limits the current available to the nozzle 109 to an amount which is less than that which would support corona arcing to the atmosphere in the tank 100.

The power for the control system 200 is generated locally by the generator 106. The alternating signal from the generator is supplied to a voltage regulating and rectifying unit 210 which then provides the circuits of the system with direct current.

Since it is vital to the safety of the oil carrier that the discharging system operate without failure, numerous safeguards are provided to warn the crew in the event that the system becomes inoperable due to a malfunction. The generator 106 is equipped with an alarm A1 which will cause a signal to be sounded on the bridge of the oil carrier in the event that the voltage produced by the generator 106 falls below a predetermined level.

The output from the phase comparators 203 and 204 are also fed to a fail safe circuit 205 which operates an alarm A2 and which feeds a signal to a testing circuit 211. In the event that the signals from the phase comparators 203 and 204 exceed a predetermined level, thus indicating that the sensor 110 is saturated, the alarm A2 is activated by the circuit 205 to notify the officers of the oil carrier of the situation.

The high voltage output from the high impedance 209 is also connected to the testing circuit 211. The testing circuit 211 is connected to sound an alarm A3 if the voltage falls below the required level when the signal from the circuit 205 indicates that there is a charge present in the tank. The testing circuit 211 also allows the officers of the oil carrier to periodically test the operation of the circuit 200 by applying a high voltage field to the casing 112 surrounding the vanes 102 and 103. If the circuit 200 does not respond by producing a corresponding signal of the same polarity and magnitude at the high impedance circuit 209, the testing circuit 211 activates the alarm A3 or otherwise indicates that the system is not working properly. The alarms A1, A2 and A3 are generally operated by a control and alarm unit 212 (FIG. 7) which hydraulically connects the alarms through a pipe P3 to the control panel for the system on the oil carrier's bridge.

The system is further designed to be able to be short circuited without producing arcs. For example, as was described in reference to the embodiment of FIG. 2A the ionizer nozzle is provided with a high impedance to prevent current of magnitude sufficient to cause corona arcing from flowing in the nozzle. The generator 106 is also designed to be able to carry a short circuit current without arcing.

While in the above embodiment a particular type of ionizing nozzle has been described as being most efficient for the operation of this system, in other embodiments other forms of devices may be utilized for ionizing the spray of water. Such other devices may not depend on the dielectric ionization process utilized by the nozzle in the present invention. Thus in such embodiments the polarity of the high voltage signal may neces-

sarily be required to be the opposite of the polarity of the electrostatic field sensed within the tank.

In some embodiments it is preferable to have a recording system to constantly record the electrostatic field strength and polarity within the tank for later analysis. Information can then be correlated to circumstances of time, period, and place of the oil carrier and other navigation details.

The system above has been described in reference to its use in the tanks of a sea going oil carrier but it should be apparent that the system is also suitable for use in any situation requiring the discharge of an electrostatic field within a container. Thus, the invention may be employed in railroad oil tanks, truck tanks, or even fixed, liquid fuel storage tanks.

Although the output signal from the sensor of the above embodiments contains the information regarding the electrostatic field sensed by being phase modulated with respect to the output from the generator, in other embodiments the sensor signal is varied in other ways to convey the sensor information.

The terms and expressions which have been employed here are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions, of excluding equivalents of the features shown and described, or portions thereof, it being recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. A discharging system for use in neutralizing an electrostatic field inside a liquid fuel container comprising means for sensing the magnitude and polarity of the electrostatic field within the container and for producing a first output signal representative of the magnitude and polarity of the electrostatic field sensed, a first circuit responsive to the first output signal for producing a second output signal when the polarity of the field sensed is positive, a second circuit responsive to the first output signal for producing a third output signal when the polarity of the field sensed is negative, means responsive to the second and the third output signals for producing a high voltage, electrostatic potential proportional in magnitude to the electrostatic field by the sensor and having a predetermined polarity, and means for applying this high voltage, electrostatic potential to water particles sprayed into the container to electrostatically charge the water particles with a polarity opposite to that sensed by the sensing means.

