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[54] PULSE-OPERATED ELECTROSTATIC PRECIPITATOR

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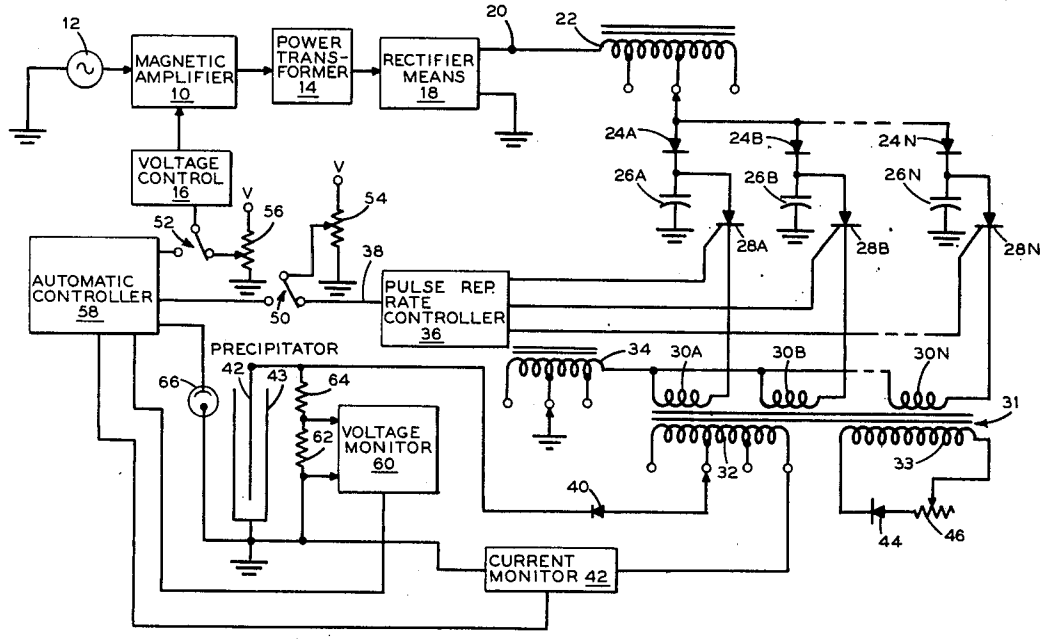
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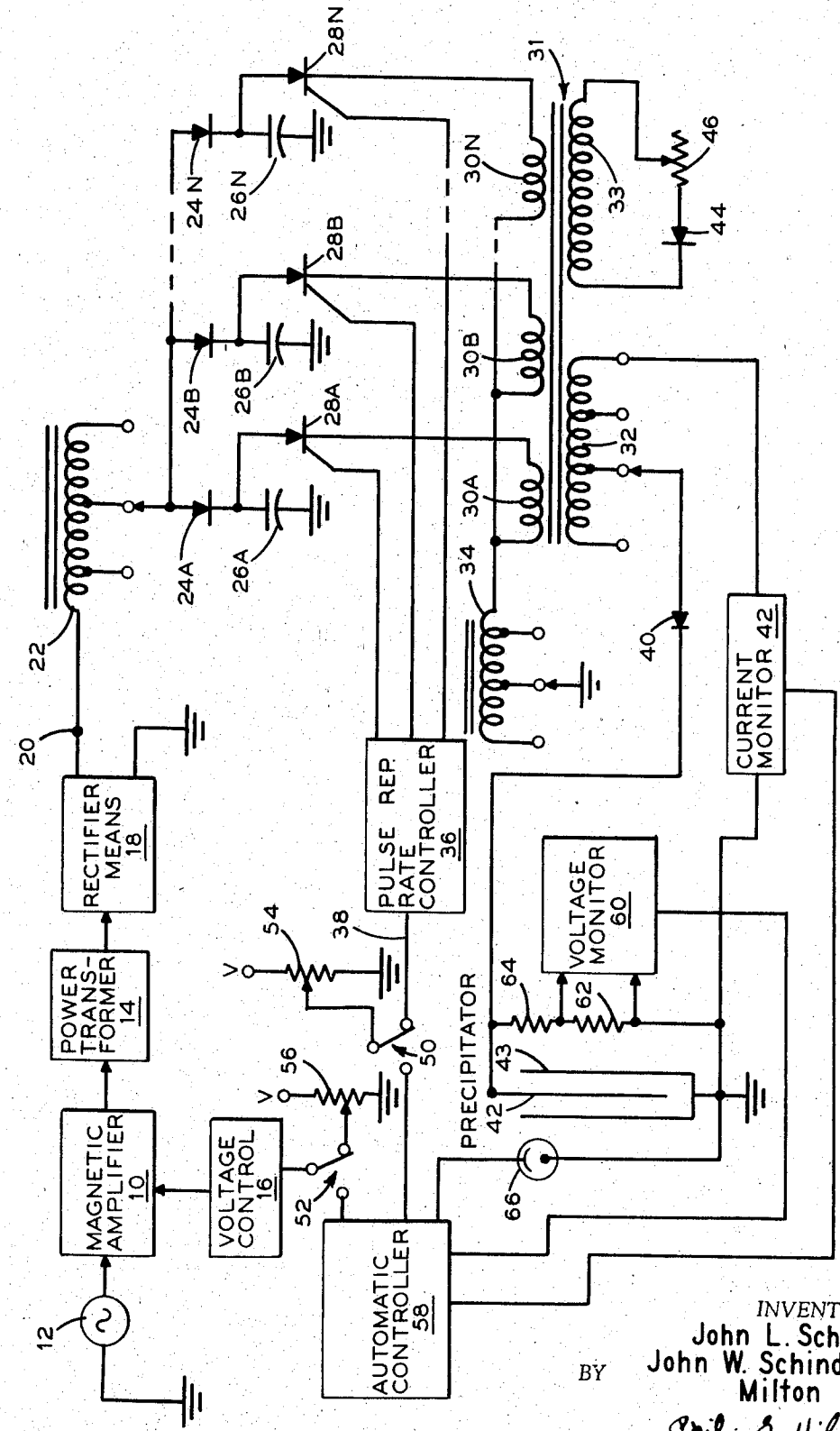
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[57] **ABSTRACT**

