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(54) **MULTI PULSE LINEAR IONIZER**

MEHRFACHPULS LINEARIONISIERER

IONISATEUR LINAIRE A IMPULSIONS MULTIPLES

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of U.S. Application No. 13/210,267, filed 15 August 2011, which is a continuation of U.S. Application 12/049,350, filed 16 March 2008 and issued as U.S. Patent 8,009,405, which claims the benefit of and priority to U.S. Provisional Application No. 60/918,512, filed 17 March 2007.

[0002] This Application is also a continuation-in-part of U.S. Application No. 13/023,397, filed 8 February 2011.

BACKGROUND OF THE INVENTION

[0003] Field of the Invention: This invention relates to AC corona ionizers for both positive and negative static charges neutralization. More particularly, this invention is relates to AC corona ionizers with a relatively low by-product emission, such as, ozone, nitrogen oxides and the like, and that achieves a low rate of ion emitter contamination.

[0004] Background Art: AC corona ionizers are commonly used for static charge neutralization of charged objects. It is known in the art that AC corona ionizers include the features of, for example, a relatively simple design, high reliability, and low cost. These features are particularly true for AC ionizers using a single ion emitter configured as a line thin wire(s) or line of pointed electrodes. However, these ionizers are prone to a relatively high ozone emission and higher rate of electrode contamination by collecting debris from the surrounding air. Electrode contamination decreases the ionization efficiency and may affect ion balance.

[0005] Accordingly, a need exists for a solution for static charge neutralization that has a relatively low rate of emitter contamination, a relatively low ozone emission, and/or a combination of the foregoing.

SUMMARY

[0006] The invention as defined by claim 1 provides an air/gas ionizing apparatus and method that produce both positive and negative ions for reducing electrostatic charges on various objects. Embodiments of the invention may achieve one or more of the following possible advantages:

- (1) Providing a sufficient level of plus and minus ion currents while limiting the ozone and other corona byproducts emission(s);
- (2) Reducing the buildup of particles on the emitter points or wire electrodes and minimizing the contamination associated with corona discharge particle emission from the ionizing bar;
- (3) Automatically maintaining a reasonably close to zero ions stream balance; and/or
- (4) Providing a design of a low cost power supply

and low maintenance ions generating system.

[0007] In one particular embodiment, the high voltage applied to the points or the wire electrode is designed to be of very low power and high ionization efficiency. This is accomplished by using very strong, micro-second wide pulses at a very low rate. A flyback type generator produces such waves naturally in a resonant circuit. Each wave includes at least three voltage peaks: a beginning low amplitude peak, a second high amplitude peak of opposite polarity, and a final low amplitude peak (wave). Typically, only the high level wave is used for ionization. The first wave and third wave can be reduced greatly in amplitude by a proper damping, as explained later. The use of such low power reduces ozone generation, corona byproduct production, collection and shedding of particles, and wear of the emitters.

[0008] In yet another particular embodiment, an ionization method includes providing a pulse duration that is relatively short such that an applied power is enough (or sufficient) for a corona discharge to generate positive and negative ions but not enough (not sufficient) to generate ozone and nitrogen oxides, erode emitter, and/or attract particles from ambient air

[0009] In yet another particular embodiment, an ionization method may optionally include providing a simultaneous application of voltage to a linear wire or group of linear emitters in order to reduce the usual ion density variation effect between points, and allow an even ion balance distribution along the length of the ion emitter structure. In another embodiment, this optional method may be omitted.

In another embodiment, a method for generating ions within a space separating an emitter and a reference electrode, the method comprising: generating a variable number of small sharp pulses and rate of the pulses depending on the distance of the target from the emitter.

[0010] In yet another embodiment, an apparatus and a method for generating ions within a space separating an emitter and a reference electrode, includes: providing at least one pulse train to the emitter, the pulse train pair including a positive pulse train and a negative pulse train the alternate in sequence, the positive pulse train including a first plurality of ionizing positive voltage pulses during a positive phase and a second plurality of ionizing positive voltage pulses during an ionization frequency phase which occur after the positive phase, and the negative pulse train including a first plurality of ionizing negative voltage pulses during the ionization frequency phases a second plurality of ionizing negative voltage pulses during a negative phase which occur after the ionization frequency phase; wherein each of the first plurality of ionizing positive voltage pulses has a greater magnitude than a magnitude of each of the second plurality of ionizing positive voltage pulses; and wherein each of the first plurality of ionizing negative voltage waveform has a greater magnitude than a magnitude of each of the second plurality of ionizing negative voltage

pulses.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Figure 1 illustrates voltage waveforms of positive and negative ionizing pulses and pulse trains, in accordance with an embodiment of the present invention.

Figure 2 illustrates a scope screen shot with a voltage waveform of exemplary train positive and negative ionizing pulses in the real time domain.

Figure 3a shows schematic diagram of one analog/logic base embodiment for an ionizing bar with one wire type emitter electrode.

Figure 3b shows waveform diagrams into various inputs of various components in Figure 3a.

Figures 4a and 4b are block diagram of a microprocessor based embodiment.

Figures 5a, 5b and 5c shows multi-Pulses in three differed modes to optimize high voltage waveform (pulse trains) for different charge neutralization conditions, in accordance with an embodiment of the present invention.

Figure 5d is a flow diagram of a method performed by a software executed by the controller of Figures 4a and 4b, in accordance with an embodiment

Figure 5e is a table that shows multi-pulse settable parameters and corresponding definitions and exemplary parameter range values, in accordance with an embodiment of the present invention.

Figures 5f, 5g, and 5h shows multi-pulses in three differed modes based on settings different from Figures 5a, 5b, and 5c, in accordance with an embodiment of the present invention.

Figure 6[[a and 6b]] shows schematic diagrams of another embodiment as a dual phase ionizing bar with two (wire or point type) emitter electrodes.

Figure 7 shows variants of self balancing ionization structures for linear bar, in accordance with an embodiment.

Figure 8 shows general view of linear bar with wire emitter and air assist ion delivery system, in accordance with an embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0012] In the following detailed description, for purposes of explanation, numerous specific details are set forth to provide a thorough understanding of the various embodiments.

[0013] An embodiment of the present invention can apply to many types of air-gas ionizers configured as ionizing bars, blowers, or in-line ionization devices.

[0014] Pulse mode ionizers are known in the art. For example, patent application publications JP2008124035, US 20060151465, and US 20090116828 describe AC ionizing bars. U.S. Patent 8,009,405 discloses a design of ionizing blowers with high voltage power supplies generating periodically burst of positive and negative pulses.

[0015] These power supplies include plus and minus DC high voltage sources and a summing block connected to an ion emitting structure. Low frequency pulses (in the range of approximately 0.1 Hz to 100 Hz) are generated by independently switching on and off each of high voltage source. However, these AC pulse ionization systems are complicated, have low efficiency, and are prone to accumulate particles on the ion emitting structures.

[0016] One of the main features of an embodiment is the use of groups of predominately asymmetric (in magnitude of positive or negative voltages) short duration bipolar ionizing pulses. A train (i.e., pulse group) of positive and negative pulses is applied to a linear emitter or group of emitters.

[0017] The short duration pulses (in the asymmetric waveform) create a high voltage gradient, which reduces ion recombination at the emitter, which in turn increases the emitter ionization efficiency, thus allowing the use of a relatively or extremely low power consumption method to generate high concentration plus and minus ions.

[0018] In an embodiment, positive and negative ion clouds are periodically generated by trains of pulses having variable pulse number, for each pulse duration, train pulse duration and voltage amplitude. The number of voltage waveforms can be generated by a small high voltage transformer with primary winding controlled by low voltage pulse generator and secondary winding forming a resonance circuit including an ion emitter and reference electrode of the bar.

[0019] Figure 1 illustrates voltage waveforms of positive and negative ionizing pulses and pulse trains, in accordance with an embodiment. Low voltage pulses 105a and 105b (for controlling an input of a high voltage transformer) are shown in top part of Figure 1. Each ionizing pulse, for example, a positive pulse, may include a sequence of three different voltage wave components. The output pulse starts with negative voltage wave having amplitude lower than corona discharge threshold (see waveform 110 in the bottom part of Figure 1). The duration of this period is in the range of few micro-seconds or nano-seconds.

[0020] As shown in Figure 1, the pulse train 105 is dis-

posed to include the positive pulse train 105a and the negative pulse train 105b, with pulse trains 105a and 105b alternating in sequence. The pulse train 105 is provided to an emitter. Figure 1 also illustrates the effective emitter signal 110 that results from the pulse train 105.

[0021] The positive pulse train 105a includes the following: a plurality of ionizing positive voltage pulses 106 having a period of $T_{\text{pulse_rep}}$ and a pulse width of T_p during a time period 115 (positive phase 115), a plurality of ionizing positive voltage pulses 107 having a period of $T_{\text{pulse_rep}}$ and a pulse width of T_o (where $T_o < T_p$) during a time period 120 (ionization frequency phase 120) which occurs after the positive phase 115, and a zero value during a time period 125 (negative phase 125) which occurs after the ionization frequency phase 120.

[0022] The negative pulse train 105b includes the following: a zero value during a time period 115 (positive phase 115), a plurality of ionizing negative voltage pulses 108 having a period of $T_{\text{pulse_rep}}$ and a pulse width of T_o (where $T_o < T_p$) during the ionization frequency phase 120 and were the pulses 107 and 108 are offset from each other and are not generated concurrently, a plurality of ionizing negative voltage pulses 109 having a period of $T_{\text{pulse_rep}}$ and a pulse width of T_n during the time period 125 (negative phase 125), where T_p and T_n may or may not be equal in time magnitude.

[0023] These ionizing positive and negative voltage pulses alternately create voltage gradients across the emitter and a reference electrode of the ionizer and generate by corona discharge an ion cloud that include positive and negative ions. As discussed further below, the positive and negative ionizing voltage pulses 107 and 108 during the ionization frequency phase 120 results in an effective emitter signal 110 having small magnitude alternating pulses 130.

[0024] As shown for time period 115, waveform 110 includes a high positive voltage wave with amplitude higher than positive corona threshold for a given ion emitting structure. At that period of time, the ion emitter generates positive ions in a gap between the ion emitter and non-ionizing (or reference) electrode. This gap between the ion emitter and non-ionizing electrode is shown, for example, in Figure 6 of the above-referenced parent application U.S. serial no. 13/210,267. The positive ion cloud is electro-statically repelled from the ion emitter and moves (or is most likely blown) to the reference electrode.

[0025] During the time period 125 is a negative voltage with amplitude significantly lower than that required for a corona discharge. This voltage creates electrostatic field which slows down movement of positive ions and decreases ion losses to the reference electrode. The amplitude of the negative voltages may be adjusted by damping feature in the HVPS (High Voltage Power Supply) circuitry.

[0026] A positive ionizing pulse is followed by a high amplitude negative pulse (also shown in Figure 1) which produces negative ion cloud during short period of time

in the same manner as previously discussed. A repetition rate of ionizing pulses may be in the range of one to several thousand pulses per second.

[0027] The effective emitter signal 110 includes the ionization pulses 142 and 144, where the pulses 142 and 144 may be followed by smaller negative and positive oscillations 146. The negative and positive oscillations 146 are due to circuit resonance of a power supply used to generate the signal 110 and are not intended to limit the present invention in any way. The oscillations 146 may be substantially reduced or completely eliminated by, for example, used of a damping circuit as disclosed in, for example, to U.S. Application No. 13/023,387.

[0028] The non-ionizing pulses 148 and 150 has a polarity (negative) that is opposite of the polarity (positive) of the ionizing pulses 142 and 144.

[0029] Figure 1 also shows simultaneously (in the middle time period 120 between time periods 115 and 125) a group of positive and negative ionizing pulses 130. The upper dashed line 135 shows positive corona threshold voltage, for example, usually approximately in the 4.0 kV to 5.0 kV range, and the lower dashed line 140 shows negative corona threshold voltage, for example, approximately in the 3.75 kV 4.50 kV range. Pulses exceeding negative corona threshold voltage generate negative ions and pulses exceeding positive corona threshold voltage generate positive ions.

[0030] A solution for static charge neutralization that uses few, short, higher voltage pulses 151, 152, 153, 154, and 155 in the microsecond range has been discovered to provide sufficient ionization with a low generation of ozone and reduced collection of contaminants on the emitter surfaces.

[0031] A pulse train is disposed to provide alternating positive and negative voltage waveforms with each pulse including a first non-ionizing voltage level, a second ionizing voltage level, a third non-ionizing voltage level and insignificant further oscillations due to circuit resonance. An analog or logic type switching circuit (see Figure 3) provides for a series of alternating positive and negative ionization pulses.

[0032] The use of flyback generation of high voltage (generated by a flyback-type generator) in a Ferrite core transformer provides a simple, efficient and inexpensive ionizer high voltage power supply which can use a very small transformer (e.g., about 1" x 1" x 1") with moderate turn ratio and without the need for a voltage multiplier circuit for the positive and negative ionizing pulses. The use of a Ferrite core with small gap between core halves and proper voltage oscillation damping reduces core magnetic memory effect, allowing the use of multiple series of ionization pulses of one or the other polarity pulses.

[0033] As a result, trains (series or group) of ionizing positive and negative pulses provide efficient bipolar ionization for at least one emitter electrode having length in the range approximately 100 mm - 2000 mm or more.

