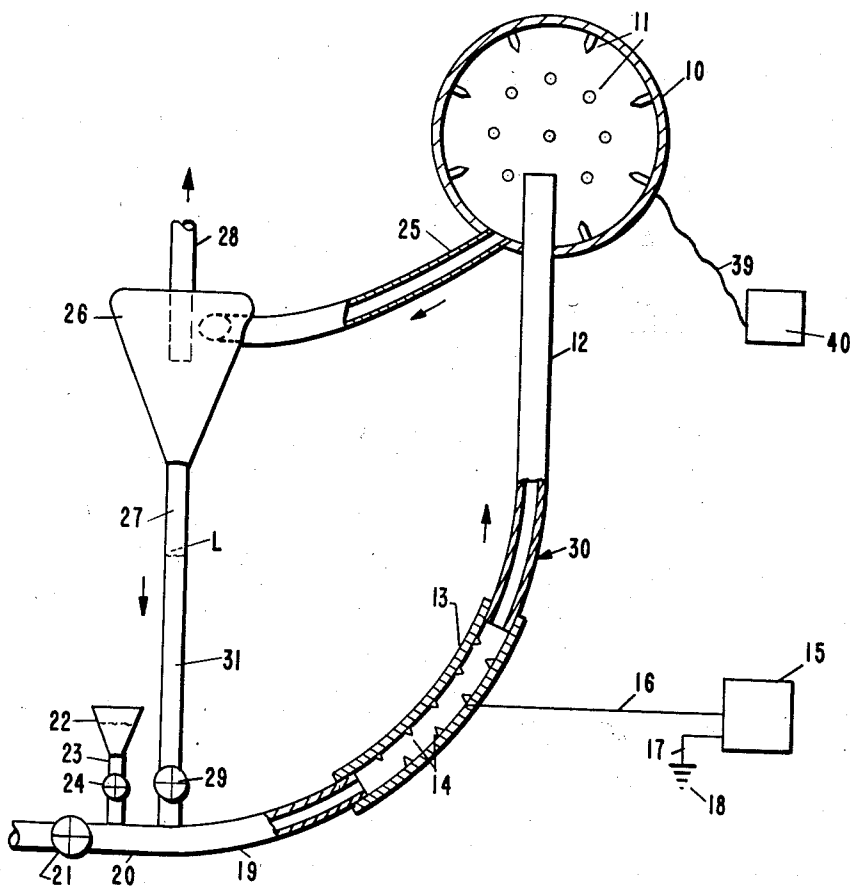


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ELECTROSTATIC MACHINE

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CHARLES N. KIMBERLIN JR. INVENTORS
LEO BROUSSARD

BY *Gary J. Anthony* ATTORNEY

2,827,577

ELECTROSTATIC MACHINE

Charles N. Kimberlin, Jr., and Leo Broussard, Baton Rouge, La., assignors to Esso Research and Engineering Company, a corporation of Delaware

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This invention relates to a method and apparatus for developing electrical potentials and more particularly relates to a method and apparatus for developing high electrical potentials by continuous electrostatic induction.

Ever since Michael Faraday discovered the laws of electrostatic induction in the nineteenth century with his classic "ice pail experiments," there has been considerable effort expended to develop improved apparatus and methods for developing high electrical potentials by continuous electrostatic induction. Early electrostatic machines were developed by Wimshurst, Toepler and Holtz. In these older forms of electrostatic machines the development of high electrical potentials was accomplished mechanically by turning a handle and allowing two charged discs to rotate in opposite directions, with the resulting induced charges being removed by conducting brushes to condensers for storage.

The modern form of electrostatic machine is represented by the van de Graaf generator. In this machine, a silk belt is passed continuously over two pulleys, one of which is arranged inside a hollow conducting sphere mounted on an insulating stand. Electrical charges are picked up from the ground by the belt and are carried by the belt into the hollow conducting sphere where they are discharged to the sphere. In this manner, small electrical charges are continuously discharged from the belt to the sphere to thereby develop a high electrical potential on the sphere. From this electrostatic machine of van de Graaf, voltages in excess of 2,000,000 volts are attained. Such high voltages find application in nuclear physics, for example, to accelerate charged particles for use in research.