An electrostatic precipitator in which the discharge electrodes thereof receive electrical pulses from a power supply. The power supply includes a source of DC (direct current) energy which feeds, in parallel, a bank of capacitors, via a plurality of diodes. Periodically the capacitors are discharged, via thyristors, into parallel primary windings of a step-up transformer whose secondary winding is connected to the discharge electrode.

3 Claims, 1 Drawing Figure





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PULSE-OPERATED ELECTROSTATIC PRECIPITATOR

BACKGROUND OF THE INVENTION

This invention pertains to electrostatic precipitators and more particularly to such precipitators wherein the electrodes are fed voltage pulses.

In electrostatic precipitators, performance is influenced by the amplitude of the voltage which can be impressed on the dust-laden gas. The amplitude of the voltage which can be impressed on a well-aligned electrostatic precipitator largely depends on the gas and dust conditions between the electrodes but is also dependent on the frequency, duration and amplitude of the voltage pulses applied to the electrodes. With presently available power supplies, the pulse frequency and width are limited by the frequency of the power source, namely 60 Hz., with the pulse frequency being either 120 Hz. or 60 Hz., dependent on whether full-wave or half-wave rectification is used. In either case, pulse width is limited by the sinusoidal shape of the power source, hence, the amplitude of the voltage pulses emitted by presently available power supplies is limited by dust and gas conditions since the pulse width and frequency are essentially constant.

However, if the frequency and/or duration of the pulses can be changed, the peak amplitude of the voltage pulses can be increased to and even beyond the arcing voltage since the arc would be extinguished before it is established. Therefore, by varying the frequency and/or pulse width, momentarily higher voltages can be impressed across the collection field of the precipitator so that the increased field strength can materially enhance the deposition of gas-borne dust particles onto the grounded collector electrode or plate.

