(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 124 210**
B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification: **14.10.87**

(51) Int. Cl.⁴: **H 02 M 3/335**

(21) Application number: **84301060.4**

(22) Date of filing: **17.02.84**

(54) Current driven flyback power supply.

(30) Priority: **27.04.83 US 489263**

(43) Date of publication of application:
07.11.84 Bulletin 84/45

(45) Publication of the grant of the patent:
14.10.87 Bulletin 87/42

(84) Designated Contracting States:
AT CH DE FR GB IT LI LU NL SE

(56) References cited:
DE-A-2 041 341
DE-A-2 725 531
GB-A-1 456 383
US-A-4 135 234

(73) Proprietor: **ASTEC COMPONENTS LTD.**
Kaiser Estate, Phase 2, 6/FL 51 Man Yue Street
Hunghom Kowloon (HK)

(72) Inventor: **Josephson, Elliot**
1206 Windimer Drive
Los Altos California 94022 (US)
Inventor: **Parker, Frederick Stetson**
735 Condor Avenue
Ben Lomand California 95005 (US)

(74) Representative: **Cross, Rupert Edward Blount et al**
BOULT, WADE & TENNANT 27 Furnival Street
London EC4A 1PQ (GB)

Courier Press, Leamington Spa, England.

EP 0 124 210 B1

Description

The present invention relates generally to DC power supplies, and more particularly to a current driven, free running flyback power supply.

Known DC flyback power supplies provide one or more regulated output DC voltages from an unregulated DC source. Power from the DC source is transferred first to a power transformer during a drive cycle and secondly to an output rectifier circuit during a flyback cycle, the rectifier circuit providing the output voltage. During the drive cycle, a switch closes, thereby coupling a primary winding of the power transformer in series with the DC source. This develops a current in the primary winding causing energy to be stored in the transformer. To start the flyback cycle, the switch is opened. The stored energy is then coupled out through a secondary winding of the power transformer to the rectifier circuit. The switch is usually a transistor switch in series with the primary winding and the DC source. The "on" time of the transistor switch during the drive cycle determines the amount of magnetic energy stored in the power transformer. The switching rate of the transistor switch is controlled through negative feedback of the output voltage to provide output voltage regulation.

With negative feedback of the output voltage, a transformer coupled switching regulator is realized. Normally, the regulator samples the output DC voltage and compares it with a voltage reference, and uses the resultant error voltage signal to control the transistor switch. This error signal is usually applied to the transistor switch through an isolation circuit to maintain isolation between the DC source and output voltage. To properly regulate the output voltage during minimum and maximum load conditions, the transistor switch oscillates so that it has minimum on time during minimum load and maximum on time at maximum load.

During periods of high output load, the free running power supply can also be operated as a clocked power supply. If the stored energy of the power transformer during the flyback cycle has not been fully transferred to the rectifier circuit, and hence to the load, after a predetermined time interval, a timing circuit can initiate turn-on of the transistor switch to begin a new drive cycle. The initial current in the primary winding is boosted by the residual stored energy of the power transformer which is coupled back to the primary winding, thereby increasing the amount of stored energy which may be transferred out of the secondary winding to the rectifier circuit during the next flyback cycle. In an isolated, voltage driven regulator, this timing circuit can be driven from the voltage of a tertiary or feedback winding of the power transformer, which avoids DC coupling between the secondary winding and the switching transistor.

DC isolation between the primary and secondary windings of the power transformer is usually provided when the power supply must meet certain safety standards of performance requirements. For example, high voltage transients and electromagnetic interference (noise) are not coupled through to the secondary winding and output rectifier circuit, or, at least, are substantially minimized when DC isolation is provided.

Such a flyback power supply is disclosed in GB—A—1456383 which discloses a flyback power supply for developing an output DC voltage from a source of DC, comprising a power transformer including a primary winding and a secondary winding; current switch means for periodically coupling a primary current during a first interval of time through said primary winding from said source, whereby energy is stored in said transformer during said first interval, said primary current having an increasing amplitude during each said interval; means for developing a drive current whose amplitude is a function of said primary current and for coupling said drive current to said current switch means, said current switch means being responsive to said drive current for enabling said current switch means to remain on; feedback means for developing a feedback pulse at a point in time after said current switch means turns on as a function of the deviation of said output voltage from a predetermined voltage; electrical switch means for turning off said current switch means in response to said feedback pulse, said energy stored in said transformer being transferred out through said secondary winding when said current switch means is off during a second interval of time; means responsive to said energy transferred out through said secondary winding during said second interval of time for developing said output DC voltage; and means for developing a first current pulse when all of said stored energy has been transferred out through said secondary winding, said first current pulse being applied to said current switch means to initiate coupling of said primary current through said primary winding.

A power supply for a small, portable computer does not generally need to meet such safety and performance requirements. It is such desirable to provide DC coupling between the primary and secondary winding sides of the power transformer. Such DC coupling allows simplification in circuit design while providing the plurality of well regulated output voltages required in such a computer, and also minimizing the space occupied by the power supply. In a briefcase size computer designed to have a minimal overall dimension, it is especially desirable to reduce the space occupied by the power supply.

According to this invention there is provided a flyback power supply as set out above characterised by means for developing a second current pulse at a selected point in time during said second interval of time, said second current pulse being applied to said current switch means to initiate coupling of said primary current through said primary winding prior to all of said stored energy being transferred out through said secondary winding.

This invention will now be described by way of example with reference to the drawings, in which:—

FIG. 1 is a schematic diagram of a current driven free running flyback power supply according to the present invention;

FIG. 2A—C are a timing diagram illustrating the operation of a portion of the circuit of Fig. 1;

FIG. 3 is a timing diagram illustrating the operation of another portion of Fig. 1; and

FIG. 4 is a schematic diagram of another embodiment of a current driven free running flyback power supply power supply according to the present invention.

Referring now to Fig. 1, the present invention is described in greater detail with respect to a schematic diagram of a preferred embodiment of a current driven, free running flyback power supply 10. Power supply 10 develops one or more output voltages from a conventional, unregulated DC voltage source 12. In a preferred embodiment, source 12 develops this unregulated DC voltage in a conventional manner from an AC power source by means of a filter 14, a diode bridge 16 and one or more LC filter stages 18. A fuse 20 may also be provided for short circuit protection within power supply 10.

Power supply 10 includes a power transformer 22 and a current switch 24. Power transformer 22 has a primary winding 26 and one or more secondary windings 28 and 30. Primary winding 26 is electrically coupled in series between source 12 and current switch 24. When current switch 24 is on, it causes a primary current to be coupled through primary winding 26 from source 12. The primary current causes energy to be stored in power transformer 22. Current switch 24 is preferably a transistor biased as a switch which functions to couple primary current from primary winding 26 to ground when an appropriate drive current is applied to the base of this transistor.

Power supply 10 further includes means for developing a drive current to drive current switch 25 regeneratively from the primary current. Current switch 24, as the primary current constantly increases in amplitude, receives a drive current which also proportionally increases in amplitude, thereby maintaining current switch 24 on. In the preferred embodiment of power supply 10, the drive current developing means includes a current transformer 32, a diode 34 and a damping resistor 36. Current transformer 32 has a first winding 38 in series with primary winding 26 to sense the primary current and a second winding 40 which regeneratively develops the drive current. Therefore, the drive current generated by second winding 40 is proportional to the primary current. During positive transitions of the primary current, a voltage is induced in first winding 38 which is magnetically coupled to second winding 40. First and second windings 38 and 40 are arranged so that the voltage across second winding 40 during positive transitions of the primary current forward biases diode 34, to complete a drive current loop for the drive current through current switch 24, diode 34 and second winding 40. The drive current is applied to the base of transistor current switch 24 through a resistor 42, as described in greater detail hereinbelow. Damping resistor 36 damps ringing of second winding 40 when diode 34 becomes reversed biased and opens the drive current loop.