It has now been found that improved results over these prior art devices may be attained by employing finely divided solids as the means for carrying the small electrical charges into the collecting sphere employed to store the electrical charges. Briefly, the apparatus of the present invention in its preferred embodiment comprises a hollow collecting sphere made of a conducting material and adapted to store electrical charges, an inlet conduit member made of a non-conducting material which extends into the interior of the collecting sphere and which is adapted to convey fluidized finely-divided solids, an inlet means for introducing a gasiform fluid into the inlet conduit member, so as to fluidize finely-divided solids contained therein, an outlet conduit member made of a non-conducting material which is adapted to convey fluidized finely-divided solids from the interior of the collecting sphere, separating means communicating with the outlet conduit member for separating the finely-divided solids from the gasiform fluid, means to impart a small electrical charge to the finely-divided solids passing to the collecting sphere, and means for conveying the separated finely-divided solids from the separating means to the inlet conduit member. Thus, in the method of the present invention, finely-divided solids which have been fluidized by a gasiform fluid and which have been charged with small electrical charges

are continuously passed into the interior of a collecting sphere wherein the small electrical charges carried by the finely divided solids are discharged to the collecting sphere. The electrically discharged finely-divided solids are continuously removed from the collecting sphere and are separated from the aerating gasiform fluid and thereafter are again fluidized and charged for further passage to the collecting sphere. The present invention thereby provides a continuous method for developing high electrical potentials by the continuous circulation of finely-divided solids wherein small electrical charges are continuously discharged to the collecting sphere to thereby develop high electrical potentials.

The instant invention exhibits several advantages over the prior art machines. One of these advantages is that the fluidized solids in the present invention may be circulated at a very rapid rate, thus supplying large charging currents to the collecting sphere. A further advantage of this invention is that the nature of the finely-divided fluidized solids permits intimate contact between the charge-carrying medium and the charging means which in the present invention preferably comprises electrodes arranged within the inlet conduit member. In addition, the present invention for the most part is devoid of mechanical difficulties ordinarily encountered with rotating discs or belts and pulleys. Thus, the mechanical energy required to move the small electrical charges to the collecting sphere to overcome the repelling force exerted on the charged particles by the charge on the collecting sphere is provided in this invention by the gasiform fluid rather than by the motor-driven belts or discs of the prior art machine.

It is an object of this invention to provide an improved method and apparatus for developing high electrical potentials by continuous electrostatic induction.

Other objects of this invention will be apparent from a reading of the present specification, which will be best understood when read in conjunction with the single figure of the drawing, which is a diagrammatic illustration of apparatus made in accordance with the present invention for generating high electrical potentials by continuous electrostatic induction. The drawing is shown partially in cross section to facilitate the present disclosure.

Referring now to the drawing, reference character 10 designates a hollow collector for receiving and storing electrical charges. Collector 10 is constructed of an electrically-conducting material which is preferably a metal such as copper, aluminum, or iron, for example. Preferably, collector 10 is spherical in shape in order to minimize leakage of electricity therefrom to the surrounding medium. It is essential to the present invention, as in any form of electrostatic machine, that collector 10 be electrically insulated from the ground, or in other words, electrically isolated. Preferably, collector 10 is provided at its interior surface with a plurality of symmetrically spaced sharp-pointed collecting electrodes 11 which facilitate the transfer of electrical charges from the finely-divided solids to collector 10, as will hereinafter be described in greater detail.