Furthermore, it now becomes possible to apply voltage pulses in the kilovolt range to the discharge electrodes. However, presently available high-voltage pulse generators cannot supply these voltage peaks with sufficient power since they use conventional amplifier circuits.

It is accordingly a general object of the invention to provide an improved electrostatic precipitator.

It is another object of the invention to provide an electrostatic precipitator which utilizes variable frequency and width voltage pulses to energize the precipitator electrodes.

It is a further object of the invention to provide electrostatic precipitators operating at peak voltage pulse amplitudes which approach or exceed the arcing voltage so as to enhance the efficiency of dust collection.

Briefly, the invention contemplates a system for transmitting controlled electrical energy pulses to an electrostatic precipitator which comprises a source of DC energy which is connected, via a unidirectional-current conduction means, to an electric-charge accumulating means. An electric-pulse-controlled rectifier-switching means periodically connects the charge-accumulating means to the primary winding of a step-up transformer whose secondary winding is connected to the discharge electrode of the precipitator.

Other objects, the features and advantages of the invention will be apparent from the following detailed description when read with the accompanying drawing whose sole FIGURE shows, in schematic form, apparatus in accordance with the invention.

In a pulse-type precipitator system, power is applied in discrete increments of electrical energy for short periods of time separated by time intervals of much greater duration. Thus, to obtain significant average power it is necessary that each energy increment be at a much higher level than pure DC or pulsating 60 Hz. DC. For example, if the power pulse is only present for 5 percent of the operating cycle and it is desired to have an average power of 60 kilowatts, then each power pulse must deliver 1.2 megawatts. Since this rate is difficult to obtain from the public utilities, the invention utilizes the technique of continuously tapping energy from a commercial source and accumulating the energy in the interval between pulses for controlled release at each pulse time.

The apparatus embodying the invention comprises the magnetic amplifier **10** which receives power from 220 volt AC (alternating current) source **12**, for example, and transmits the received power to power transformer **14**. Magnetic amplifier **10** which is of conventional design, also receives a control signal from voltage control **16** which is used to control the amplitude of the voltage fed from source **12** to power transformer **14**. The AC signal from transformer **14** is fed to rectifier means **18** which take the form of a bank of power rectifiers. The DC voltage on line **20** (connected to the output of a DC source comprising AC source **12**, magnetic amplifier **10**, power transformer **14** and rectifier means **18**) is of the order of 500 volts.

Line **20** is connected via a charging choke **22** to the anodes of diodes **24A** to **24N** (a unidirectional-current conduction means). The cathode of each diode is connected to one terminal of one of the capacitors **26A** to **26N**, respectively, whose respective other terminals are grounded. The capacitors are electrical energy or charge-accumulating means. The charging current into the capacitors is controlled by charging choke **22** so that there is just enough time to "fill" the capacitors between power pulses, i.e., the inductance of choke **22** is selected to control the charging current at a desired rate, which is a function of the pulse repetition rate and duty cycle. Due to the "resonance effect" the capacitors will be charged to twice the voltage on line **20**, i.e., about 1,000 volts, for the given example. When the capacitors **26A** to **26N** attain this voltage, diodes **24A** to **24N** are back-biased, disconnecting the capacitors from the DC power supply.

The capacitors **26A** to **26N** are connected via electric pulse-controlled rectifier-switching means to the primary circuit of a step-up pulse transformer. In particular, the junction of the anode of each diode, such as diode **24A**, and the ungrounded terminal of a capacitor, such as capacitor **26A** is connected to the anode of thyristor **28A**, with similar connections for thyristors **28B** to **28N**. While the rectifier-switching means are preferably thyristors, thyratrons, ignitrons and the like can be used. The cathode of each thyristor is connected to one leg of a primary winding of step-up pulse transformer **31**. For example, the cathode of thyristor **28A** is connected to one leg of primary winding **30A**. The other leg of each of the primary windings **30A** to **30N** is connected via discharge choke **34** to ground.

