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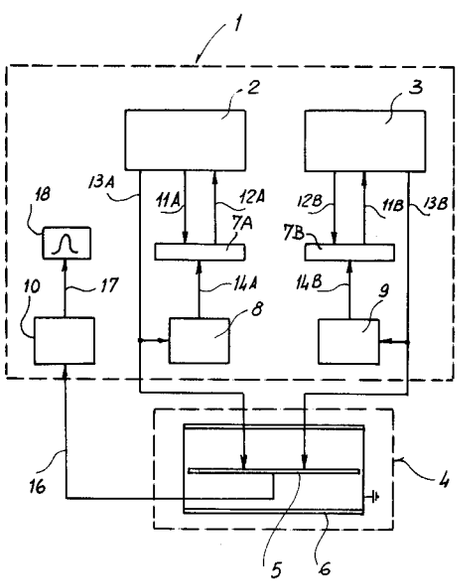
(54) An assembly for controlling a voltage pulse feeder in a electrostatic precipitator.

(57) This assembly is provided with sender electrodes (5) and collecting electrodes (6), is associated with a first generator (2) of a base direct voltage, which voltage is applied to said sender electrodes (5), is associated with a second generator (3) of auxiliary direct voltage, which voltage generates voltage pulses applied to said sender electrodes (5), and comprises a first voltage controller (7A) located between said first generator (2) and a first voltage divider (8) for the base direct voltage as well as a second voltage controller (7B) located between said second generator (3) and a second voltage divider (9) for the auxiliary direct voltage in order to draw to zero all the variations of said two voltages as caused by a the interdependency between said same two voltages.

Fig. 1



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This present invention relates to an assembly for controlling a voltage pulse feeder in an electrostatic precipitator, in particular in an electrostatic precipitator in a coal combustion plant and, anyway, in a plant wherein particles are to be collected which have an high resistivity, from 10^8 Ω . cm and over.

The prior art comprises in said precipitators voltage pulse feeders (which will be referred to only as - feeder(s) - in the following description) by means of which the insulated electrode is given a negative polarity direct voltage of some tens of kV, to which direct voltage, voltage pulses are added which range from tens to hundreds of microseconds (μ s) with a convenient frequency and peak values of some tens of kV (said negative polarity direct voltage will be referred to only as - base direct voltage - in the following description). As known, the voltage pulses having short life and proper voltage give the ash particles in the smokes remarkable electric charges so that the electric field generated by the base direct voltage works to collect the particles by electrostatic action.

In particular, the prior art comprises feeders made according to two different assemblies :

a) an assembly that generates the voltage pulses starting from an auxiliary direct voltage source of relatively low voltage and adds said pulses to the base direct voltage through a step-up transformer and the interpositioning of a capacitor having capacity suitable for said auxiliary direct voltage.

b) an assembly that generates the voltage pulses starting from an auxiliary direct voltage source of high voltage and adds said voltage pulses to the base direct voltage, still by the interpositioning of a capacitor of capacity suitable for said auxiliary direct voltage , but without using a stepup transformer.

The peculiarity of both said assemblies is to afford manually or automatically an independent control of the base direct voltage and voltage pulse amplitude.

A drawback in the prior art is that the efficiency in collecting the solid particles is much jeopardized by unsteadyness of said voltages and, particularly after a discharge in a precipitator, is jeopardized on resetting the base direct voltage and the amplitude of the voltage pulses. After investigating about the reasons of such drawback, the inventor found that the base direct voltage and the pulse voltage added thereto are interdependent in other words, when one of said voltages rises the other lows, and vice versa. It is just this interdependency that makes unsteady the working of the voltage pulse feeder and prevents from optimizing its control assembly, the nature of this drawback being well realized if one considers that the ashes produced from coals of different kinds present different resistivities and consequently the precipitators installed in a combustion plant should fit with different ashes.

The object of this invention is to obviate the low efficiency caused by said interdependency between said voltages in the assemblies according to the prior art.

The invention, as characterized in the claims, provides an assembly which automatically keeps steady the base direct voltage on varying the pulse amplitudes added thereto and, similarly, automatically keeps steady the auxiliary direct voltage in order to generate the pulse on varying the base direct voltage. This assembly works to generate the base current voltage and/or the pulse voltage irrespective of the control being manual or automatic.