Extending up into collector 10 through the bottom wall thereof is conduit 12 which has its upper end spaced between the upper and lower ends of collector 10. Conduit 12 is constructed of an electrically non-conducting material such as glass, for example, and may serve in this invention as the insulated support required for collector 10. A fluid-tight seal is maintained between the outside of conduit 12 and the wall of collector 10. Conduit 12 connects at its lower end to the upper end of charging means 13 which in this form of the invention comprises a tubular member provided along its inner surface with a plurality of spaced sharp-pointed charging electrodes

14. In this specific embodiment of the present invention, charging means 13 and charging electrodes 14 are constructed of an electrically-conducting material which is preferably a metal such as copper, aluminum, or iron, for example. Charging means 13 is electrically connected to one pole of a source 15 of electrical potential by means of wire 16, with wire 17 connected to the opposite pole of electrical source 15 being connected to ground 18. Source 15 of electrical potential may comprise a battery or other well-known source of direct current potential. It is not necessary in the operation of the present invention that the electrical potential of source 15 be large. However, source 15 of electrical potential is preferably employed in this invention to assure the presence of a potential at charging means 13. The magnitude of the potential at charging means 13 is preferably less than about 50,000 volts and may be about 5,000 to 20,000 volts. In any event it is to be understood that the potential at charging means 13 is considerably less than the ultimate potential developed on collector 10. In a simplified modification of the invention, charging means 13 may comprise a device wherein electrical charges are produced by friction against a surface such as rubber, silk, wool, or various resinous materials.

Charging means 13 communicates at its lower end in the drawing with the upper end of conduit 19, which is constructed of a non-conducting material. Conduit 20 communicates with the lower end of conduit 19 and is employed in this invention for the purpose of introducing a gasiform fluid into conduit 19. Conduit 20 is provided with valve 21 which is employed to regulate the amount of gasiform fluid introduced into conduit 19 through conduit 20. The gasiform material utilized in the present invention may be air, nitrogen, or carbon dioxide, for example. Air is normally preferred since it is inexpensive and readily available. It is preferable for the purposes of the present invention to employ air which is relatively moisture-free so as to preclude leakage of electricity through the moisture.

Finely-divided solids which are originally contained in hopper 22 are initially introduced into conduit 20 through line 23 by opening valve 24 to place the system of the present invention in operation. The finely-divided solids employed in this invention may have a size up to about 500 microns in average diameter although it is preferable that the size range employed be about 20 to 100 microns in average diameter. Subdivided solids in excess of about 500 microns are not so readily transported by means of the aerating gas introduced into the present invention through conduit 20. On the other hand, the utilization of finely-divided solids of less than about 20 microns in average diameter may result in an excessive loss of these finely-divided solids from the system due to their small size. The finely-divided solids of this invention may be any powdered solid capable of receiving an electrical charge, such as alumina silica mullite and clays, for example. It is preferred to employ finely-divided solids of electrically non-conducting materials such as metal oxides or silicates; however, finely-divided conducting materials such as powdered metals may also be employed, although at some loss in efficiency. Finely-divided solids having a rounded or microspherical shape are particularly desirable; for example, microspheres of silica gel, alumina gel, silica-alumina cracking catalyst, glass beads and the like.

Thus, in the operation of the present invention the finely-divided solids introduced into conduit 20 are fluidized by means of the gasiform fluid passing therethrough such that the finely divided solids flow upwardly as a disperse phase through conduit 19, charging means 13, and conduit 12, which effective act as continuous disperse phase riser 30, into the interior of hollow collector 10. The superficial velocity of the gasiform fluid in disperse phase riser 30 will be about 5 to 30 feet/second and the density of the suspension therein will be about

0.1 to 10 lbs./ft.³. The particular velocity and density employed will of course depend upon the size range and material of the finely-divided solids involved. In passing through charging means 13, the finely divided solids contact charging electrodes 14 so that small electrical charges are imparted to the finely-divided solids, which charges are subsequently given up by the finely-divided solids to collector 10 primarily through contact with collecting electrodes 11. In this manner an electrical potential is developed on collector 10 which is far in excess of that potential employed at charging means 13.

