Sept. 8, 1970 W. E. ARCHER ET AL 3,527,022

ELECTRICAL CONTROL METHOD AND APPARATUS

Filed June 18, 1969 3 Sheets-Sheet 1

Fig. 1.

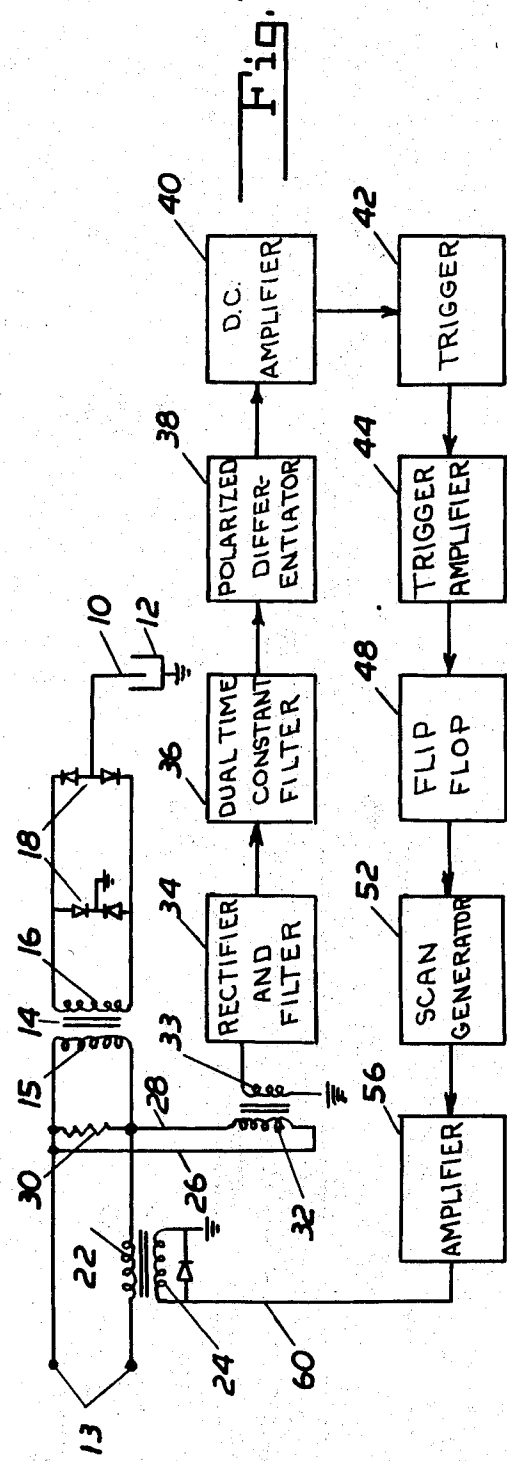
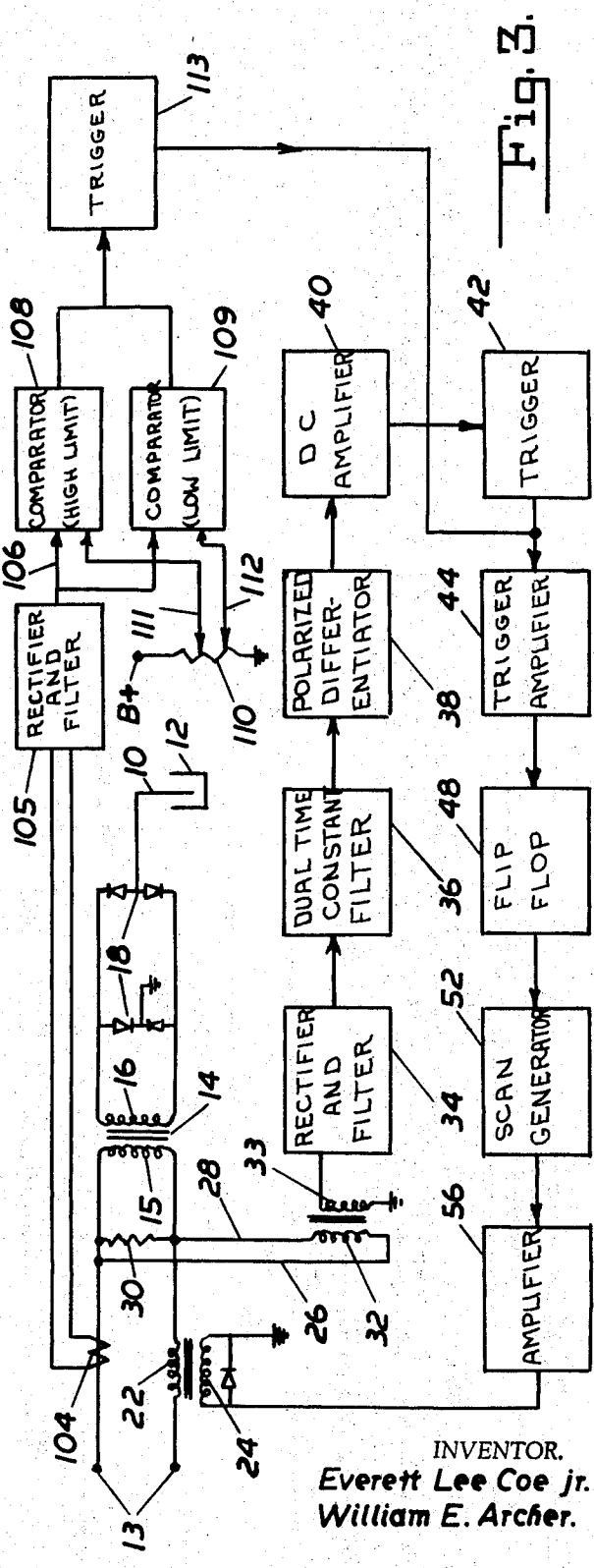


