US 20090231776A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2009/0231776 A1

(43) Pub. Date: Sep. 17, 2009

Kramer et al.

(54) ELECTRONIC DISABLING DEVICE HAVING A NON-OSCILLATING OUTPUT WAVEFORM

(75) Inventors: Michael Kramer, Casper, WY (US); Corey Rutz, Casper, WY (US)

Correspondence Address:
CHRISTIE, PARKER & HALE, LLP
PO BOX 7068
PASADENA, CA 91109-7068 (US)

(73) Assignee: Defense Technology Corporation of America

(21) Appl. No.: 12/473,080

(22) Filed: May 27, 2009

Related U.S. Application Data

(63) Continuation-in-part of application No. 11/359,251, filed on Feb. 21, 2006, now Pat. No. 7,554,786.

(60) Provisional application No. 60/655,145, filed on Feb. 22, 2005, provisional application No. 60/657,294, filed on Feb. 28, 2005.

Publication Classification

(51) Int. Cl.
F41B 15/04 (2006.01)

(52) U.S. Cl. 361/232

(57) ABSTRACT

A system and/or an associated method for providing an electronic disabling device with an output having an output waveform other than a sinusoidal waveform (e.g., a non-oscillating output waveform). In one embodiment, the method includes: producing an energy to have a first energy portion with a first polarity and a second energy portion with a second polarity opposite the first polarity; charging the first energy portion with the first polarity into a high voltage capacitor to produce the non-oscillating output waveform with a pulse having the first polarity; blocking the high voltage capacitor from being charged by the second energy portion with the second polarity; recycling the second energy portion having the second polarity; and adding the recycled second energy portion back into the pulse having the first polarity to produce an increase in pulse width of the pulse having the first polarity.

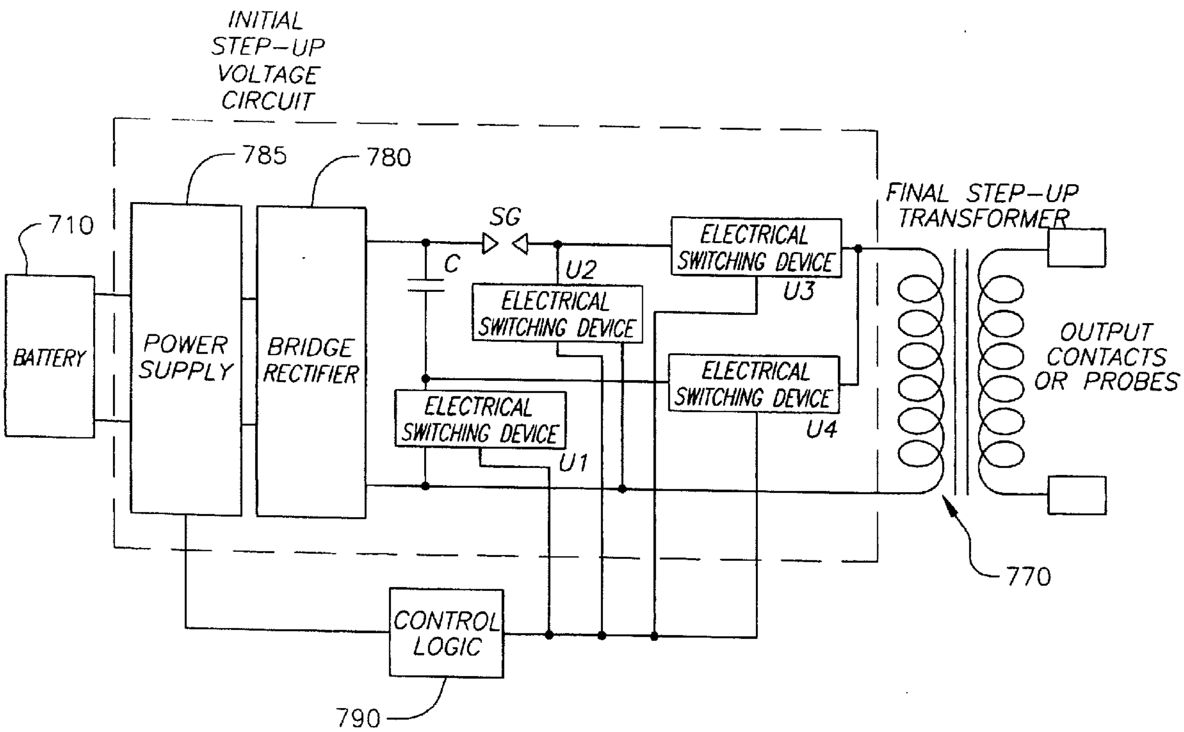


FIG.1

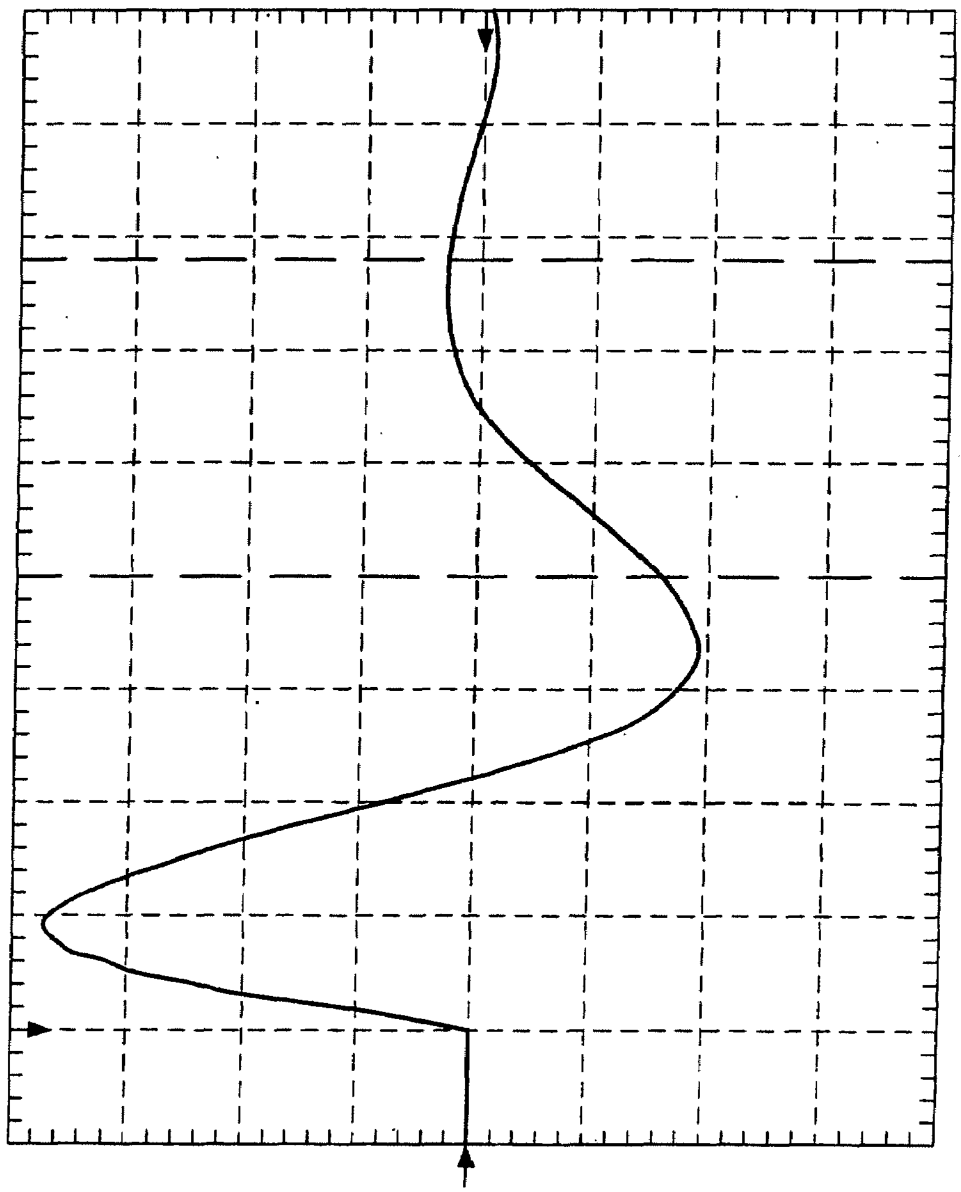
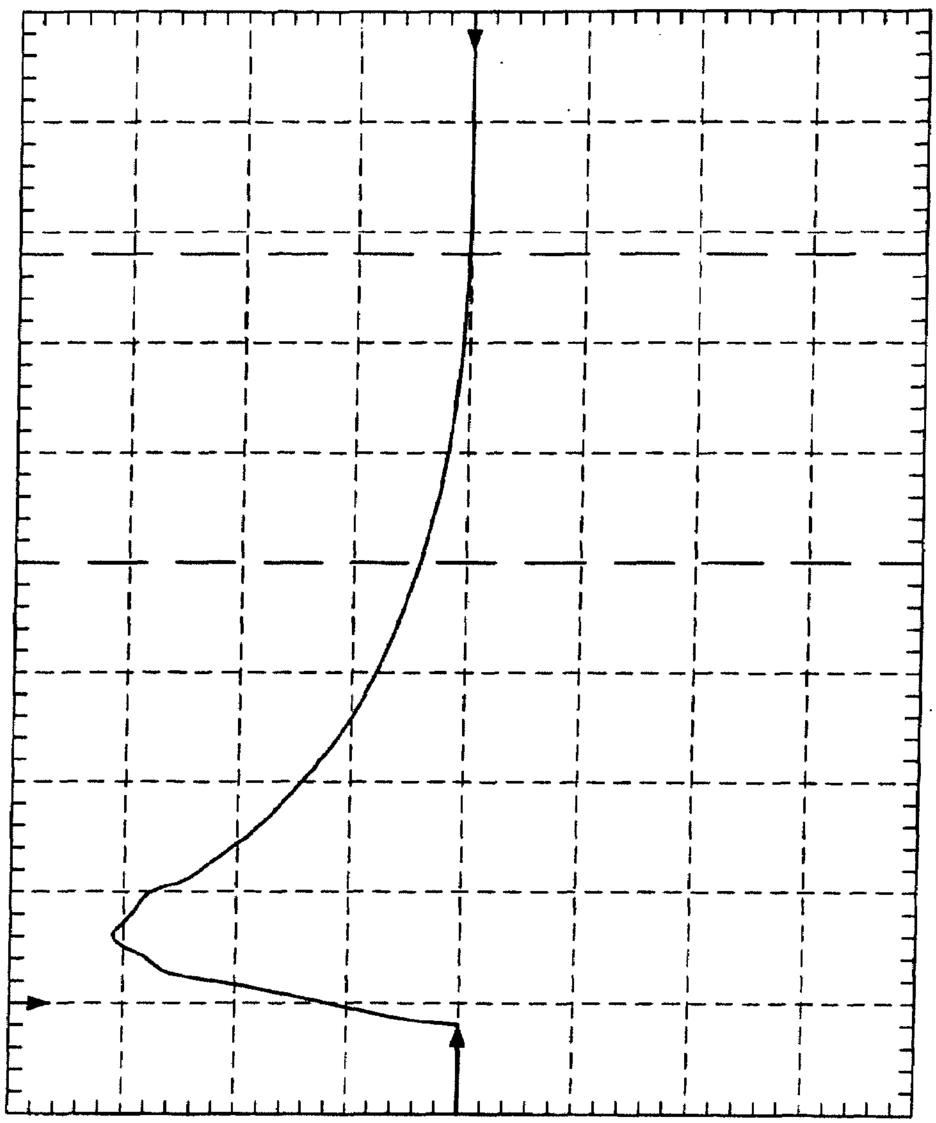