The invention will be described in detail herebelow with reference to the accompanying drawings which illustrate specific embodiments , in which:

FIG. 1 is a much simplified diagram showing a control assembly,

FIG. 2 is the diagram of pulse feeder assembly provided with a step-up transformer,

FIG. 3 is the diagram of a pulse feeder assembly not provided with a step-up transformer and

FIG. 4 is the diagram of an electronic controller for operating the feeders allustrated in Figures 1, 2 and 3 by a base current voltage kept steady automatically.

Fig. 1 shows an assembly comprising: a feeder 1 comprising a base direct voltage generator 2; an auxiliary direct voltage generator 3 which generates voltage pulses; a precipitator 4 comprising an insulated filiform sender electrode 5, and a collecting electrode 6 for collecting solid particles; a couple of electronic controllers 7A, 7B made by the firm SIATEM in Padova (Italy) with components type L141 and μ A747, respectively adapted to control automatically the base direct voltage and the auxiliary direct voltage for generating pulses and to balance for both voltages all the variations caused by said interdependency; a voltage divider 8 which shows continuously the value of the base direct voltage; a voltage divider 9 which shows continuously the value of the direct voltage associated with the voltage pulses; a voltage divider 10 which shows continuously the value of total voltage on the precipitator 4; wires 11A, 11B; 12A, 12B respectively connecting said generators with said electronic controllers 7A, 7B; wires 13A, 13B respectively connecting said generators with the voltage dividers 8, 9 and said sender electrode 5; wires 14A, 14B respectively connecting said voltage dividers 8, 9 with said electronic controllers 7A, 7B; a wire 16 connecting said sender electrode 5 with said total voltage divider 10 and a wire 17 connecting said total voltage divider 10 with an oscilloscope 18 which continuously shows the value of the total voltage on the sender electrode 5.

In general, it was experienced that the collecting highest efficiency in the electrostatic precipitator is obtained by setting and keeping steady a predetermined value of the base direct voltage selected depending on the amount and quality of the solid particles in the precipitator; to the base direct voltage a collecting voltage pulse is added whose amplitude is increased gradually until a discharge occurs in the precipitator. Said collecting voltage pulse shall be of low frequency, from 1 Hz to 50 Hz. Immediately after the discharge, the base direct voltage and the pulse voltage are drawn to zero by the control assembly and, after a predetermined time period of some tens of milliseconds, the base direct voltage rapidly returns to the predetermined value, while the pulse voltage rapidly returns to that value which caused the discharge, reduced by a predetermined percentage, and then it increases along a low slope until a further discharge occurs in the precipitator.

Fig. 2 shows an assembly comprising:

- a set of thyristors 20 in antiparallel which control the three-phase voltage applied to a step-up transformer 22 that, feeds the circuit which generates the pulses;
- a group 21 controlling the starting step of thyristors 20;
- said step-up transformer 22;
- a group 23 for rectifying the feeding of a capacitor 24 whose discharge causes the pulse generating voltage;
- a block and equalization inductance 25;
- a step-up transformer 26 for the pulse amplitude provided with
  a primary winding 27 under a maximum voltage of about 8 kV,
  a secondary winding 28 under a high voltage with a maximum pulse amplitude of about 100 kV;
- thyristors 29 provided with diodes in antiparallel whose starting generates the oscillating voltage which causes the pulse;
- an inductance 30 that, added to the leakage inductance of the step-up transformer 26, defines the pulse life;
- a set of thyristors 31 in antiparallel for controlling the three-phase voltage applied to a transformer 33 which feeds the circuit of the base direct voltage;
- a group 32 which controls the starting step of the thyristors 31;
- a step-up transformer 33;
- a rectifier 34 for the base direct voltage;
- a block inductance 35;
- a capacitor 36 which separates the base direct voltage from the secondary winding of the pulse step-up transformer 26;
- electrodes 37 receiving the sum of the base direct voltage and the pulse voltage;
- a voltage divider 38 detecting the value of the direct voltage associated with the pulse voltage;
- a voltage divider 39 for the base direct voltage;
- an electronic controller 40 receiving the voltage from the voltage dividers 38, 39 and from a voltage divider 41 which will be better described hereinafter; in particular, this voltage divider 41 receives the voltages from the voltage dividers 38, 39 and delivers to the assemblies 42, 43 (defined hereinafter) separate signals proportional with the value of the base voltage and of the direct voltage associated with the pulses;
- the above mentioned assembly 42 that receives the signal of the direct voltage associated with the voltage pulse supplied from the electronic controller 40 and delivers said signal to the phase control 21 which finally is the means that controls the pulse amplitude;
- the above mentioned assembly 43 that receives the signal of the base direct voltage supplied from the electronic controller 40 and delivers said signal to the phase control 32 which finally is the means that controls the value of the base direct voltage;
- the above mentioned voltage divider 41 for detecting the peak value of the voltage applied to the node A (base voltage plus pulse amplitude), this node being connected with said electrodes 37 in the precipitator 44.

