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METHOD AND APPARATUS FOR NEUTRALIZING ELECTROSTATIC CHARGES IN AN ELECTRICALLY CHARGED LIQUID

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Fig. 1

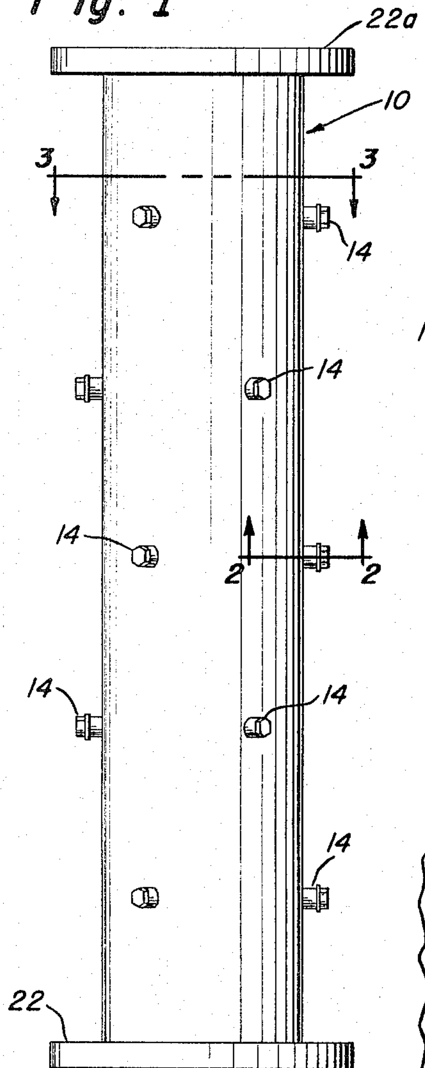


Fig. 3

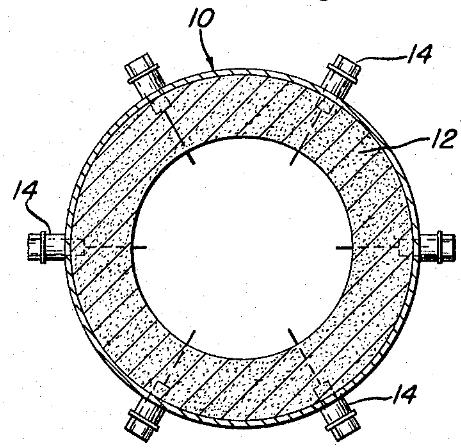
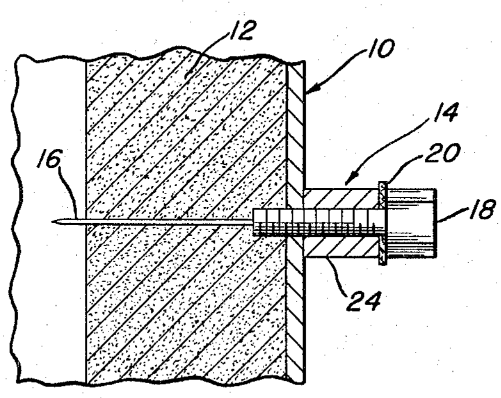


Fig. 2



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METHOD AND APPARATUS FOR NEUTRALIZING ELECTROSTATIC CHARGES IN AN ELECTRICALLY CHARGED LIQUID

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ABSTRACT OF THE DISCLOSURE

Electrostatic charges in an electrically charged liquid are reduced by flowing the charged liquid through a tubular capacitator having an inner electrically non-conductive dielectric of high resistivity and low dielectric constant and a grounded electrically conductive outer plate. As the charged liquid flows through the capacitor it contacts a plurality of spaced apart sharply pointed grounded electrodes while confined within the dielectric.

This invention relates to a method and apparatus for reducing electrostatic charges. More particularly, this invention relates to an improved method and apparatus for neutralizing electrostatic charges contained in liquids.

The problem of reducing electrostatic charges in flammable liquids is a particularly serious one. The problem more specifically concerns fluids of low conductivity since fluids of high or moderately high electrical conductivity generally allow the charges to rapidly leak away or "relax." However, when fluids of low conductivity are moved through a transfer system, the electrical charges generated may produce high potential differences between various sections of the transfer system and between the fluid and its surroundings. Such high potential differences may produce electrical discharges which may release sufficient energy to cause ignition of a flammable gaseous mixture. Hazardous situations may therefore arise during, and within a short period after, the transfer to previously empty or partially filled vessels of certain materials which are of low electrical conductivity and which can form explosive mixtures with air, as is the case with many petroleum products. For instance, many fires and explosions which have occurred during the transfer of such liquids have been directly attributed to sparks caused by the discharge of static electricity.