Also included in power supply 10 is an electrical switch means 44 for turning off current switch 24. When switch 44 goes on, it provides a path to ground for the drive current. Preferably, switch 44 is connected directly between the base of transistor switch 24 and ground. As described below in greater detail, when current switch 24 turns off, the flyback cycle begins, and energy is transferred out of the power transformer 22 via secondary windings 28 and 30.

Electrical switch means 44 includes a first switching transistor Q1, a second switching transistor Q2, a resistor 46, as well as the above mentioned resistor 42. When transistor Q1 goes on, it saturates to short the drive current and the base of current switch 24 to ground, whereby current switch 24 is turned off. Transistor Q1 is caused to go on in one of two ways. Usually it will go on in response to a feedback pulse, developed as hereinbelow described, from the secondary winding side of power supply 10 which is applied to the base of transistor Q1. It will also go on as a function of transistor Q2 and resistor 42. When the primary current reaches a predetermined maximum, the proportional drive current develops a voltage across resistor 42 sufficient to forward bias the base-emitter junction of transistor Q2 which then turns on. Resistor 46 is a bias resistor for transistor Q1. When transistor Q2 turns on, its collector current develops a voltage across resistor 46 sufficient to allow transistor Q1 to turn on.

A rectifier means 48 and 50 is associated with each respective secondary winding 28 and 30. Each rectifier means 48 and 50 develops an output voltage from the stored energy transferred to its associated secondary winding. Rectifier means 48 is of conventional design and includes a diode 60, a capacitor 62 and an output LC filter stage having an inductor 64 and a capacitor 66. Rectifier means 48 also includes a bleeder resistor 68 which bleeds a small amount of stored charge from capacitor 66. Rectifier means 50 is also of conventional design, and includes a diode 70, a capacitor 72, and an output LC filter stage having an inductor 74 and a capacitor 76.

When all the stored energy of secondary winding 28 has been delivered to rectifier means 48, secondary winding 28 will change polarity. A current pulse developing means 52 develops a short current pulse in response to this change of polarity. This current pulse is applied to current switch 24 through resistor 42. Current switch 24 is turned on by this current pulse to initiate the flow of primary current through primary winding 26. Once the primary current is initiated, the drive current generated by current transformer 32 drives current switch 24.

Current pulse developing means 52 includes a tertiary winding 54, a resistor 56 and a capacitor 58. Tertiary winding 54 is a feedback winding of power transformer 22. When the polarity of secondary windings 28, 30 change after their stored energy has been delivered to respective rectifier means 48, 50, tertiary winding 54 changes polarity, causing a positive current to flow through resistor 56, capacitor 58 and resistor 42 into the base of current switch 24. The time constant of resistor 56 and capacitor 58 is selected so that this current quickly charges capacitor 58, and only the short current pulse described above passes through capacitor 58. The time constant of this R—C circuit is preferably on the order of one microsecond.

Power supply 10 also includes pulse-width modulating means 78 for developing a feedback pulse at a time determined by the output voltage developed by rectifier means 50. Electrical switch means 44 responds to this feedback pulse by shorting the drive current and the base of current switch 24 to ground, thereby turning off switch 24. Timing of the feedback pulse provides regulation of the output voltage by controlling the time duration of the drive cycle. In one embodiment of the present invention, the feedback pulse is DC coupled to the electrical switch means at the base of transistor Q1.

Pulse-width modulating means 78 includes a switching transistor Q3, and means for generating a ramp voltage having an indicator 80 and resistor 82. Pulse-width modulating means 78 also includes means for developing an error voltage as a function of the deviance of the output voltage of rectifier means 50 from a desired output voltage, and a voltage averaging circuit formed by resistors 92 and 94. The error voltage developing means includes a comparator 84, a source of reference potential having a zener diode 86, and a voltage divider network formed by resistors 88 and 90.

The error voltage developed by comparator 84 is proportional to the difference between the reference voltage developed by zener diode 86 and the divided output voltage between resistors 88 and 90. The reference voltage of zener diode 86 and the values of resistors 88 and 90 are selected so that when the output voltage of rectifier means 50 is at its desired regulated value, the error voltage goes low. Thus, in an exemplary embodiment of the present invention, with the output of rectifier means 50 set at 5 volts, when resistors 88 and 90 are of equal value, zener diode 86 is selected to provide a reference of 2.5 volts. The error voltage is weighted with the present output voltage through resistors 92 and 94 to provide the base drive voltage for transistor Q3.

When the ramp voltage applied to the emitter of transistor Q3 exceeds the base drive voltage, transistor Q3 turns on, developing the feedback pulse which is applied to the base of transistor Q1 of electronic switch means 44. Electronic switch means 44, in response thereto, shorts the drive current to ground to turn off current switch 24.

Power supply 10 also includes boost circuit means for developing a short, second current pulse at a predetermined time after current switch 24 is switched off. This boost circuit means includes a resistor 96 and capacitor 58. Capacitor 58 has been described above in conjunction with first current pulse generating means 52. When secondary winding 28 is transferring stored power to rectifier means 48 during a flyback interval, a current is developed through resistor 96 which charges capacitor 58. At the predetermined time, which would only be reached during periods of high loading on power supply 10, the voltage on capacitor 58 is sufficient to start turn-on of current switch 24. Current-pulse developing means 52 is triggered at this point to develop a second short current pulse which is applied to current switch 24 through resistor 42. In this boost mode, when current switch 24 turns on and causes the primary current to be coupled through primary winding 26, there is residual stored energy in power transformer 22, which enables the initial primary current in primary winding 26 to start at a boosted level. This boosted primary current increases the stored energy which is transferred to rectifier means 48 and 50 during the next successive flyback cycle.

In parallel with primary winding 26 between source 12 and current switch 24 is a turn-off snubber circuit 98. This circuit is designed to eliminate voltage spikes in the primary current and clamp the maximum voltage at the collector of current switch 24 to a safe voltage. Snubber circuit 98 includes a capacitor 100 in series with a parallel connection of a diode 102 and a resistor 104. When current switch 24 turns off, the primary current, which cannot instantaneously change because of the inductive reactance of primary winding 26, charges capacitor 100 through diode 102. Since capacitor 100 already has an initial charge from being charged from source 12 through resistor 104 when current switch 24 is on, and such voltage cannot instantaneously change, the voltage transient at the collector of current switch 24 when it switches off is slowed by the time duration required to charge capacitor 100. When current switch 24 turns on, capacitor 100 is charged through resistor 104, diode 102 being reverse biased.

To initially start up power supply 10, power supply 10 includes resistor 106 which forms a voltage divider network with resistor 96. At start up, resistor 96 is effectively grounded via the output impedance seen by supply 10. The value of resistor 96 is selected in accordance with the predetermined time constant for the boost circuit means, which is determined by resistor 96 and capacitor 58. Thus, resistor 106 need only be selected so that the divided voltage appearing between resistor 106 and resistor 96 at initial power up (output voltages at 0) is sufficient to turn on current switch 24 to initiate coupling of the primary current through primary winding 26 at a selected turn on threshold voltage of source 12.

Power supply 10 also includes a pair of diodes 107 and 108. Diode 107 clamps the voltage of capacitor 58 to ground potential less the forward bias voltage drop across diode 107. Diode 108 isolates voltage transients of capacitor 58 from the base of current switch 24.