Fig. 2.



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ELECTRICAL CONTROL METHOD AND APPARATUS

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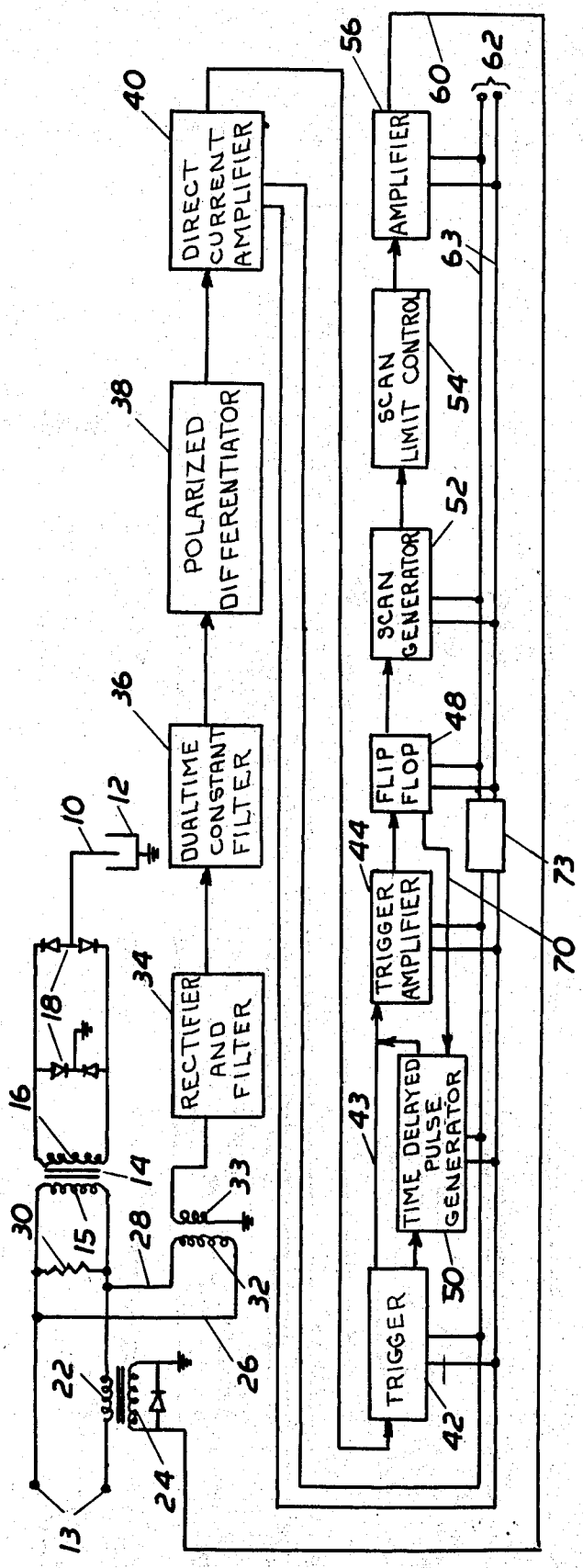


Fig. 5.

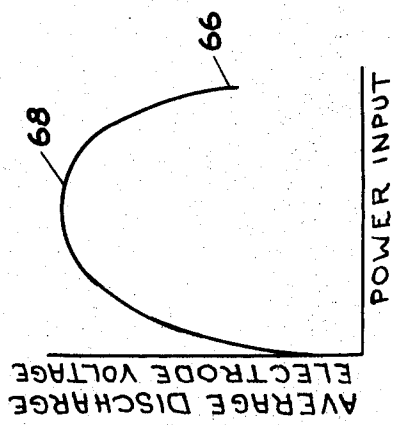


Fig. 2.