A recent survey by the American Petroleum Institute covering a four-year period indicated over 60 tank loading accidents which were attributed to static electricity. The modern use of filters and high pumping rates leads to large quantities of static electricity in liquid hydrocarbons. The relatively clean products now produced are very good electrical insulators and retain the electric charges for long periods of time. This charged oil can build high surface voltages in tank trucks; if these voltages exceed 20,000 volts, static discharges may occur to the fill pipe, tank walls, or tank internals even though these parts are adequately grounded and bonded. If a flammable mixture exists in the vapor space of the truck compartment, ignition may occur, resulting in fire or explosion. Frammable mixtures are usually present in the case of military jet fuel such as JP–4 and other stocks in the 1 to 4 RVP range. They also are present in switch loading, in which a tank truck that, for example, carried a high vapor pressure product such as gasoline as its last load is subsequently loaded with a low vapor pressure distillate. The empty truck contains gasoline vapor, and during loading with distillate, the liquid absorbs gasoline vapors and air is sucked in, thus the vapor space goes through the flammable region before becoming lean.

A number of procedures have been used in an attempt to cope with this problem, but none of them is completely satisfactory. Charge level in the oil can be reduced by using low pumping rates, by providing substantial relaxation time in the delivery line, and by using antistatic additives in the oil. These procedures are not always satisfactory and may increase loading cost. An alternate approach is to educt the gasoline vapors from a truck and to replace them with air. This, however, is time consuming and education does not help in the case of a material such as JP–4 or other intermediate vapor pressure products. Purging of the vessel or compartment with inert gas is effective but very costly.

There are many methods and devices previously disclosed for removal of electrostatic charges from flammable liquids. The use of grounded pointed electrodes in a non-conductive pipe or cylinder is a method known in the art. While not specifically disclosed in the art, it is apparent that this method works on the charge injection principle. Simply stated, this method operates by injecting charges through the pointed electrode from the ground into the charged liquid while the liquid is confined by the non-conductive pipe. The charge injected, being of opposite sign from the charge contained in the liquid, will have a neutralizing effect on the liquid charge. It is known that flowing a charged oil through a non-conductive pipe developes a very high voltage in the oil, compared to similar flow through a metal pipe. Depending on the charge density in the incoming oil, these voltages may well range from several thousand volts to over 50,000 volts. The effectiveness of this method is greatly increased by developing this very high voltage. The voltage also depends on the radius of the pipe, and a pipe smaller than 3" internal diameter would probably be an inefficient charge neutralizer.

However, for various reasons this method is not adequate for the effective removal of these charges. Chief among these reasons is the failure of this method to achieve high charge reductions. As an example, a method which achieves a charge reduction in the order of 40 to 70 percent will not, in most instances, be adequate. Significantly more reduction is needed. It has been determined, for instance, that a charge density of about 30 micro colombs/cubic meter in a 5-foot sized tank truck compartment is hazardous. As the size of the compartment increases, oil of lower charge density becomes hazardous. While charge densities in tank truck size compartments may well be higher, it can be seen that a 70% reduction in a charge density of about 250 micro colombs/cubic meter would leave a resultant density in the order of 75 micro colombs/cubic meter and therefore a hazardous condition would continue to exist.

The failure of this method to achieve a high degree of charge reduction may be due in whole or in part to any one or more of several factors. For example, the art for the most part teaches the use of only one electrode. The use of one point requires either adjusting the resistance to ground or the position of the point in the liquid in order to obtain substantial neutralization. The art also teaches that the composition of the electrode and the sharpness of the point is not particularly critical. But, as is discussed in reference to one of the accompanying figures, the use of a material without a sufficiently high melting point will result in burning the tip or point of the electrode. The effectiveness of the electrode is substantially lessened when the point becomes rounded or less pointed. In addition, the use of plastic or glass pipe is not fitted for refinery use. This type of pipe is not fire-proof and it, of course, does not have sufficient mechanical strength for refinery and other industrial uses.

It has now been discovered that these short comings as exist in the present known methods of charge injection to neutralize electrostatic charges in flammable liquids can be eliminated or substantially reduced through the utilization of the method and apparatus in accordance with this invention.