The electrically discharged fluidized finely-divided solids are removed from the interior of collector 10 by means of conduit 25 which communicates with the bottom portion of collector 10. A fluid-tight seal is maintained between the outside of conduit 25 and the wall of collector 10. The suspension of the finely-divided solids in the aerating gasiform fluid passes through conduit 25 to a conventional separating means such as cyclone separator 26 wherein the suspension is introduced tangentially to the interior thereof so that the suspension is swirled around therein. In cyclone separator 26 the finely-divided solids are thrown by centrifugal action against the outer wall thereof and fall downwardly therefrom into standpipe 27. The gasiform fluid which has been substantially freed of finely-divided solids passes centrally upwardly from cyclone separator 26 through outlet pipe 28 from whence the gasiform fluid may be discharged to the atmosphere or recovered by recovery equipment (not shown), if desired.

Valve 29 in standpipe 27 is employed to regulate the amount of finely-divided solids reintroduced into conduit 19 from cyclone separator 26. Normally a portion of the circulating finely-divided solid in the system of the present invention will be maintained as a dense fluidized column 31 having an upper level L in standpipe 27. Thus, after sufficient finely-divided solids have been introduced to the system from hopper 22 to form column 31, valve 24 in line 23 will be closed and no further finely-divided solids need be added to the system except to replace any small losses which may occur through outlet pipe 28 resulting from the entrainment of a small amount of the finely-divided solids in the gasiform fluid leaving cyclone separator 26. If necessary an aerating gas may be introduced into standpipe 27 through one or more conduits (not shown) to maintain the finely-divided solids therein in a fluidized condition. Valves 29 and 21 are employed in the present system to regulate the amount of finely-divided solids circulated through the apparatus of the present invention. By opening valve 29, for example, more finely-divided solids are introduced into conduit 19, and by opening valve 21 more gasiform fluid is introduced to conduit 19 to increase the superficial velocity of the aerating gas of the present invention.

Thus, it will be seen that the present invention provides for a continuous circulation of finely-divided solids with the finely-divided solids continuously passing from standpipe 27 into conduit 19 from whence the finely-divided solids pass successively through charging means 13 and conduit 12 into the interior of collector 10. Thereafter the electrically discharged finely-divided solids are continuously withdrawn from collector 10 through conduit 25 to cyclone separator 26 from whence the separated finely-divided solids are reintroduced into standpipe 27, thus completing the cycle. It is to be understood, of course, that the present invention could be operated on a once-through basis in which case the finely divided solid would be passed through collector 10 and then discarded or recovered without any subsequent recycle of the finely-divided solid. It will be noted that the finely-divided solids in the present invention may be intimately contacted with charging electrodes 14 of charging means 13 so that a rapid transfer of electrical charges is effected. The electrical charges imparted to

the flowing finely-divided solids are then collected in collector 10 primarily through collecting electrodes 11 so that a large electrical potential on collector 10 is rapidly built up by the continuous transfer of electrical charges from charging means 13 to collector 10. The rate of transfer of these electrical charges may be increased by opening valve 29 and/or valve 21 as previously described. Although charging means 13 is shown in this specific embodiment of the present invention as being a portion of riser 30, it is to be clearly understood that the charging means could actually be installed at any other place in the system other than, of course, in collector 10. Thus, the charging means could be arranged in standpipe 27 for example, if desired.

If desired the electrical potential on collector 10 may be imparted to body 40 through electrical conduit 39 so that the high electrical potential developed by the present invention may be more readily utilized. For example, body 40 may comprise one or more voltage plates utilized to accelerate charged particles in atom smashing machines. The high electrical potential provided by the present invention may also be utilized for the generation of high energy X-rays. It may also be employed for the production of high energy electron beams which are useful for the sterilization of foodstuffs, for destruction of bacteria, for inducing mutations in seeds, for initiating certain chemical reactions and the like. The high potentials are also useful for testing insulating and dielectric materials.