2. A discharging system as recited in claim 1 wherein the means for electrostatically charging the spray of water comprises a source of water under pressure, an ionizer nozzle having a hollow cylindrical body for receiving the pressurized water from the source, an inner core contained in the cylindrical body, the core being helically grooved around its periphery to impart a rotating motion to the water, the cylindrical body having an exit opening downstream from the entrance of the pressurized water and the core, the exit opening being encircled by an insulated, enveloping metal cone which is connected to the means for producing the high voltage electrostatic potential whereby the rotating water expelled through the exit opening forms a hollow cone within the enveloping insulated metal cone and having a wall thickness which diminishes outwardly to the point where the wall of water finally breaks into particles charged with a polarity opposite to that of the high voltage electrostatic potential to which the metal cone

is connected, the broken away particles of charged water thereafter being carried by their own momentum into the interior of the container to neutralize the electrostatically charged atmosphere therein.

3. A discharging system as recited in claim 2 wherein the enveloping metal cone comprises an insulating and mechanically resistant substrate, a plurality of conductor rings deposited on the substrate and having a high specific resistance, and a plurality of high value resistors interconnecting the rings and encapsulated within the cone, the resistance of the rings and of the resistors being great enough to prevent current from flowing in the cone which would otherwise be sufficient in magnitude to sustain corona arcing from the cone, and means for connecting the rings through the resistors to the high voltage, electrostatic potential.

4. A discharging system as recited in claim 1 wherein the sensing means comprises a first and a second vane, means for coaxially and rotatably mounting the first and the second vanes inside the container, means for rotating the vanes relative to each other at a predetermined speed, each of the first and the second vanes having a predetermined number of spaced apart segments, means for shielding the first and the second vanes such that the first vane is continuously exposed to the electrostatic field within the container and the second vane is periodically exposed by the spaces between the segments of the first vane as the first and the second vanes are rotated relative to each other, and means connected to the first and the second vanes for amplifying the voltage difference between the vanes induced by the electrostatic field within the container and for producing the first output signal representative of the magnitude and the polarity of the electrostatic field within the container.

5. A discharging system as recited in claim 4 wherein the means for rotating the first and the second vanes counterrotates the first and the second vanes and wherein each of the first and the second vanes has four 45° segments.

6. A discharging system as recited in claim 4 wherein the amplifying means connected to the first and the second vanes includes an integrated amplifier connected to the second vane, a first coil having one lead connected to the output of the integrated amplifier, means for mounting the integrated amplifier and the first coil for rotation with the second vane, a second coil, means for mounting the second coil adjacent the first coil such that the first and the second coils are magnetically coupled, means connected to the second coil for amplifying the signal magnetically induced in the second coil by the first coil and means for grounding the first vane and the other lead of the first coil.

7. A discharging system as recited in claim 4 further comprising means for generating an alternating current reference signal whose frequency is synchronized with the rotation of the first and the second vanes in such a manner that the alternating signal has substantially zero voltage potential at the moments in time when segments of the second vane are shielded from the electrostatic field within the container by the segments of the first vane, and wherein the first and the second circuits both include means responsive to the reference signal for comparing the phase of the first output signal with the phase of the reference signal.

8. A discharging system as recited in claim 4 wherein the means for shielding the first and the second vanes

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includes an electrode and means for applying a high voltage to the electrode to impress a test electrostatic charge on the first and the second vanes.

9. A discharging system as recited in claim 4 further comprising means for cleaning the first and the second vanes with high pressure streams of water and compressed air.

10. A discharging system as recited in claim 1 wherein the system is powered by a hydraulic turbine mounted in the immediate vicinity of the liquid fuel container.

11. A system for neutralizing an electrostatic charge existing inside a tank designed to contain liquid fuel comprising means for sensing the existence, magnitude and polarity of the electrostatic charge present inside the tank and for generating a first signal representative

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of the magnitude and polarity of the electrostatic charge sensed, means for amplifying the first signal, means for generating a reference signal, means for comparing the phase of the amplified first signal with that of the reference signal to determine the polarity of the electrostatic charge existing in the tank and for generating a resulting D.C. voltage proportional in magnitude to the tank's charge and with the same polarity as the tank's charge, a high-pressure ionized water sprayer for spraying water into the interior of the tank, means for applying the D.C. voltage to the water sprayer so that the water spray will carry a charge of polarity opposite to that of the electrostatic charge existing in the atmosphere inside the tank and thereby neutralize the electrostatic charge.

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