FIG. 2



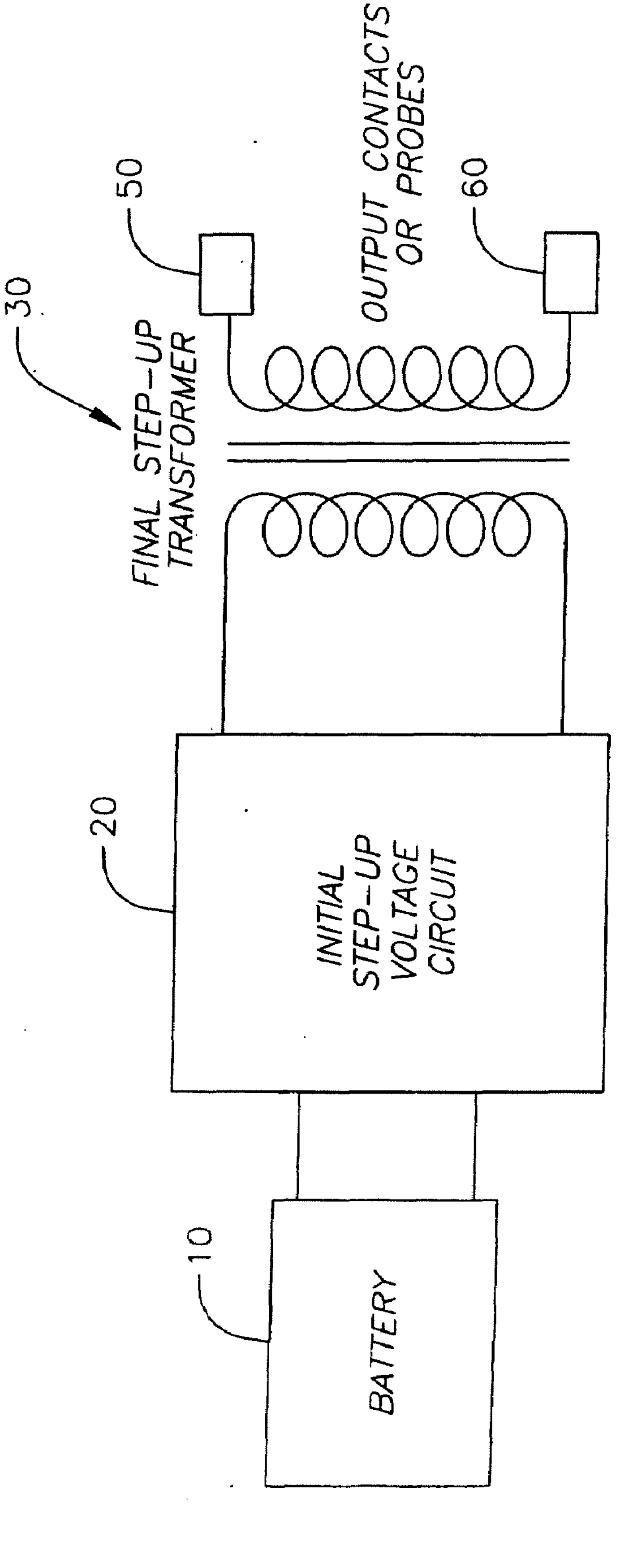

OUTPUT CONTACTS
OR PROBES
50
60
30
FINAL STEP-UP
TRANSFORMER
20
INITIAL
STEP-UP
VOLTAGE
CIRCUIT
10
BATTERY

FIG. 3

FIG. 4

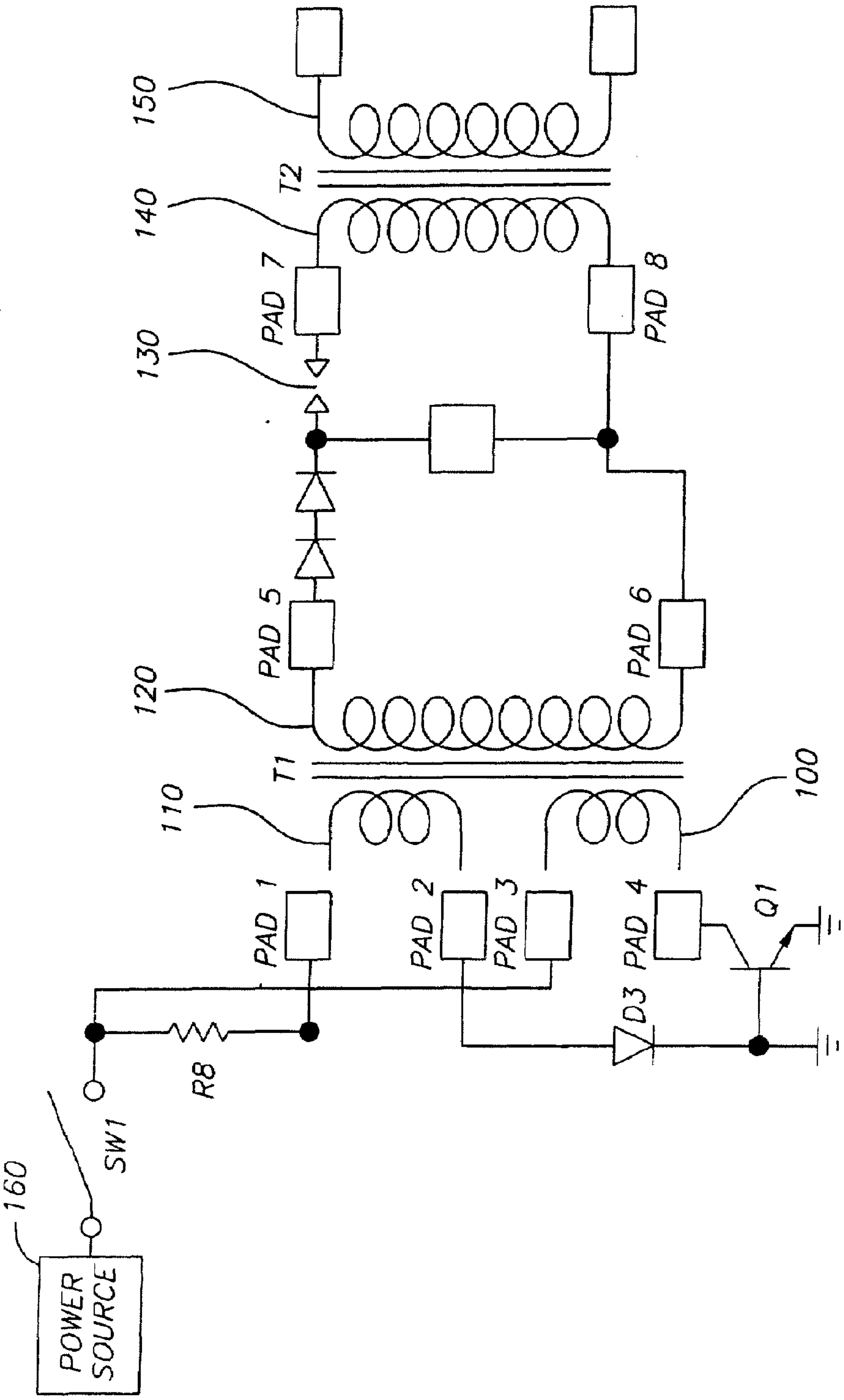
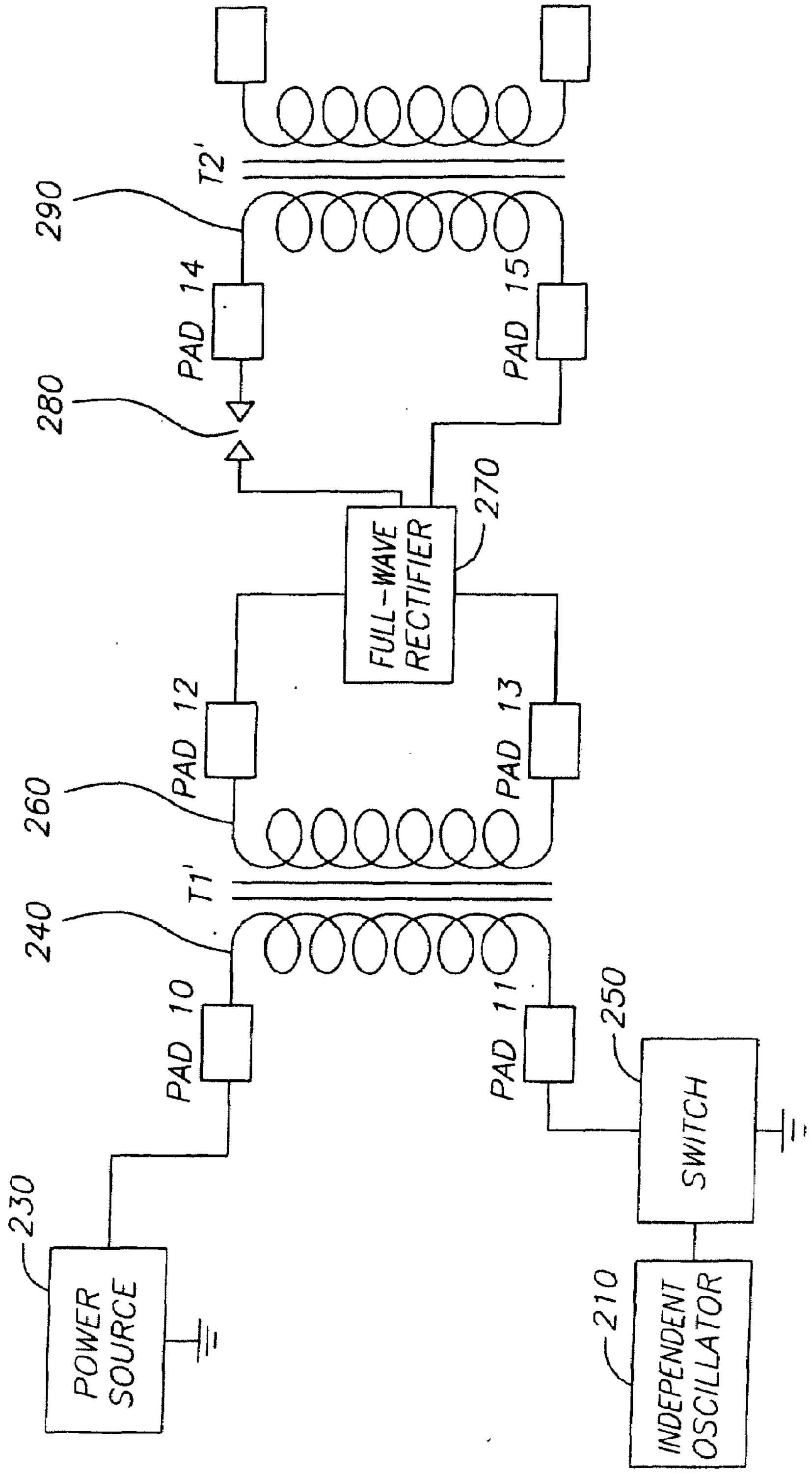