[0034] The number of pulses of one polarity can be adjusted for the best object neutralization discharge time

depending on air flow and distance to a charged target. The concentration of alternating polarities ions is sufficient for ionizing bars for neutralizing moving targets at distances up to approximate 1000 mm or more.

[0035] Figure 2 illustrates a scope screen shot with a voltage waveform of exemplary train positive and negative ionizing pulses in the real time domain, in accordance with an embodiment. As seen in Figure 2, pulse train pair 18 includes positive and negative pulse trains 30 and 32 that alternate in serial sequence. The upper dashed line 44 represents a positive corona threshold voltage (e.g., 4.5 kV), and the lower dashed line 46 represents a negative corona threshold voltage (e.g., -4.25 kV). The positive corona threshold voltage level 44 and negative corona threshold voltage level 46 are shown in the real time domain. Each positive pulse train 30 is disposed to include an ionizing positive voltage waveform that has a maximum positive voltage amplitude that exceeds the voltage threshold for creating positive ions by corona discharge. Similarly, the negative pulse train 32 is disposed to include an ionizing negative voltage waveform that has a maximum negative voltage amplitude that exceeds the voltage threshold for creating negative ions by corona discharge. Thus, these respective positive and ionizing negative voltage waveforms alternatively create voltage gradients across a space between the emitter and reference electrode, generating by corona discharge an ion cloud that includes positive and negative ions.

[0036] Pulses repetition rate can be adjusted depending upon required ionization power level and velocity of the moving target. This screen shot demonstrates that an effective ratio of high voltage power "On" vs. power "Off" can be about 0.0015 or smaller. That is why according an ionization method disclosed in an embodiment of this invention, the corona discharge typically exists for only a tiny portion of time (less than about 0.1%) necessary for ion generation but less than required for ozone emissions as well as particles attraction to the ion emitters.

[0037] Experiments with one wire type ionization system (or ionization cell) showed that the voltage wave form with micro ionizing pulses provides approximately 3 to 5 times reduction of ozone emission at approximately the equal charge neutralization efficiency. For example, an ionizer similar to described in US application publication 2008/0232021, powered by AC high frequency supply generates ozone concentration of approximately 50 parts-per-billion (ppb) or higher, compared with approximately 10 ppb to 15 ppb for same ionizer in accordance with an embodiment.

[0038] Figure 3a shows schematic diagram of one embodiment of an analog/logic base 300 for an ionizing bar with one wire type emitter electrode 305. Additionally, Figure 3b shows waveform diagrams into various inputs of various components in Figure 3a. A gas source 310 is disposed to provide a flow of gas and is electrically coupled to a voltage source V+. The pulse train 105 (formed by positive pulse train 105a and negative pulse

train 105b as shown in Figure 1) is received by the emitter 305.

[0039] The power source 306 may be part of the analog/logic base 300 or may be a separate component that provides power to the components in the base 300. For purposes of clarity in the drawings, the reference node (such as ground) is omitted in Figure 3a. The values of the components (e.g., passive elements such as resistors, inductors, and capacitors) in Figure 3a are not intended to limit embodiments of the invention in any way.

[0040] In circuit operation of the analog/logic base 300, a timer chip (U3) 315 provides short pulses for a pulse drive circuit 317 (or power supply 317) formed by a Dual Delay logic chip (U1) 320, Adder logic chip (U2) 325, transistors (Q1) 330 and (Q2) 335, and switching circuit 340. The transistors 330 and 335 may be, for example, MOSFETs. However, the use of MOSFETs (e.g., n-channel MOSFETs or other MOSFET-type transistors) is not intended to limit embodiments of the invention in any way.

[0041] The timing of high voltage pulses from the high voltage output transformer 345 depends first upon the clock signal generated by the trapezoid oscillator (U1) 320. Its oscillating frequency determines the alternating switch from positive pulse generation to negative pulse generation, called Frequency of operation. The frequency is determined by the fixed capacitor (C1) 346 and adjustable resistor (R1) 347. A frequency range of approximately 0.2 to 60 Hertz is commonly used, with a low frequency used for targets at a distance and a higher frequency used for targets at close distance.

[0042] The output signal from oscillator (U1) 320 is fed to Delay device (U2) 325, which generates opposite phase signals at half the frequency. The output from device (U2) 325 is then fed to AND gate (U4) 340, which is used to flip the possible activation of transistors 330 and 335 (e.g., MOSFET drive transistors (Q1) 330 and (Q2) 335).

[0043] The main activating pulse is generated by timer device (U3) 315. Feedback (signal 351) from the output pin 3 (of timer device 315) is fed back to its trigger pin 2 and threshold pin 6. This allows a very short positive pulse to be generated at output pin 3. The pulse width is controlled by the fixed capacitor (C2) 350 and adjustable resistor (R3) 352. The pulse width is generally adjusted to approximately 2 microseconds to 24 microseconds, depending on the design of the flyback output driver 317. The repetition rate of the pulses is determined by the fixed capacitor (C2) 350 and variable resistor (R4) 354. The repetition rate is equal to the inverse of the pulse period. This pulse repetition rate can range from approximately 20 Hertz to 1000 Hertz and thus determines the power output of the high voltage generator and is typically approximately 250 Hertz.

[0044] The AND gate (U4) 340 mixes the flip flop signal and the microsecond wide pulses from the chip (U3) 315 and thereby applies activation pulses to the gates of driver transistors (Q1) 330 and (Q2) 335, alternately.

[0045] One output phase from the pin 7 (of comparator

356 of the chip (U1) 320) is used to stop the oscillation in chip (U3) 315, thus interrupting the output pulses from Pin 3 of chip (U3) 315. This interruption can be used to provide an Off-time between the positive and negative ionizations. This interruption is sometimes used to decrease ion cloud recombination at large target distance, or simply to reduce the power output. The Off-time or Dead-time is adjusted by the bias applied to pins 10 and 13 (of comparators 358 and 359, respectively, in chip (U1) 320).

[0046] A formation of a micro pulse is achieved by the following operation. As an example, a short positive pulse (in the micro second range) to the gate of MOSFET (Q2) 335 causes current to flow in high voltage transformer 345 primary winding coil (2,3) 360, producing first a small negative voltage pulse across the primary winding coil 360. At the end of the negative voltage pulse, a large positive flyback pulse of voltage is produced, along with small negative and positive oscillations due to circuit resonance.

[0047] Alternatively, a short pulse to the gate of MOSFET (Q1) 330 produces a large negative pulse. These pulse voltages are magnified and phase reversed by transformer 345 secondary winding 362 by use of a large turns ratio which can be in the order of about 50 to 500 to one. Thus MOSFET (Q2) 335 initiates a negative high voltage pulse and MOSFET (Q1) 330 initiates a positive high voltage pulse. These pulses generate positive and negative ions by the same wire or a pointed emitter.

[0048] The pulse voltage amplitude for both positive and negative polarities is determined by the following parameters:

1. the transformer (T1) 345 winding turns ratio;
2. the transformer primary coil 360 inductance;
3. the duration of the MOSFETs gate pulse driven into the gates of transistors 330 and 335;
4. the input DC voltage as seen at capacitor 364 which is an electrolytic filter;
5. the primary damping circuit 363 which is formed by the damping circuit resistor 365 (e.g., 2 Ohms in resistance), inductor 367 (e.g., 22 uH in inductance), and shunt resistor (Rp) 368 across the primary coil 360;
6. the resistance of series connected transistors 330 and 335 (e.g., MOSFETs (Q1) 330 and (Q2) 335); and
7. the capacitive load of the ionizing assembly (as measured at the output of the transformer secondary winding 362).

[0049] The high voltage output pulses from the transformer (T1) 345 have a wave shape set by the inductance of the primary winding 360, and the capacitive load on the secondary and primary damping components of damping circuit 363. The shunt resistor (Rs) 365 and inductor (Ls) 367 placed between the transformer center tap 2 and power input (Vin) prevents a rapid rise-time of

current in the transformer 345, thus decreasing the peak value of the first part (part 115 in Figure 1) of the wave-form 110 (Figure 1). The third part 125 (Figure 1) of the wave-form 110 is reduced by shunt resistor (Rs) 365. Selected or careful adjustment of these components will result in maximum ionization efficiency beyond the requirement of a high peak level of the second part 120 (Figure 1) of the wave-form 110.

[0050] Referring again to Figure 2, there is seen a high slew rate of the generated pulses. For the primary coil 360, the voltage rise the rate is about 270 V/ps and the fall rate is about 1800 V/ps. For the secondary coil 362, the slew rate may go up to about 35 (+/- 8) kV/ps. Asymmetric positive and negative pulses may be continuously produced by driving circuit 317 with use of only one small power high voltage transformer 345 without any multipliers, rectifiers and summing blocks.

[0051] It is also noted that the pulse repetition rate may be adjusted depending upon the charge density and speed of the neutralization target. Other details regarding signal transmissions (e.g., current signals or voltage signals) that are known to those skilled in the relevant art(s) is not discussed further for purposes of focusing on embodiments of the present invention. Various standard signal transmissions occurring AC corona ionizers are discussed in additional details in the above-cited references. The wave shapes are fixed by the resistance, capacitance, and inductance (R, C, L, respectively) values of all the components. The pulse heights can be adjusted by changing the pulse duration which is set in Figure 3 by the resistor (R3) 352 and capacitor (C2) 350 associated with the device (U3) 315.

[0052] Figures 4a and 4b are block diagram of a microprocessor based embodiment. As shown in Figure 4a, the pulse drive circuit includes a microcontroller 400 (or other processor or controller 400) for controlling the switching of the transistors 330. The microcontroller 400, under software control, generates narrow software adjusted pulses, typically approximately 19 microseconds wide, with one pulse train 402a for positive ionization pulses and one pulse train 402b for negative ionization pulses. From the microcontroller 400, the pulses are applied to a set of pulse drivers 405 (Figure 4b) which amplify the pulses in a suitable magnitude to drive the switching transistors 330 and 335 (Figure 3a) which can be, for example, high power MOSFETs. As discussed above, these MOSFETs then drive the high voltage pulse transformer 345.

[0053] As an option that can be omitted in other embodiments, the microcontroller 400 can also receive signals 410 and 415 from a spark detector 410 and a broken wire detector 425, respectively. In either of the embodiments shown in Figures 3a and 4a and/or other figures/drawings herein, the pulse duration may be short such that applied power is enough for corona discharge to generate positive and negative ions but not enough to generate ozone and nitrogen oxides, erode an emitter and attract particles from ambient air. In either of the em-

bodiments shown in Figures 3a and 4a and/or other figures/drawings herein, the ionizer provides strong (or relatively strong) ionizing pulses of at least about 1000 Volts above an ionizing threshold at a very slow rate, such as, for example, about 250 Hertz (or less) instead of the usual approximately 50,000 to 70,000 Hertz, thus producing ions with low ozone.

[0054] Figures 5a, 5b and 5c shows multi-Pulses in three differed modes to optimize high voltage waveform (pulse trains) for different charge neutralization conditions and Figure 5d shows a method performed by a software executed by the microcontroller 400, in accordance with an embodiment of the present invention. The modes A, B, and A+B depends on the charge neutralization requirements such as, for example, the discharge time for positive and negative charges, acceptable voltage swing (electrical field effect), and distance to the target. The microcontroller 400 executes software that can provide the three (3) modes of ionization pulse: Mode A, Mode B and Mode A+B as required by the application implementing an embodiment of the invention.

[0055] Mode A: As shown in Figure 5a, Mode A is defined by a repeating series of interlacing positive and negative pulses. Each positive pulse 505 (exceeding the positive corona threshold 506a) is followed by a negative pulse 510 (exceeding in the negative corona threshold 506b), and each negative pulse 510 then followed by a positive pulse 505. The positive pulse train 515a and negative pulse train 515b are shown with the alternative positive and negative voltage pulses. This mode is typically used at very close target distance (e.g., about 200 mm or closer) where ionization fields voltage needs to be small.

[0056] In Mode A, the pulse amplitude 529, micropulse period 525, and pulse widths 530 and 535 of the positive micropulse 505 and negative micropulse 510, respectively, are adjustable, by the software executed by the microcontroller 400. The positive micropulse amplitude and positive micropulse duration is adjusted by the timer/counter with Load Pulse MP_P value in block 563 (Figure 5d). The negative micropulse amplitude and negative micropulse duration is adjusted by the Load Pulse MP_N in block 566 (Figure 5d). The period for the positive micropulse and negative micropulse is adjusted by the Load Reprate timer/counter with the reprate value in block 551 (Figure 5d).

[0057] Mode B: As shown in Figure 5b, Mode B is defined by a repeating series 540 of positive pulses 541 followed by a repeating series 542 of negative pulses 543 followed by a repeating series 540 of positive pulses 541, and so on as shown in the drawings. In between the positive series 540 and negative series 542 of pulses, a small delay 544, Off Time, can be added, to reduce ion recombination. The OffTime is a time where no ionization pulse is created. This mode is typically used at very far (500mm and above) target distances. The number of MP_N values in block 568 (Figure 5d) loaded into block 554 (Figure 5d) is used to set the Off Time delay value

544 (Figure 5b) where no pulse is generated. The positive ionization pulse width is adjusted by the load pulse timer/counter with T_{pmax} value in block 556 (Figure 5d). The positive ionization pulse period is adjusted by the load reprate timer/counter with reprate value in block 551 (Figure 5d). The negative ionization pulse width is adjusted by the load pulse timer/counter with T_{nmax} value in block 560 (Figure 5d). The negative ionization pulse period is adjusted by the load reprate timer/counter with reprate value in block 551 (Figure 5d).