The operation of this invention was carried out in the following experiment in which an apparatus somewhat similar to that shown in the drawing was employed. A finely-divided microspherical solid comprising 88% silica and 12% alumina and having a size range of about 20 to 100 microns was employed in this experiment as the charge carrying medium. The finely-divided solids in the amount of about 0.033 lb. were originally contained in standpipe 27, which was made of glass and which contained a glass stopcock valve 29. Glass standpipe 27 was about 1/2" in diameter and about 20" long. In the operation of this experiment, valve 29 was maintained partially open to permit finely-divided solids to continuously flow into conduit 19, which was also constructed of glass. A stream of air was simultaneously passed through conduit 20, which was made of glass, into conduit 19 at a superficial velocity of about 5 ft./sec. to thereby fluidize the finely-divided solids therein. In this particular experiment, charging means 13 comprised a rubber tube 8 inches long having a grounded copper wire screen wound around it. The internal diameter of the rubber tube charging means was about 1/2" in diameter. The upper portion of the rubber tube charging means communicated with a glass tube of 1/2" internal diameter which served as conduit 12. In this experiment, collector 10 comprised a round flask made of copper metal and having a capacity of one liter, which was electrically insulated from the ground by being supported by glass conduit 12.

The grounded copper wire screen was placed over about a 4" section of the rubber tube charging means near its lower end to facilitate the transfer of electrical charges from the ground to the finely-divided solids passing through the interior of the rubber tube charging means. The finely-divided solids passing upwardly with the air stream through the rubber tube charging means became electrically charged by friction against the walls of the rubber tube. The density of the air-solids suspension in the rubber tube was about 0.15 lb./ft.³. In passing into the copper flask, the finely-divided solids gave up their charges, thereby causing the copper flask collector to become electrically charged. The electrically discharged suspension of finely-divided silica-alumina and air then passed from the copper flask collector through conduit 25, which in this experiment comprised a rubber tube of about 1/2" internal diameter into cyclone sepa-

rator 26, which was made of glass. Thereafter, the separated finely-divided silica-alumina passed downwardly into glass standpipe 27. In this manner, the continuous circuit was completed.

In this experiment, a grounded 1/2" diameter aluminum rod was placed in close proximity to the copper flask collector to provide a spark gap so that the electrical potential developed on the copper flask collector could be determined. When this aluminum rod was placed about 1" from the copper flask, the copper flask was discharged across this 1" spark gap about once a second, which corresponded to an electrical potential of about 60,000 volts. From the length of the spark gap, the rate of discharge, and the dimensions of the copper flask, it was calculated that the total flow of electrical current carried by the fluidized particles amounted to about 0.4 microampere.

The efficiency of operation of the apparatus of this experiment can be improved considerably by substituting for the rubber tubing and copper wire screen an electrode or electrodes connected to a D. C. power source wherein the electrodes are arranged to be in intimate contact with the finely-divided solids flowing through charging means 13. The use of such an arrangement to charge the finely-divided solids will substantially increase the quantity of circulating finely-divided solids which are charged and, at the same time, will reduce the resistance of the path supplying the transfer of electrical charges. The high electrical potential developed on the collecting sphere in this invention may be employed in any well known manner as will be apparent to those skilled in the art. If desired, the collecting sphere of this invention may be enclosed in a high pressure chamber or a vacuum in order to minimize leakage of the high electrical potential developed on the collecting sphere to the surrounding medium.

What is claimed is:

1. Apparatus of the character described for developing a high electrical potential by continuous electrostatic induction which comprises a hollow metallic sphere adapted to receive and store electrical charges, inlet conduit means communicating with the interior of said metallic sphere and adapted to convey fluidized finely-divided solids thereto, means adapted to introduce a gasiform fluid into said inlet conduit means to fluidize finely-divided solids contained therein, outlet conduit means communicating with the interior of said metallic sphere and adapted to convey fluidized finely-divided solids therefrom, and charging means in a portion only of said inlet conduit means and adapted to impart an electrical charge to said finely-divided solids passing through said inlet conduit means.