150
T2
140
PAD 7
PAD 8
130
PAD 5
PAD 6
120
T1
110
100
PAD 1
PAD 2
PAD 3
PAD 4
Q1
D3
R8
SW1
160
POWER SOURCE

FIG. 5



T2'
290
PAD 14
PAD 15
280
270
FULL-WAVE RECTIFIER
PAD 12
PAD 13
260
T1'
240
PAD 10
PAD 11
250
SWITCH
230
POWER SOURCE
210
INDEPENDENT OSCILLATOR

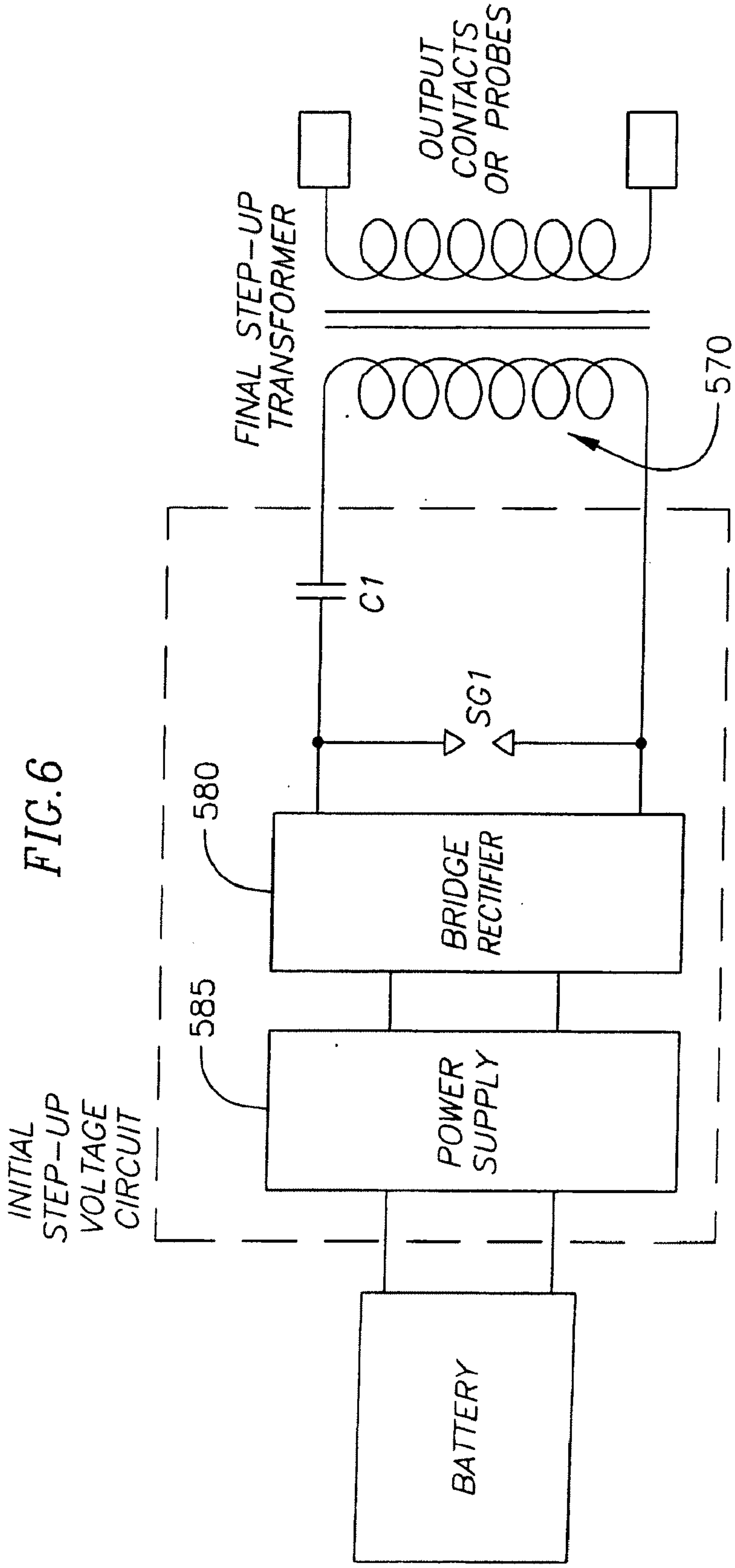

OUTPUT CONTACTS OR PROBES
FINAL STEP-UP TRANSFORMER
570
C1
SG1
580
BRIDGE RECTIFIER
585
POWER SUPPLY
INITIAL STEP-UP VOLTAGE CIRCUIT
BATTERY

FIG. 6

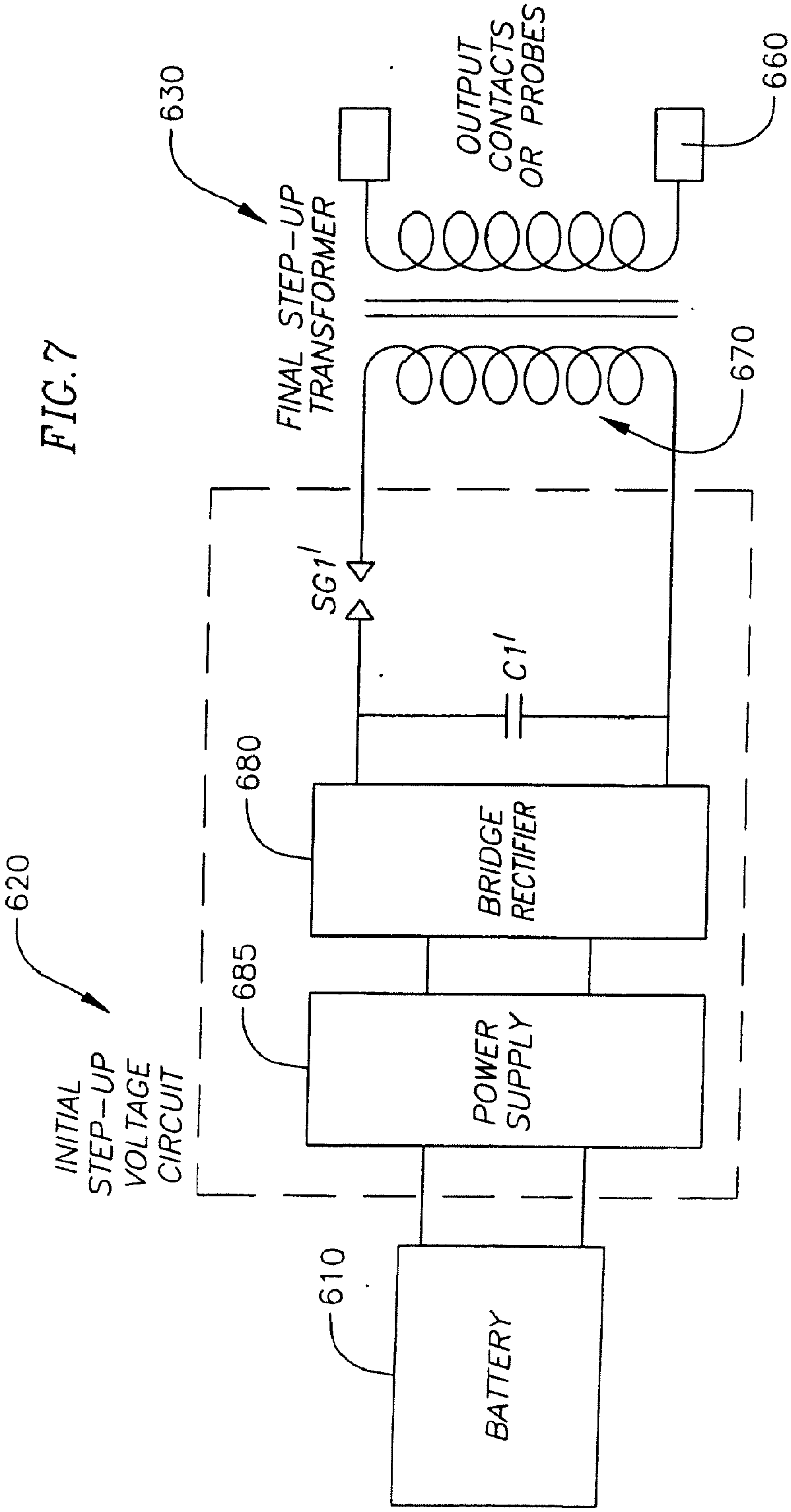

630
FINAL STEP-UP TRANSFORMER
OUTPUT CONTACTS OR PROBES
660
670
SG1'
C1'
680
BRIDGE RECTIFIER
685
POWER SUPPLY
620
INITIAL STEP-UP VOLTAGE CIRCUIT
610
BATTERY