A third rectifier means 109 of power supply 10 may be used to develop a negative output voltage with respect to the ground potential. Third rectifier means 109 includes a diode 110, a zener diode 112, a capacitor 114, and an output LC filter stage having an inductor 116 and capacitor 118. Diode 110 and capacitor 114 rectify and filter, respectively, the voltage of tertiary winding 54 when current switch 24 is switched off. Zener diode 112 regulates the negative output voltage of rectifier means 109 to a maximum negative voltage with reference to the voltage of the base of current switch 24. In a preferred embodiment of power supply 10, rectifier means 109 normally provides a negative 12 volt output. Zener diode 112 is selected to provide a 15 volt reference, the output of rectifier 109 is limited to this voltage reference since current switch 24 will turn off if it's base is pulled below the ground potential.

Referring further to Figs. 2A—2C, there is shown representative waveforms useful in describing the operation of electrical switch means 44 and pulse-width modulating means 78.

Beginning at the start of the drive cycle, with current switch 24 turned on, a generally linearly increasing primary current, I_p, exemplarily illustrated at 120, is developed in primary winding 26 as hereinabove described. The slope of this current is directly proportional to the present voltage of source 12.

The primary current, I_p, develops a generally constant opposing voltage in primary winding 26 which is magnetically coupled to secondary windings 28 and 30. The polarity relationship of the voltage between the primary winding 26 and the secondary windings 28 and 30 is shown by the well known dot convention. The voltage, V_s, at the node between secondary winding 30, the cathode of diode 70 and inductor 80 is exemplarily illustrated at 122. The voltage V_s develops a current through inductor 80 and resistor 82. This current is proportional to the integral of the voltage V_s, and linearly increases during the drive cycle developing a ramp voltage, V_E, exemplarily shown at 124, at the emitter of Q3. When this ramp voltage crosses the base drive voltage, V_B, exemplarily shown at 126, of transistor Q3, transistor Q3 turns on and applies a feedback pulse to the base of transistor Q1. The base voltage, V_B, of transistor Q3 is the weighted average of the error voltage and the output of rectifier means 50 and is exemplarily shown at 126. As mentioned above, the feedback pulse generated by transistor Q3 causes transistor Q1 to saturate, shorting the drive current and base of current switch 24 to ground to turn off current switch 24, to thereby begin the flyback cycle. During the interval of time when the primary current, I_p, is increasing as shown at 120, the voltage, V_c, of capacitor 58 at the anode of diode 108 is generally constant, as exemplarily shown at 128, and the current, I_c, through capacitor 58 is zero, as exemplarily shown at 130.

When current switch 24 turns off to begin the flyback cycle, the primary current through primary winding 26 loops through capacitor 100 and diode 102 of snubber circuit 98. Capacitor 100 is chosen so that the current through current switch 24 substantially falls instantaneously to zero, as shown at 132, to transfer maximum power to secondary windings 28 and 30. Tertiary winding 54 changes polarity forward biasing diode 107 and clamping the voltage of capacitor 58 to approximately −0.6 to −1.0 v, as shown at 134. Resistor 96 charges capacitor 58 during the flyback cycle as shown at 136. When the stored energy in secondary windings 28 and 30 has been delivered to rectifier means 48 and 50, respectively, diodes 60 and 70 reverse bias as the polarity of these windings reverses. Tertiary winding 54 also reverses polarity in response thereto to develop the short current pulse, exemplarily shown at 138, which turns on current switch 24 as hereinabove described. The voltage of capacitor 58 also has a short spike, shown at 140, during this polarity change to forward bias diode 108.

When the output of rectifier means 50 is well regulated, so shown in Fig. 2A, the error voltage of comparator 84 is low. Also shown are exemplary waveforms of the primary current, the voltage of secondary winding 30 and the ramp voltage at the emitter of transistor Q3 for heavy load conditions, in Fig. 2B, and for light load conditions, in Fig. 2C. During heavy loads, the output voltage of rectifier means 50 will be lowered because of the rapid discharging of capacitor 76. The error voltage developed by comparator 84 thus increases, increasing the base voltage, V_B, of transistor Q3, as illustrated at 126′. Thus, the ramp voltage takes longer to cross the base voltage allowing the primary current to increase in amplitude thereby storing a greater amount of energy in power transformer 22 before the start of the next flyback cycle.

Similarly, when the output voltage of rectifier means 50 is above its desired level such as during a very light load condition, the error voltage developed by comparator 84 decreases, lowering the base voltage of transistor Q3 as exemplarily illustrated at 126″. The time duration for the ramp voltage to cross the base voltage is decreased, thus the primary current is at a much smaller amplitude at the beginning of the flyback cycle, whereby the energy transferred by power transformer 22 is decreased.

Thus, it is seen that feedback pulse developing means 78 regulates the switching of current switch 24 as a function of the present output voltage. Also, since the slope of the primary current is dependent upon the present voltage of source 12, the level of the voltage of secondary winding 30 and the slope of the ramp voltage is similarly dependent upon the present voltage of source 12. For example, if the voltage of source 12 is increasing, the slope of the ramp voltage similarly increases, such that the base voltage threshold is crossed sooner to initiate the flyback cycle, thereby providing regulation as a function of the present voltage of source 12.

Referring now to Fig. 3, there is shown representative waveforms useful in describing the operation of the boost circuit means of resistor 96 and capacitor 58. During extremely heavy load conditions, diode 60 remains forward biased for a substantial period of time while secondary winding 28 or 30 is delivering its power to rectifier means 48 or 50. The voltage at the anode of diode 60 develops a current through resistor 96 which charges capacitor 58 as shown at 136. If capacitor 58 charges to a voltage, exemplarily shown at 140, sufficient to forward bias diode 108 and the base emitter junction of current switch 24 prior to the normal end of the flyback interval, it discharges a short current pulse, shown at 138. This pulse is applied to current switch 24, and causes switch 24 to turn on. A new drive cycle is initiated when current switch 24 turns on whereby the primary current, exemplarily illustrated at 120 (Fig. 3), is initially boosted to a level above zero as a result of the residual energy stored in power transformer 22, the boost level being shown at 142. The boosted primary current thus stores more energy during the boosted drive cycle. This increased energy is transferred to secondary winding 28 during the next successive flyback cycle. The drive cycle and the termination of the drive cycle is identical to the above description with reference to Figs. 2A—2C.

Referring now to Fig. 4, there is shown another embodiment of a flyback power supply 10′ which provides DC isolation between secondary winding 30 and current switch 24. Where convenient, corresponding elements of Fig. 4 are designated by the same reference symbols of Fig. 1, these elements having been fully described with reference thereto.

Power supply 10′ includes an isolation transformer 150 for isolating pulse-width modulating means 78 from electronic switching means 44. Isolation transformer 150 includes a first winding 152 serially connected between the collector of transistor Q3 and the output return line, and a second winding 154 connected in parallel with resistor 46. When transistor Q3 turns on, as hereinabove described, it applies a current to first winding 152 which develops a voltage in opposition to the current. This voltage is magnetically coupled to second winding 154 and is of sufficient amplitude to turn on transistor Q1. A pair of resistors 156 and 158 are connected in parallel with windings 152 and 154, respectively. Resistors 156 and 158 damp ringing of windings 152 and 154, respectively, when transistor Q3 turns off.