[0058] Mode A+B: As shown in Figure 5c, Mode A+B is a combination of Mode A and Mode B where Mode A occurs in the OffTime region (time) 550 and Mode B occurs in the OnTime regions (time) 551 and 552. This mode is typically used at a mid-distance (200mm to 500mm) target where ionization fields voltage need to be kept low but the target distance changes depending on the process. The OnTime regions 551 and 553 are adjusted in block 554. The OffTime region 550 is adjusted by the number of pulses MP_P and MP_N determining this region width (i.e. set in block 554). The positive micropulse width is adjusted by block 563. The negative micropulse width is adjusted by block 566. The negative ionization pulse width is determined by block 560. The negative pulse repetition rate is determined by block 551. Figure 5d shows various blocks 550-573 describing other functions of a method 574 performed by a software executed by the microcontroller 400. Figure 5e is a table 575 that shows multi-pulse settable parameters and corresponding definitions and exemplary parameter range values, in accordance with an embodiment of the present invention. Figures 5f, 5g, and 5h also shows multi-pulses in three differed modes based on settings different from Figures 5a, 5b, and 5c, in accordance with an embodiment of the present invention.

[0059] In all three (3) modes, the user can change the ion balance by: (1) changing the pulse width of the positive or negative or both, and control the amount of ionization in OnTime region (T_{pmax} and T_{nmax}) independently of the OffTime region (MP_P, MP_N); and (2) changing the ratio of time between the Positive OnTime region versus the Negative OnTime region. The time between pulses (T_{reprate}) is the same in all regions and is adjustable to control the amount of ionization power. A high power is where T_{reprate} is small, and creates more often ionization pulses, resulting in more ionization. On the other hand, a larger T_{reprate} creates less often ionization pulses, resulting in less ionization.

[0060] Therefore, an embodiment of the present invention provides a method of ionization and associated schematic (apparatus). This embodiment generates very short bipolar micro pulses and creates efficient bipolar air (or other gases) ionization with regular emitters at normal atmospheric pressure.

[0061] In an embodiment shown in Figure 8, a high voltage pulse generator may power different ionizing cells (structures) with variety of ion emitters: single or group of wires, saw blade type emitter, and pointed elec-

trode(s). Also, the ionizing bar may have internal source of air flow (air channel) connected to a nozzle, small diameter orifices or slots positioned in closed proximity to the ion emitter. Therefore, Figure 8 shows general view of linear bar with wire emitter and air assist ion delivery system, in accordance with an embodiment.

[0062] Another embodiment relates primarily to ionizing bars design. Figure 6[[a and 6b]] shows schematic diagrams of another embodiment as a dual phase ionizing bar with two (wire or point type) emitter electrodes E1 and E2. In this dual phase ionizer with two emitters, the emitters both may be configured as a row of sharp pointed electrodes, wires or blades, or row of nozzles with pointed emitters. Additional details of elements in the linear bar are disclosed in the above-referenced U.S. Provisional Application No. 61/584,173.

[0063] The design of high a voltage section uses the same driver circuit for the MOSFETS (as previously discussed), but with the MOSFET transistor Drains (M1 and M2) connected to a pair of high voltage transformers T1 and T2 with opposing connections to the primaries.

[0064] Control Resistor R1 and damping capacitor C2 (in Figure 6) are chosen to produce the same alternating polarity pulses as in the circuit design shown in Figure 3. Each pulse will therefore have predominately positive or negative peak amplitude and will alternate in polarity.

[0065] In Figure 7, the capacitor C2 in series with the transformers T1 and T2 bottom legs allow the ionization system works in self balance mode. Both ion emitters are floating relatively to ground and according to the law of charge conservation output ion cloud should to be fairly well balanced. Otherwise, any normal unbalance produces an opposing DC voltage across capacitor C2. Additional details on methods for obtaining the above-mentioned balance is found in commonly-owned and commonly-assigned U.S. Patent No. 5,055,963 by Leslie W. Partridge. U.S. Patent No. 5,055,963.

[0066] The ion emitters connected to the transformers T1 and T2 have exactly opposite polarity voltage ionizing pulses. The voltage waveform 602 for this dual phase ionization system is shown in [[Figure 6a]] and simplified bar cross-section 605 with emitter (1) E1 and emitter (2) E2 is shown in Figure 6[[b]].

[0067] This embodiment in Figure 6 has at least a couple of advantages compare to single phase ionization system. Often objects of charge neutralization are sensitive to electrical field and require to have an ionizer with field canceling effect. Dual phase ionization system simultaneously generates opposite polarity voltages and thereby considerably reducing the radiated electrical field.

[0068] This feature is important also in cases when ionizing bar should be positioned in close proximity to the charged object. For a distance between ionizing bar and object duration of, for example, positive pulse train (pulse duration, amplitude or pulse frequency and so on), the distance may be longer than for negative pulse train in one cycle for one emitter; and to be opposite polarity

situation in the next one cycle. That will crate ion cloud "pushing" effect and accelerate their movement to the target.

[0069] Dual phase ionization system has another advantage that it not has bulky reference electrode at all and avoids ion losses on these electrodes.

[0070] Moreover, the opposite phase voltage source significantly (almost twice) may decrease the required voltage amplitude at each emitter for producing corona discharge. Therefore, these transformers may be identical in design, or may have a lower primary to secondary turns ratio. A lower turns ratio may be used since the emitters, being close to each other, tend to increase the electric field between the emitter pair.

[0071] Figure 6 shows also embodiment of a dual phase line ionizer where each emitter is capacitive connected (C3 and C4) to output of transformer T1 and T2. The secondary coils of both transformers T1 and T2 are grounded. This is another variant of capacitive coupled self balanced ionization system.

[0072] The difference between embodiments shown Figures 3 and 6 is mainly in time to react on ion balance offset. Capacitors (C3 and C4) may provide a shorter transition time for balancing. Also, small capacitors in series with each emitter may help to fine tune the phase shift between them and limit current in case of emitter touching.

Ion balance control:

[0073] In one embodiment, the ionizer may have self balance system in several different variants (shown in Figure 7): a wire emitter (shown by dash line 705) may be capacitively coupled to HVPS output and grounded to a reference electrode, and the floated transformer secondary, both emitter and reference capacitively coupled to HVPS.

[0074] The linear ionizer also may have active ion balance system using external ion balance sensor(s) positioned in close proximity to the charged target. In this case microprocessor based control system and HVPS of the bar may generate primarily ionizing micro pulses and ions of one polarity opposite to the charge of the target.

[0075] A general view of linear ionizing bar with wire type emitter shown in Figure 8. The wire electrode 801 is attached to the bar's chassis (or cartridge) by spring 802. The spring 802 provides wire tension and is connected to the output of one previously discussed high voltage power supplies (not shown in Figure 8). The reference electrode 803 is configured as two stainless steel strips mounted on the sides of the chassis. A high intensity electrical field creates corona discharge in form of ion plasma sheath shrouding wire emitter.

[0076] The air orifices 804 supply air flow to help generated by emitter ions move to the target. Therefore, ions are moving to the charged target by combination of electrical field and aerodynamic forces. The result is short

discharge time (in the range of seconds) to neutralize charge of the object.

[0077] While the present invention has been described in particular embodiments, it should be appreciated that the present invention should not be construed as limited by such embodiments. Rather, the present invention should be construed according to the claims below.

Claims

1. A method for charge neutralization of a target by generating ions within a space separating an emitter (305) and a reference electrode, the method comprising:

generating short duration positive and negative pulses (505, 541, 510, 543) by providing a positive pulse train (105a, 515a) and a negative pulse train (105b, 515b), said positive pulse train (105a, 515a) including an ionizing positive voltage waveform (110) and said negative pulse train (105b, 515b) including an ionizing negative voltage waveform (110);

generating a variable number of said positive and negative pulses (505, 541, 510, 543) and rate of the pulses (505, 541, 510, 543) depending on the distance of the target from the emitter (305),

characterized in that

a mode A of repeating series of interlacing positive and negative pulses (505, 510) is configured to be used for close target distances about 200 mm or closer; a mode B of repeating series (540) of positive pulses (541) followed by a repeating series (542) of negative pulses (543) followed by a repeating series (540) of positive pulses (541), and so on, is configured to be used for very far target distances of 500 mm and above; and

a combined mode of mode A and mode B is configured to be used for mid-distances targets of 200 mm to 500 mm.

2. The method of claim 1, wherein a pulse duration of the pulses (505, 541, 510, 543) is short such that an applied power is sufficient for corona discharge to generate positive and negative ions but not sufficient to generate ozone and nitrogen oxides, erode the emitter (305) and attract particles from ambient air, wherein the pulses (505, 541, 510, 543) comprise strong ionizing pulses (505, 541, 510, 543) having amplitude higher than corona thresholds (135, 140, 506a, 506b) for both polarities.
3. The method of claim 1, wherein a pulse duration of the pulses (505, 541, 510, 543) is short such that an applied power is sufficient for corona discharge to

generate positive and negative ions while reducing a buildup of particles on the emitter (305) points or wire electrodes (801) and minimizing a contamination associated with corona discharge particle emission from an ionizing bar, wherein the pulses (505, 541, 510, 543) comprises strong micro pulses at a very low rate in order to allow a use of a low power supply to provide high voltage applied to the emitter (305).

4. The method of claim 1, further comprising: maintaining a reasonably close to zero ions stream balance.

5. The method of claim 1, wherein the pulse train (105, 105b, 515a, 515b) comprises a plurality of waves, each wave comprising a beginning low amplitude peak, a second high amplitude peak of opposite polarity, and a final low amplitude peak.

6. The method of claim 1, further comprising: providing a simultaneous application of voltage to a linear wire or group of linear emitters (305) in order to reduce an ion density variation effect between points, and allow an even ion balance distribution along a length of the emitter (305).

7. The method of claim 1, further comprising: using a microcontroller (400) for controlling the pulse train (105, 105b, 515a, 515b).

8. The method of claim 1, further comprising:

using dual ion emitters (305) generating opposite polarity voltages and thereby reducing a radiated electrical field.

9. An apparatus for charge neutralization of a target by generating positive and negative ions within a space separating an emitter (305) and a reference electrode, the apparatus comprising:

an emitter (305);

a reference electrode; and

a pulse drive circuit (317) configured to generate short duration positive and negative pulses (505, 541, 510, 543),

wherein the pulse drive circuit (317) generates a variable number of small sharp pulses (505, 541, 510, 543), the train and rate of the pulses (505, 541, 510, 543) depending on the distance of the target from the emitter (305),

characterized in that a mode A of repeating series of interlacing positive and negative pulses (505, 510) is configured to be used for close target distances about 200 mm or closer; a mode B of repeating series (540) of positive pulses (541) followed by a repeating series (542)

of negative pulses (543) followed by a repeating series (540) of positive pulses (541), and so on, is configured to be used for very far target distances of 500 mm and above; and a combined mode of mode A and mode B is configured to be used for mid-distances targets of 200 mm to 500 mm.

10. The apparatus of claim 9, wherein a pulse duration of the pulses (505, 541, 510, 543) is short such that an applied power is sufficient for corona discharge to generate positive and negative ions but not sufficient to generate ozone and nitrogen oxides, erode the emitter (305) and attract particles from ambient air, wherein the pulses (505, 541, 510, 543) comprise strong ionizing pulses (505, 541, 510, 543) of at least approximately 1000 Volts above an ionizing threshold (135, 140, 506a, 506b) at a very slow rate, such as approximately 250 Hertz instead of the usual approximately 50,000 to 70,000 Hertz, thus producing ions with low ozone.
11. The apparatus of claim 10, wherein a pulse duration of the pulses (505, 541, 510, 543) is short such that an applied power is sufficient for corona discharge to generate positive and negative ions while reducing a buildup of particles on the emitter (305) points or wire electrodes (801) and minimizing a contamination associated with corona discharge particle emission from an ionizing bar, wherein the pulses (505, 541, 510, 543) comprises strong micro pulses at a very low rate in order to allow a use of a low power supply to provide high voltage applied to the emitter (305).
12. The apparatus of claim 9, wherein the drive circuit (317) is configured to maintain a reasonably close to zero ions stream balance, wherein the pulse train (105, 105b, 515a, 515b) comprises a plurality of waves, each wave comprising a beginning low amplitude peak, a second high amplitude peak of opposite polarity, and a final low amplitude peak.
13. The apparatus of claim 9, wherein the drive circuit (317) is configured to provide a simultaneous application of voltage to a linear wire or group of linear emitters (305) in order to reduce an ion density variation effect between points, and allow an even ion balance distribution along a length of the emitter (305).
14. The apparatus of claim 9, further comprising: a microcontroller (400) configured to control the pulse train (105, 105b, 515a, 515b).
15. The apparatus of claim 9, wherein the emitter (305)

further comprising: dual ion emitters (305) configured to generate opposite polarity voltages and thereby reduce a radiated electrical field.