FIG.7

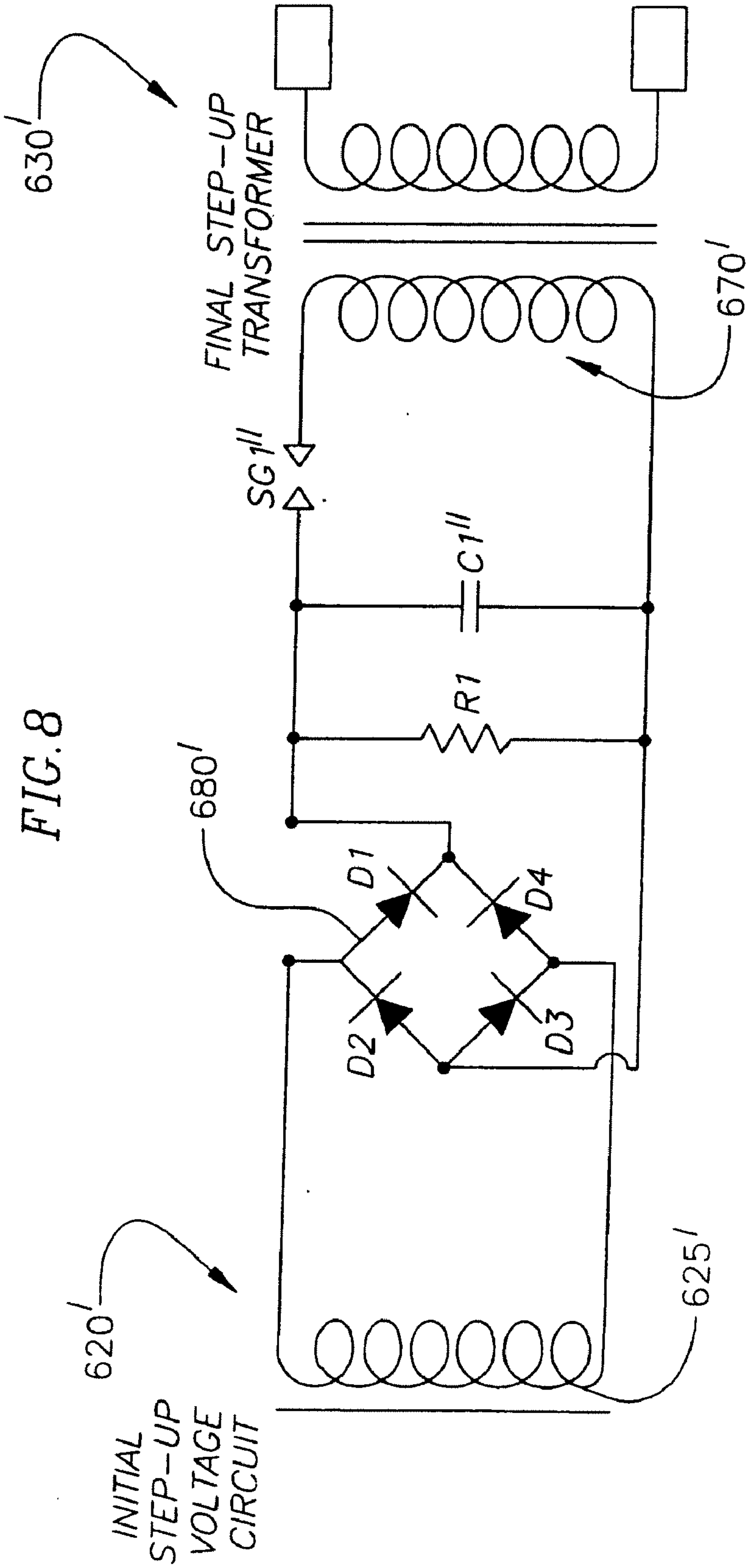

630'
FINAL STEP-UP TRANSFORMER
670'
SG1''
C1''
R1
680'
D1
D2
D3
D4
620'
625'
INITIAL STEP-UP VOLTAGE CIRCUIT

FIG. 8

FIG. 9

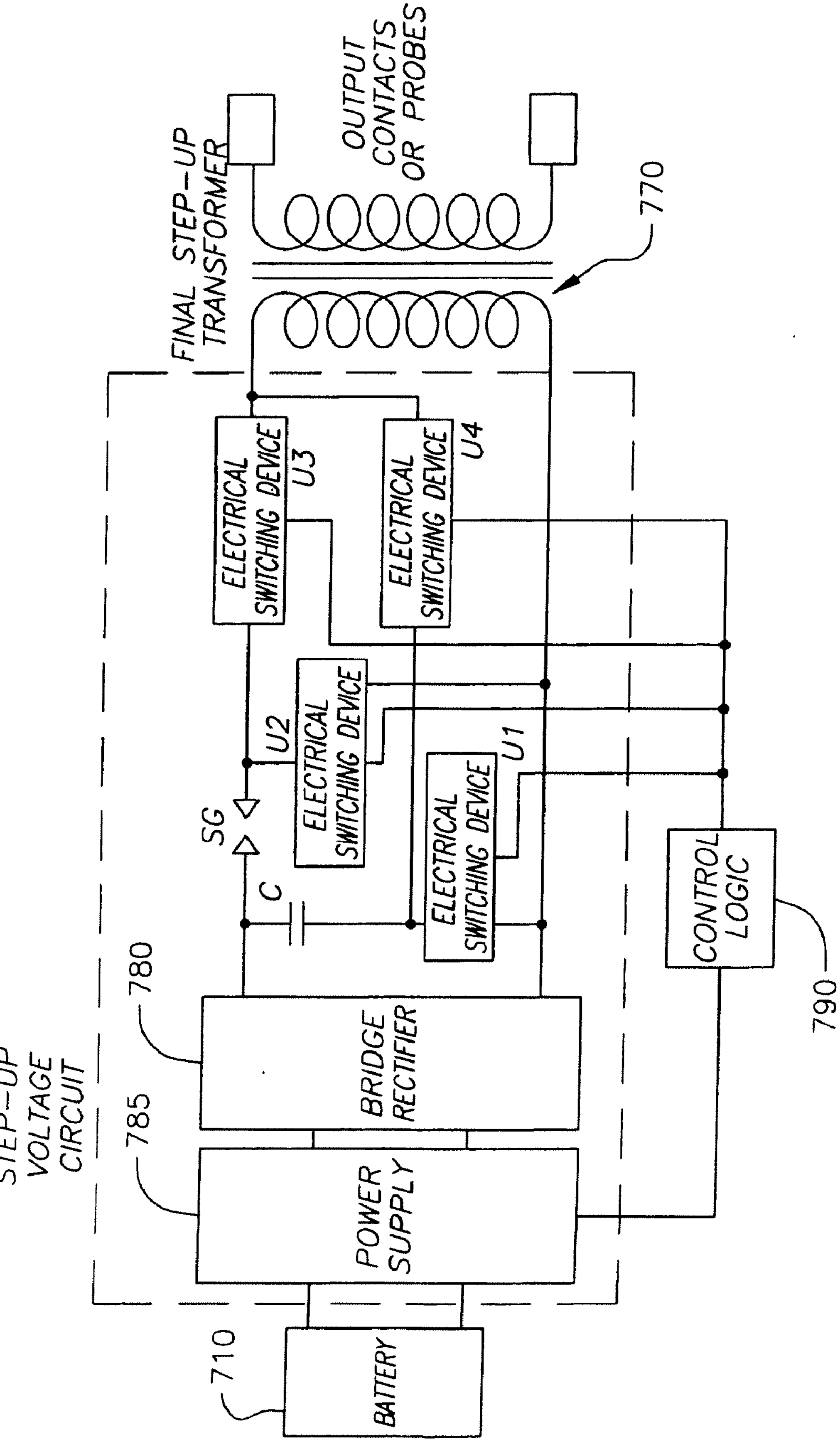

OUTPUT CONTACTS OR PROBES
FINAL STEP-UP TRANSFORMER
770
ELECTRICAL SWITCHING DEVICE
U3
ELECTRICAL SWITCHING DEVICE
U4
ELECTRICAL SWITCHING DEVICE
U2
SG
C
ELECTRICAL SWITCHING DEVICE
U1
CONTROL LOGIC
790
780
BRIDGE RECTIFIER
INITIAL STEP-UP VOLTAGE CIRCUIT
785
POWER SUPPLY
710
BATTERY