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ELECTRICAL CONTROL METHOD AND APPARATUS

Filed June 18, 1969 3 Sheets-Sheet 3

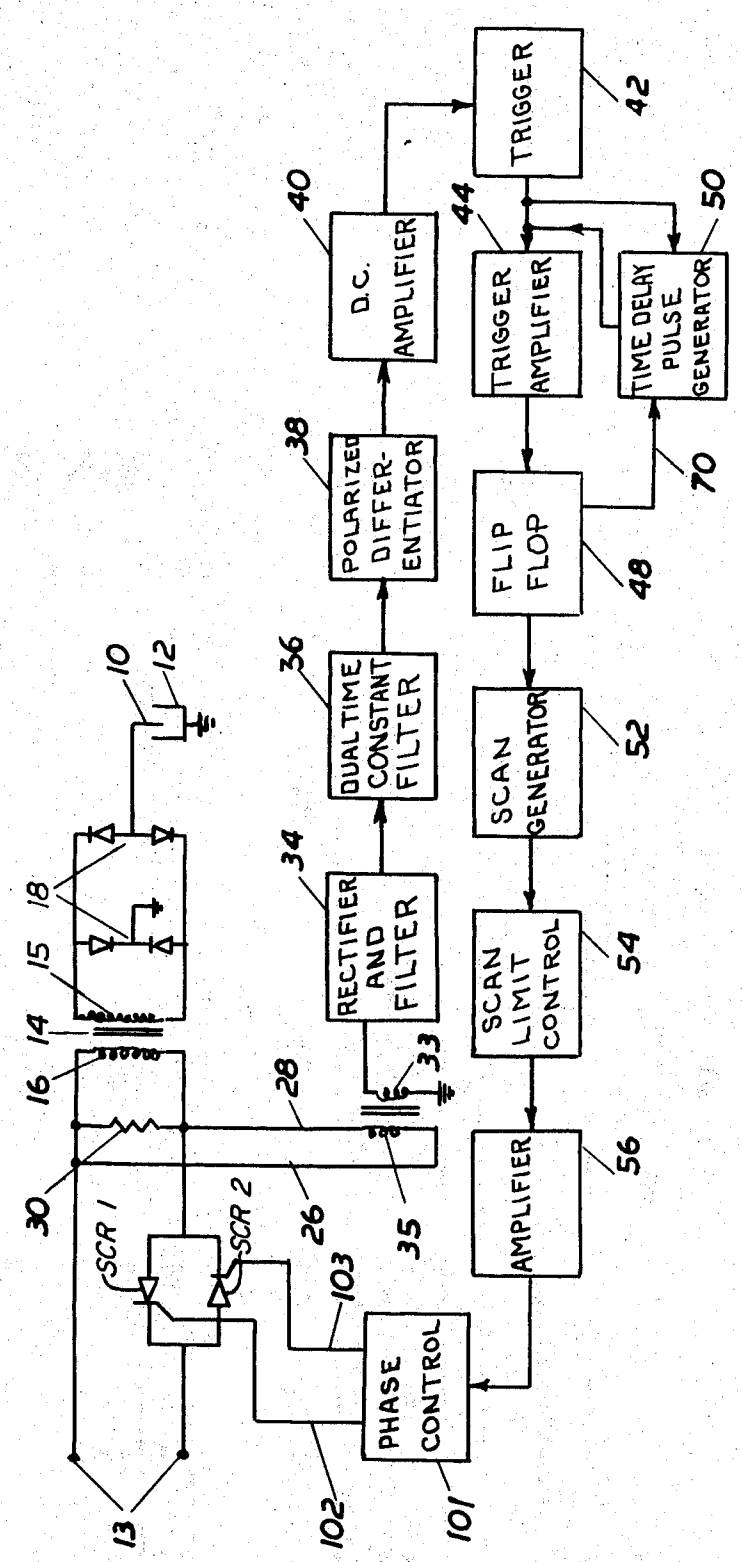


Fig. 4.

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3,527,022

ELECTRICAL CONTROL METHOD AND APPARATUS

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Int. Cl. B03c 3/68

U.S. Cl. 55—2 15 Claims

ABSTRACT OF THE DISCLOSURE

A system for controlling the average discharge electrode voltage of discharge electrodes of an electrostatic precipitator, said system having a device for generating control signals in response to a decreasing average discharge electrode voltage and a device for alternately increasing and decreasing the power input to said discharge electrodes in response to successive ones of said control signals to cause said average discharge electrode voltage to be increased through its peak value.

This is a continuation-in-part application of co-pending application Ser. No. 491,605, filed Sept. 30, 1965, now abandoned.

In the past, many systems for the automatic control of electrostatic precipitators have been developed which have recognized the various physical phenomenons occurring within an electrostatic precipitator during the operation thereof such that it is not necessary to fully describe such phenomena to those skilled in the art. For example British Pat. 859,784 published on Jan. 25, 1961, U.S. Pats. 2,943,697; 3,048,955; 3,039,253; 2,907,403 and 2,935,155 well describe various apparatuses for and methods of operating an electrostatic precipitator. As is well known during normal operation of an electrostatic precipitator:

(1) There is a continuous variation in the electrical properties of a continuously flowing stream passing through the precipitator which necessitates changes in the voltage and current to the electrode system for optimum efficiency.

(2) There is no fixed value for the discharge electrode voltage for the commencement of arc discharge.

(3) Current supplied to an electrostatic precipitator is dissipated either as corona or arc discharge.