Patentansprüche

1. Verfahren zur Ladungsneutralisation eines Targets durch Generieren von Ionen in einem Raum, der einen Emitter (305) und eine Referenzelektrode trennt, wobei das Verfahren umfasst:

Generieren von positiven und negativen Impulsen mit kurzer Dauer (505, 541, 510, 543) durch Bereitstellen einer positiven Impulsfolge (105a, 515a) und einer negativen Impulsfolge (105b, 515b), wobei die positive Impulsfolge (105a, 515a) eine ionisierende positive Spannungswellenform (110) einschließt und die negative Impulsfolge (105b, 515b) eine ionisierende negative Spannungswellenform (110) einschließt; Generieren einer variablen Anzahl der positiven und negativen Impulse (505, 541, 510, 543) und Rate der Impulse (505, 541, 510, 543) in Abhängigkeit von dem Abstand des Targets zu dem Emitter (305),

dadurch gekennzeichnet, dass

ein Modus A der sich wiederholenden Reihe von verschachtelten positiven und negativen Impulsen (505, 510) so konfiguriert ist, dass er für nahe Target-Abstände von etwa 200 mm oder näher zu verwenden ist;

ein Modus B der sich wiederholenden Reihe (540) von positiven Impulsen (541), gefolgt von einer sich wiederholenden Reihe (542) von negativen Impulsen (543), gefolgt von einer sich wiederholenden Reihe (540) von positiven Impulsen (541) und so weiter, so konfiguriert ist, dass er für sehr weite Target-Abstände von 500 mm und darüber zu verwenden ist; und ein kombinierter Modus aus Modus A und Modus B so konfiguriert ist, dass er für Targets in mittleren Abständen von 200 mm bis 500 mm zu verwenden ist.

2. Verfahren nach Anspruch 1, wobei eine Impulsdauer der Impulse (505, 541, 510, 543) kurz ist, so dass eine angelegte Leistung zur Koronaentladung ausreicht, um positive und negative Ionen zu generieren, jedoch nicht ausreicht, um Ozon und Stickoxide zu generieren, den Emitter (305) zu erodieren und Partikel aus der Umgebungsluft anzuziehen, wobei die Impulse (505, 541, 510, 543) starke Ionisierungsimpulse (505, 541, 510, 543) mit einer Amplitude über den Koronaschwellenwerten (135, 140, 506a, 506b) für beide Polaritäten umfassen.
3. Verfahren nach Anspruch 1, wobei eine Impulsdauer

- der Impulse (505, 541, 510, 543) kurz ist, so dass eine angelegte Leistung zur Koronaentladung ausreichend ist, um positive und negative Ionen zu generieren, während eine Anreicherung von Partikeln auf den Emitterpunkten (305) oder Drahtelektroden (801) reduziert wird und eine Kontamination minimiert wird, die mit Koronaentladungspartikelionisation aus einem Ionisierungsstab verbunden ist, wobei die Impulse (505, 541, 510, 543) starke Mikroimpulse in einer sehr niedrigen Rate umfassen, um eine Verwendung einer Versorgung mit niedriger Leistung zur Bereitstellung von Hochspannung zu ermöglichen, die an den Emitter (305) angelegt wird.
4. Verfahren nach Anspruch 1, des Weiteren umfassend: Aufrechterhalten einer Ionenstrombilanz, die in vernünftigem Maß nahe an Null liegt.
 5. Verfahren nach Anspruch 1, wobei die Impulsfolge (105, 105b, 515a, 515b) eine Vielzahl von Wellen umfasst, wobei jede Welle einen anfänglichen Peak mit niedriger Amplitude, einen zweiten Peak mit entgegengesetzter Polarität und hoher Amplitude und einen am Ende liegenden Peak mit niedriger Amplitude umfasst.
 6. Verfahren nach Anspruch 1, des Weiteren umfassend: Bereitstellen von gleichzeitigem Anlegen von Spannung an einen linearen Draht oder eine Gruppe von linearen Emittlern (305), um einen Effekt der Variation der Ionendichte zwischen Punkten zu reduzieren und eine gleichmäßige Ionenbilanzverteilung entlang einer Länge des Emitters (305) zu ermöglichen.
 7. Verfahren nach Anspruch 1, des Weiteren umfassend: Verwenden eines Mikrocontrollers (400) zum Steuern der Impulsfolge (105, 105b, 515a, 515b).
 8. Verfahren nach Anspruch 1, des Weiteren umfassend: Verwendung von Doppelionenemittern (305), die Spannungen mit entgegengesetzter Polarität generieren und dadurch ein abgestrahltes elektrisches Feld reduzieren.
 9. Vorrichtung zur Ladungsneutralisation eines Targets durch Generieren von positiven und negativen Ionen in einem Raum, der einen Emitter (305) und eine Referenzelektrode trennt, wobei die Vorrichtung umfasst:
 - einen Emitter (305),
 - eine Referenzelektrode; und
 - eine Impulstreiberschaltung (317), die konfiguriert ist, um positive und negative Impulse mit kurzer Dauer (505, 541, 510, 543) zu generieren,
 - wobei die Impulstreiberschaltung (317) eine variable Anzahl an kleinen scharfen Impulsen (505, 541, 510, 543) generiert, wobei die Folge und Rate der Impulse (505, 541, 510, 543) von dem Abstand des Targets zu dem Emitter (305) abhängen,
 - dadurch gekennzeichnet, dass**
 - ein Modus A der sich wiederholenden Reihe von verschachtelten positiven und negativen Impulsen (505, 510) so konfiguriert ist, dass er für nahe Target-Abstände von etwa 200 mm oder näher zu verwenden ist;
 - ein Modus B der sich wiederholenden Reihe (540) von positiven Impulsen (541), gefolgt von einer sich wiederholenden Reihe (542) von negativen Impulsen (543), gefolgt von einer sich wiederholenden Reihe (540) von positiven Impulsen (541) und so weiter, so konfiguriert ist, dass er für sehr weite Target-Abstände von 500 mm und darüber zu verwenden ist; und
 - ein kombinierter Modus aus Modus A und Modus B so konfiguriert ist, dass er für Targets in mittleren Abständen von 200 mm bis 500 mm zu verwenden ist.
 10. Verfahren nach Anspruch 9, wobei eine Impulsdauer der Impulse (505, 541, 510, 543) kurz ist, so dass eine angelegte Leistung zur Koronaentladung ausreichend ist, um positive und negative Ionen zu generieren, jedoch nicht ausreicht, um Ozon und Stickoxide zu generieren, den Emitter (305) zu erodieren und Partikel aus der Umgebungsluft anzuziehen, wobei die Impulse (505, 541, 510, 543) starke Ionisierungsimpulse (505, 541, 510, 543) von mindestens annähernd 1000 Volt über einem Ionisierungsschwellenwert (135, 140, 506a, 506b) mit einer sehr langsamen Rate, wie annähernd 250 Hertz anstelle der üblichen annähernd 50.000 bis 70.000 Hertz, umfassen, wodurch Ionen mit wenig Ozon produziert werden.
 11. Verfahren nach Anspruch 10, wobei eine Impulsdauer der Impulse (505, 541, 510, 543) kurz ist, so dass eine angelegte Leistung zur Koronaentladung ausreichend ist, um positive und negative Ionen zu generieren, während eine Anreicherung von Partikeln auf den Emitterpunkten (305) oder Drahtelektroden (801) reduziert wird und eine Kontamination minimiert wird, die mit Koronaentladungspartikelionisation aus einem Ionisierungsstab verbunden ist, wobei die Impulse (505, 541, 510, 543) starke Mikroimpulse in einer sehr niedrigen Rate umfassen, um eine Verwendung einer Versorgung mit niedriger Leistung zur Bereitstellung von Hochspannung zu ermöglichen, die an den Emitter (305) angelegt wird.
 12. Vorrichtung nach Anspruch 9, wobei die Treiberschaltung (317) konfiguriert ist, um eine Ionenstrombilanz aufrechtzuerhalten, die in vernünftigem Maße

nahe an Null ist,
wobei die Impulsfolge (105, 105b, 515a, 515b) eine Vielzahl von Wellen umfasst, wobei jede Welle einen anfänglichen Peak mit niedriger Amplitude, einen zweiten Peak mit entgegengesetzter Polarität und hoher Amplitude und einen am Ende liegenden Peak mit niedriger Amplitude umfasst.

13. Vorrichtung nach Anspruch 9, wobei die Treiberschaltung (317) konfiguriert ist, um gleichzeitiges Anlegen von Spannung an einen linearen Draht oder eine Gruppe von linearen Emittlern (305) bereitzustellen, um einen Effekt der Variation der Ionendichte zwischen Punkten zu reduzieren und eine gleichmäßige Ionenbilanzverteilung entlang einer Länge des Emitters (305) zu ermöglichen.

14. Vorrichtung nach Anspruch 9, des Weiteren umfassend:
einen Mikrocontroller (400), der zum Steuern der Impulsfolge (105, 105b, 515a, 515b) konfiguriert ist.

15. Vorrichtung nach Anspruch 9, wobei der Emitter (305) des Weiteren umfasst:
Doppelionenemitter (305), die konfiguriert sind, um Spannungen mit entgegengesetzter Polarität zu generieren und dadurch ein abgestrahltes elektrisches Feld zu reduzieren.

Revendications

1. Procédé de neutralisation de charges d'une cible par génération d'ions à l'intérieur d'un espace séparant un émetteur (305) et une électrode de référence, le procédé comprenant :

la génération d'impulsions positives et négatives de courte durée (505, 541, 510, 543) par fourniture d'un train d'impulsions positives (105a, 515a) et d'un train d'impulsions négatives (105b, 515b), ledit train d'impulsions positives (105a, 515a) comportant une forme d'onde de tension positive ionisante (110) et ledit train d'impulsions négatives (105b, 515b) comportant une forme d'onde de tension négative ionisante (110) ;

la génération d'un nombre variable desdites impulsions positives et négatives (505, 541, 510, 543) et d'un rythme des impulsions (505, 541, 510, 543) dépendant de la distance entre la cible et l'émetteur (305),

caractérisé en ce que

un mode A constitué d'une série répétitive d'impulsions positives et négatives entrelacées (505, 510) est configuré pour être utilisé pour des cibles proches, à des distances d'environ 200 mm ou moins ;

un mode B constitué d'une série répétitive (540) d'impulsions positives (541) suivie d'une série répétitive (542) d'impulsions négatives (543) suivie d'une série répétitive (540) d'impulsions positives (541), et ainsi de suite, est configuré pour être utilisé pour des cibles très lointaines, à des distances de 500 mm et plus ; et
un mode de combinaison du mode A et du mode B est configuré pour être utilisé pour des cibles à des distances moyennes, de 200 mm à 500 mm.

2. Procédé de la revendication 1, dans lequel une durée d'impulsion des impulsions (505, 541, 510, 543) est courte, de telle sorte qu'une puissance appliquée est suffisante pour une décharge par effet couronne pour générer des ions positifs et négatifs, mais insuffisante pour générer de l'ozone et des oxydes d'azote, éroder l'émetteur (305) et attirer des particules depuis l'air ambiant, dans lequel les impulsions (505, 541, 510, 543) comprennent de fortes impulsions ionisantes (505, 541, 510, 543) ayant une amplitude supérieure à des seuils d'effet couronne (135, 140, 506a, 506b) pour les deux polarités.

3. Procédé de la revendication 1, dans lequel une durée d'impulsion des impulsions (505, 541, 510, 543) est courte, de telle sorte qu'une puissance appliquée est suffisante pour une décharge par effet couronne pour générer des ions positifs et négatifs tout en réduisant une accumulation de particules sur des points de l'émetteur (305) ou des électrodes en fil (801) et en minimisant une contamination associée à l'émission de particules par décharge par effet couronne depuis une barre ionisante, dans lequel les impulsions (505, 541, 510, 543) comprennent de fortes micro-impulsions à un rythme très faible afin de permettre l'utilisation d'une faible alimentation pour fournir une tension élevée appliquée à l'émetteur (305).

4. Procédé de la revendication 1, comprenant en outre :
le maintien d'un équilibre de courant d'ions raisonnablement proche de zéro.

5. Procédé de la revendication 1, dans lequel le train d'impulsions (105, 105b, 515a, 515b) comprend une pluralité d'ondes, chaque onde comprenant un pic initial de faible amplitude, un deuxième pic de forte amplitude de polarité opposée, et un pic final de faible amplitude.

6. Procédé de la revendication 1, comprenant en outre :
la fourniture d'une application simultanée d'une tension à un fil linéaire ou un groupe d'émetteurs linéaires.

res (305) afin de réduire un effet de variation de densité d'ions entre des points, et permettre une distribution équilibrée d'ions régulière sur une longueur de l'émetteur (305).

7. Procédé de la revendication 1, comprenant en outre :
l'utilisation d'un microcontrôleur (400) pour contrôler le train d'impulsions (105, 105b, 515a, 515b).

8. Procédé de la revendication 1, comprenant en outre :
l'utilisation d'émetteurs d'ions doubles (305) générant des tensions de polarité opposée et réduisant ainsi un champ électrique rayonné.