FIG.10

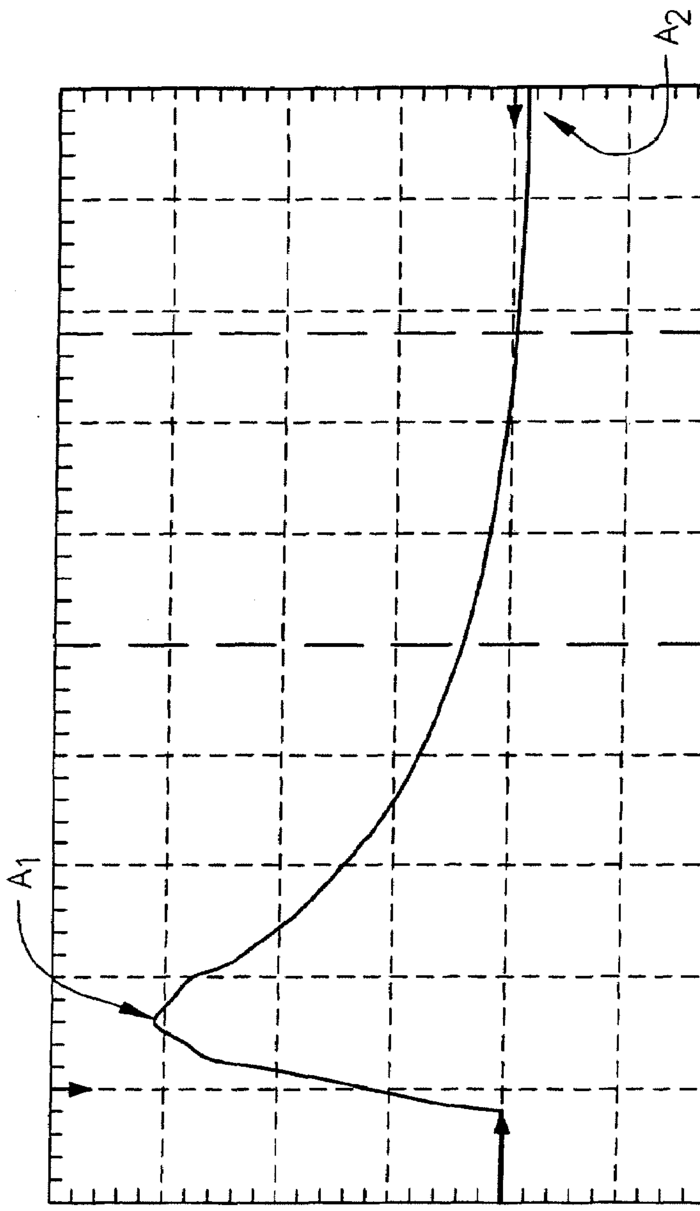


FIG. 11

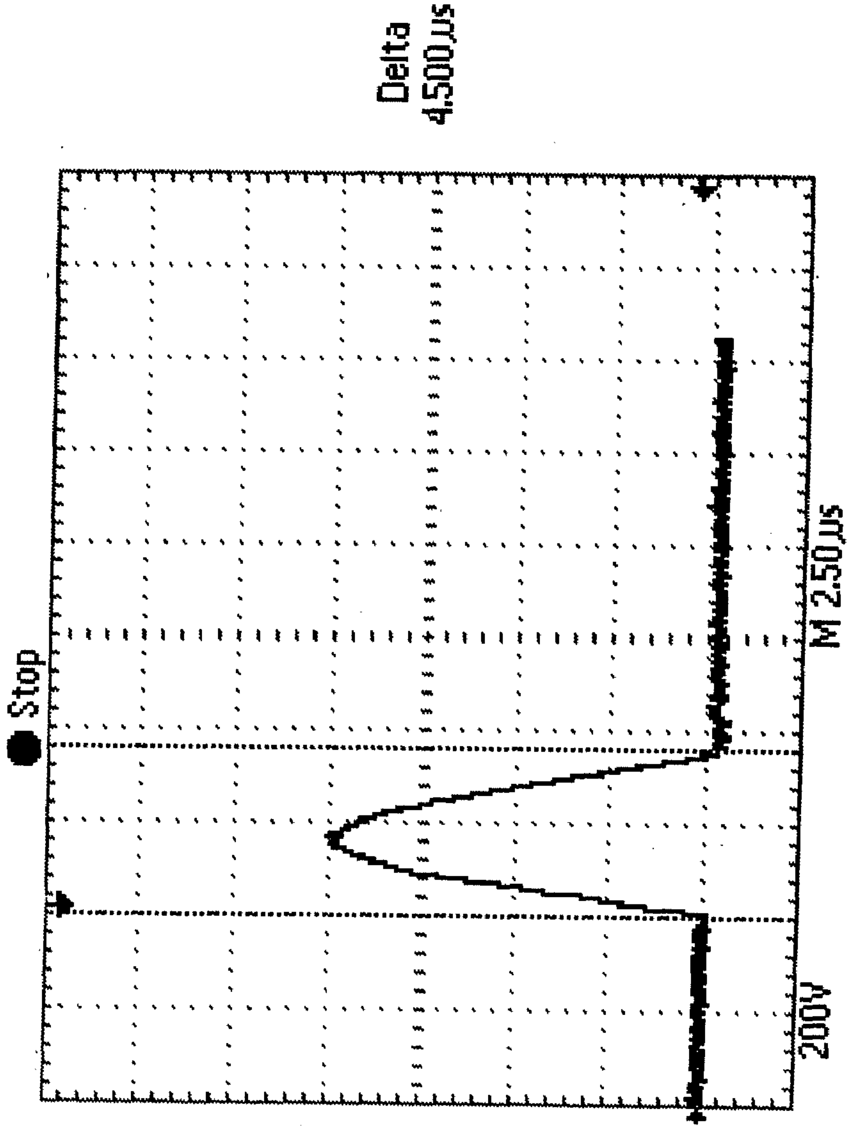


FIG. 12

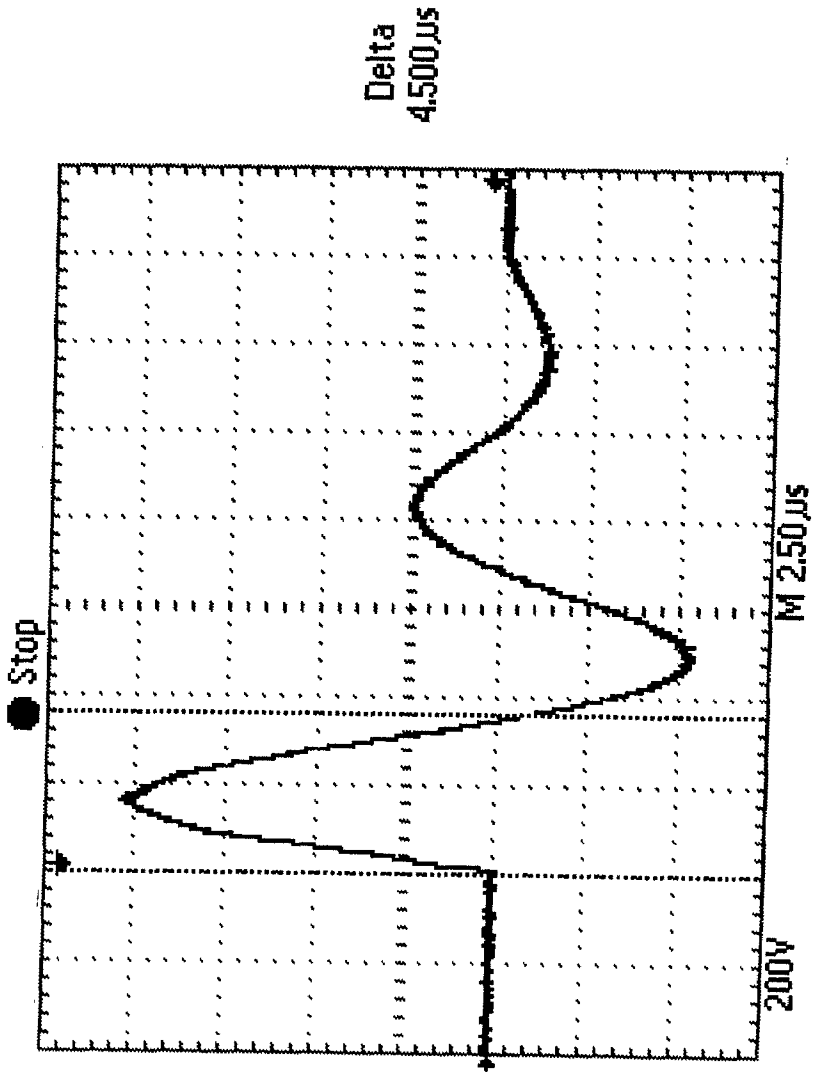


FIG. 13

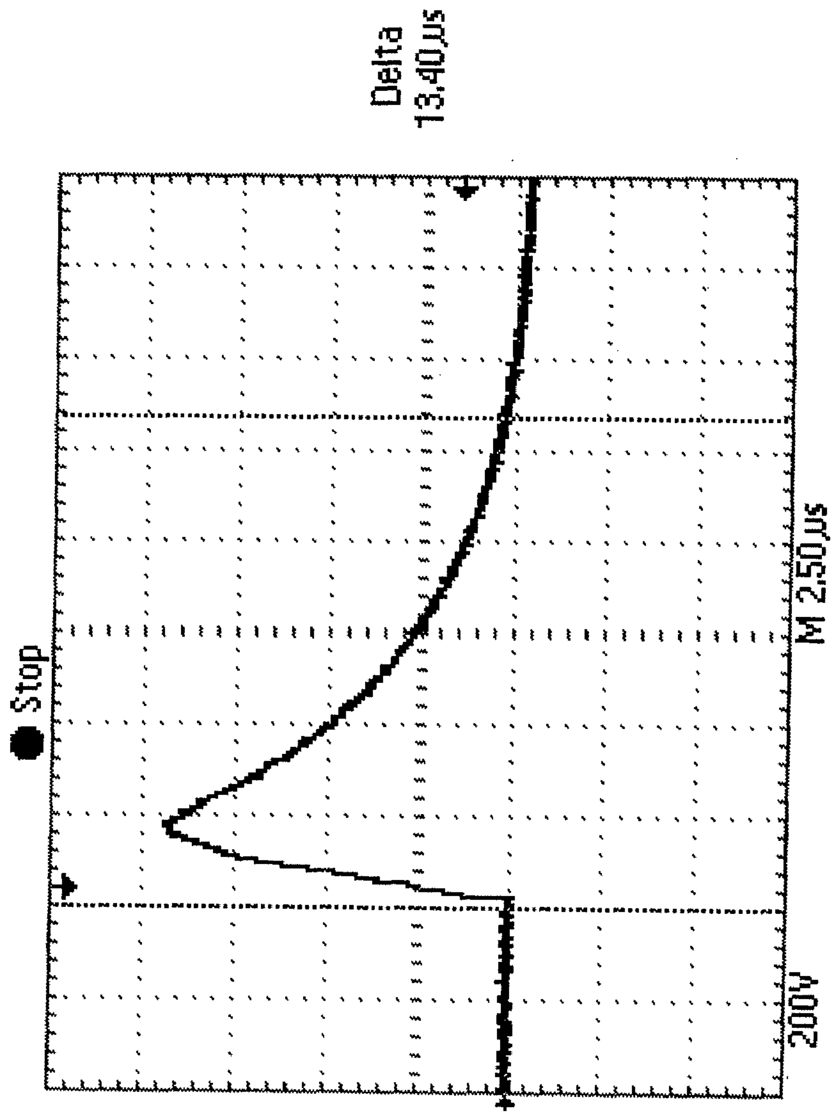
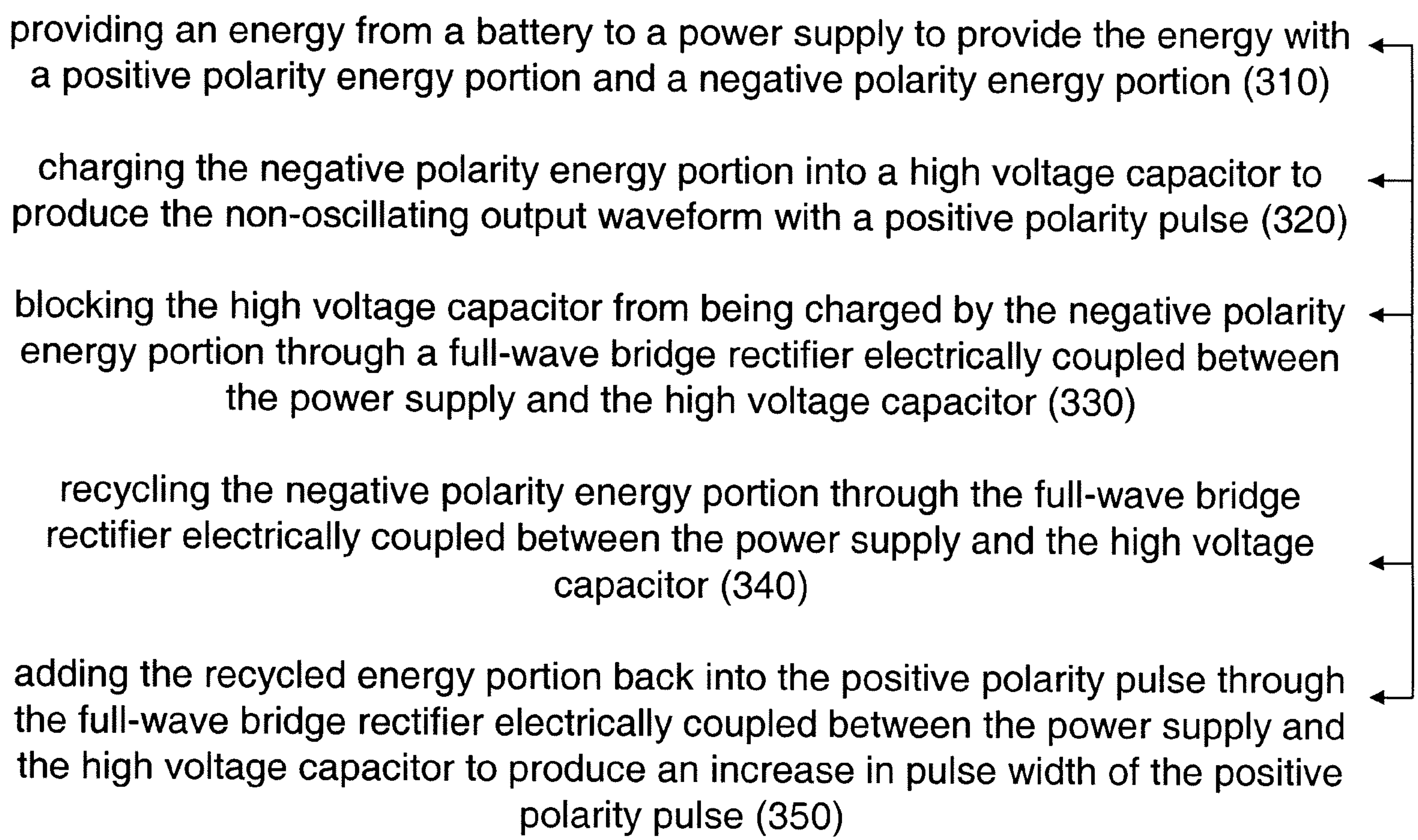


FIG. 14


providing an energy from a battery to a power supply to provide the energy with a positive polarity energy portion and a negative polarity energy portion (310)
charging the negative polarity energy portion into a high voltage capacitor to produce the non-oscillating output waveform with a positive polarity pulse (320)
blocking the high voltage capacitor from being charged by the negative polarity energy portion through a full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor (330)
recycling the negative polarity energy portion through the full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor (340)
adding the recycled energy portion back into the positive polarity pulse through the full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor to produce an increase in pulse width of the positive polarity pulse (350)

ELECTRONIC DISABLING DEVICE HAVING A NON-OSCILLATING OUTPUT WAVEFORM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation-in-part of U.S. patent application Ser. No. 11/359,251, filed Feb. 21, 2006, which claims priority to and the benefit of U.S. Provisional Application No. 60/655,145, filed on Feb. 22, 2005, and U.S. Provisional Application No. 60/657,294, filed on Feb. 28, 2005. The entire content in each of the above-referenced applications is incorporated by reference.

FIELD OF THE INVENTION

[0002] The present invention relates generally to the field of an electronic disabling device for immobilizing a live target. More specifically, the present invention is related to an electronic disabling device having a non-oscillating output waveform and a method for providing the same.

BACKGROUND OF THE INVENTION

[0003] An electronic disabling device can be used to refer to an electrical discharge weapon or a stun gun. The electrical discharge weapon connects a shocking power to a live target by the use of darts projected with trailing wires from the electrical discharge weapon. The shocks debilitate violent suspects, so peace officers can more easily subdue and capture them. The stun gun, by contrast, connects the shocking power to the live target that are brought into direct contact with the stun gun to subdue the target. Electronic disabling devices are far less lethal than other more conventional weapons such as firearms.