(4) That at any given time in operating an electrostatic precipitator there is a maximum value of the average discharge electrode voltage to obtain the maximum possible efficiency of dust collection under the conditions existing at such time. The term average discharge electrode voltage has been previously defined in the prior art and is similarly defined hereinafter for the purposes of this invention.

The prior art has also recognized the limitations of the various systems of automatic control of electrostatic precipitator such as the limitations set forth in British Pat. 859,784.

Accordingly, one object of this invention is to provide a new and improved method and apparatus for operating an electrostatic precipitator to obtain the maximum value of the average discharge electrode voltage.

Another object of this invention is to provide a new and improved method of operating an electrostatic precipitator by causing the power supplied to the electrostatic precipitator to be changed as a consequence of any decrease in voltage between the precipitator electrodes, such change being made in a manner to increase the electrode voltage.

These and other objects of this invention will become more apparent when taken in conjunction with the following detailed description of a preferred embodiment thereof and the following drawings, in which:

FIG. 1 is a schematic-block diagram of a basic control system constructed in accordance with principles of this invention;

FIG. 2 is a characteristic curve of the average discharge electrode voltage plotted as a function of the power input to an electrostatic precipitator;

FIG. 3 is a schematic-block diagram of another embodiment of the control system constructed in accordance with the principles of this invention;

FIG. 4 is a schematic-block diagram of another embodiment of the present invention; and

FIG. 5 is a schematic-block diagram of a preferred embodiment of this invention.

An electrostatic precipitator as controlled in accordance with the principles of this invention comprises a plurality of discharge electrodes suitably spaced with respect to opposed collecting electrodes, which are schematically represented (FIG. 1) by discharge electrodes **10** and opposed collecting electrodes **12**. The precipitator electrodes are connected to a suitable power input circuit, which is electrically energized at input terminals **13** from a suitable source of alternating current and includes a suitable step-up transformer **14** having its secondary **16** connected to a suitable rectifier **18** the output of which rectifier **18** is connected to the discharge electrodes **10**, the collecting electrode **12** being grounded. Primary **15** of transformer **14** is connected in series with a load winding **22** of a saturable reactor and the terminals **13**. The saturable reactor has a control winding **24**, shunted by a diode **25**, for varying the current in the transformer primary **15** and consequently the voltage across the precipitator electrodes. With such a power input circuit the voltage across the primary **15** is proportional to the voltage across the precipitator electrodes. The above described components and electrical energization of an electrostatic precipitator are all well known.

For this invention a first electrical signal or input voltage signal is derived or obtained in any suitable manner whereby the derived voltage is proportional to the voltage between the precipitator electrodes. One such means comprises conductors **26–28** connected across the primary **15** and to a transformer primary **32**. A resistor **30** is preferably connected in parallel with the primary **15** to eliminate unwanted portions of the wave form in the power input circuit from the signal circuit.

A transformer secondary **33** is coupled to the primary **32** and has a pair of output conductors connected to a rectifier-filter **34**. Secondary **33** provides a continuous input signal to the rectifier-filter **34** which is isolated from the precipitator input circuit and permits the components of the remainder of the control circuit to operate at any desired voltage. Rectifier-filter **34** is of any suitable construction to provide a direct current output substantially proportional to the interelectrode voltage in a dual time constant filter **36**. Filter **36** is of any suitable structure to average its input voltage for a period of time such that its output voltage is proportional to the time average of the precipitator interelectrode voltage.

In this invention the decrease in average discharge electrode voltage initiates the desired control and as the control signal is continuously received from the precipitator input circuit the filter **36** has a dual time constant so that rising voltage signals are quickly averaged to insure that the filter **36** is capable of accepting decreasing or falling voltage signals as quickly as possible. In this context, averaging means that fluctuations of the input

voltage of the averaging circuit about its mean value, which occur at a fast rate compared to the time constant of the circuit, produce almost no change in the output from the averaging circuit, but similar fluctuations at a slower rate cause the output to vary in accordance with the applied fluctuation. Thus the output from the averaging circuit is an approximation of the mean value of the input voltage averaged over the period of the averaging circuit time constant. With increasing or rising precipitator voltage, a one second time constant for filter **36** has been satisfactory when a three second time constant is provided for decreasing precipitator voltage. Obviously other time periods can be employed; however, with a three second time period for falling voltage, the control circuit is capable of ignoring any spurious falling voltage signal received by the filter **36**, such as, for example, momentary voltage drops in the precipitator caused by occasional sparking of the precipitator. If desired, such dual time constant need not be utilized; however, the advantage of quick acceptance of decreasing voltage signals would not be obtained.