Isolation of the boost circuit means is accomplished by providing a feedback winding 28′ on the primary winding 26 side of power transformer 20 and referenced to ground potential as shown by the dot convention. A resistor 96′ may then be serially connected between the ungrounded side of feedback winding 28′ and capacitor 58. During the flyback cycle, feedback winding 28′, arranged to develop a positive voltage, causes a current to be developed through resistor 96′ which charges capacitor 58. The voltage of feedback winding 28′ and the value of resistor 96′ is selected so that after a selected time, capacitor 58 develops the current pulse, illustrated in Fig. 3 at 138, to turn on current switch 24. Once the time constant of resistor 96′ and capacitor 58 has been selected, resistor 98′ may then be selected so that power supply 10′ turns on at a selected start-up voltage as hereinabove described.

Claims

1. A flyback power supply (10) for developing an output DC voltage from a source (12) of DC, comprising a power transformer (22) including a primary winding (26) and a secondary winding (28; 30); current switch means (24) for periodically coupling a primary current during a first interval of time through said primary winding (26) from said source (12), whereby energy is stored in said transformer (22) during said first interval, said primary current having an increasing amplitude during each said interval; means (32, 34, 36) for developing a drive current whose amplitude is a function of said primary current and for coupling said drive current to said current switch means (24), said current switch means (24) being responsive to said drive current for enabling said current switch means (24) to remain on; feedback means (78) for developing a feedback pulse at a point in time after said current switch means (24) turns on as a function of the deviation of said output voltage from a predetermined voltage; electrical switch means (44) for turning off said current switch means (24) in response to said feedback pulse, said energy stored in said transformer (22) being transferred out through said secondary winding (28; 30) when said current switch means (24) is off during a second interval of time; means (50) responsive to said energy transferred out through said secondary winding (28; 30) during said second interval of time for developing said output DC voltage; and means (52) for developing a first current pulse when all of said stored energy has been transferred out through said secondary winding (28; 30), said first current pulse being applied to said current switch means (24) to initiate coupling of said primary current through said primary winding (26), characterised by means (96, 58) for developing a second current pulse at a selected point in time during said second interval of time, said second current pulse being applied to said current switch means (24) to initiate coupling of said primary current through said primary winding (26) prior to all of said stored energy being transferred out through said secondary winding (28; 30).

2. A power supply as claimed in Claim 1, charac-

terised in that said feedback means (78) includes means (84, 86, 88, 90) for developing an error voltage as a function of the deviation of said output voltage from said predetermined voltage; means (80, 82) for developing a ramp voltage as a function of the voltage of said secondary winding (28; 30) during said first interval of time; and means (Q3, 92, 94) for developing said feedback pulse when said ramp voltage obtains an amplitude determined by said error voltage.

3. A power supply as claimed in Claim 1 or Claim 2, characterised in that said first current pulse developing means (52) includes a feedback winding (54) of said power transformer (22) and a capacitor (58) in a series with said feedback winding (54), said feedback winding (54) applying a voltage to said capacitor (58) when said stored energy has been transferred out through said secondary winding (30) to charge said capacitor (58), said capacitor (58) emitting said first current pulse while being charged by said voltage.

4. A power supply as claimed in Claim 3, characterised by a second resistor (106) coupled between said source (12) and said first resistor (96), said first resistor (96) being effectively grounded at initial power up of said power supply (12), said second resistor (106) being selected so that at a selected voltage of said source (12) during power up, a voltage between said first resistor (106) and said second resistor (96) is sufficient to turn on said current switch means (24).

5. A power supply as claimed in any preceding claim, characterised in that said second current pulse developing means (96, 58) includes a capacitor (58) and a resistor (96) coupled between said secondary winding (28, 30) and said capacitor (58), the voltage of said secondary winding (28, 30) developing a current through said resistor (96) to charge said capacitor (58) during said second interval of time, said capacitor (58) emitting said second current pulse when its voltage is sufficient to turn on said current switch means (24).

6. A power supply as claimed in any preceding claim, characterised in that said drive current developing means (32, 34, 36) includes a current transformer (32) whose primary winding (38) is connected in series between said primary winding (26) of said power transformer (22) and said current switch means (24), a diode (34) connected in series with a second winding (40) of said current transformer (32), said second winding (40) and said diode (34) being arranged so that said diode (34) is forward biased during said first interval of time, said diode (34) and second winding (40) being connected in series between said current switch means (24) and the ground return of said source (12).

7. A power supply as claimed in any preceding claim, characterised by a snubber circuit means (98) for slowing voltage transients when said current switch means (24) turns off, and including a capacitor (100) and a diode (102) connected in series between said source (12) and said current switch means (24), said diode (102) being arranged to be forward biased when said current switch means (24) turns off.

8. A power supply as claimed in any preceding claim, characterised in that said electrical switch means (44) includes a switching transistor (Q1) having a base, an emitter coupled to the ground return of said source (12) and a collector, said collector of said switching transistor (Q1) being coupled to said current switch means (24), said feedback pulse being coupled to said base of said switching transistor (Q1), said switching transistor (Q1) turning on in response to said feedback pulse to short said drive current to said ground return of said source (12) through said emitter of said switching transistor (Q1), and characterised by a second switching transistor (Q2) having a collector coupled to said base of said first switching transistor (Q1), a base coupled to said collector of said first switching transistor (Q1) and said current switch means (24), an emitter, and a resistor (42) coupled between said emitter and said current switch means (24), said drive current being further coupled through said resistor (42), said drive current developing a voltage across said resistor (42) sufficient to turn on said second switching transistor (Q2) when said primary current obtains a preselected maximum amplitude, said first switching transistor (Q1) turning on in response to said second switching transistor (Q2) turning on.

Patentansprüche

1. Energieversorgung mit stromgesteuerten Sperrwandler (10) zur Erzeugung einer von einer Gleichspannungsquelle (12) abgeleiteten ausgangsseitigen Gleichspannung, bestehend aus:

einem Leistungstransformator (22) mit einer Primär- und einer Sekundärwicklung (28; 30);

einem Stromschalter (24), welcher periodisch während eines ersten Zeitintervalls einen Primärstrom von der Gleichspannungsquelle (12) an die Primärwicklung (26) ankoppelt, um während dieses ersten Zeitintervalls in den Leistungstransformator (22) Energie einzuspeichern, wobei die Amplitude des Primärstromes dabei ansteigt;

Einrichtungen (32, 34, 36) zur Erzeugung eines Steuerstromes, dessen Amplitude eine Funktion des Primärstromes ist, und zum Anlegen dieses Steuerstromes an den Stromschalter (24), welcher seinerseits auf den Steuerstrom anspricht und von diesem im eingeschalteten Zustand gehalten wird;

Rückkopplungseinrichtungen (78), welche nach dem Einschalten des Stromschalters (24) einen Rückkopplungsimpuls als Funktion der Abweichung der Ausgangsspannung von einer vorgegebenen Spannung erzeugen;

Schalteinrichtungen (44), welche den Stromschalter (24) in Abhängigkeit vom Rückkopplungsimpuls öffnen, wodurch die im Leistungstransformator (22) gespeicherte Energie im geöffneten Zustand des Stromschalters (24) während eines zweiten Zeitintervalls über die Sekundärwicklung (28; 30) abgegeben wird;

Einrichtungen (50), welche auf die während des zweiten Zeitintervalls durch die Sekundärwicklung (28; 30) zur Erzeugung der ausgangsseitigen Gleichspannung übertragene Energie ansprechen;

und Einrichtungen (52) zur Erzeugung eines ersten Stromimpulses, wenn die gesamte gespeicherte Energie über die Sekundärwicklung (28; 30) übertragen ist, wobei dieser erste Stromimpuls an den Stromschalter (24) angelegt wird, um die Übertragung des Primärstromes durch die Primärwicklung (26) auszulösen, gekennzeichnet durch Einrichtungen (96, 58) zur Erzeugung eines zweiten Stromimpulses zu ausgewählten Zeitpunkten während des zweiten Zeitintervalls, wobei dieser zweite Stromimpuls an den Stromschalter (24) zur Auslösung des Primärstroms durch die Primärwicklung (26) vor der Übertragung der gesamten gespeicherten Energie über die Sekundärwicklung (28; 30) angelegt wird.