Fig. 3 shows an assembly comprising;

- a set of thyristors 50 in antiparallel for controlling the three-phase voltage applied to a transformer 52 which feeds the base direct voltage circuit;
- a group 51 which controls the starting-phase in the thyristors 50;
- a step-up transformer 52;
- a rectifier 53 for the base direct voltage;
- a block inductance 54;
- a capacitor 55 for separating the base direct voltage circuit from the pulse generating circuit;

- a voltage divider 56 for the base direct voltage;
- a set of thyristors 57 in antiparallel for controlling the three-phase voltage applied to a step-up transformer 59 which feeds the pulse generating circuit;
- a group 58 for controlling the starting phase in the thyristors 57;
- said step-up transformer 59;
- a group 60 for rectifying the feeding to a capacitor 61 whose discharge causes the pulse generating voltage;
- a block inductance 62;
- a voltage divider 63 for detecting the value of the direct voltage associated with the voltage pulse (because the life of the pulse is very short with respect to the time between two subsequent pulses);
- thyristors 64 provided with diodes in antiparallel whose starting causes the oscillating voltage which generates the pulse;
- a voltage dividers 65 for detecting the peak voltage applied to node A (base voltage plus pulse amplitude);
- an inductance 66 for defining the pulse life by the capacity provided by capacitors 55, 61 and a precipitator 67 as mentioned hereinafter, in series;
- electrodes 68 that receive the sum of the base voltages and the pulse voltage,
- said precipitator 67;
- an electronic controller 69 which receives the voltages from the voltage dividers 56, 63 and 65. In particular, this controller takes the voltage values supplied from the voltage dividers 56 and 63 and delivers to the below specified assemblies 70, 71 separate signals relevant to the base voltage value and to the direct voltage value associated with the pulses;
- the above mentioned assembly 70 takes the signal from the base direct voltage as delivered by the electronic controller 69 and supplies said signal to the control group 51 that finally controls the value of the base direct voltage;
- the above mentioned assembly 71 takes the signal from the base direct voltage associated with the voltage pulse as delivered by the electronic controller 69 and supplies said signal to the control group 58 that controls the starting step which finally controls the voltage pulse amplitude.

Fig. 4 is a diagram of an electronic controller which may be used for automatically keeping steady, in the illustrated case, the base direct voltage for the feeder as illustrated in Figures 1, 2 and 3. A similar electronic controller is used for automatically keeping steady the auxiliary direct voltage associated with the pulses.

Said controller comprises:

- a potentiometer 80 located on the feeder control boards for setting the base direct voltage to be stabilized;
- a terminal 81 in the potentiometer 80 fed with a direct stabilized voltage of 15 V;
- a voltage divider 82;
- a terminal 83 connected with the low voltage shunt in the voltage dividers 39, 56 respectively of Figures 2 and 3;
- a chart 84 containing all the components of the controller ;
- an input impedance 85;
- an operational amplifier 86;
- an integration grid 87 for generating rapid upward slopes after discharges;
- an input impedance 88;
- an operational amplifier 89 working as a reverser;
- a resistor 90 for adapting the signal;
- resistors 91 for comparing the signals coming from potentiometer 80 and voltage divider 82;
- an input impedance 92;
- an operational amplifier 93 working as error amplifier;
- a regulation grid 94 for the control system of the base direct voltage;
- an assembly 95, equivalent to assemblies 43 and 70 respectively in Figures 2 and 3, which receives the control signal at a terminal 96;

Specifications are supplied herebelow which show operational values for a pulse feeder according to the invention associated with an electrostatic precipitator wherein the plate spacing is 300 mm and the diameter of the filiform electrodes is 5 mm, the SCA, specific collecting area, is about 150 $m^2/m^3/sec$, there are three electric fields in series and the smokes enter at about 150 ° C temperature produced by combustion of a South African coal known as AMCOAL:

- Base direct voltage: about 30kV

  This voltage is steady since the control assembly which generates the voltage is set manual. Anyway, this voltage is inclined to lower while increasing the amplitude of the voltage pulse, but the assembly according to the invention keeps this voltage steady at the predetermined value.