2. The apparatus of claim 1 in which said charging means comprises a tubular member provided at its interior surface with a plurality of spaced sharp-pointed electrodes, said tubular member being electrically connected to a source of direct current electrical potential of 5,000 to 20,000 volts.

3. Apparatus of the character described for developing a high electrical potential by continuous electrostatic induction which comprises a hollow metallic sphere adapted to receive and store electrical charges, an inlet conduit communicating with the interior of said metallic sphere and adapted to convey fluidized finely divided solids thereto, aerating means adapted to introduce a gasiform fluid into said inlet conduit to fluidize finely-divided solids contained therein, an outlet conduit communicating with the interior of said metallic sphere and adapted to convey finely-divided solids therefrom, separating means communicating with said outlet conduit and adapted to separate finely-divided solids from gasiform fluid, said separating means being provided with an outlet for separated gasiform fluid, a return conduit means adapted to convey separated finely-divided solids from said separating means to said inlet conduit, and

charging means in a portion only of said inlet conduit adapted to impart an electrical charge to said finely divided solids during passage to said metallic sphere.

4. Apparatus of the character described for developing a high electrical potential by continuous electrostatic induction which comprises a hollow metallic sphere electrically insulated from ground, said sphere being provided on its interior surface with a plurality of symmetrically spaced sharp-pointed collecting electrodes, an inlet conduit member communicating at one end with the interior of said sphere and comprising an electrically non-conducting substance, a metallic tubular member communicating at one end with the other end of said inlet conduit member and provided on its interior surface with a plurality of sharp-pointed charging electrodes, said tubular member being electrically connected to a source of direct current electrical potential, tubular means for introducing a gasiform fluid into the other end of said tubular member, an outlet conduit member communicating at one end with the bottom interior of said sphere and comprising an electrically non-conducting substance, a cyclone separator communicating at its inlet with the other end of said outlet conduit member, and a standpipe communicating at its upper end with the solids outlet of said cyclone separator and at its lower end with the inlet to said tubular means.

5. A method for developing a high electrical potential by continuous electrostatic induction, which comprises fluidizing a finely-divided solid with a gasiform fluid in an aeration zone to form a fluidized solids suspension having a density in the range of between about 0.1 and 10 lbs. per cubic feet, said gasiform fluid having a superficial velocity of about 5 to 30 ft. per sec. passing the resultant suspension through a charging zone wherein an electrical charge is imparted to the finely-divided solid, passing said suspension containing the resultant electrically charged finely-divided solid to a collecting zone wherein the electrical charge of said electrically charged finely-divided solid is discharged therefrom and stored in said collecting zone, withdrawing said suspension containing the resultant electrically discharged finely-divided solid from said collecting zone and passing said suspension to a separating zone wherein said

finely-divided solid is separated from said gasiform fluid and the separated solid is resuspended in gasiform fluid and again passed through said charging zone.

6. Apparatus of the character described for developing a high electrical potential by continuous electrostatic induction which comprises a hollow metallic sphere adapted to receive and store electrical charges from finely divided charged solids discharged thereinto, said sphere being provided on its interior surface with a plurality of symmetrically spaced, sharp-pointed collecting electrodes, conduit means communicating with the interior of said metallic sphere and adapted to convey fluidized finely divided solids thereto, means communicating with the inlet to said conduit means at a region remote from said metallic sphere and adapted to introduce a gasiform fluid to said conduit means, an outlet conduit communicating at one end with the interior of said metallic sphere and adapted to convey fluidized finely divided solids therefrom, a cyclone separator communicating at its inlet with the other end of said outlet conduit, a standpipe communicating at its upper end with the solids outlet of said cyclone separator and at its lower end with the inlet to said conduit means, said conduit means being provided for a portion only of its length with charging means adapted to impart an electrical charge to said finely divided solids passing through said conduit means, said charging means being electrically connected to a source of direct current electrical potential and being electrically isolated from said conduit means.

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