2. Energieversorgung nach Anspruch 1, dadurch gekennzeichnet, daß die Rückkopplungseinrichtungen (78) Vorrichtungen (84, 86, 88, 90) zur Erzeugung einer Fehlerspannung als Funktion der Abweichung der Ausgangsspannung von der vorgegebenen Spannung umfassen, daß Einrichtungen (80, 82) zur Erzeugung einer Ramp-Spannung als Funktion der Spannung an den Sekundärwicklung (28; 30) während des ersten Zeitintervalls vorhanden sind, und daß Einrichtungen (Q3, 92, 94) den Rückkopplungsimpuls erzeugen, wenn die Ramp-Spannung eine durch die Fehlerspannung bestimmte Amplitude erreicht.

3. Energieversorgung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Einrichtungen (52) zur Erzeugung des ersten Stromimpulses eine Rückkopplungswicklung (54) am Leistungstransformator (22) und einen Kondensator (58) umfassen, der in Serie zu der Rückkopplungswicklung (54) liegt, wodurch die Rückkopplungswicklung (54) eine Spannung an den Kondensator (58) anlegt, wenn die gespeicherte Energie über die Sekundärwicklung (30) zur Aufladung des Kondensators (58) übertragen wird, und wobei der Kondensator (58) beim Aufladen durch diese Spannung den ersten Stromimpuls abgibt.

4. Energieversorgung nach Anspruch 3, dadurch gekennzeichnet, daß ein zweiter Widerstand (106) zwischen der Gleichspannungsquelle (12) und dem ersten Widerstand (96) liegt, daß der erste Widerstand (96) beim anfänglichen Leistungsaufbau durch die Gleichspannungsquelle (12) wirksam geerdet wird und daß der zweite Widerstand (106) derart ausgewählt ist, daß zu einer vorgegebenen Spannung der Gleichspannungsquelle (12) während des Leistungsaufbaues eine Spannung zwischen dem ersten Widerstand (106) und dem zweiten Widerstand (96) ausreicht, um den Stromschalter (24) einzuschalten.

5. Energieversorgung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Einrichtungen (96, 58) zur Erzeugung des zweiten Stromimpulses einen Kondensator (58) und einen zwischen die Sekundärwicklung (28, 30) und den Kondensator (58) geschalteten Widerstand (96) umfassen, daß die Spannung an der Sekundärwicklung (28, 30) einen über den Widerstand (96) fließenden Strom zum Aufladen des Kondensators (58) während des zweiten Zeitintervalls erzeugt, und daß der Kondensator (58) den zweiten Stromimpuls abgibt, wenn seine Spannung ausreicht, um den Stromschalter (24) einzuschalten.

6. Energieversorgung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Einrichtung (32, 34, 36) zur Erzeugung eines Steuerstromes einen Stromtransformator (32) umfaßt, dessen Primärwicklung (38) in Serie zwischen der Primärwicklung (26) des Leistungstransformators (22) und dem Stromschalter (24) liegt, daß eine Diode (34) in Serie mit der Sekundärwicklung (40) des Stromtransformators (32) geschaltet ist, wobei die Sekundärwicklung (40) und die Diode (34) derart angeordnet sind, daß die Diode (34) in Durchlaßrichtung während des ersten Zeitintervalls geschaltet ist, und daß die Diode (34) und die Sekundärwicklung (40) in Serie zwischen den Stromschalter (24) und den Masseanschluß der Gleichspannungsquelle (12) geschaltet sind.

7. Energieversorgung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß eine Schutzschaltung (98) zum Verlangsamen der Übergangsspannung beim Abschalten des Stromschalters (24) vorhanden ist, welcher einen Kondensator (100) und eine Diode (102) in Serienschaltung zwischen der Gleichspannungsquelle (12) und dem Stromschalter (24) aufweist, und daß die Diode (102) in Durchlaßrichtung geschaltet ist, wenn der Stromschalter (24) abgeschaltet ist.

8. Energieversorgung nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Schalteinrichtungen (44) einen Umschalttransistor (Q1) umfassen, dessen Emitter mit der Masse der Gleichspannungsquelle (12) verbunden ist und dessen Kollektor an den Stromschalter (24) angekoppelt ist, daß der Rückkopplungsimpuls an die Basis des Umschalttransistors (Q1) übertragen wird, um diesen Transistor einzuschalten und damit den Steuerstrom über den Emitter des Umschalttransistors (Q1) nach Masse abzuleiten, daß ferner ein zweiter Umschalttransistor (Q2) vorhanden ist, dessen Kollektor an der Basis des ersten Umschalttransistors (Q1) liegt und dessen Basis mit dem Kollektor des ersten Umschalttransistors (Q1) sowie mit dem Stromschalter (24) verbunden ist, daß der Emitter über einen Widerstand (42) an dem Stromschalter (24) liegt, daß der Steuerstrom ferner über diesen Widerstand (42) übertragen wird und an diesem einen Spannungsabfall auslöst, der ausreicht, um den zweiten Umschalttransistor (Q2) einzuschalten, wenn der Primärstrom eine vorgegebene maximale Amplitude annimmt, und daß der erste Umschalttransistor (Q1) in Abhängigkeit vom Einschalten

des zweiten Umschalttransistors (Q2) eingeschaltet wird.

Revendications

1. Une alimentation du type à impulsion de retour de balayage (10) destinée à produire une tension continue de sortie à partir d'une source (12) de tension continue, comprenant un transformateur de puissance (22) qui comporte un enroulement primaire (26) et un enroulement secondaire (28; 30); des moyens de commutation de courant (24) destinés à faire circuler périodiquement un courant primaire dans l'enroulement primaire (26) à partir de la source (12), pendant un premier intervalle de temps, grâce à quoi de l'énergie est emmagasinée dans le transformateur (22) pendant ce premier intervalle de temps, ce courant primaire ayant une intensité croissante pendant chacun de ces intervalles; des moyens (32, 34, 36) destinés à produire un courant d'attaque dont l'intensité est fonction du courant primaire, et à appliquer ce courant d'attaque aux moyens de commutation de courant (24), les moyens de commutation de courant (24) réagissant au courant d'attaque en permettant aux moyens de commutation de courant (24) de rester à l'état conducteur; des moyens de réaction (78) destinés à produire une impulsion de réaction à un instant postérieur au passage à l'état conducteur des moyens de commutation de courant (24), et qui est fonction de l'écart de la tension de sortie par rapport à une tension prédéterminée; des moyens de commutation électriques (44) destinés à bloquer les moyens de commutation de courant (24) sous la dépendance de l'impulsion de réaction, l'énergie emmagasinée dans le transformateur (22) étant transférée dans l'enroulement secondaire (28; 30) lorsque les moyens de commutation de courant (24) sont bloqués, pendant un second intervalle de temps; des moyens (50) qui réagissent au transfert d'énergie dans l'enroulement secondaire (28; 30) pendant le second intervalle de temps en produisant la tension continue de sortie; et des moyens (52) destinés à produire une première impulsion de courant lorsque toute l'énergie emmagasinée a été transférée vers l'enroulement secondaire (28; 30), cette première impulsion de courant étant appliquée aux moyens de commutation de courant (24) pour déclencher la circulation du courant primaire dans l'enroulement primaire (26), caractérisée par des moyens (96, 58) destinés à produire une seconde impulsion de courant à un instant sélectionné pendant le second intervalle de temps, cette seconde impulsion de courant étant appliquée aux moyens de commutation de courant (24) pour déclencher la circulation du courant primaire dans l'enroulement primaire (26) avant que toute l'énergie emmagasinée soit transférée vers l'enroulement secondaire (28; 30).