- Voltage pulse value about 45kV

  The control system for generating the pulses is set in automatic and the amplitude of the pulse increases until discharge is reached.

- Life of the voltage pulse about 70μs
- Pulse frequency " 10Hz
- Total voltage on the precipitator " 75kV

  Such voltage value corresponds to the voltage level at which the discharge occurs and results from the addition of the base direct voltage with the voltage pulse.

- Current density in the precipitator about 1-2 $\eta A/cm^2$
- Number of dicharges in a minute in the precipitator 2 - 4
- Collecting efficiency in the precipitator about 99.9%

Claims

1. An assembly for controlling voltage pulse feeders for an electrostatic precipitator (4) which is provided

with insulated sender electrodes (5) and collecting electrodes (6) for collecting solid particles in the smokes and is associated with a generator (2) of a base direct voltage applied to said sender electrodes and to a generator (3) of an auxiliary direct voltage in order to generate voltage pulses applied to said sender electrodes, the assembly being characterized in that it comprises a first voltage controller (7A) located between said generator (2) of base direct voltage and a voltage divider (8) for the base direct voltage as well as a second voltage controller (7B) located between said generator (3) of auxiliary direct voltage and a voltage divider (9) for the auxiliary direct voltage in order to draw to zero all the variations of said two voltages caused by the interdependency of said same two voltages.

2. An assembly according to claim 1 characterized in that the frequency of said voltage pulses ranges between 1 Hz and 50 Hz.

3. An assembly according to claim 1 characterized in that it comprises: a first voltage divider (8) connected with said first voltage controller (7A) and said generator (2) of base direct voltage for continuously detecting and indicating to said voltage controller (7A) and to an operator the value of the base direct voltage; a second voltage divider (9) connected with said second voltage controller (7B) and said generator (3) of auxiliary direct voltage for continuously detecting and indicating to said voltage controller (7B) and to an operator the value of the auxiliary direct voltage associated with the voltage pulses; a third voltage divider (10) connected with said sender electrode (5) for continuously detecting and indicating the value of the total voltage in the precipitator (4).

4. An assembly according to claims 1, 2, 3 characterized in that it adds a voltage pulse which increases gradually until a discharge occurs in the precipitator to a preselected value of the base direct voltage , that after said discharge the base direct voltage and the pulse direct voltage are drawn to zero during a time period of some tens of milliseconds and then the base direct voltage is rapidly drawn to said preselected value and the direct voltage associated with the pulses is rapidly drawn to that value it had before the discharge , but reduced by a predetermined percentage, and then, by a predetermined low rise slope, it increases until a value required for a further discharge is reached.