[0004] In general, the basic idea of the above described electronic disabling devices is to disrupt the electric communication system of muscle cells in a live target. That is, an electronic disabling device generates a high-voltage, low-amperage electrical charge. When the charge passes into the live target's body, it is combined with the electrical signals from the brain of the live target. The brain's original signals are mixed in with random noise, making it very difficult for the muscle cells to decipher the original signals. As such, the live target is stunned or temporarily paralyzed. The current of the charge may be generated with a pulse frequency that mimics a live target's own electrical signal to further stun or paralyze the live target.

[0005] To dump this high-voltage, low-amperage electrical charge, the electronic disabling device includes a shock circuit having multiple transformers and/or autoformers that boost the voltage in the circuit and/or reduce the amperage. The shock circuit may also include an oscillator to produce a specific pulse pattern of electricity and/or frequency.

[0006] Current electronic disabling devices take the lower voltage, higher current of a battery or batteries and convert it into a higher voltage, lower current output. This output must contact an individual in two places to create a full path for the energy to flow. For stun guns, this output is provided to two metal contacts on the contacting side of the device that are a short distance apart. On the electronic discharge weapons, this output is provided to two metal darts (or probes) that are propelled into the live target (or individual). The distance between the probes is normally larger than the stun gun contacts to allow for a greater effect of the live target. The metal probes are connected to the electrical circuitry in the device by thin conducting wires that carry the energy from/to the device and from/to the metal probes.

[0007] Typically, an electronic disabling device produces an output having an oscillating or sinusoidal output waveform with positive and negative amplitudes in the one output waveform as shown in FIG. **1**. This indicates that the electrons will first flow in a first (e.g., positive) direction, and a substantial number of the electrons will then flow in a second, opposite (e.g., negative) direction. That is, the negative (or opposite) amplitude in the sinusoidal output waveform shown in FIG. **1** is mainly caused by the electrons flowing in the opposite direction for a part of the cycle of the waveform. Therefore, a larger than necessary amount of electrons flowing in the opposite direction may be used on a person that could have been sufficiently immobilized by the electrons flowing in the first direction.

[0008] In view of the foregoing, it would be desirable to create an electronic disabling device for immobilization and capture of a live target having a non-oscillating pulse output waveform as shown in FIG. **2** and/or having an output waveform other than a non-oscillating or sinusoidal output waveform (or a non-sinusoidal output waveform) as, e.g., shown in FIGS. **2** and **10**. In addition, it would be desirable to provide an electronic disabling device that can selectively apply an oscillating or sinusoidal output waveform and a non-oscillating waveform such that the electronic disabling device does not apply an output waveform to a live target that might possibly be unsafe to that particular individual.

SUMMARY OF THE INVENTION

[0009] An aspect of the present invention is directed toward a system and/or an associated method for providing an electronic disabling device with an output having an output waveform other than an oscillating or sinusoidal waveform (e.g., a non-oscillating (or non-sinusoidal output waveform) and/or for providing the electronic disabling device that can selectively apply the non-oscillating output waveform and a sinusoidal output waveform in one device package. This would allow a user of the electronic disabling device to start with the non-oscillating output waveform and if the non-oscillating output wave was not effective, change to the sinusoidal output waveform. This adds a level of safety such that the user does not apply an output waveform to a live target that might possibly be unsafe to that particular individual.

[0010] In one exemplary embodiment of the present invention, an electronic disabling device for producing a non-sinusoidal output waveform to immobilize a live target is provided. The electronic disabling device includes a battery, a power supply, a final step-up transformer, a first electrical output contact, a second electrical output contact, and a bridge rectifier. The power supply is coupled to receive an initial power from the battery. The final step-up transformer is adapted to provide an output power having the non-sinusoidal output waveform. The first electrical output contact is coupled to receive the output power having the non-sinusoidal output waveform from the final step-up transformer. The second electrical output contact is coupled to receive the output power having the non-sinusoidal output waveform from the first electrical output through the live target. In addition, the bridge rectifier is coupled between the initial step-up voltage circuit and the final step-up transformer to produce the non-sinusoidal output waveform.

[0011] In one exemplary embodiment of the present invention, a method provides an electronic disabling device with a non-sinusoidal output waveform to immobilize a live target. The method includes: providing an input power from a battery to a power supply; stepping-up a voltage of the input power through the power supply; rectifying and transforming the input power to an output power through a bridge rectifier and a final step-up transformer to produce the non-sinusoidal output waveform; and providing the output power having the non-sinusoidal output waveform to an electrical output contact.

[0012] In one exemplary embodiment of the present invention, a method provides an electronic disabling device with an output waveform to immobilize a live target. The method includes: selecting a non-oscillating waveform or a sinusoidal waveform as the output waveform of the electronic disabling device; providing an input power from a battery to a power supply; stepping-up a voltage of the input power through the power supply; rectifying and transforming the input power to an output power through a bridge rectifier and a final step-up transformer to produce the selected output waveform; and providing the output power having the selected output waveform to an electrical output contact.

[0013] In one exemplary embodiment of the present invention, a method produces a non-oscillating output waveform from an electronic disabling device to immobilize a live target. The method includes: providing an energy from a battery to a power supply to provide the energy with a first energy portion having a first polarity and a second energy portion having a second polarity opposite the first polarity; charging the first energy portion having the first polarity into a high voltage capacitor to produce the non-oscillating output waveform with a pulse having the first polarity; blocking the high voltage capacitor from being charged by the second energy portion having the second polarity; recycling the second energy portion having the second polarity; and adding the recycled second energy portion back into the pulse having the first polarity to produce an increase in pulse width of the pulse having the first polarity.

[0014] In one exemplary embodiment of the present invention, a method produces a non-oscillating output waveform from an electronic disabling device to immobilize a live target. The method includes: producing an energy to have a first energy portion with a first polarity and a second energy portion with a second polarity opposite the first polarity; charging the first energy portion with the first polarity into a high voltage capacitor to produce the non-oscillating output waveform with a pulse having the first polarity; blocking the high voltage capacitor from being charged by the second energy portion with the second polarity; recycling the second energy portion having the second polarity; and adding the recycled second energy portion back into the pulse having the first polarity to produce an increase in pulse width of the pulse having the first polarity.

[0015] In one exemplary embodiment of the present invention, a method produces a non-oscillating output waveform from an electronic disabling device to immobilize a live target. The method includes: providing an energy from a battery to a power supply to provide the energy with a positive polarity energy portion and a negative polarity energy portion; charging the negative polarity energy portion into a high voltage capacitor to produce the non-oscillating output waveform with a positive polarity pulse; blocking the high voltage capacitor from being charged by the negative polarity energy portion through a full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor; recycling the negative polarity energy portion through the full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor; and adding the recycled energy portion back into the positive polarity pulse through the full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor to produce an increase in pulse width of the positive polarity pulse.

[0016] A more complete understanding of the electronic disabling device having a non-sinusoidal or non-oscillating output waveform will be afforded to those skilled in the art and by a consideration of the following detailed description. Reference will be made to the appended sheets of drawings which will first be described briefly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The accompanying drawings, together with the specification, illustrate exemplary embodiments of the present invention, and, together with the description, serve to explain the principles of the present invention.

[0018] FIG. **1** illustrates an exemplary sinusoidal output waveform.

[0019] FIG. **2** illustrates an exemplary non-oscillating output waveform.

[0020] FIG. **3** illustrates an exemplary electronic disabling device.

[0021] FIG. **4** illustrates an exemplary electronic disabling device using a relaxation oscillator.

[0022] FIG. **5** illustrates an exemplary electronic disabling device using an independently driven oscillator.

[0023] FIG. **6** illustrates an exemplary electronic disabling device for producing a sinusoidal output waveform.

[0024] FIG. **7** illustrates an exemplary electronic disabling device for producing a non-oscillating output waveform.

[0025] FIG. **8** illustrates another exemplary electronic disabling device for producing a non-oscillating output waveform.

[0026] FIG. **9** illustrates an exemplary electronic disabling device for producing a sinusoidal output waveform and a non-oscillating output waveform.

[0027] FIG. **10** illustrates an exemplary non-sinusoidal output waveform having a main uni-polar half-cycle pulse followed by an opposite polarity secondary uni-polar half-cycle pulse.

[0028] FIG. **11** shows an output waveform in voltage (200V block) versus time (μS block) produced by the circuit shown in FIG. 5 of U.S. Pat. No. 5,193,048.

[0029] FIG. **12** shows an output waveform in voltage (200V block) versus time (μS block) produced by a circuit similar to the circuit shown in FIG. 5 of U.S. Pat. No. 5,193,048 with the pair of diodes (i.e., diodes D**4** and D**5**) removed.

[0030] FIG. **13** shows an output waveform in voltage (200V block) versus time (μS block) produced by a circuit built with a full-wave bridge diode circuit as shown in FIG. **8** and pursuant to an embodiment of the present invention.

[0031] FIG. **14** is a flow diagram on a method of producing a non-oscillating output waveform from an electronic disabling device to immobilize a live target pursuant to an embodiment of the present invention.

DETAILED DESCRIPTION

[0032] In the following detailed description, only certain exemplary embodiments of the present invention are shown and described, by way of illustration. As those skilled in the art would recognize, the described exemplary embodiments may be modified in various ways, all without departing from the spirit or scope of the present invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not restrictive.

[0033] There may be parts shown in the drawings, or parts not shown in the drawings, that are not discussed in the specification as they are not essential to a complete understanding of the invention. Like reference numerals designate like elements.

[0034] Referring to FIG. **3**, an example of an electronic disabling device is shown to include a battery **10**, an initial step-up voltage circuit **20**, a trigger (not shown), a final step-up transformer **30**, a first electrically conductive output contact (or probe) **50**, and a second electrically conductive output contact (or probe) **60**. Each of the contacts **50**, **60** can be connected to the housing of the electronic disabling device by electrically conductive wires.

[0035] In operation, an electrical charge which travels into the contact **50** is activated by squeezing the trigger. The power for the electrical charge is provided by the battery **10**. That is, when the trigger is turned on, it allows the power to travel to the initial step-up voltage circuit **20**. The initial step-up voltage circuit **20** includes a first transformer that receives electricity from the battery **10** and causes a predetermined amount of voltage to be transmitted to and stored in a storage capacitor. Once the storage capacitor stores the predetermined amount of voltage, it is able to discharge an electrical pulse into the final step-up transformer **30** (e.g., a second transformer and/or autoformer). The output from the final step-up transformer **30** then goes into the first contact **50**. When the first and second contacts **50**, **60** contact a live target, charges from the first contact **50** travel into tissue in the target's body, then through the tissue into the second contact **60**, and then to a ground. Pulses are delivered from the first contact **50** into target's tissue for a predetermined number of seconds. The pulses cause contraction of skeletal muscles and make the muscles inoperable, thereby preventing use of the muscles in locomotion of the target.

[0036] In one embodiment, the shock pulses from an electronic disabling device can be generated by an oscillator such as a classic relaxation oscillator that produces distorted saw-tooth pulses. An electronic disabling device having the relaxation oscillator is shown as FIG. **4**.