Filter **36** is connected to a polarized differentiator **38** which is energized by the output of the filter **36**. Differentiator **38** is of a structure to provide a direct currrent voltage signal output only when a decreasing voltage signal is received from the filter **36**. In this invention the voltage output of differentiator **38** is proportional to the rate of decrease of the voltage signal applied thereto and, due to the operation of the circuitry previously described, proportional to the rate of decrease of the interelectrode voltage. During normal precipitator operation with the control system of this invention, the interelectrode voltage will decrease for variable periods of time at various intervals, including periods greater than three seconds; accordingly, the output of differentiator **38** will be of variable duration or length at various or randomly spaced periods of time. The differentiator **38** is connected to a direct current amplifier **40** which amplifies each signal output of the differentiator **38** to direct current signals of a desired magnitude. Amplifier **40** is connected to the input of a pulse trigger **42** to energize the trigger **42** by each output signal of the differentiator **38**. Trigger **42** is of a structure to provide a single pulse output or signal output each time it is electrically energized by an output signal from the amplifier **40** regardless of the length of time such signal is received. The trigger **42** is connected to the input of a trigger amplifier **44**, which is of a construction to amplify each received input pulse to a desired magnitude to effect operation of a steering flip flop **48**.

The steering flip flop **48** is designed to provide one of two outputs, that is, either a high level output, for example a positive DC voltage, or a low level output, for example a zero voltage, in response to the input thereto from the trigger amplifier **44**.

The either high or low level output from the flip flop **48** is applied to a scan generator **52**. When energized at the high level output of the flip flop **48**, the generator **52** provides an increasing or rising voltage output, and, when energized at the low output level, the generator **52** provides a falling or decreasing voltage level, with the direction of change of such voltage output being the opposite or the reverse of the direction of change of the voltage output when the high level was applied.

Thus, generator **52** alternately has a slowly rising or falling direct current output dependent upon which output of the flip flop **48** is provided. Further, the change in output voltage of the generator **52** is slow in comparison with the change in output voltage of the other components previously described, typically requiring about 15 seconds to go from one extreme volue to the other while the other components have time constants typically in the order of 2 or 3 seconds. The output of the scan generator **52** is connected to the input of an amplifier **56** which is of suitable design to amplify the rising or falling voltage output signal from the scan generator **52** to a magnitude as desired. The output of amplifier **56** is connected via lead **60** to the control winding **24** of the saturable reactor.

As is known the current flow through the control winding **24** determines the impedance of the saturable reactor load winding **22** and as winding **22** is in series with the power source the impedance of the saturable reactor controls the magnitude of the current supplied to the precipitator electrodes. Increasing current in winding **24** causes the impedance of the saturable reactor to vary such that the current supplied to the precipitator electrodes also increases. Similarly decreasing current in winding **24** causes the current supplied to the precipitator electrodes to decrease. Inasmuch as the output of scan generator **52** controls the current flow to the control winding **24** further description of this invention is with reference to the output of generator **52**.

As is known, the maximum average discharge electrode voltage of an electrostatic precipitator is not constant and does not necessarily correspond to the maximum available primary current which can be applied to primary **14** or to any fixed values of current or voltage or rate of flash or arc-over. The maximum average discharge electrode voltage changes with many varying conditions; however, under all conditions of operation it does correspond to the magnitude of the precipitator current which gives the maximum possible dust collection efficiency under the conditions existing at the time the maximum average discharge electrode voltage is being determined. Thus, the term average discharge electrode voltage is for this description and invention the average value of the discharge electrode voltage measured over a reasonably long period of time up to and including several seconds dependent upon the nature of the process in which the precipitator is operating. A period as long as 3 seconds has been satisfactory; however, longer or shorter periods may be employed.

FIG. 2 illustrates a characteristic curve **66** of a precipitator as heretofore identified from which it will be noted that the average discharge electrode voltage and power input increases up to a maximum point **68** after which the average discharge electrode voltage decreases as the power input further increases. The curve **66** is merely typical of many characteristic curves that may be plotted for a given precipitator; however, the basic shape of the characteristic curve is essentially the same for all operating conditions of a precipitator.

As the average discharge electrode voltage between the electrodes increases to its maximum value shown by point **68** on curve **66**, further increases of power input to the precipitator electrodes causes the average discharge electrode voltage to decrease along the characteristic curve to the right of point **68**. Any decrease in power input to the precipitator electrodes at any time after the point **68** has been reached will also cause the average electrode voltage to decrease along curve **66** to the left of point **68**.

The control system of this invention is responsive to any decrease in average discharge electrode voltage to vary the power input such that the average discharge electrode voltage is constantly attempting to be held at a maximum. Thus, the control circuit of this invention causes the power input to the precipitator electrodes to move along the characteristic curve **66** from a point to either side of point **68**, through point **68** to a point to the other side of point **68** so that if the average discharge electrode voltage decreases on either side of point **68** the power input is changed to increase the average discharge electrode voltage. Thus, the control of this invention constantly controls the power input to the precipitator electrodes such that the average discharge electrode voltage is constantly varied toward the point **68** of maximum average discharge electrode voltage.