9. Appareil destiné à neutraliser des charges d'une cible en générant des ions positifs et négatifs à l'intérieur d'un espace séparant un émetteur (305) et une électrode de référence, l'appareil comprenant :

un émetteur (305) ;

une électrode de référence ; et

un circuit de commande d'impulsions (317) configuré pour générer des impulsions positives et négatives de courte durée (505, 541, 510, 543), dans lequel le circuit de commande d'impulsions (317) génère un nombre variable de petites impulsions brusques (505, 541, 510, 543), le train et le rythme des impulsions (505, 541, 510, 543) dépendant de la distance entre la cible et l'émetteur (305),

caractérisé en ce que

un mode A constitué d'une série répétitive d'impulsions positives et négatives entrelacées (505, 510) est configuré pour être utilisé pour des cibles proches, à des distances d'environ 200 mm ou moins ;

un mode B constitué d'une série répétitive (540) d'impulsions positives (541) suivie d'une série répétitive (542) d'impulsions négatives (543) suivie d'une série répétitive (540) d'impulsions positives (541), et ainsi de suite, est configuré pour être utilisé pour des cibles très lointaines, à des distances de 500 mm et plus ; et

un mode de combinaison du mode A et du mode B est configuré pour être utilisé pour des cibles à des distances moyennes, de 200 mm à 500 mm.

10. Appareil de la revendication 9, dans lequel une durée d'impulsion des impulsions (505, 541, 510, 543) est courte, de telle sorte qu'une puissance appliquée est suffisante pour une décharge par effet couronne pour générer des ions positifs et négatifs, mais insuffisante pour générer de l'ozone et des oxydes d'azote, éroder l'émetteur (305) et attirer des particules depuis l'air ambiant,

dans lequel les impulsions (505, 541, 510, 543) comprennent de fortes impulsions ionisantes (505, 541, 510, 543) supérieures d'au moins environ 1000 volts à un seul d'ionisation (135, 140, 506a, 506b) à un rythme très lent, comme approximativement 250 hertz à la place des 50 000 à 70 000 hertz environ habituels, produisant ainsi des ions avec peu d'ozone.

11. Appareil de la revendication 10, dans lequel une durée d'impulsion des impulsions (505, 541, 510, 543) est courte, de telle sorte qu'une puissance appliquée est suffisante pour une décharge par effet couronne pour générer des ions positifs et négatifs tout en réduisant une accumulation de particules sur des points de l'émetteur (305) ou des électrodes en fil (801) et en minimisant une contamination associée à l'émission de particules par décharge par effet couronne depuis une barre ionisante, dans lequel les impulsions (505, 541, 510, 543) comprennent de fortes micro-impulsions à un rythme très faible afin de permettre l'utilisation d'une faible alimentation pour fournir une tension élevée appliquée à l'émetteur (305).

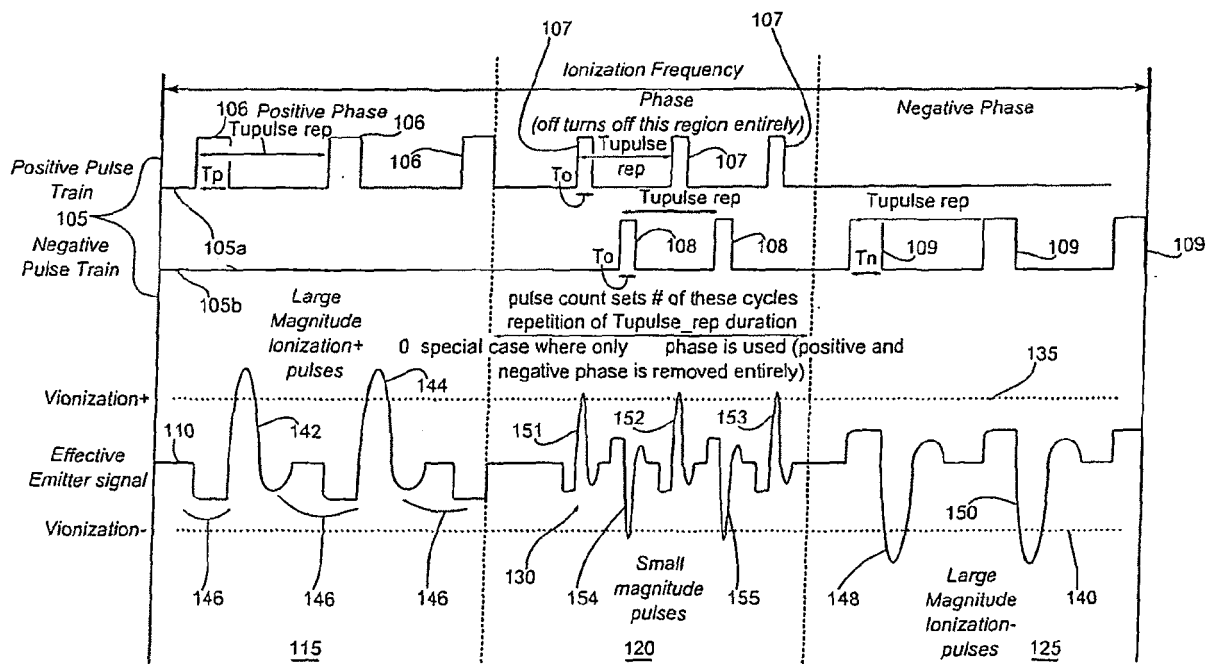
12. Appareil de la revendication 9, dans lequel le circuit de commande (317) est configuré pour maintenir un équilibre de courant d'ions raisonnablement proche de zéro, dans lequel le train d'impulsions (105, 105b, 515a, 515b) comprend une pluralité d'ondes, chaque onde comprenant un pic initial de faible amplitude, un deuxième pic d'amplitude élevée de polarité opposée, et un pic final de faible amplitude.

13. Appareil de la revendication 9, dans lequel le circuit de commande (317) est configuré pour fournir une application simultanée d'une tension à un fil linéaire ou un groupe d'émetteurs linéaires (305) afin de réduire un effet de variation de densité d'ions entre des points, et permettre une distribution équilibrée d'ions régulière sur une longueur de l'émetteur (305).

14. Appareil de la revendication 9, comprenant en outre :
un microcontrôleur (400) configuré pour contrôler le train d'impulsions (105, 105b, 515a, 515b).

15. Appareil de la revendication 9, dans lequel l'émetteur (305) comprend en outre :
des émetteurs d'ions doubles (305) configurés pour générer des tensions de polarité opposée et réduire ainsi un champ électrique rayonné.

Multi-Pulse Pulse Definitions Positive/Bipolar/Negative Modes (V5)



Phase balance sets % time spent Positive v.s. negative (i.e. 50/50 means equal time in positive phase and negative phase)

FIG. 1

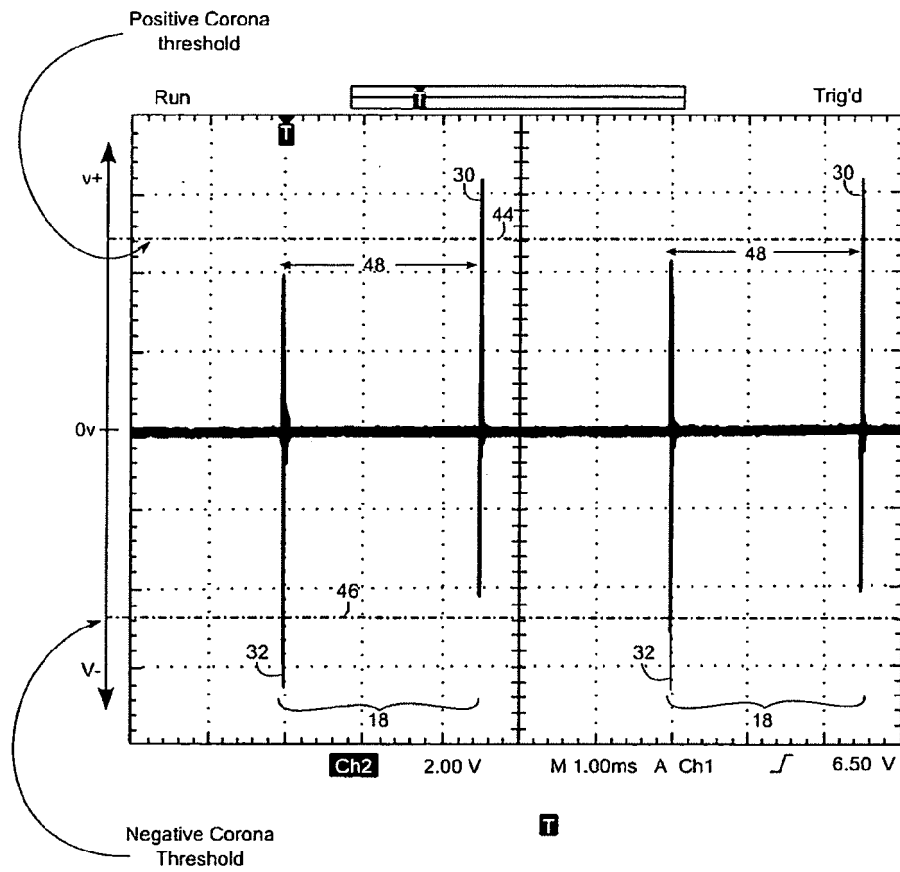


FIG. 2

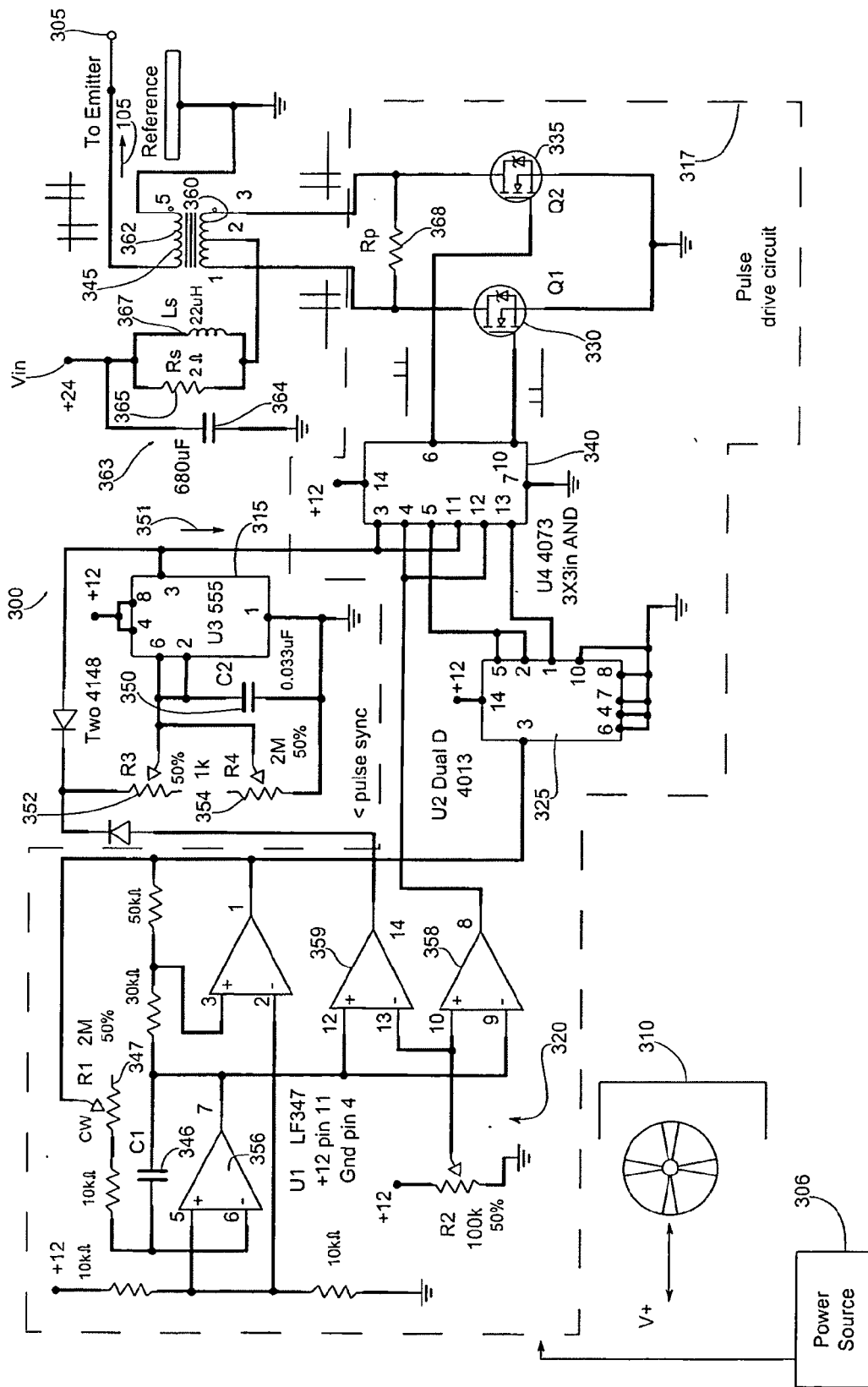


FIG. 3A

WAVEFORMS:

