CONTROL SYSTEM FOR ELECTROSTATIC PRECIPITATION

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This invention relates to an improved potential control for electrostatic dust precipitators.

A conventional electrostatic precipitator includes spaced apart electrodes connected to opposite sides of a high voltage D.C. source. Dust laden gases pass between these electrodes, where dust particles acquire negative charges and collect on the positive electrode. Dust particles conduct current between the electrodes and thus complete the precipitator circuit. To provide the most efficient dust collection, the potential applied to the electrodes should be as high as possible without producing excessive spark-over. At a given potential both the sparking rate and the current flow are functions of dust concentration. It is desirable to control the potential so that an increase in concentration beyond a predetermined allowable limit lowers the potential to minimize sparking, but otherwise the potential remains at its maximum value to collect particles more efficiently. Previous controls for this purpose with which we are familiar are governed by counting the sparking rate for a definite interval, e.g., five minutes. They embody delicate mechanical parts that respond slowly and are not dependable under the adverse operating conditions often encountered.

An object of the present invention is to provide a precipitator control which constantly monitors the precipitator current flow and immediately adjusts the potential to the electrodes whenever dust concentration increases to a point where the corresponding current flow attempts to exceed a predetermined limit.

A further object is to provide a precipitator control which eliminates mechanical parts and relies exclusively on simpler and more rugged electronic circuits and saturable reactors.

A further object is to provide a control which is governed by current flow through the precipitator rather than the sparking rate, thus eliminating any time consuming count of the latter.

In accomplishing these and other objects of the invention, we have provided improved details of structure, a preferred form of which is shown in the accompanying drawing in which:

The single figure is a schematic wiring diagram of our improved control.

The figure shows schematically a pair of A.C. supply lines 10 and 12 which are connected to opposite ends of the primary winding of a high voltage step-up transformer 13. A conductor 14 connects one end of the secondary winding of this transformer with the cathode of a conventional high voltage half wave rectifier tube 15. A conductor 16 connects the plate of this tube with the negative electrode of a conventional electrostatic precipitator 17. A grounded conductor 18 connects the positive electrode of the precipitator with one side of a load measuring resistor 19. A conductor 20 connects the other side of this resistor with the other end of the secondary winding of the transformer 13. The potential across this secondary winding is of a magnitude of several thousand volts to produce a sufficient electrostatic field between the precipitator electrodes to collect dust particles. The circuit thus far described, apart from the resistor 19, is conventional for the purpose and hence is not described in greater detail.

At any given potential the electrical conductivity between the precipitator electrodes, and hence the current flow therebetween, increase and decrease with the dust concentration. Inasmuch as the sparking rate likewise varies with dust concentration, measurement of the current flow affords a measure of the sparking rate. Our control maintains the potential at a predetermined maximum unless the dust concentration becomes so high that it produces excessive sparking, whereupon our control automatically diminishes the potential.

We employ the voltage drop across the resistor 19 as a measure of the current flow through the precipitator; the greater the current, the greater the drop. Conductors 22 and 23 are connected to the conductors 19 and 20 respectively on opposite sides of this resistor. The voltage drop across the resistor appears as a variable voltage 24 across the conductors 22 and 23.

A D.C. reference voltage source 25 is connected to the lines 10 and 12 to produce a constant but adjustable voltage V1 which opposes the voltage V2. Per se the voltage source 25 can embody conventional circuits. As illustrated, it includes a transformer 26 whose primary winding is connected to the lines 10 and 12. A rectifier 27, a voltage regulator resistor 28 and a variable resistor 29 are connected in series across the secondary winding of this transformer. A filter condenser 30 and a voltage regulator tube 31 are also connected across the secondary winding in parallel with each other and with the variable resistor 29. The conductors 22 and 23 are connected to this variable resistor, and the magnitude of the voltage V2 is controlled by adjustment of the point at which conductor 23 is connected thereto. The adjustment is such that within the operating range V1 normally remains larger than V2. Nevertheless conductor 23 contains a rectifier 32 to assure that current flows only in one direction through this part of the circuit, the direction of electron flow being indicated by the arrows. An increase in dust concentration raises the voltage V2 and thus makes it more nearly equal to the voltage V1. Conversely a decrease in concentration lowers the voltage V2 and thus increases the difference between it and V1. Consequently the magnitude of current flow in conductor 23 bears an inverse relation to the dust concentration, and if V2 increases sufficiently to overcome V1, this current flow ceases.