2. Une alimentation du type à impulsion de retour de balayage selon la revendication 1, caractérisée en ce que les moyens de réaction (78) comprennent des moyens (84, 86, 88, 90) destinés à produire une tension d'erreur en fonction de l'écart de la tension de sortie par rapport à la tension prédéterminée; des moyens (80, 82) destinés à produire une tension en rampe en fonction de la tension de l'enroulement secondaire (28; 30) pendant le premier intervalle de temps; et des moyens (Q3, 92, 94) destinés à produire l'impulsion de réaction lorsque la tension en rampe atteint un niveau déterminé par la tension d'erreur.

3. Une alimentation selon la revendication 1 ou la revendication 2, caractérisée en ce que les moyens de génération de la première impulsion de courant (52) comprennent un enroulement de réaction (54) du transformateur de puissance (22) et un condensateur (58) en série avec cet enroulement de réaction (54), l'enroulement de réaction (54) appliquant une tension au condensateur (58) lorsque l'énergie emmagasinée a été transférée vers l'enroulement secondaire (30) pour charger le condensateur (58), ce condensateur (58) émettant la première impulsion de courant pendant qu'il est chargé par la tension précitée.

4. Une alimentation selon la revendication 3, caractérisée par une seconde résistance (106) connectée entre la source (12) et la première résistance (96), la première résistance (96) étant effectivement reliée à la masse à la mise sous tension initiale de l'alimentation (12), et la seconde résistance (106) étant sélectionnée de façon qu'à une tension sélectionnée de la source (12) pendant la mise sous tension, une tension présente entre la première résistance (106) et la seconde résistance (96) soit suffisante pour provoquer la conduction des moyens de commutation de courant (24).

5. Une alimentation selon l'une quelconque des revendications précédentes, caractérisée en ce que les moyens produisant la seconde impulsion de courant (96, 58) comprennent un condensateur (58) et une résistance (96) connectée entre l'enroulement secondaire (28, 30) et le condensateur (58), la tension de l'enroulement secondaire (28, 30) fait circuler un courant dans cette résistance (96) pour charger le condensateur (58) pendant le second intervalle de temps, et le condensateur (58) émet la secónde impulsion de courant lorsque sa tension est suffisante pour provoquer la conduction des moyens de commutation de courant (24).

6. Une alimentation selon l'une quelconque des revendications précédentes, caractérisée en ce que les moyens produisant le courant d'attaque (32, 34, 36) comprennent un transformateur de courant (32) dont l'enroulement primaire (38) est connecté en série entre l'enroulement primaire (26) du transformateur de puissance (22) et les moyens de commutation de courant (24), une diode (34) connectée en série avec un second enroulement (40) du transformateur de courant (32), ce second enroulement (40) et la diode (34) étant connectés de façon que la diode (34) soit polarisée en sens direct pendant le premier intervalle de temps, et la diode (34) et le second

enroulement (40) sont connectés en série entre les moyens de commutation de courant (24) et le retour de masse de la source (12).

7. Une alimentation selon l'une quelconque des revendications précédentes, caractérisée par un circuit amortisseur (98) destiné à réduire la vitesse de variation de tensions transitoires lorsque les moyens de commutation de courant (24) se bloquent, et comprenant un condensateur (100) et une diode (102) connectés en série entre la source (12) et les moyens de commutation de courant (24), cette diode (102) étant connectée de façon à être polarisée en sens direct lorsque les moyens de commutation de courant (24) se bloquent.

8. Une alimentation selon l'une quelconque des revendications précédentes, caractérisée en ce que les moyens de commutation électriques (44) comprennent un transistor de commutation (Q1) ayant une base, un émetteur connecté au retour de masse de la source (12) et un collecteur, le collecteur du transistor de commutation (Q1) est connecté aux moyens de commutation de courant (24), l'impulsion de réaction est appliquée à la base du transistor de commutation (Q1), ce transistor de commutation (Q1) passe à l'état conducteur sous l'effet de l'impulsion de réaction de façon à court-circuiter le courant d'attaque vers le retour de masse de la source (12), par l'intermédiaire de l'émetteur du transistor de commutation (Q1), et caractérisée par un second transistor de commutation (Q2) ayant un collecteur connecté à la base du premier transistor de commutation (Q1), une base connectée au collecteur du premier transistor de commutation (Q1) et aux moyens de commutation de courant (24), et un émetteur, avec une résistance (42) connectée entre cet émetteur et les moyens de commutation de courant (24), le courant d'attaque étant en outre appliqué à cette résistance (42), et ce courant d'attaque développant aux bornes de la résistance (42) une tension suffisante pour faire passer le second transistor de commutation (Q2) à l'état conducteur lorsque le courant primaire atteint une intensité maximale présélectionnée, le premier transistor de commutation (Q1) passant à l'état conducteur sous l'effet du passage à l'état conducteur du second transistor de commutation (Q2).