Fig. 1

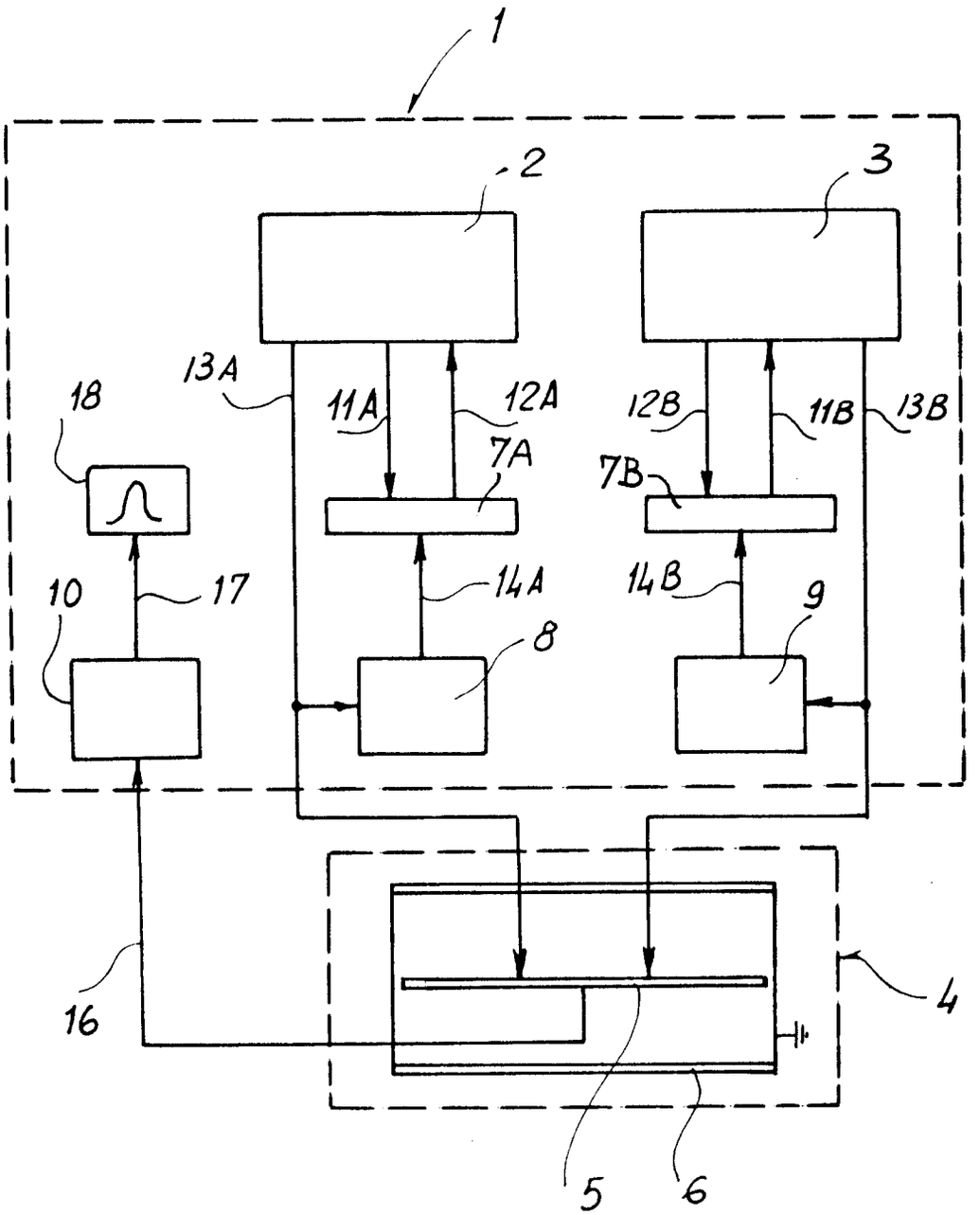

Fig. 2

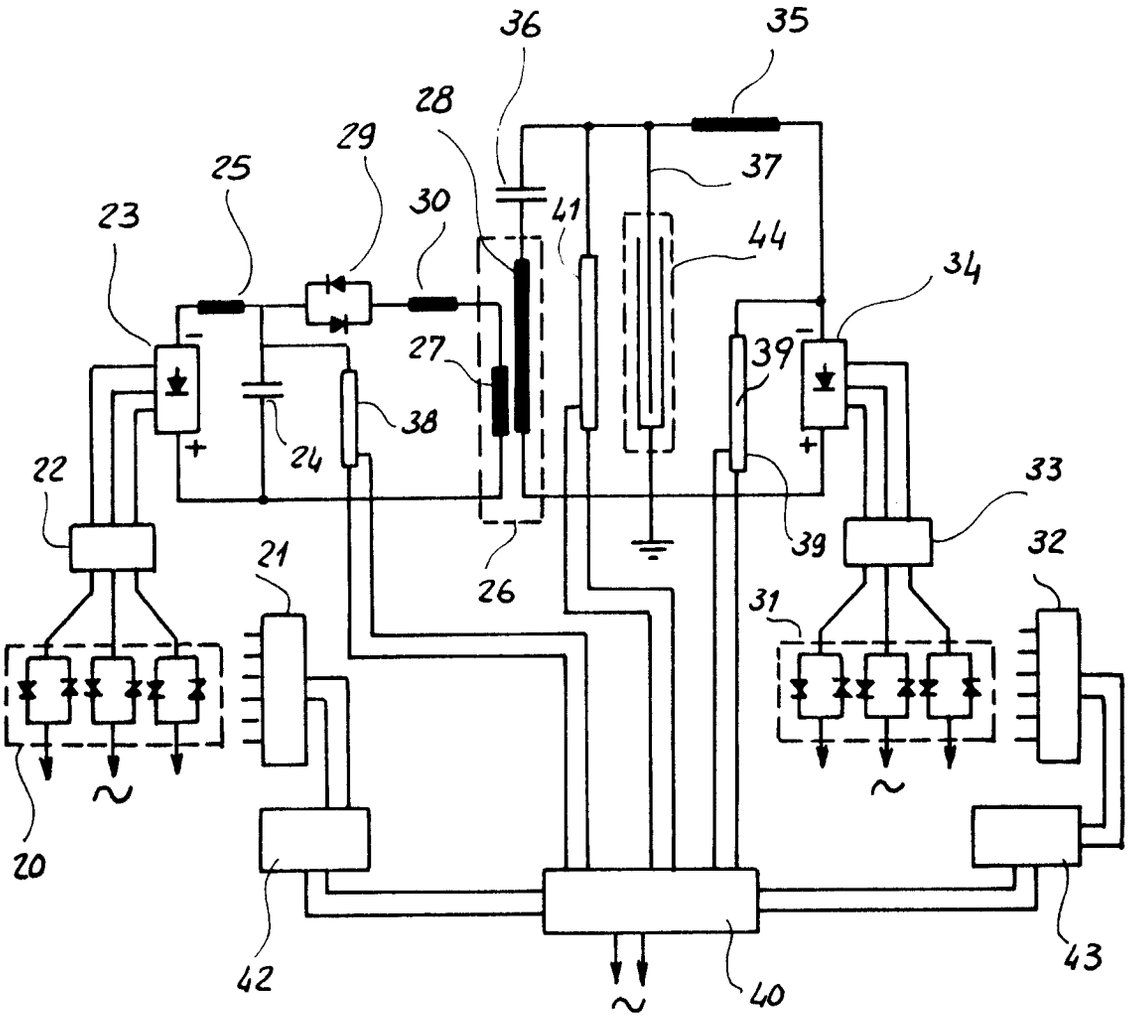
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Fig. 3