Our control comprises a thyratron rectifier 33 and a phase shifter 34 for governing the rectifier output. The phase shifter includes a transformer 36 whose primary winding is connected across the lines 10 and 12. A resistor 37 and a saturable reactor 38 are connected across the secondary winding of this transformer. The primary winding of a transformer 39 is connected to a center tap in the secondary winding of the transformer 36 and to the connection between the resistor 37 and the reactor 38. The A.C. voltage across the primary winding of transformer 39 can be out of phase with the voltage applied to the transformer 36, that is, the voltage across lines 10 and 12. The angle by which these voltages are out of phase depends on the relative impedance offered by the resistor 37 and that offered by the reactor 38, the latter acting as an inductor across the resistance 37 constant, the greater the inductance, the greater the phase difference. The reactor has a control winding 40 which is connected in the aforementioned conductor 23.

In accordance with well-known principles, the inductance of the reactor 38 remains at a minimum as long as there is sufficient direct current through its control winding 40 to saturate its core. Whenever current ceases to flow...
through this winding, the inductance sharply increases. Thus when dust concentration becomes excessive, the voltage across the primary winding of transformer 39 becomes far out of phase with the voltage across lines 10 and 12.

The thyatron rectifier 33 includes a transformer 43 and a pair of triode tubes 44 and 44a. The primary winding of this transformer is connected across the lines 10 and 12. The plates of the two tubes are connected to the respective ends of the secondary winding of this transformer. A conductor 45 is connected to a center tap in this secondary winding and to the cathodes of the two tubes. The grids of the two tubes are connected to opposite ends of the secondary winding of the transformer 39. The conductor 45 is connected to a center tap in this secondary winding to complete the grid circuit.

In accordance with usual principles of grid controlled rectifiers, whichever tube 44 or 44a whose plate at the moment is connected to the positive end of the secondary winding of transformer 43 tends to conduct current. The other tube whose plate is connected to the negative end does not conduct. Since the current is continually changing direction, first one tube then the other tends to conduct and produces a flow of direct current in the conductor 45. The magnitude of this current flow is governed by the phase relation between the application of a positive potential to the plates of these tubes and the application of a positive potential to the grids thereof. The grids alternately receive positive and negative potentials from the secondary winding of the transformer 39. When the voltages from the transformers 39 and 43 are in phase, both the conductivity of the tubes and the flow of current in conductor 45 are at a maximum. When these voltages are far out of phase, little or no current flows through the tubes and the conductor 45.

The line 12 contains a saturable reactor 46 beyond its connections with the reference voltage source 25. Thyatron rectifier 33 and phase shifter 34. This reactor has a control winding 47 which is connected in the conductor 45. In accordance with well-known principles, the impedance of the reactor 46 remains at a minimum as long as there is any appreciable flow of current through its control winding. Thus the voltage applied to the primary winding of the transformer 13 is a function of the current flow through this control winding. Excessive dust concentrations substantially stop flow of currents in the control winding and thus diminish the potential on the electrodes of the precipitator 17.

From the foregoing description it is seen that our control automatically and immediately lowers the potential applied to the precipitator plates whenever dust concentration becomes excessive and raises the potential when the condition passes. The operating level is determined by the value of the reference voltage V, which is set by adjustment of the variable resistor 29. Once this adjustment is made, no further adjustments are needed except when it is desired to change the operating level.

Our control operates without mechanical parts and hence is much simpler and more rugged than previous controls. While we have shown and described only a single embodiment of our invention, it is apparent that modifications may arise. Therefore, we do not wish to be limited to the disclosure set forth but only by the scope of the appended claims.

We claim:

1. The combination, with an electrostatic precipitator having an energizing circuit which includes a high voltage transformer and a rectifier, said precipitator and said rectifier being connected in series with the secondary winding of said transformer, of a control for varying the potential applied to said precipitator inversely with respect to the dust concentration comprising a variable impedance in series with the primary winding of said transformer, a resistor in series with the secondary winding of said transformer for producing a direct current voltage drop proportional to the current flow through said precipitator, means for producing a constant direct current reference voltage larger than said voltage drop and opposed thereto, a control circuit to which said voltage drop and said reference voltage are applied to produce a current whose value is a function of their difference and hence varies inversely with respect to the precipitator current, and means for regulating the magnitude of said impedance in accordance with the current in said control circuit.

2. A combination as defined in claim 1 wherein said impedance includes a saturable reactor having a control winding and said last named means includes a phase shifter connected to said control circuit and a thyatron rectifier connected to said phase shifter and to said control winding.

3. A combination as defined in claim 2 wherein said phase shifter includes another saturable reactor having a control winding, said control circuit being connected to the latter control winding to vary the phase between the input and output voltages of the phase shifter.

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