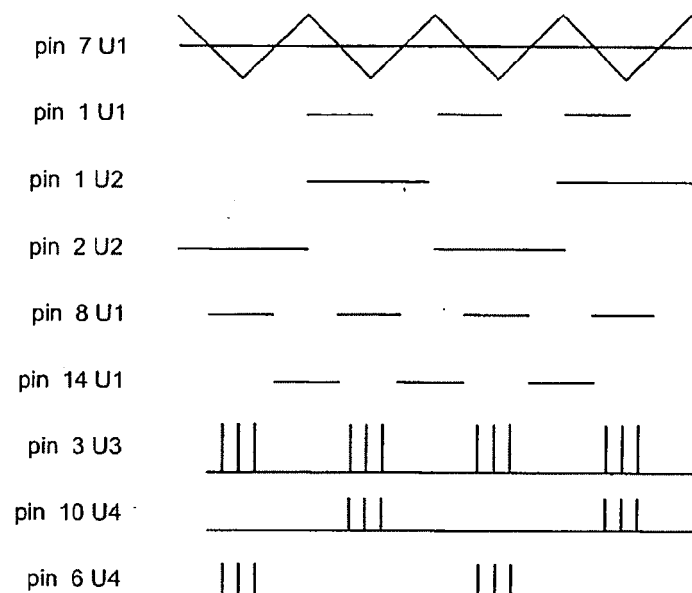
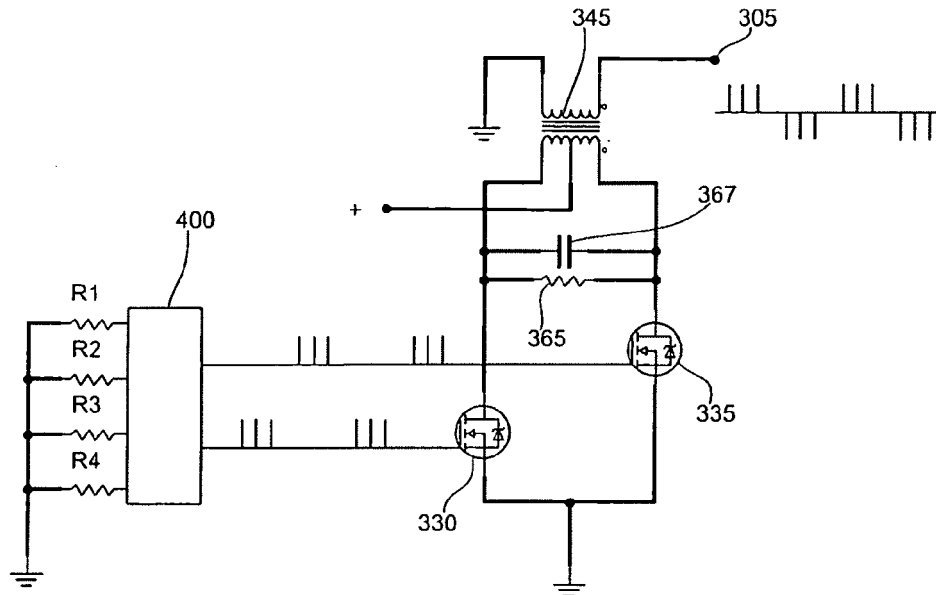