Briefly stated, the method and apparatus of this invention comprises a charge injection system where high voltage is developed by flowing a charged fluid through a capacitor system having a grounded tubular metallic outer plate and a dielectric of a thick nonconductive material of high resistivity and low dielectric constant. The dielectric which has a hollow core is fixed within the outer plate. The surface of the core serves as the other plate of the capacitor. In addition, the system utilizes a plurality of sharply pointed grounded electrodes which are spaced about the periphery of the capacitor. The points slightly protrude into the hollow core where they contact the charged liquid, thus injecting a charge of opposite sign from the charge contained in the liquid. The normal flow properties of the charged liquid are such as to mix the incoming charge with the charge present, thereby causing effective neutralization. It is now possible through the utilization of the system in accordance with this invention to produce a reduction in charge density such that the resultant charge density is of the order of ten micro colombs per cubic meter or less.

As previously mentioned, it is known that, depending on charge density, a very high voltage develops when a charged oil flows through a non-conductive pipe. It is believed that positioning a sharp, grounded point in the oil in a region of high voltage will cause a very intense electric voltage gradient to be set up in the vicinity of the point. Some impurity molecules in the oil are ionized in this intense electric field. The charged ions are repelled away from the sharp point in the oil. The sign of the charge on these repelled ions is opposite to the charge originally in the oil. Thus, the point injects the proper type of charge to offset the charge that is present. The injected charge mixes with the original charge and neutralization results. The use of a plurality of points, properly spaced, as disclosed herein, permits other points downstream to repeat the process. At each point the amount of charge injected is proportional to the amount of unneutralized charge that flows past the point. These successive neutralizations ultimately have the effect of reducing the charge to a point where a hazard no longer exists.

The full nature of the invention will be understood from the accompanying figures, examples, and the following description and claims.

FIGURE 1 is an elevational view illustrating one embodiment of the apparatus in accordance with the invention.

FIGURE 2 is a sectional view taken along line 2—2 of FIGURE 1 illustrating in detail the construction of a typical electrode which may be utilized in this invention.

FIGURE 3 is a top cross-sectional view taken along line 3—3 of FIGURE 1.

In FIGURE 1 and FIGURE 3 the capacitor or neutralizing chamber is shown. Electrodes **14** are shown in peripheral rows on outer plate **10**. In FIGURE 3 dielectric **12** is shown fixed within outer plate **10**. Dielectric **12** is cylindrical in shape and has a hollow core. It is made of a thick non-conductive material. Preferably dielectric **12** should be made of a material having as low a dielectric constant as possible and a resistivity in the order of about 10^{15} ohms centimeter or greater. The internal diameter of the chamber formed by dielectric **12** should as closely as possible match the internal diameter of the piping in the system to which it is to be installed. This will help in avoiding pressure drops in the system as the fluid flows through. Moreover, a smooth inner surface should be provided at the junction of the capacitor to the system piping in order to decrease turbulence as much as possible within the chamber. When turbulence is at minimum, the effectiveness of the charge reduction

will be increased. A transition cone may be utilized if the sizes are sufficiently different. It has been found that material such as polyethylene, Teflon, polystyrene, polyvinylchloride rigid Type 1, Kel-F, and the like are very satisfactory in meeting the requirements of high resistivity.

The thickness of dielectric **12** is an important factor for two reasons: (1) insulation and (2) control of starting transient time. When the internal diameter of dielectric **12** is between about 4 and 6 inches, it is preferred that the thickness of **12** be about 1¼ to 2 inches. As the internal diameter of dielectric **12** is increased, the wall thickness should be increased to decrease the capacity as the size of the capacitor increases. For example, if dielectric **12** has an internal diameter of 4 or 6 inches, a dielectric much thinner than 2 inches would be satisfactory for insulation, but not for a sufficiently short starting transient time. When the oil is at rest and uncharged in the chamber, all voltages are zero. When charged oil starts to flow, dielectric **12** acts as the dielectric of the cylindrical capacitor, with outer plate **10** and the surface of the hollow core acting as the two "plates." This capacitor becomes charged as the voltage in the oil increases. With about a two-inch thick dielectric, charging requires only about 15 to 20 seconds before the device becomes effective. With a one-inch thick inner plate, it would require about 30 to 40 seconds.