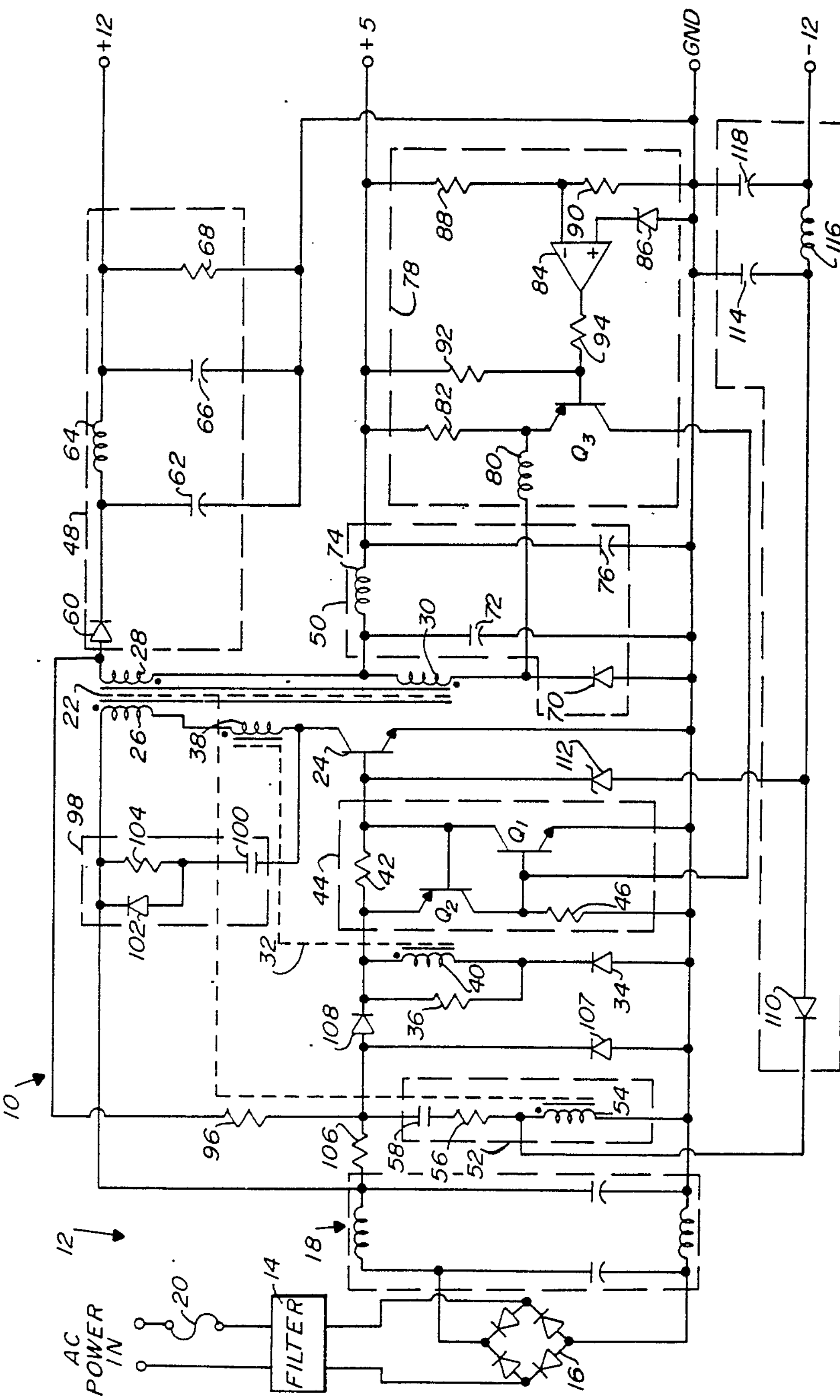


FIG. 1

FIG. 2A

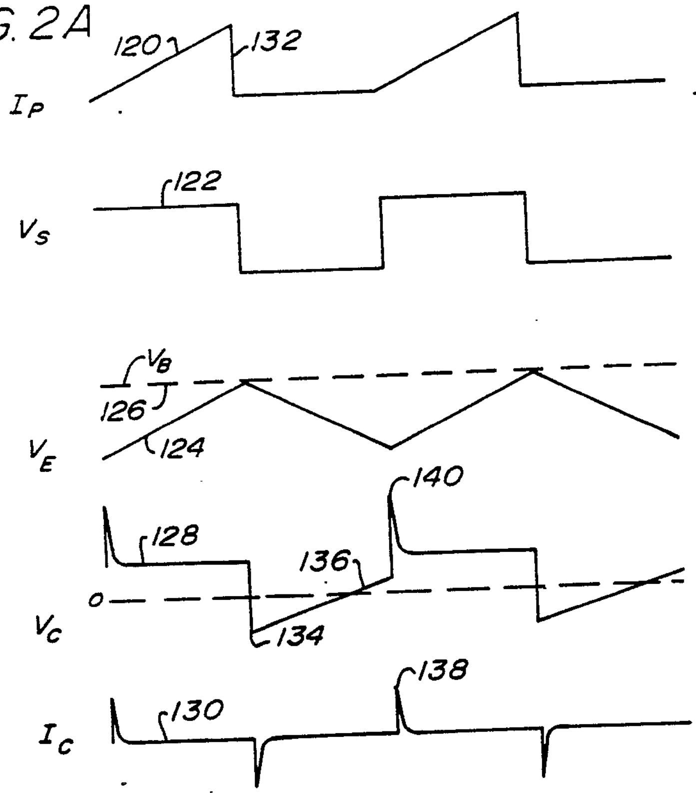


FIG. 2C

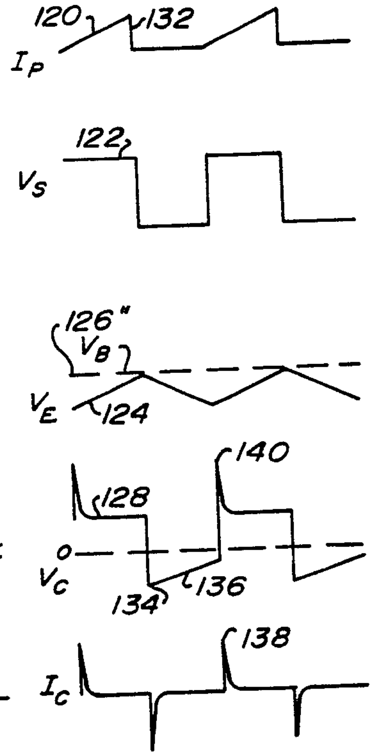


FIG. 2B

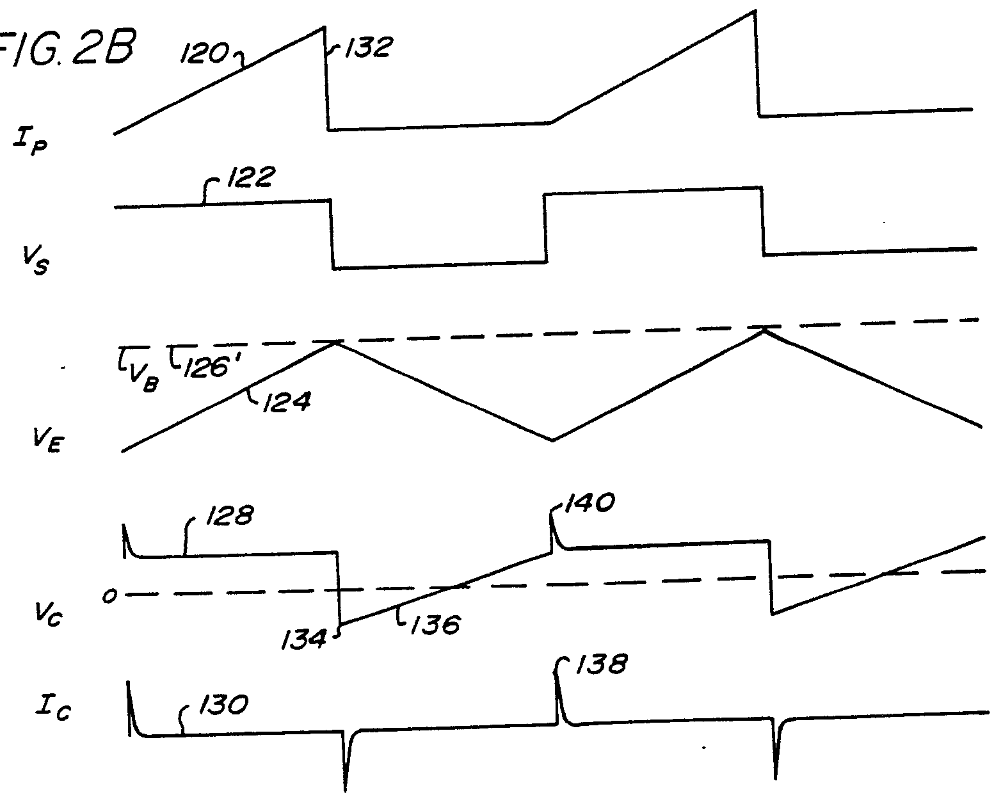
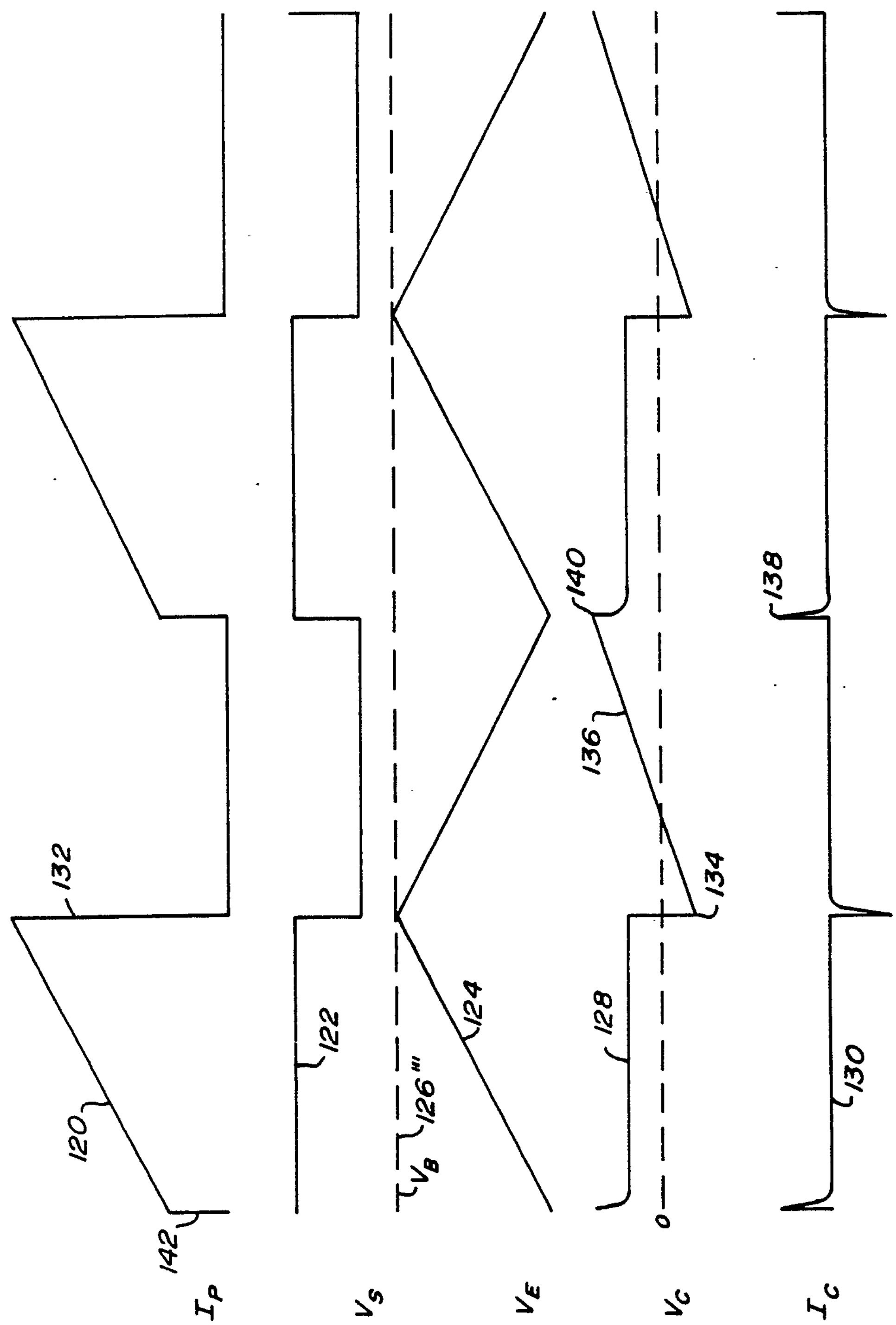


FIG. 3