FIG. 3B



Microprocessor

R1 sets pulse width

R2 sets pulse rate

R3 sets pulse number

R4 sets dead time

Multi Pulse Drive for one or more emitter or parallel emitters

File: Multi Pulse Drive

FIG. 4A

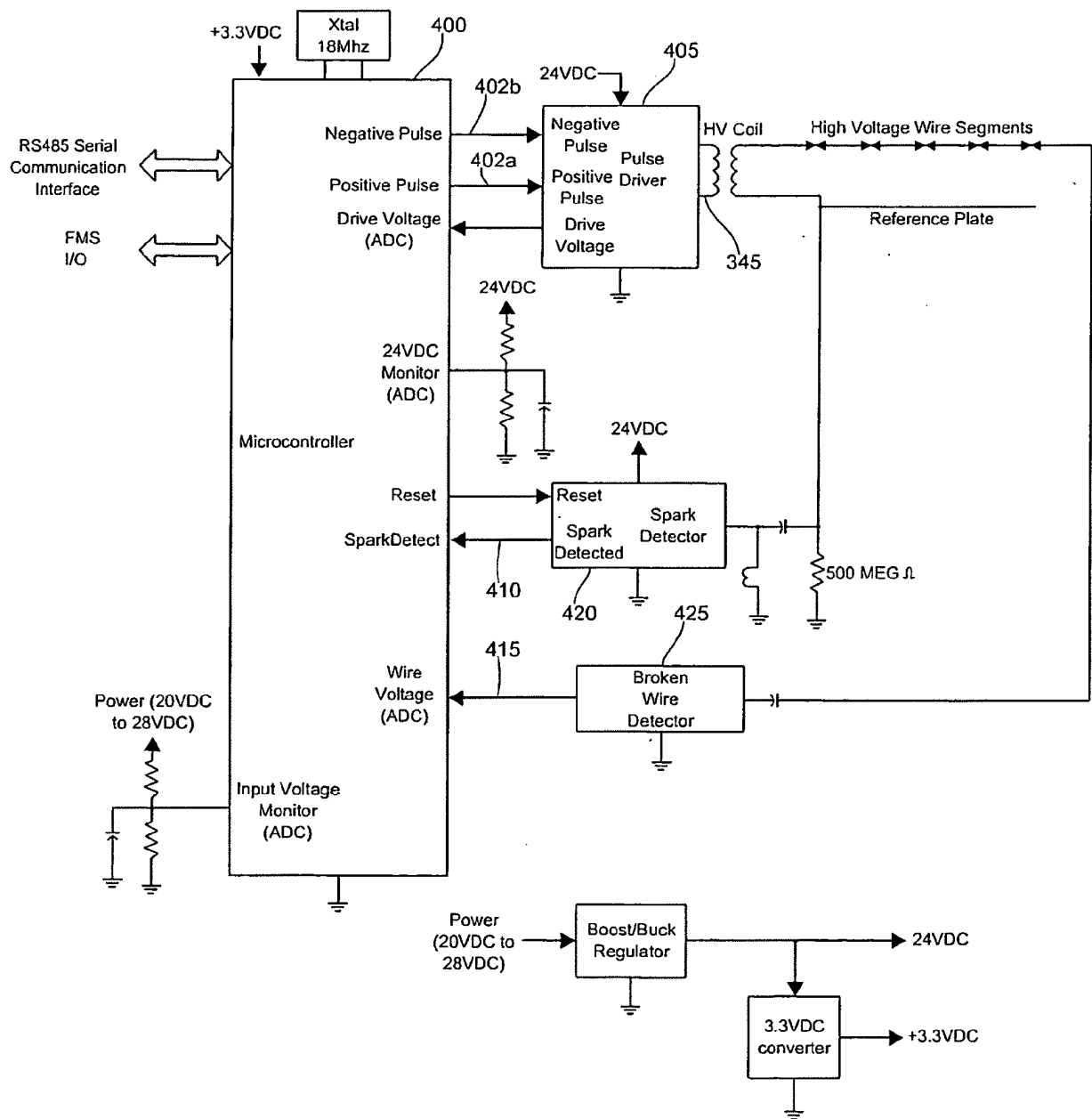


FIG. 4B

Multi-Pulse Pulse Definitions
Mode A

Close Distance
Small Swing

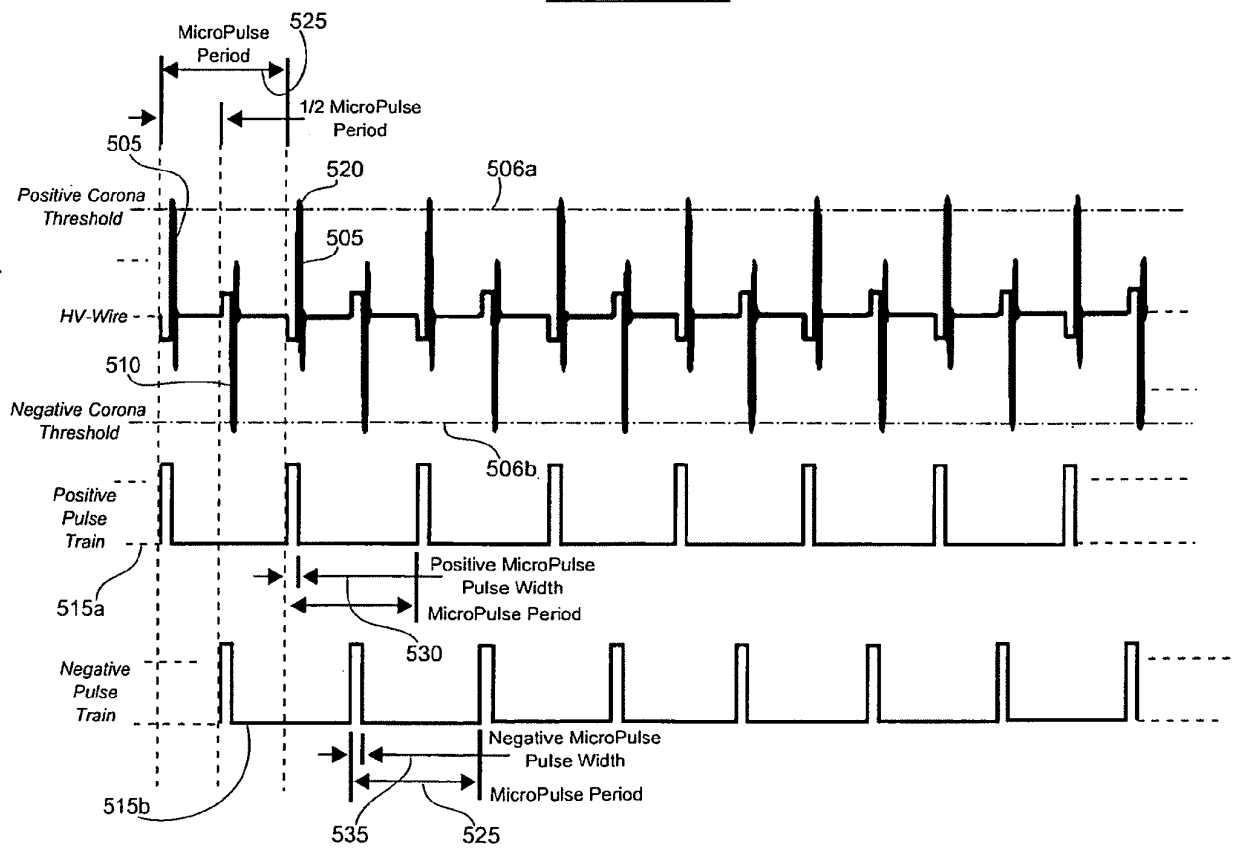


FIG. 5A

Multi-Pulse Pulse Definitions Mode B

Middle distance
Minimum ionization time

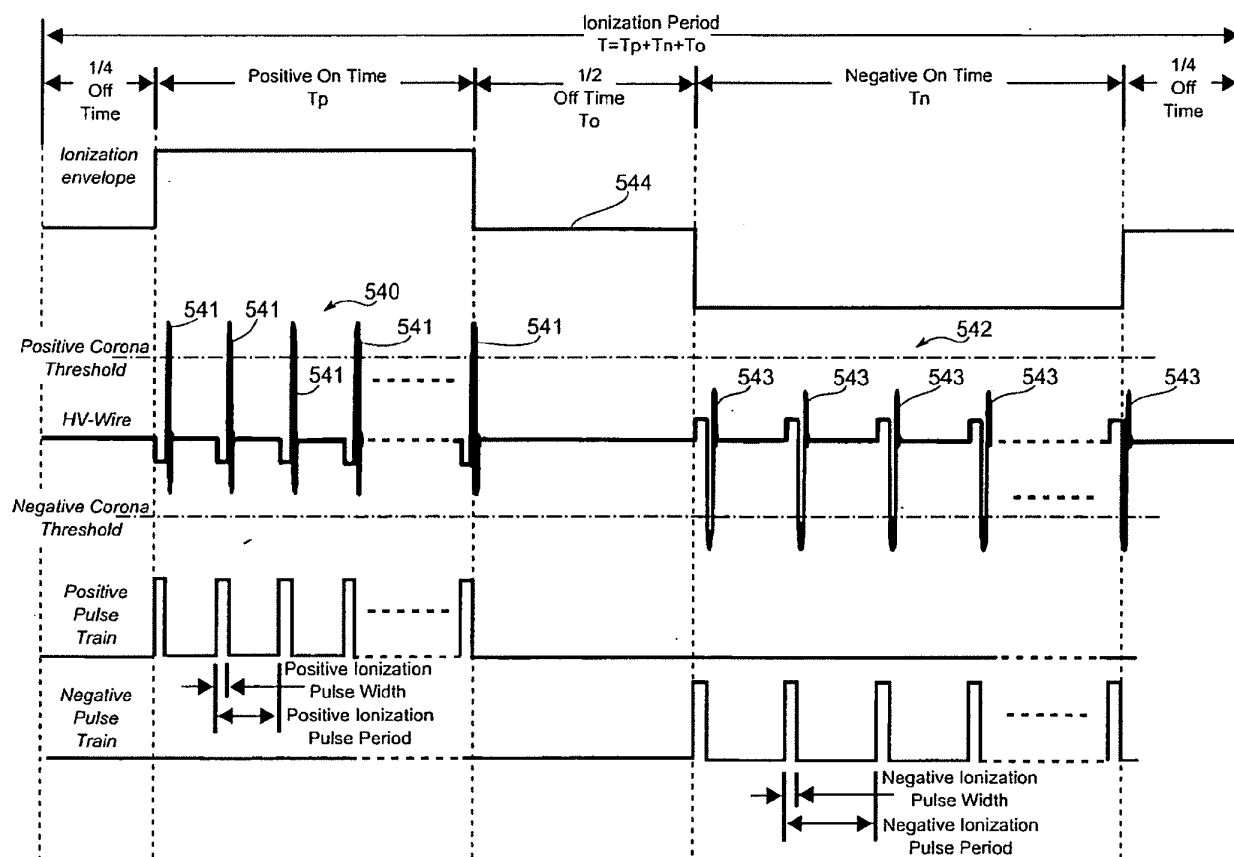


FIG. 5B

Multi-Pulse Pulse Definitions
Mode A&B

Long distance
Minimum Swing
+ cell particle attraction

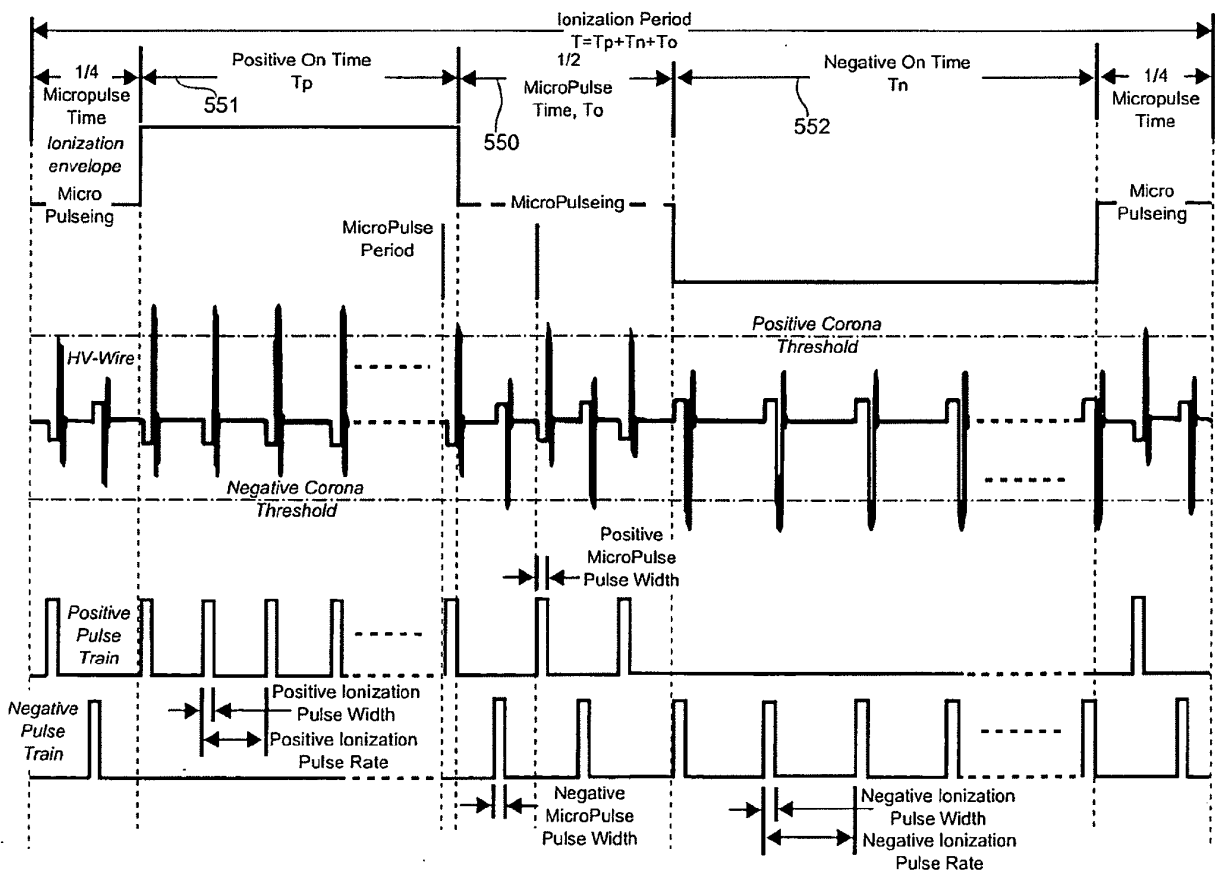


FIG. 5C

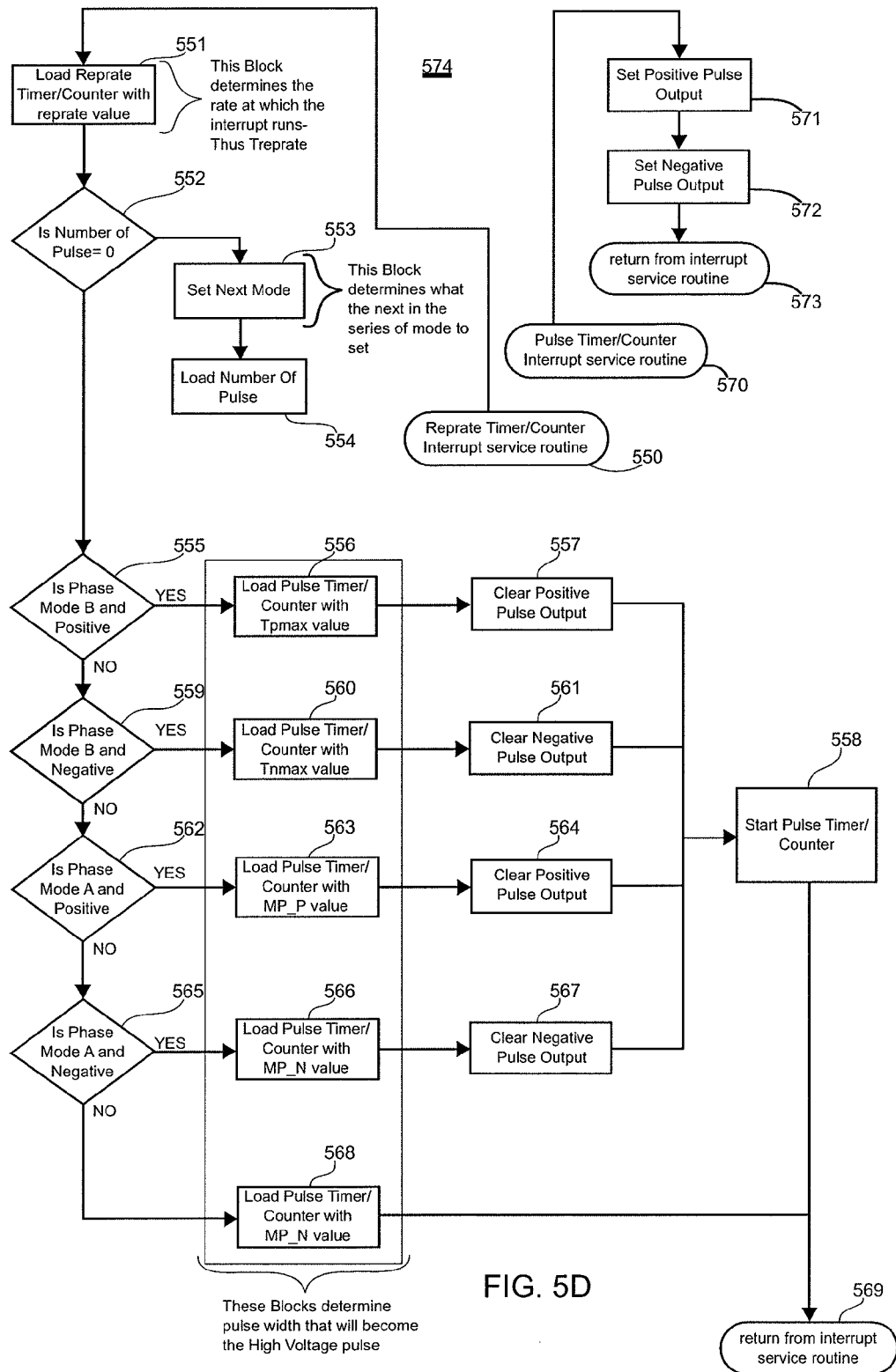


FIG. 5D

Multi-Pulse Pulse Definitions (V4)

575

Mode A: Alternating (+/-) MicroPulse

Mode B: Many Positive MicroPulses followed by OffTime
followed by many Negative MicroPulses

Mode A-B: A combination of Modes A and B, where
the OffTime of Mode B is filled with Mode A micropulses

<u>Settable Parameters</u>	<u>Range</u>	<u>Comments</u>
Ionization Period	10s-30ms	Ionization Period = Positive On Time(T_p) + Negative OnTime(T_n) + OffTime(T_o)
ON Time	10%-100% Ionization Period	Ionization Period= OnTime + OffTime(T_o) where OnTime is always= Positive OnTime(T_p) + Negative OnTime(T_n)
Balance	5/95%-95/5% of On Time	Positive OnTime(T_p) + Negative OnTime(T_n) Is a Constant. Balance is then a ratio of T_p to T_n
Positive Ionization Pulse Width	10 to 30us (0.25us res)	Applies to Mode B and Mode A-B
Negative Ionization Pulse Width	10 to 30us (0.25us res)	Applies to Mode B and Mode A-B
Positive MicroPulse Pulse Width	10 to 30us (0.25us res)	Applies to Mode A and Mode A-B
Negative MicroPulse Pulse Width	10 to 30us (0.25us res)	Applies to Mode A and Mode A-B
Positive Ionization Pulse Period	0.1s-1ms	Applies to Mode B and Mode A-B
Negative Ionization Pulse Period	0.1s-1ms	Applies to Mode B and Mode A-B
Micro Pulse Period	0.1s-1ms	Applies to Mode A and Mode A-B