Standard steel pipe may conveniently be used for outer plate **10**. The main consideration being the pressure requirements of the particular system. Depending on the particular system, outer plate **10** may be fitted with standard type flanges such as **22** and **22*a***. Outer plate **10** should, of course, be sized or have an internal diameter sufficient to meet the internal diameter requirements of the chamber for the particular system in which it is to be employed.

The length of outer plate **10** and dielectric **12**, and hence the length of the capacitor, is for the most part dependent on the arrangement of the electrodes, i.e., spacing and number of rows. It has been found that to facilitate injection, 3 electrodes at the same peripheral location, spaced equally from one another or about 120° apart, is the preferred arrangement for a row. Fewer electrodes will inject less charge at this location and more will not inject more charge than three. If the points of the electrodes are placed too closely together, interference between the field gradients will occur and injection will be impaired. This arrangement may be more clearly seen by referring to FIGURE 3. In order to facilitate mixture of the charge in the liquid and the charge injected, it is preferred to offset the pins of the next succeeding row about 60° from the pins of the previous row. It has also been found that the number of rows and the spacing between rows is important in order to achieve efficient charge reduction. The rows should be sufficiently spaced so that mixing will occur between the charge in the liquid and the charge injected before additional charge is injected. This spacing is usually less than one inner plate internal diameter, but it could be as long as 5 diameters or more. The number of rows of electrodes should be between about 3 to 5. It has been found the one row gives incomplete reduction and that two rows tend to over neutralize. The first and last rows should be spaced at least one internal diameter from their respective ends of the capacitor, and preferably two. Again, reference to internal diameter means the internal diameter of the dielectric. This spacing of one to two internal diameters provides enough separation from the bare grounded metallic pipe of the system in which the capacitor is used, so that, a high voltage can be built on the interior surface of dielectric **12**.

FIGURE 2 illustrates the construction details of a typical electrode as used in this invention. Sharply pointed pivot **16** is mounted on bolt **18**. Half-inch diameter bolts have been found to be satisfactory. Bolt **18** is threaded into adapter ring **24** which is welded to the outside of outer plate **10**. Pivot **16** protrudes slightly through dielectric **12** into the hollow core of the capacitor. A point that protrudes far into the core could be damaged by any large object that inadvertently came down the pipe. Having the threads of bolt **18** extend into dielectric **12** provides a good mechanical bond. Since the thermal expansion of the plastic is greatly different from that of metal, dielectric **12** will tend to separate from outer plate **10** if it is not sufficiently bonded to the outer plate. Thread seal gasket **20** prevents leakage of internal fluids around the threads of bolt **18**.

It is essential that pivot **16** be constructed of a non-corroding, conductive material the point of which has a sufficiently high melting point so that charge injection will not cause the point to melt or burn. A hard, non-corroding precious metal such as osmium has been found to be very satisfactory. Points made of spark plug electrode metal are also satisfactory. The sharpness of the point of pivot **16** is also important. It should have a radius of 2 mils to 3 mils. A point of less than 2 mils will tend to burn and with a point over 3 mils the efficiency of the charge reduction will decrease.

Referring again to FIGURE 3, it should be noted that dielectric **12** may be constructed as a piece of tubing. Machining a continuous spiral groove into the back of the dielectric **12** will provide a holding surface so that epoxy cement can be used for affixing the dielectric within outer plate **10**. Normally, for example, epoxy will not hold a smooth polyethylene surface but a grooved back provides a three-dimensional surface to which the epoxy can mechanically fasten.

The invention is illustrated further by the following examples:

Example I

This example illustrates the effectiveness of the charge reduction of the invention. The oil was charged by flowing through a filter device. The following table shows the flow rate in a 4-inch internal diameter chamber, the charge density in the oil entering the capacitor and the charge density in the oil after neutralization. The particular chamber used in this example had 5 rows of pins spaced along the capacitor. Each row had 3 pins equally spaced with the pins of each succeeding row being offset about 60° from the previous row. The first and last rows were spaced about 2 internal diameters from each end of the capacitor. The dielectric of the capacitor was about 2 inches thick and was made of polyethylene.

Flow Rate in 4" Line (g.p.m.)	Charge Density (μ colombs/cu. meter) of Oil Entering Capacitor	Charge Density (μ colombs/cu. meter) of Oil Leaving Capacitor
108	−99.5	−2.6
155	−156	−3.1
278	−262	−6.3
410	−286	−3.8

Example II

In a six-inch internal diameter line, of the same construction as Example I, the charge density of oil, flowing from 400 to 1200 gallons a minute, ranged from 50 to over 400 microcolombs/cubic meter. After flowing through a neutralizing chamber with a six-inch internal diameter and a 2-inch wall thickness, the resultant charge density was reduced to 3 microcolombs/cubic meter or less.