[0037] Referring to FIG. **4**, power is supplied to the relaxation oscillator from a battery source **160**. The closure of a switch SW**1** connects the battery source **160** with an inverter transformer TI. In FIG. **4**, a tickler coil **110** of the inverter transformer T**1** between PAD**1** and PAD**2** is used to form the classic relaxation oscillator. A primary coil **100** of the inverter transformer T**1** is connected between PAD**3** and PAD**4**. Upon closure of the power switch SW**1**, the primary coil **100** of the inverter transformer T**1** is energized as a current flows through the coil **100** from PAD**3** to PAD**4** as the power transistor Q**1** is turned ON. The tickler coil **110** of the inverter transformer T**1** is energized upon closure of the power switch SW**1** through a resistor R**8** and a diode D**3**. The current through the tickler coil **110** also forms the base current of the power transistor Q**1**, thus causing it to turn ON. Since the tickler coil **110** and the primary coil **100** of the inverter transformer T**1** oppose one another, the current through power transistor Q**1** causes a flux in the inverter transformer T**1** to, in effect, backdrive the tickler coil **110** and cut off the power transistor Q**1** base current, thus causing it to turn OFF and forming the relaxation oscillator.

[0038] In addition, a secondary coil **120** of the inverter transformer T**1** between PAD**5** and PAD**6** is connected to a pair of diodes D**4** and D**5** that form a half-wave rectifier. The pair of diodes D**4** and D**5** are then serially connected with a spark gap **130** and then with a primary coil **140** of the output transformer T**2**. The primary coil **140** of the output transformer T**2** is connected between PAD**7** and PAD**8**. The spark gap **130** is selected to have particular ionization characteristics tailored to a specific spark gap breakover voltage to "tune" the output of the shock circuit.

[0039] In more detail, when sufficient energy is charged on a storage capacitor, a gas gap breaks down on the spark gap **130** such that the spark gap **130** begins to conduct electricity. This energy is then passed through the primary coil **140** of output or step-up transformer T**2**, which typically has a turn ratio of 1:35 to 1:37 primary coil **140** to secondary coil **150**.

[0040] However, the present invention is not limited to the above described exemplary oscillator embodiment. For example, an embodiment of an electronic disabling device can include a digital oscillator coupled to digitally generate switching signals or an independent oscillator **210** as shown in FIG. **5**.

[0041] In the disabling device of FIG. **5**, a power is supplied from a battery source **230** to an inverter transformer TI'. In FIG. **5**, a primary coil **240** of the inverter transformer T**1'** is connected between PAD**10** and PAD**11**. A power switch **250** is connected between the inverter transformer T**1'** and a ground. The power switch **250** (or a base or a gate of the power switch **250**) is also connected to the independent oscillator **210**.

[0042] In more detail, the primary coil **240** of the inverter transformer T**1'** is energized as current flows through the coil **240** from PAD**10** to PAD**11** as the switch (or transistor) **250** is turned ON. The independent oscillator **210** is coupled to the switch **250** (e.g., at the base or the gate of the switch **250**) to turn the switch **250** ON and OFF. A secondary coil **260** of the inverter transformer T**1'** between PAD**12** and PAD**13** is connected to a full-wave rectifier **270**. The full-wave rectifier **270** is then serially connected with a spark gap **280** and then with a primary coil **290** of the output transformer T**2'**. The primary coil **290** of the output transformer T**2'** is connected between PAD**14** and PAD**15**.

[0043] In operation, the oscillator **210** creates a periodic output that varies from a positive voltage (V+) to a ground voltage. This periodic waveform creates the drive function that causes current to flow through the primary coil **240** of the transformer T**1'**. This current flow causes current to flow in the secondary coil **260** of the transformer T**1'** based on the turn ratio of the transformer T**1'**. A power current from the battery source **230** then flows in the primary coil **240** of the transformer T**1'** only when the switch **250** is turned on and is in the process of conducting. The full wave bridge rectifier **270** then rectifies the voltage from the power source **230** when the switch **250** is caused to conduct.

[0044] In view of the foregoing, electronic disabling devices with high powered sinusoidal output waveforms can be formed. However, the propriety of forming weapons capable of producing such high powered sinusoidal output waveforms may be in question because the sinusoidal output waveforms may increase the weapons lethality, especially where a circuit operating at an output waveform other than an sinusoidal output waveform (e.g., a non-oscillating output waveform) can completely disable most test subjects. In addition, some seventy deaths have occurred proximate to use of such weapons. As such, using these weapons at only sinusoidal output waveforms may run contrary to the idea that electronic disabling devices are intended to subdue and capture live targets without seriously injuring them.

[0045] In accordance with an embodiment of the present invention, an electronic disabling device produces an output waveform other than a sinusoidal output waveform (e.g., a non-oscillating output waveform) and/or can selectively apply the non-oscillating output waveform and a sinusoidal output waveform in one device package. This would allow a user of the electronic disabling device to start with the non-oscillating output waveform and if the non-oscillating output wave was not effective, change to the sinusoidal output waveform. This adds a level of safety such that the user does not apply an output waveform to a live target that might possibly be unsafe to that particular individual.

[0046] FIG. **6** shows a view into an initial step-up circuit of an electronic disabling device connected with a final step-up transformer of the electronic disabling device. The initial step-up circuit includes a power supply **585** having an oscillator (e.g., the oscillator shown in FIGS. **4** or **5** for providing a pulse rate), a bridge rectifier **580**, a spark gap SG**1**, and a storage capacitor C**1**. Here, the storage capacitor C**1** is connected to a primary coil **570** of the final step-up transformer in series, and the spark gap SG**1** is connected to the storage capacitor C**1** and the primary coil **570** in parallel. As such, the spark gap SG**1** and the storage capacitor C**1** are positioned to provide a sinusoidal output waveform as shown in FIG. **1**.

[0047] In more detail, an energy from the bridge rectifier **580** of the initial step-up voltage circuit (e.g., a full-wave bridge rectifier circuit having at least four diodes) is initially used to charge up one plate of the storage capacitor C**1**. The spark gap SG**1** fires whenever the voltage of the storage capacitor C**1** reaches a fixed breakdown voltage of the spark gap SG**1**, and the stored energy discharges through the primary coil **570**. In addition, because the storage capacitor C**1** and the primary coil **570** are connected to create a tank circuit, as the capacitor C**1** discharges, the primary coil **570** will try to keep the current in the circuit moving, so it will charge up the other plate of the capacitor C**1**. Once the field of the primary coil **570** collapses, the capacitor C**1** has been recharged (but with the opposite polarity), so it discharges again through the primary coil **570**. As such, the sinusoidal output waveform as shown in FIG. **1** is provided by the electronic disabling device of FIG. **6**.

[0048] Alternatively, referring to FIG. **7**, an electronic disabling device in accordance with one embodiment of the present invention includes a battery **610**, an initial step-up voltage circuit **620**, a trigger (not shown), a final step-up transformer **630**, a first electrically conductive output contact (or probe) **650**, and a second electrically conductive output contact (or probe) **660**. Also, in FIG. **7**, the initial step-up circuit includes a spark gap SG**1'**, a storage capacitor C**1'**, a power supply **685** having an oscillator, and a bridge rectifier **680**. Here, the spark gap SG**1'** is connected to a primary coil **670** of the final step-up transformer **670** in series, and the storage capacitor C**1'** is connected to the spark gap SG**1'** and the primary coil **670** in parallel. As such, the spark gap SG**1'** and the storage capacitor C**1'** are positioned to provide the non-oscillating output waveform as shown in FIG. **2**.

[0049] In more detail, the spark gap SG**1'** and the storage capacitor C**1'** of FIG. **7** are positionally switched as compared to the spark gap SG**1** and the storage capacitor C**1** to remove the tank circuit and to produce the non-oscillating output waveform as shown in FIG. **2**. As such, the electronic disabling device of FIG. **7** produces a mostly positive pulse waveform or a mostly negative pulse waveform. Also, this indicates that electrons flow mainly in one direction with fewer electrons flowing in the opposite direction. That is, as described above, the opposite amplitude in the sinusoidal output waveform of FIG. **1** is caused by the electrons flowing in the opposite direction for part of the cycle.

[0050] Referring to FIG. **8**, an electronic disabling device according to a more specific embodiment of the present invention includes a secondary coil **625'** of an initial step-up voltage circuit **620**. The secondary coil **625'** is connected to a first pair of diodes D**2** and D**4** and a second pair of diodes D**1** and D**3**. The first and second pairs of diodes D**1**, D**2**, D**3**, and D**4** form a full-wave rectifier **680'**. The bridge rectifier **680'** is then serially connected with a spark gap SG**1"** and then a primary coil **670'** of a final step-up transformer **630'**. Here, a resistor R**1** and a capacitor C**1"** are also connected to the spark gap SG**1"** and the primary coil **670'** in parallel. As such, the bridge rectifier **680'**, the spark gap SG**1"** and the storage capacitor C**1"** are positioned to provide the non-oscillating output waveform as shown in FIG. **2**.

[0051] Referring to FIG. **9**, an electronic disabling device in accordance with another embodiment of the present invention includes a battery **710**, a power supply **785**, a bridge rectifier circuit **780**, a primary coil **770** of a final step-up transformer, and a control logic **790**. In addition, the electronic disabling device of FIG. **9** includes a spark gap SG, a storage capacitor C, first electrical switching devices U**1** and U**3**, and second electrical switching devices U**2** and U**4** to allow on-the-fly changing of the output waveform. That is, the electronic disabling device of FIG. **9** outputs the sinusoidal output waveform (e.g., as shown in FIG. **1**) when the first electrical switching devices U**1** and U**3** are switched on (to create a closed circuit) and the second electrical switching devices U**2** and U**4** are switched off (to create an opened circuit). By contrast, the electronic disabling device of FIG. **9** outputs the non-oscillating output waveform (e.g., as shown in FIG. **2**) when the first switching devices U**1** and U**3** are switched off and the second switching devices U**2** and U**4** are switched on.

[0052] In more detail, when the first electrical switching devices U**1** and U**3** are switched on (i.e., closed) and the second electrical switching devices U**2** and U**4** are switched off (i.e., opened), the device of FIG. **9** has a configuration that is substantially the same as the device shown in FIG. **7**. That is, the spark gap SG**1** is connected to the primary coil **770** in series, and the storage capacitor C is connected to the spark gap SG and the primary coil **770** in parallel to provide the non-oscillating output waveform. By contrast, when the second electrical switching devices U**2** and U**4** are switched on (i.e., closed) and the first electrical switching devices U**1** and U**3** are switched off (i.e., opened), the device of FIG. **9** has a configuration that is substantially the same as the device shown in FIG. **6**. That is, the storage capacitor C is connected to the primary coil **770** in series, and the spark gap SG is connected to the storage capacitor C and the primary coil **770** in parallel to provide the sinusoidal output waveform. In FIG. **9**, the control logic **790** is added to control the switching devices U**1**, U**2**, U**3**, and U**4** to allow a control input from a user. This control logic **790** would also provide an input to the power supply **785** including an oscillator to keep the same output pulse rate. As such, the electronic disabling device of

FIG. **9** can selectively apply the non-oscillating output waveform and the sinusoidal output waveform in one device package.

[0053] FIG. **10** shows another output waveform other than a sinusoidal output waveform according to an embodiment of the present invention. Here, the output waveform of FIG. **10** includes a first (or main) uni-polar half-cycle pulse followed by an opposite polarity second (or secondary) uni-polar half-cycle pulse. That is, the entire output waveform of FIG. **10** has a first (or peak) amplitude A_1 and a second amplitude A_2 having an opposite polarity with the first amplitude A_1. The second amplitude A_2 has an amplitude that is equal to or less (i.e., not greater) than 25 percent of the first (or peak) amplitude A_1. In FIG. **10**, the first amplitude A_1 can be a positive voltage amplitude or a negative voltage amplitude as long as the second amplitude A_2 oscillates in the opposite polarity at an amplitude not greater than 25 percent of the first (or peak) amplitude A_1.