The gate electrode of each of the thyristors **28A** to **28N** is connected to the output of pulse rate controller **36** which can be free-running astable multivibrator or blocking oscillator whose repetition rate is controlled by the voltage on line **38**. Thus each time controller **36** emits a pulse, each thyristor **28A** to **28N** fires and current pulses are transferred, in parallel, from the capacitors **26A** to **26N** to their associated primary windings **30A** to **30N**. These current pulses induce a stepped-up voltage pulse in the secondary winding **32** of pulse transformer **31**. One leg of secondary winding **32** is connected via diode **40** to the discharge electrode **42** of the precipitator whose collector electrode **43** is grounded, the other leg of secondary winding **32** is connected via current monitor **42** to ground. Diode **40**, of the high-voltage type, prevents the flow back currents in the electrode circuit. In addition, pulse transformer **31** is provided with another secondary winding **33** across which are connected a diode **44** and resistor **46** in series to provide a damping circuit for the transformer. It should be noted that discharge choke **34** controls the width and "back porch" of the pulses.

The control of the pulse repetition rate and pulse amplitude can be performed manually or automatically. During manual operation, single-pole, double-throw switches **50** and **52** are in the positions shown in the drawing. Accordingly, the control voltage for pulse rate controller **36** is determined by the position of slides of potentiometer **54** connected between voltage source V and ground. Similarly, the control voltage for voltage control **16** which controls the output of magnetic amplifier **10** is determined by the position of the slides of potentiometer **56** connected between voltage source V and ground.

The automatic operation switches **50** and **52** are in their alternate position and the control voltages are generated by automatic controller **58**. The control voltages are generated in response to the current flow through the secondary circuit **32** of the pulse transformer **31** as monitored by current monitor **42**, the voltage of the discharge electrode **42** as monitored by voltage monitor **60** which measures the voltage across resistor **62** which is connected in series with dropping resistor **64** between electrode **42** and ground, or the dust content of the gas as measured by photocell **66** which is in the outlet of the precipitator.

Any one or a combination of these parameters can be used to generate the control voltages to modify the amplitude, frequency and/or width of the high-voltage pulses to optimum values for dust collection without actual arcing over in the precipitator.

What is claimed is:

1. A system for transmitting controlled electrical energy pulses to electrostatic precipitator electrodes comprising a source of direct-current energy, unidirectional-current conduction means having one terminal connected to said source of direct-current energy and a second terminal, an electric-charge-accumulating means having one terminal connected to the other terminal of said current conduction means and a grounded second terminal, an electric-pulse-controlled rectifier-switching means having an input terminal connected to the junction of the terminals of said charge accumulating means and said current conduction means, a control terminal and an output terminal, means for applying electric pulses to said control terminal, a step-up pulse transformer having at least one primary winding connected to the output terminal of said controlled switching means and a secondary winding connected to said precipitator electrodes whereby pulses of electrical energy are applied to said precipitator electrodes, said precipitator comprising at least one discharge electrode connected to said secondary winding and one grounded collector electrode in proximity to said electrode, said unidirectional-current conduction means comprising a plurality of diodes including anodes and cathodes, means for connecting each anode, in parallel, to said source of direct-current energy, said electric-charge-accumulating means comprising a plurality of capacitors, each of said capacitors having one terminal connected to the cathode of one of said diodes, respectively, and a second grounded terminal, said electric-pulse-controlled rectifier-switching means being a plurality of thyristors, each of said thyristors having an anode connected to the cathode of one of said diodes respectively, a gate terminal connected to said electric-pulse-applying means, and a cathode, and said pulse transformer comprising a plurality of primary windings, each of said primary windings having a first end connected to the cathode of one of said thyristors, respectively, and a second end connected to ground.

2. The system of claim **1** and further comprising means for monitoring an electrical parameter of the electric pulse applied to said precipitator to control the amplitude of the direct-current energy from said source.

3. The system of claim **1** and further comprising means for monitoring an electrical parameter of the electric pulses applied to said precipitator to control the rate of the electric pulses applied to said gate terminals.

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