A system has been provided in which the charge neutralization is very effective thus assuring that a hazardous condition will not exist after neutralization. While it is believed advantageous that all pumps, filters, pipes, etc., should be grounded as they represent possible spark hazards if they are not, it is not necessary to directly ground the electrodes to these items. Rather the electrodes are grounded directly to the outer plate of the capacitor. Also the system in accordance with this invention does not, as in the case of certain of the devices and methods present in art, require any resistance from the electrodes to ground. Thus, no adjustment of resistance is required. And with this system effective neutralization may be achieved without adjusting the location of the electrode, its depth, or some other parameter of the system.

Having thus described the invention, what is claimed is:

1. Apparatus for reducing electrostatic charges in an electrically charged liquid, said apparatus comprising a capacitor having a tubular metallic grounded outer plate and a dielectric of thick non-conductive material of high resistivity and low dielectric constant fixed within said outer plate, said dielectric having a hollow core, the surface of said core serving as the other plate of said capacitor, a plurality of sharply pointed grounded electrodes spaced apart and positioned peripherally in at least three rows, each row being spaced longitudinally along the axis of said capacitor and having the points of said electrodes slightly protruding into said hollow core, whereby charged liquid flowing through said hollow core will contact said points.

2. The apparatus of claim **1** wherein said electrodes are positioned in at least three peripheral rows of at least one electrode per row about said outer plate, the electrode of each row being circumferentially offset from the electrode of the next succeeding row.

3. The apparatus of claim **1** wherein said electrodes are positioned in at least three peripheral rows of at least one electrode per row, the first and last of said rows each being at least one internal diameter of said hollow core from its respective end of said capacitor.

4. The apparatus of claim **1** wherein said electrodes are positioned in at least three peripheral rows of at least one electrode per row, the first and last of said rows each being at least one internal diameter of said hollow core from its respective end of said capacitor and each row being spaced from the next adjacent row by at least three-fourths of said internal diameter.

5. The apparatus of claim **1** wherein said high resistivity is at least 10^{15} ohm centimeters.

6. The apparatus of claim **1** wherein the points of said electrodes are osmium.

7. Apparatus for reducing charges in a flowing electrically charged hydrocarbon liquid, said apparatus comprising a capacitor having a tubular metallic grounded outer plate and a dielectric of thick nonconductive material having a resistivity of at least 10^{15} ohm centimeters and low dielectric constant fixed within said outer plate, said dielectric having a hollow core, the surface of said core serving as the other plate of said capacitor, a plurality of sharply pointed grounded electrodes spaced apart and positioned about said outer plate in at least three peripheral rows of at least one electrode per row, the electrode of each row being circumferentially offset from the electrode of the next succeeding row, the first and last of said rows each being spaced longitudinally along the axis of said capacitor at least one internal diameter of said core from its respective end of said capacitor and each row being spaced longitudinally along the axis of said capacitor from the next adjacent row by at least three-fourths of said internal diameter, and having the points of said electrodes slightly protruding into said hollow core, whereby said charged hydrocarbon liquid flowing through said hollow core will contact said points.

8. The apparatus of claim **1** wherein there are three electrodes per row spaced about 120° apart.

9. The apparatus of claim **1** wherein the electrodes of one of said rows are circumferentially offset from the electrodes of the next succeeding row by about 60°.

10. The process of reducing electrostatic charges in an electrically charged liquid said process comprising flowing said charged liquid through a tubular capacitor having an inner electrically non-conductive dielectric of high resistivity and low dielectric constant and a grounded electrically conductive outer plate, and contacting said charged liquid with a plurality of spaced apart sharply pointed grounded electrodes while said liquid is confined within said dielectric.

11. The process of claim **10** wherein said inner plate has a resistivity of at least 10^{15} ohm centimeters.

12. The process of claim **10** wherein the points of said electrodes are osmium.

13. The process of claim **10** wherein said electrical charged liquid has a charge density of greater than 10 microcolombs per cubic meter and said charge density is reduced to less than 10 microcolombs per cubic meter.

References Cited

UNITED STATES PATENTS

3,160,785 12/1964 Munday -------------- 317—2

MILTON O. HIRSHFIELD, *Primary Examiner.*

J. A. SILVERMAN, *Assistant Examiner.*