Considering a typical cycle of operation of the described control system of FIG. 1, assume that the precipitator is operating at an average discharge electrode voltage to the left of the maximum point **68** of FIG. 2 and

the flip flop is in its low level output state causing the scan generator **52** to provide a decreasing output. The decrease in the average discharge electrode voltage will be sensed across resistor **30** and translated through the transformer windings **32–33** to rectifier and filter **34** which will supply an output corresponding thereto the polarized differentiator **38**. In response to the decreasing voltage the differentiator **38** will provide an output to the DC amplifier **40** which in turn will supply an output to the trigger **42**. The trigger **42** supplies a pulse output which is amplified in trigger amplifier **44** and supplied as an input to the flip flop **48** causing the flip flop **48** to change from its low level output state to its high level output state. The change in output states to the scan generator **52** causes the output of the scan generator **52** to alternate from a decreasing voltage to an increasing voltage. The increasing voltage is then amplified in the amplifier **56** and applied to the control winding **24** of the saturable reactor. This increased current to the winding **24** causes increased power to be translated through the winding **22** to cause the power input to the precipitator electrodes to be increased. Thus the average discharge electrode voltage increases along the curve **66** toward the peak value **68**. When the peak is reached the average discharge electrode voltage will begin to decrease with increasing power input. This decrease will be sensed as previously described so that trigger **42** will generate a pulse in response thereto which causes the flip flop **48** to change output states from the high level to the low level state. The change of output states of the flip flop **48** causes the scan generator **52** to alternate from an increasing to a decreasing output. The power input to the precipitator electrodes is thereby increased as less current is provided to the control winding **24** of the saturable reactor. The average discharge electrode voltage thus increases along the curve **66** until the peak **68** is reached. The increasing and decreasing alternations of the output of the scan generator **52** is thus repeated as described, thereby causing the precipitator electrodes to be supplied with an average discharge electrode voltage which is scanned through the desired peak value **68**.

FIG. 3 shows a modified system wherein additional means are added to the basic system of FIG. 1 to limit the maximum and minimum current input to the system. In this limit control, a current transformer **104** is provided which senses the input current supplied from the terminals **13** to the primary winding **15** of the transformer **14**. The sensed current is supplied to a rectifier and filter **105** where it is converted to a filtered DC output **106** which is proportional to the magnitude of the primary current. The output **106** is applied to a high limit comparator **108** and also to a low limit comparator **109**. Reference inputs are supplied to the high level and low level comparators **108** and **109**, respectively, from a potentiometer **110**. The potentiometer **110** is connected between a suitable source of positive DC voltage designated B+ and ground. The potentiometer **110** is provided with two slider arms **111** and **112**. The slider arm **111** is connected to the high limit comparator **108** and supplies a higher voltage as compared to the voltage supplied from the slider arm **112** to the comparator **109**.

The comparator **108** is inoperative to compare input **106** proportionally to the input current with the reference voltage supplied by the potentiometer **110**. The reference voltage is so selected that the comparator **108** will supply an output when the input current sensed by the current transformer **104** has reached a maximum permissible value. When the current exceeds this permissible value the voltage at output **106** will exceed that provided at the slider arm **111** thereby causing the comparator **108** to supply an output to the trigger **113**. In response to the input to the trigger **113**, a pulse is supplied therefrom which is supplied to the trigger amplifier **44** for amplification and thence to the flip flop **48** to change its output state to cause the scan generator **52** to provide a decreasing rather than an increasing output voltage which in turn causes the saturable reactor to translate less power input to the precipitator electrodes. It can thus be seen that the upper limit of power input to the precipitator electrodes is limited by the setting of the high limit comparator **108**. As soon as this power limit is exceeded, the comparator **108** provides an output which in turn causes the flip flop **48** to change output states and causes the power input to the precipitator electrodes to be decreased.

The low limit comparator **109** operates in a similar fashion to limit the lowest permissible current in the primary winding **15**. Thus, the output **106** may decrease until it reaches a value as provided by the slider arm **112** of the potentiometer **110** and at that time the low limit comparator **109** will supply an input to the trigger **113** causing it to supply an output pulse which is amplified in trigger amplifier **44** causing the flip flop **48** to change output states. In response thereto the scan generator **52** alternates from a decreasing to an increasing output thereby causing an increased power input to the precipitator electrodes. The low limit comparator **109** thus establishes the minimum power input that can be supplied to the precipitator electrodes.

FIG. 4 shows another embodiment of the present invention wherein a back-to-back controlled rectifier system, such as silicon controlled rectifiers SCR1 and SCR2, are utilized for controlling the magnitude of current supplied to the primary winding **15** of the transformer **14** from the AC input at the terminals **13**. The devices SCR1 and SCR2 each include anode, cathode and gate electrodes, respectively. The anode and cathode electrodes of the devices are commonly connected with the device SCR1 being poled to translate current therethrough back to terminals **13** and the device SCR2 being poled to translate current away from the terminals **13**. A phase control **101** is provided having outputs **102** and **103**, respectively, connected between the gate electrodes of the devices SCR1 and SCR2. The input to the phase control **101** is supplied by the amplifier **56**. The phase control **101** is operative to supply gating pulses to the respective gate electrodes of the devices SCR1 and SCR2 at a predetermined time corresponding to the magnitude of voltage supplied thereto from the amplifier **56**. Thus for increased magnitudes of voltages supplied to the input of the phase control **101**, output gating pulses therefrom are at an earlier time in the positive or negative half cycle of the input AC at terminals **13**. This renders the devices SCR1 and SCR2 conductive for a longer portion of each half cycle thereby increasing the power input to the precipitator electrodes. Conversely, for decreasing magnitudes of inputs to the phase control **101**, the gating pulses are delayed to the gate electrodes of the devices SCR1 and SCR2 until later in the half cycle resulting in a lower power input to the precipitator electrodes.