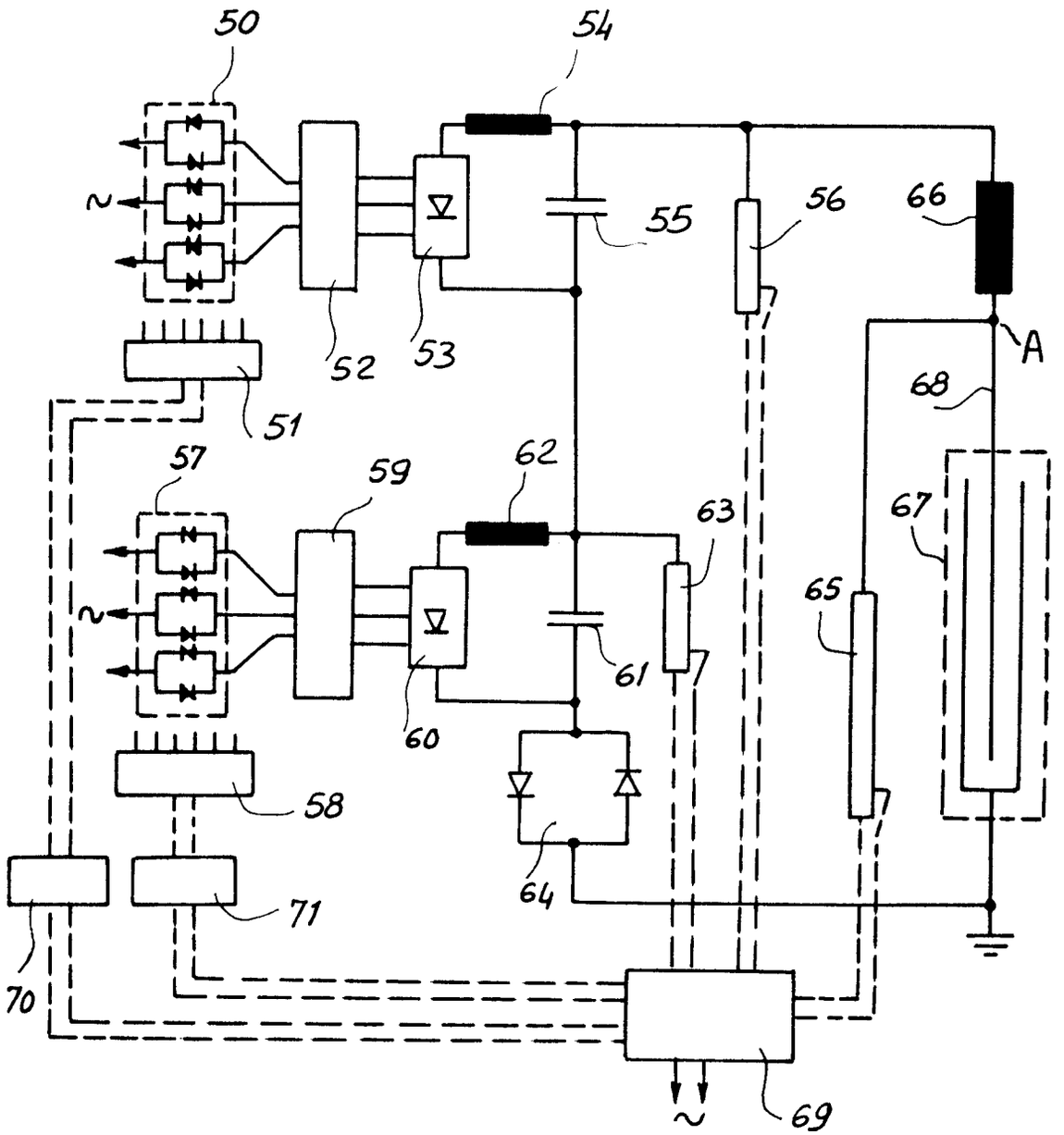
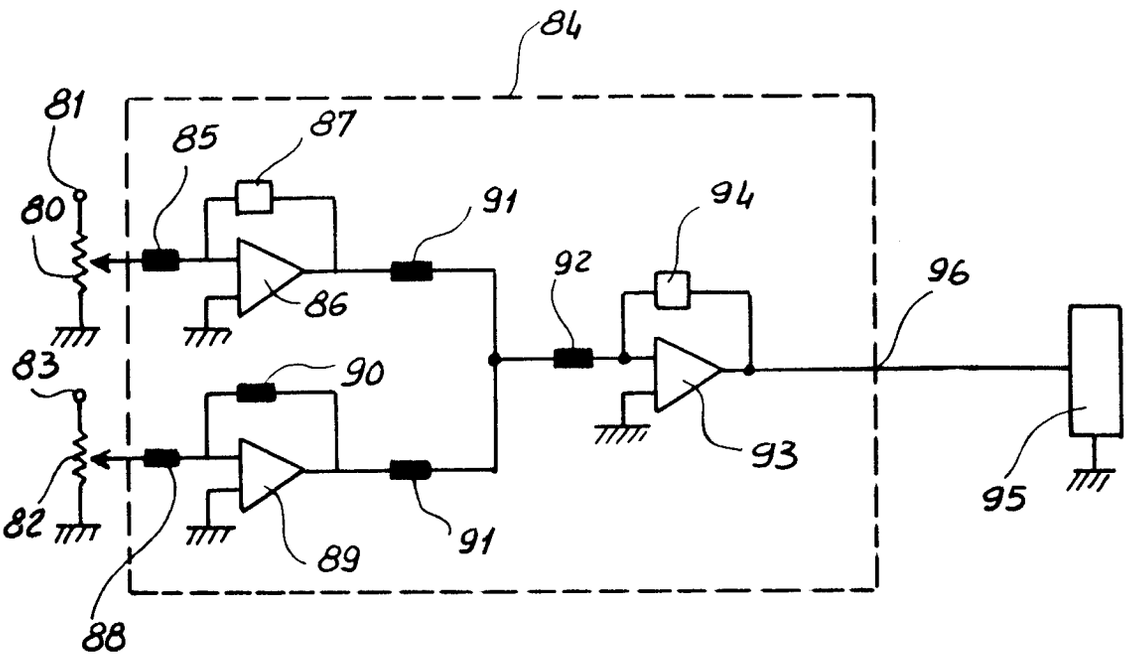
Fig. 4