FIG. 5E

Mode A

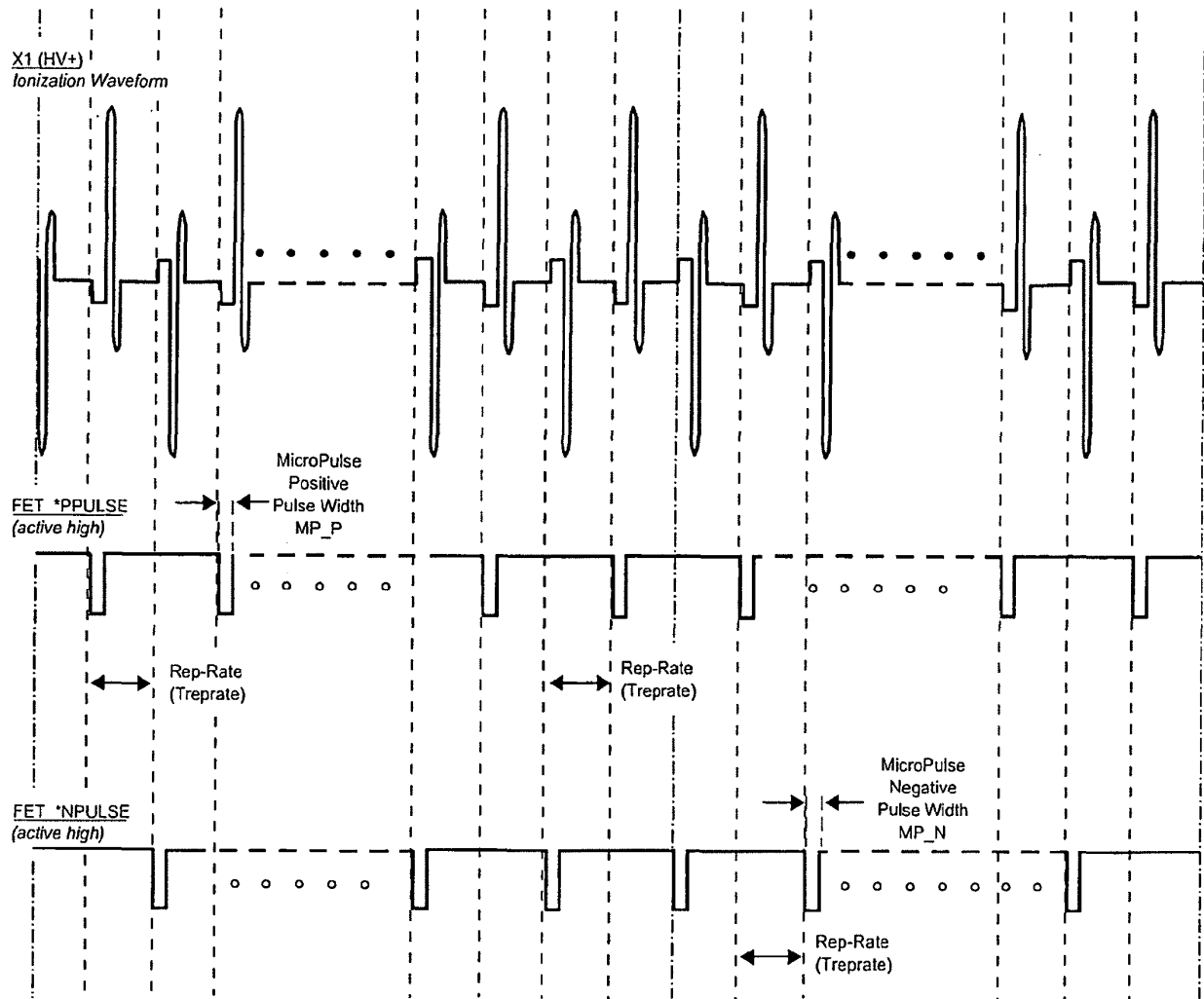


FIG. 5F

Mode B

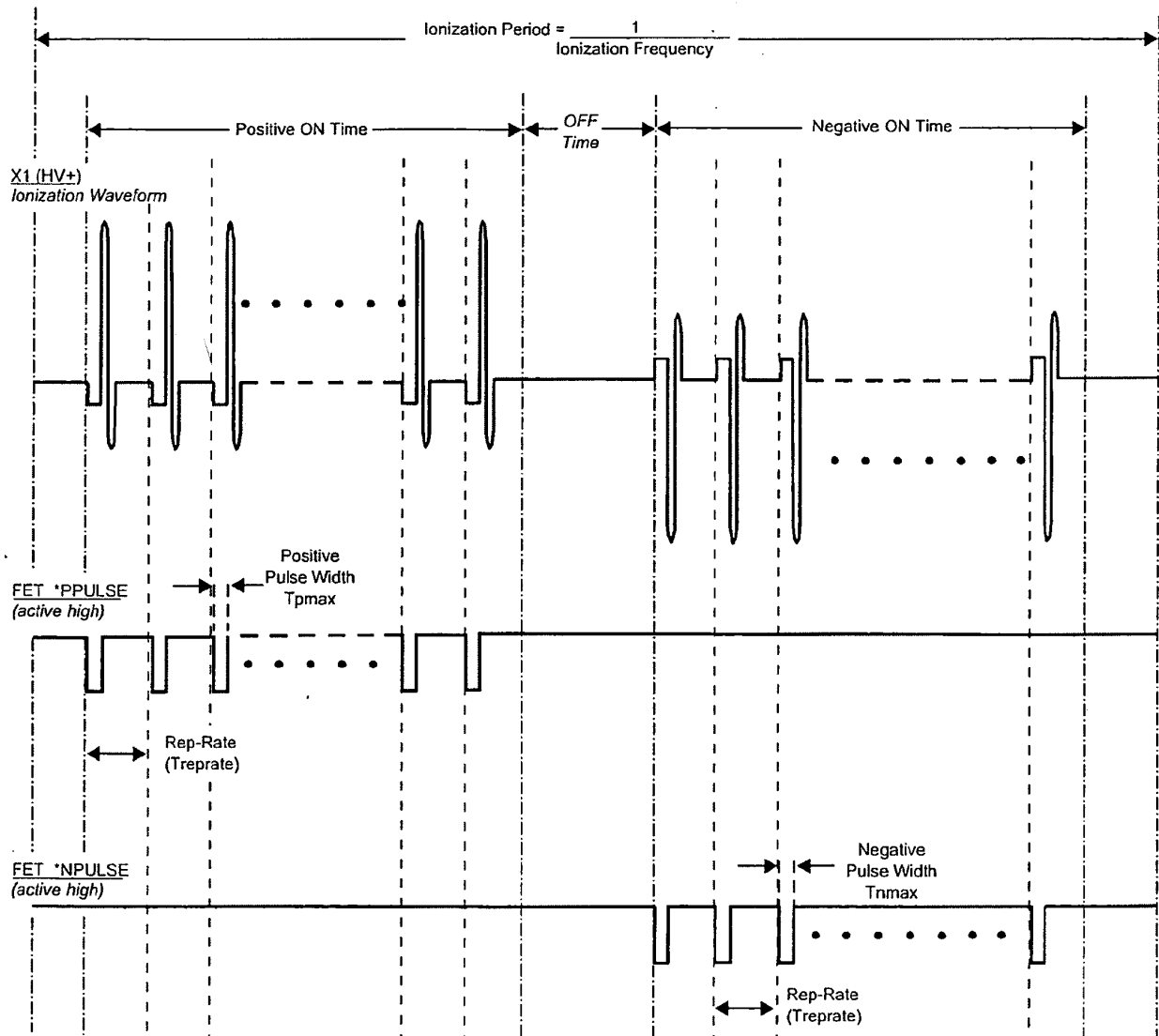


Figure 5G

Mode A+B

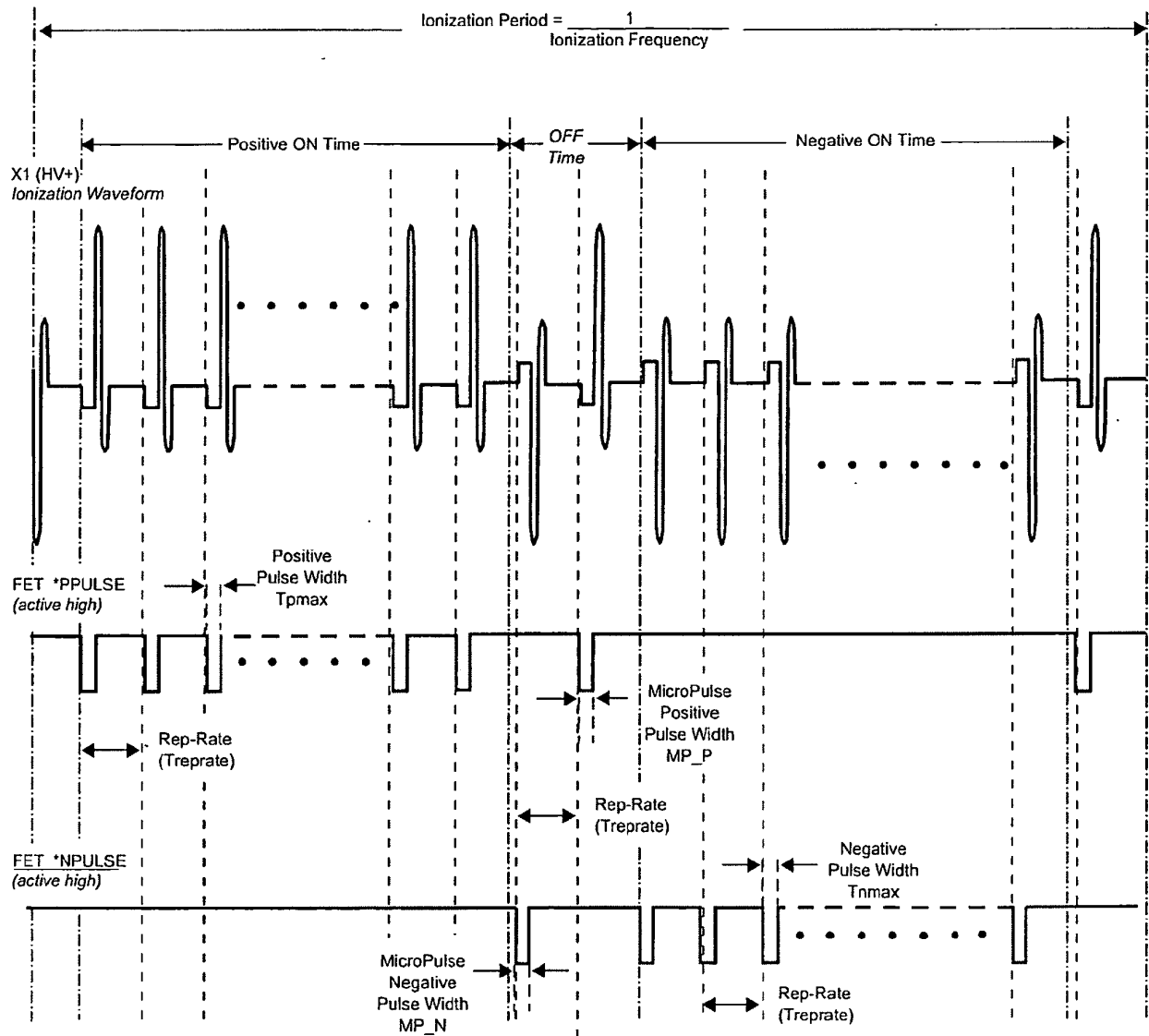


FIG. 5H

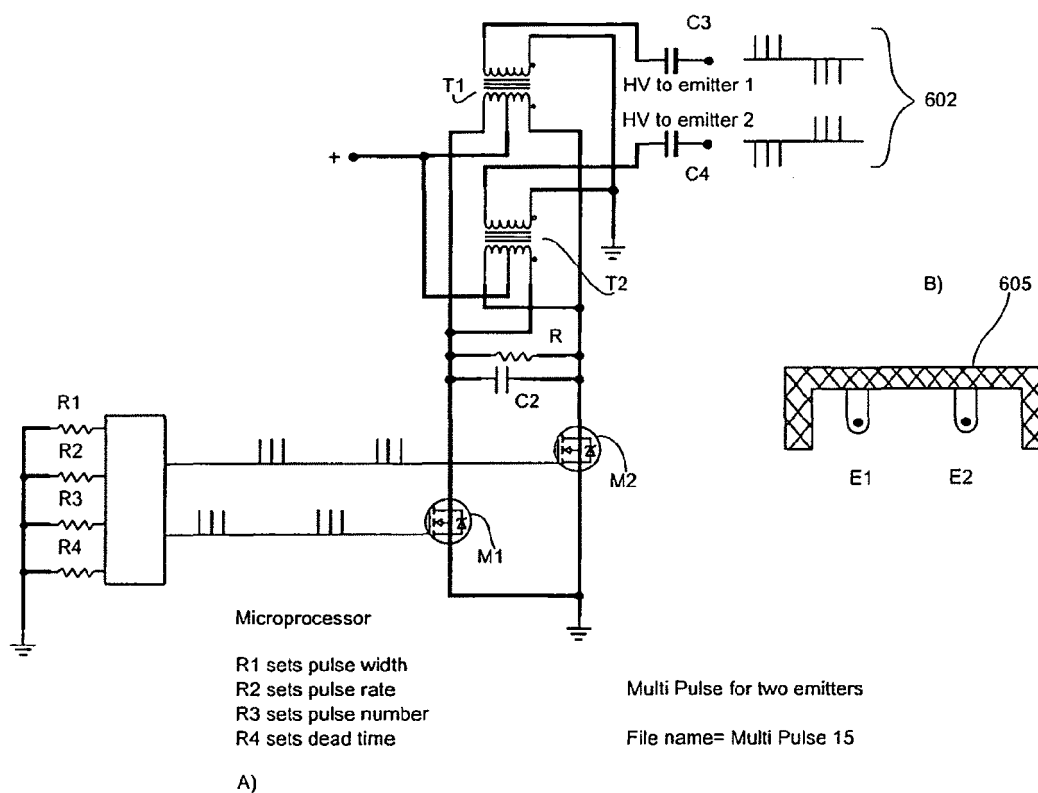


FIG. 6

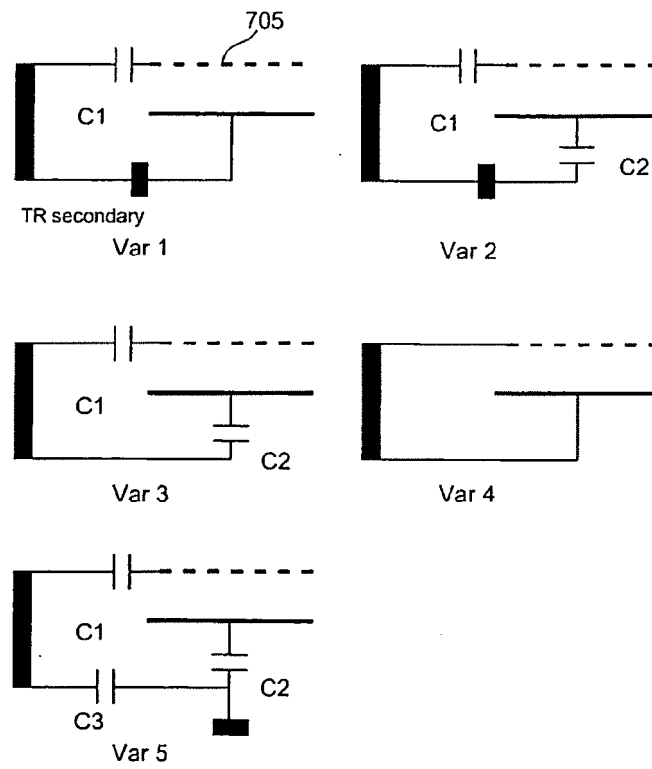


FIG. 7

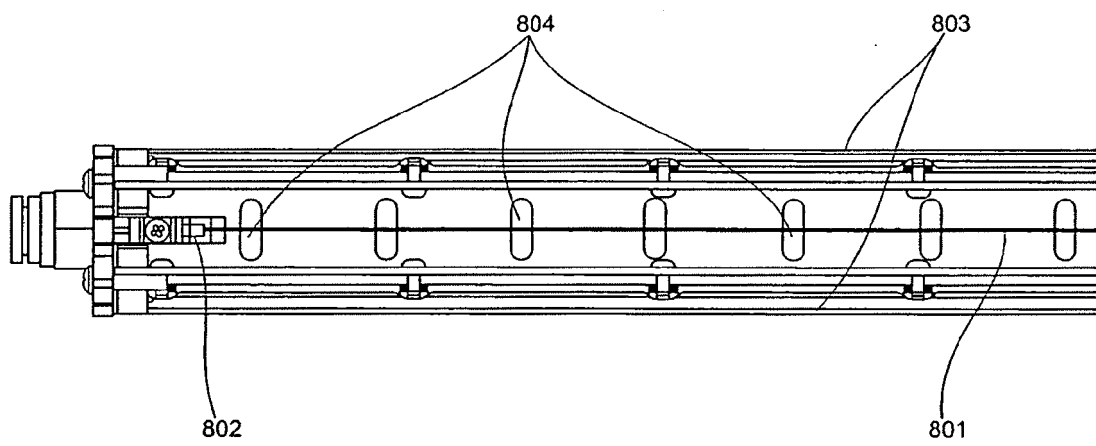


FIG. 8

REFERENCES CITED IN THE DESCRIPTION

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