Also included in the system of FIG. 4 is a scan limit control **54** connected between the scan generator **52** and the amplifier **56**. The scan limit control **54** is operative to limit the maximum and minimum voltage excursions of the scan generator **52**. Thus when the output of the scan generator **52** is increasing and reaches a predetermined maximum value, the scan limit control **54** will clamp to this value and provide a constant output until the scan generator **52** is reversed. Similarly the scan limit control will limit the minimum value of the scan generator **52** to a predetermined minimum value so that when the scan generator **52** is decreasing in voltage it cannot decrease below this preselected minimum value where it will remain clamped until the scan generator **52** is reversed. The scan limit control **54** thus maintains the maximum and minimum outputs of the scan generator **52** within defined voltage limits to insure that neither excessive power inputs are supplied which may be damaging to the various components, nor that lower than minimum power inputs are supplied which may adversely affect the operation of the system.

Additional features are provided in the system of FIG. 4 which insures proper start up of the precipitator system, prevents stalling at either limit of the output of the scan generator **52** and prevent malfunctions from disrupting system operation.

Under normal operating conditions, as described previously with respect to FIG. 1, the alternation of scan directions of the scan generator **52** in response to the flip flop **48** changing output states occurs at intervals of approximately ½ to 1½ seconds. Due to various abnormal operating conditions proper scan reversal may not take place. In order to prevent this a time delayed pulse generator **50** is provided in FIG. 4. The function of the time delayed pulse generator **50** is to cause the flip flop **48** to reverse output states after a predetermined time delay, which is non-interfering with respect to normal operation, should a malfunction occur. For example, if for some spurious condition the trigger **42** should provide an undesired output pulse causing the flip flop **48** to change output states and the scan generator **52** to reverse its direction of scan if this reversal of scan should cause the average discharge electrode voltage to decrease, the trigger **42** would be unable to respond thereto and provide an output pulse to correct the direction of scan. In the embodiment of the FIG 4, the output pulse of the trigger **42** is also applied to the time delayed pulse generator **50** wherein it is delayed a predetermined time, for example two seconds, so as not to interfere with the normal operation of the control system. Hence, if the previously described condition of decreasing voltage should persist for two seconds without scan reversal, the time delayed pulse generator **50** supplies a pulse to the trigger amplifier **44** at the end of two seconds which is amplified therein and applied to the flip flop **48** to cause it to change output states. The direction of scan of the scan generator **52** is thus reversed at this time thereby correcting the direction of scan to the proper direction so as to increase the average discharge electrode voltage as required, with proper operation of the precipitator system continuing thereafter. The spurious output of the trigger **48** is thus corrected by the delayed output of the time delayed pulse generator **50** alternating the direction of scan.

The time delayed pulse generator **50** also receives an input **70** from the flip flop **48**. The flip flop **48** is designed to provide an output **70** if the output state of the flip flop **48** does not change within a selected period of time, for example **20** seconds. The provision of the output **70** from the flip flop **48** is important at start up. For example, assume that the flip flop **48** initially goes to its low level output at start up and the scan generator **54** is at its minimum output voltage. Thus the input power to the precipitator electrodes will be very low under these conditions. Hence no trigger pulse will be provided to the trigger **42** in that no decreasing voltage is sensed. The flip flop **48** will therefore remain in its low level state indefinitely until a trigger input is supplied thereto. The output **70** is provided after a delay of, for example **20** seconds, and is further time delayed in the time delayed pulse generator for an additional time, for example two seconds, and then outputted for amplification in the trigger amplifier **44** to be applied to the flip flop **48** causing it to switch to its high level state. In response thereto the scan generator **52** will switch to its increasing output with the magnitude of the input power being increased accordingly until the peak average discharge electrode voltage (point **68** in FIG. 2) is reached. Increased power input will result in a decreased average discharge electrode voltage, and system will then operate as previously described with the decreased average input voltage being sensed to activate the trigger **42** and reverse the direction of scan.

The output **70** is also utilized if the scan generator **15** should stall at either its maximum or minimum output limits. If such were the case no further decreases in the average discharge electrode voltage could be sensed and the trigger **42** would not supply an output to cause the flip flop **48** to change to a different output state. The flip flop **48** would thus remain in the then existing output state until an output **70** were provided after the time delay of 20 seconds, for example. At the end of the time delay caused by the time delayed pulse generator **50**, an input pulse would be supplied via the trigger amplifier **44** to the flip flop **48** causing the flip flop **48** to change output states. In response thereto the scan generator **52** would reverse output states thereby reversing the stalled condition of the scan generator **52** at whichever limit the stall had occurred.