[0054] The output waveform of FIG. **10** can be formed by removing 75 percent or more of the amplitude opposite the peak amplitude. By removing more than 75 percent of peak opposite amplitude from the waveform, a mostly positive or mostly negative half-cycle waveform is formed. Furthermore, this indicates that electrons flow mainly in one direction with fewer electrons flowing in the opposite direction. This is because, referring now also to FIG. **1**, the opposite amplitude in the sinusoidal pulse output waveform is caused mainly by the electrons flowing in the opposite direction for a part of the cycle of the sinusoidal pulse output waveform.

[0055] In one embodiment, the first (or peak) amplitude A_1 is at positive 620 volts and the second amplitude A_2 is at 40 volts to produce a half-cycle uni-pulse output waveform with an opposite polarity of about 7 percent.

[0056] In view of the foregoing, an electronic disabling device according to an embodiment of the present invention utilizes a rectifier and a non-tank circuit to produce a non-oscillating output waveform. Here, the majority of electrons traveling in the opposite polarity of the peak amplitude are in essence filtered or redirected

[0057] Further, an electronic disabling device according to another embodiment of the present invention can selectively apply a non-oscillating output waveform and a sinusoidal output waveform in one device package. This would allow a user of the electronic disabling device to start with the non-oscillating output waveform and if the non-oscillating output wave was not effective, change to the sinusoidal output waveform.

[0058] In addition, as shown in FIGS. **2** and **10**, an electronic disabling device according to an embodiment of the present invention outputs: (1) a half-cycle uni-polar pulse, followed by a slow uni-polar pulse of the opposite polarity; (2) a half-cycle uni-polar pulse waveform in which amplitude oscillates to peak in one direction and exhibits a uni-polar pulse of the opposite polarity with less than 25% of the peak amplitude; (3) a half-cycle uni-polar pulse, followed by a slow uni-polar pulse of the opposite polarity through a 1000 OHM load to produce a total pulse width between 3 and 50 micro seconds, a peak voltage between 2000 and 20000 volts, between 5-25 pulses per second, between 0.05 and 1 watt contained in a single pulse peak amplitude (joules per pulse), or between 1 and 20 watts per second (joules); or (4) a non-oscillating that does not have a uni-polar pulse of the opposite polarity (e.g., as shown in FIG. **2**) with a total pulse width between 3 and 50 micro seconds, a peak voltage between 2000 and 20000 volts, between 5-25 pulses per second, between 0.05 and 1 watt contained in a single pulse peak amplitude (joules per pulse), or between 1 and 20 watts per second (joules).

[0059] In view of the foregoing, an embodiment of the present invention provides an electronic disabling device that produces a non-oscillating, increased pulse width, non opposite polarity output waveform to immobilize a live target. Here, the electronic disabling device includes a battery, an initial step-up transformer (e.g., **620'** in FIG. **8**) coupled to receive an initial power from the battery, having one output directly coupled between two switching devices, and a second output directly coupled between an additional two switching devices, and a spark gap directly coupled to a first input of a second step-up transformer (final step-up transformer), in parallel with a high voltage (HV) capacitor that is directly coupled to a second input of the second (or final) step-up transformer (e.g., **630'** in FIG. **8**).

[0060] The non-oscillating, increased pulse width, non opposite polarity output waveform produced by the above described disabling device and pursuant to an embodiment of the present invention is described in more detail with reference to FIGS. **11**, **12**, and **13** as follows.

[0061] FIG. **11** shows an output waveform in voltage (200V block) versus time (μS block) produced by the circuit shown in FIG. 5 of U.S. Pat. No. 5,193,048, the entire content of which is incorporated herein by reference. Here, the output waveform has a positive pulse width (Delta) of 4.5 μS and shows that the circuit just clamps or blocks the negative cycle from passing through as the output waveform.

[0062] FIG. **12** shows an output waveform in voltage (200V block) versus time (μS block) produced by a circuit similar to the circuit shown in FIG. 5 of U.S. Pat. No. 5,193,048 with the pair of diodes (i.e., diodes D**4** and D**5**) removed. The first part of the sine wave produced is the same as the pulse produced in FIG. **11** with a positive pulse width (Delta) of 4.5 μS. Therefore, as can be derived from FIGS. **11** and **12**, the pair of diodes D**4** and D**5** appears to only remove the negative pulse and ringing.

[0063] FIG. **13** shows an output waveform in voltage (200V block) versus time (μS block) produced by a circuit built with a full-wave bridge diode circuit as shown in FIG. **8** and pursuant to an embodiment of the present invention. Here, it is shown that the circuit in FIG. **8** does not block the negative part of the waveform from being recycled (recovered) and then utilizing the recovered energy by converting it to positive energy and passing it with the initial pulse. That is, the output waveform as shown in FIG. **13** with the full-wave bridge diode circuit (e.g., the full-wave bridge rectifier **680'** unexpectedly results in a positive pulse width (Delta) of 13.4 μS, which is about three times wider than the output waveform shown in FIG. **11**.

[0064] Here, Joule output at 19 HZ of the output waveform shown in FIG. **11** is 5.47, and Joule output at 19 HZ of the output waveform shown in FIG. **13** is 15.49. The increased Joule output is desired for the following two reasons. First it allows for much smaller electronics such as capacitors, output transformers, and spark gaps. By stretching the pulse width the electronic disabling device can use a much lower voltage. Lower voltage electronics are much smaller. This will allow for a much smaller end product. Second, smaller components or components with smaller voltage ratings are much cheaper and more readily available to the industry, thus providing cost benefits for both the manufacturer and end user.

[0065] The operation of the circuit shown in FIG. 8 pursuant to an embodiment of the present invention is described in more detail as follows.

[0066] Referring now back to FIG. 8, the full wave diode bridge 620' across the high voltage (HV) capacitor C1" blocks (or prevents) the HV capacitor C1" from recharging in the opposite direction. As such, the full wave bridge rectifier 620' recycles the negative energy and adds it to the positive pulse shown, e.g., in FIG. 13. The full wave bridge rectifier 620' causes the flow to lock-up in the reverse direction producing an exponential decay of current and produces a DC like increased pulse width on the output waveform (see FIG. 13) produced by the circuit shown in FIG. 8. That is and referring now also to FIG. 13, at time Stop, the full bridge rectifier 620' across the capacitor C1" will not allow the capacitor C1" to recharge in the opposite direction from the revised current, and causes the flow to lock-up in the reverse direction producing the exponential decay of current and produces the DC like increased pulse width on the output waveform (see FIG. 13). The exponential decay of current is represented as $e^{-t/T}$, where the time constant T=L/R and where L is the inductance of the primary coil 670' and the secondary coil 625' and R is the primary resistance, the secondary resistance (transformed) and core losses.

[0067] As such and in view of the foregoing, a method according to an embodiment of the present invention produces a non-oscillating output waveform from an electronic disabling device to immobilize a live target. The method includes: providing an energy from a battery to a power supply to provide the energy with a first energy portion having a first polarity and a second energy portion having a second polarity opposite the first polarity; charging the first energy portion having the first polarity into a high voltage capacitor to produce the non-oscillating output waveform with a pulse having the first polarity; blocking the high voltage capacitor from being charged by the second energy portion having the second polarity; recycling the second energy portion having the second polarity; and adding the recycled second energy portion back into the pulse having the first polarity to produce an increase in pulse width of the pulse having the first polarity.

[0068] A method according to another embodiment of the present invention produces a non-oscillating output waveform from an electronic disabling device to immobilize a live target. The method includes: producing an energy to have a first energy portion with a first polarity and a second energy portion with a second polarity opposite the first polarity; charging the first energy portion with the first polarity into a high voltage capacitor to produce the non-oscillating output waveform with a pulse having the first polarity; blocking the high voltage capacitor from being charged by the second energy portion with the second polarity; recycling the second energy portion having the second polarity; and adding the recycled second energy portion back into the pulse having the first polarity to produce an increase in pulse width of the pulse having the first polarity.

[0069] A method according to yet another embodiment of the present invention produces a non-oscillating output waveform from an electronic disabling device to immobilize a live target. The method includes: providing an energy from a battery to a power supply to provide the energy with a positive polarity energy portion and a negative polarity energy portion; charging the negative polarity energy portion into a high voltage capacitor to produce the non-oscillating output waveform with a positive polarity pulse; blocking the high voltage capacitor from being charged by the negative polarity energy portion through a full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor; recycling the negative polarity energy portion through the full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor; and adding the recycled energy portion back into the positive polarity pulse electrically coupled between the power supply and the high voltage capacitor to produce an increase in pulse width of the positive polarity pulse.

[0070] In more detail and as illustrated in FIG. 14, an embodiment of the present invention provides a method of producing a non-oscillating output waveform from an electronic disabling device to immobilize a live target. In step 310 of the method, an energy is provided from a battery to a power supply to provide the energy with a positive polarity energy portion and a negative polarity energy portion. The negative polarity energy portion is charged into a high voltage capacitor to produce the non-oscillating output waveform with a positive polarity pulse in step 320. The high voltage capacitor is blocked from being charged by the negative polarity energy portion through a full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor in step 330. The negative polarity energy portion is recycled through the full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor in Step 340. Then, in step 350 of the method, the recycled energy portion is added back into the positive polarity pulse through the full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor to produce an increase in pulse width of the positive polarity pulse.

[0071] While the invention has been described in connection with certain exemplary embodiments, it is to be understood by those skilled in the art that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications included within the spirit and scope of the appended claims and equivalents thereof.

What is claimed is:

1. A method of producing a non-oscillating output waveform from an electronic disabling device to immobilize a live target, the method comprising:

producing an energy to have a first energy portion with a first polarity and a second energy portion with a second polarity opposite the first polarity;

charging the first energy portion with the first polarity into a high voltage capacitor to produce the non-oscillating output waveform with a pulse having the first polarity;

blocking the high voltage capacitor from being charged by the second energy portion with the second polarity;

recycling the second energy portion having the second polarity; and

adding the recycled second energy portion back into the pulse having the first polarity to produce an increase in pulse width of the pulse having the first polarity.

2. A method of producing a non-oscillating output waveform from an electronic disabling device to immobilize a live target, the method comprising:

providing an energy from a battery to a power supply to provide the energy with a first energy portion having a first polarity and a second energy portion having a second polarity opposite the first polarity;

charging the first energy portion having the first polarity into a high voltage capacitor to produce the non-oscillating output waveform with a pulse having the first polarity;

blocking the high voltage capacitor from being charged by the second energy portion having the second polarity;

recycling the second energy portion having the second polarity; and

adding the recycled second energy portion back into the pulse having the first polarity to produce an increase in pulse width of the pulse having the first polarity.

3. A method of producing a non-oscillating output waveform from an electronic disabling device to immobilize a live target, the method comprising:

providing an energy from a battery to a power supply to provide the energy with a positive polarity energy portion and a negative polarity energy portion;

charging the negative polarity energy portion into a high voltage capacitor to produce the non-oscillating output waveform with a positive polarity pulse;

blocking the high voltage capacitor from being charged by the negative polarity energy portion through a full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor;

recycling the negative polarity energy portion through the full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor; and

adding the recycled energy portion back into the positive polarity pulse through the full-wave bridge rectifier electrically coupled between the power supply and the high voltage capacitor to produce an increase in pulse width of the positive polarity pulse.

* * * * *