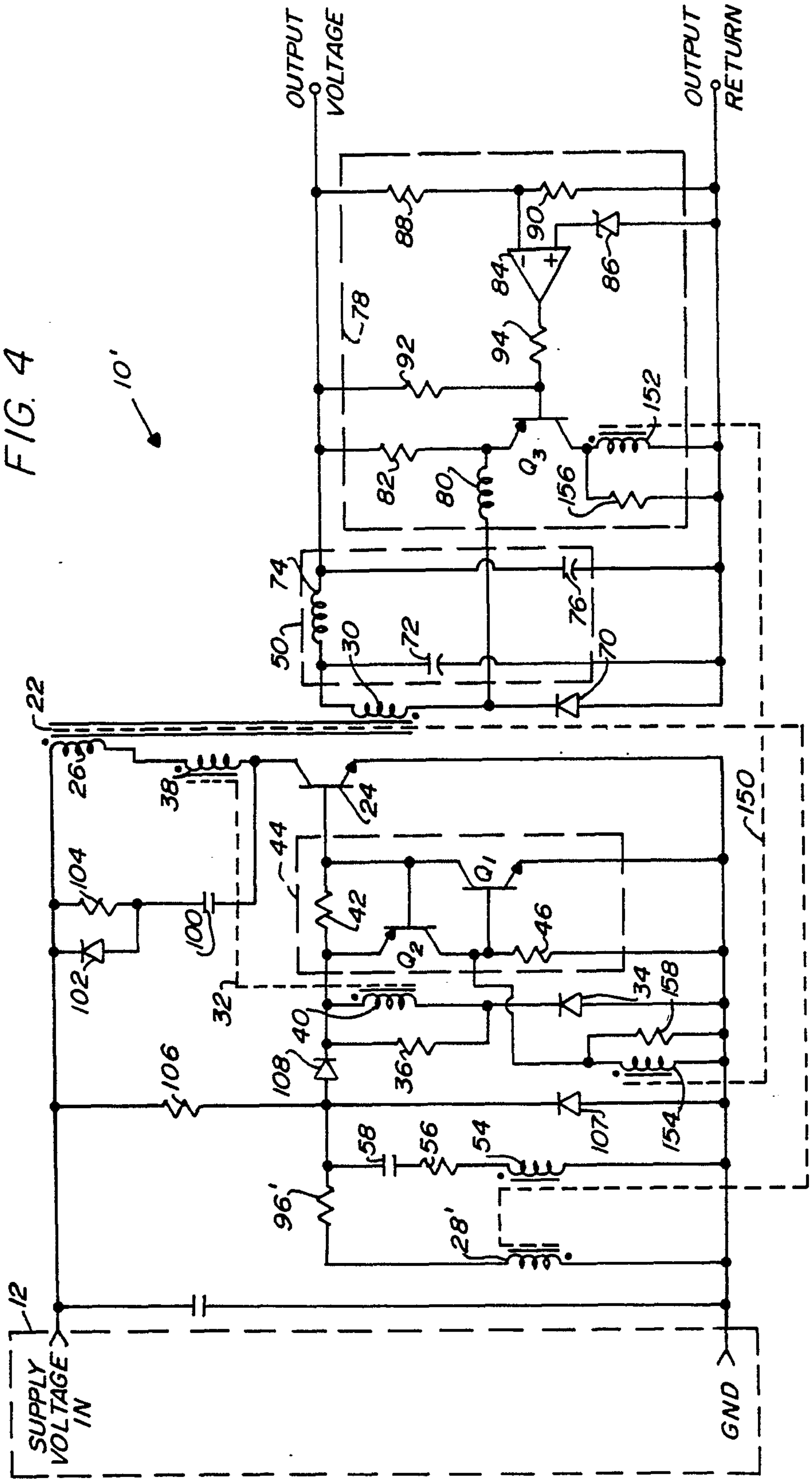

OUTPUT VOLTAGE
OUTPUT RETURN
SUPPLY VOLTAGE IN
GND
10'
12
22
24
26
28'
30
32
34
36
38
40
42
44
46
50
54
56
58
70
72
74
76
78
80
82
84
86
88
90
92
94
96'
100
102
104
106
107
108
150
152
154
156
158
Q1
Q2
Q3

FIG. 4