The system as described in FIG. 4 operates according to the basic principles of operation as discussed in the basic system of FIG. 1 and moreover included the additional feature of providing power input control by the use of the controlled rectifier devices SCR1 and SCR2 and the phase control **101**. Moreover, through the use of the time delayed pulse generator **50** and the interconnections thereto from the trigger **42** and the flip flop output **70**, malfunctions and stalling at either start up or during operation are corrected.

It should be noted that the block-schematic diagrams shown herein are given only by way of examples and that the various blocks could be combined in numerous functionally equivalent arrangements such as including various blocks within a larger functional block that would perform corresponding functions. In particular the additional features described with relation to FIG. 4 can be incorporated, as desired, in the controls as shown in FIGS. 1 and 3. FIG. 5 illustrates a preferred commercial embodiment in which the scan limit control **52** and the time delayed pulse generator **50** is incorporated in the control as shown in FIG. 1 in which the saturable reactor is utilized for varying the precipitator interelectrode voltage.

Preferred embodiments of this invention having been described and illustrated it is to be realized that modifications therein can be made without departing from the broad spirit and scope of this invention. It is therefore respectfully requested that this invention be interpreted as broadly as possible and be limited only by the prior art.

What is claimed is:

1. A method for controlling the average discharge electrode voltage of discharge electrodes of an electrostatic precipitator comprising the steps of: generating a control signal in response to a decreasing average discharge electrode voltage; and alternately increasing and decreasing the power input to the discharge electrodes in response to successive ones of said control signals to cause said average discharge electrode voltage to be increased repeatedly through its peak value.

2. The method of claim **1** wherein: said average discharge electrode voltage plotted as a function of said power input has a peak value for a particular power input and decreasing values for decreasing and increasing power inputs from said particular value, alternately increasing and decreasing the power input causes scanning back and forth over the plot of average discharge electrode voltage versus power input in directions to repeatedly pass through said peak value.

3. The method of claim **2** wherein the step of alternately increasing and decreasing the power input includes alternately generating an increasing scanning voltage and a decreasing scanning voltage in response to successive ones of said control signals and utilizing said increasing and decreasing scanning voltage for increasing and decreasing said power input.

4. The method of claim **3** wherein: said scanning voltages are utilized for controlling the quantity of current translated through a saturable reactor for supplying said power input in response thereto.

5. The method of claim **3** wherein: said scanning voltages are utilized for controlling the quantity of current

translated through a pair of back-to-back connected controlled switching devices for supplying said power input in response thereto.

6. The method of claim 2 wherein said step of generating said control signal includes sensing a decrease in said average discharge electrode voltage to provide a sensed signal indication thereof and processing said sensed signal to provide said control signals when said average discharge electrode voltage decreases at least at a given rate.

7. The method of claim 3 additionally having the steps of: sensing the magnitude of current translated to supply said input power and limiting the magnitude of said scanning voltages in response to predetermined magnitudes of said current sensed.

8. The method of claim 3 additionally having the step of: limiting the magnitudes of said scanning voltages to within predetermined limits.

9. The method of claim 1 additionally having the step of: generating a corrective control signal after a predetermined time delay to alternate said power input if a malfunction should occur causing said average discharge electrode voltage to decrease rather than increase.

10. The method of claim 1 additionally having the step of: generating a corrective control signal after a predetermined time delay to cause said power input to alternate if there is no alternation of said power input within said predetermined time delay.

11. A system for controlling the average discharge electrode voltage of discharge electrodes of an electrostatic precipitator comprising: means for generating control signals in response to a decreasing average discharge electrode voltage; and means for alternately increasing and decreasing the power input to said discharge electrodes in response to successive ones of said control signals to cause said average discharge electrode voltage to be increased repeatedly through its peak value.

12. The system of claim 11 wherein: said means for alternately increasing and decreasing the power input includes scanning means for alternately generating an increasing scanning voltage and a decreasing scanning voltage in response to successive ones of said control signals, and power translating means for translating increasing and decreasing input power to said discharge electrodes in response to said increasing and decreasing scanning voltages.

13. The system of claim 11 additionally having: means for limiting said power input to predetermined limits.

14. The system of claim 11 additionally having: delay means for causing said means for alternately increasing and decreasing said power input to alternate said power input if an alternation does not occur within predetermined delay times.

15. A method of controlling the average discharge electrode voltage during the normal operation of an electrostatic precipitator which is continuously electrically energized by electrical power obtained from a substantially constant voltage supply system and during which operation the voltage between the electrodes is variable by varying the current supplied to the electrodes and which voltage variations includes intervals of decreasing voltage of variable duration, comprising, continuously deriving an electrical signal which is proportional to the voltage between electrodes of an electrostatic precipitator, deriving an electrical control signal from said continuously derived electrical signal during each interval said continuously derived electrical signal decreases for at least a given period of time to thereby provide recurring ones of said control signals, and alternating by successive ones of said control signals the continuous supply of electrical current to the electrodes of the precipitator between periods during one of which periods the current supply continuously increases and during the other of which periods the current supply continuously decreases.

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