United States Patent [19]

Bierly

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[54] **SWITCHABLE HIGH VOLTAGE POWER SUPPLY**

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[73] Assignee: **AMP Incorporated,** Harrisburg, Pa.

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[21] Appl. No.: **477,386**

Related U.S. Application Data

[63] Continuation of Ser. No. 327,273, Jan. 29, 1973, abandoned.

[52] **U.S. Cl.** ..... **307/77;** 307/85; 315/27 TD; 315/31 TV; 321/27 R; 323/25

[51] **Int. Cl.** **H02j 3/00**

[58] **Field of Search** ..... 321/27 R; 323/22 T, 25, 323/31, 32; 307/4, 5, 44, 49, 69, 70, 71, 75, 77, 80, 85, 87; 315/31 TV, 27 TD

[56] **References Cited**

UNITED STATES PATENTS

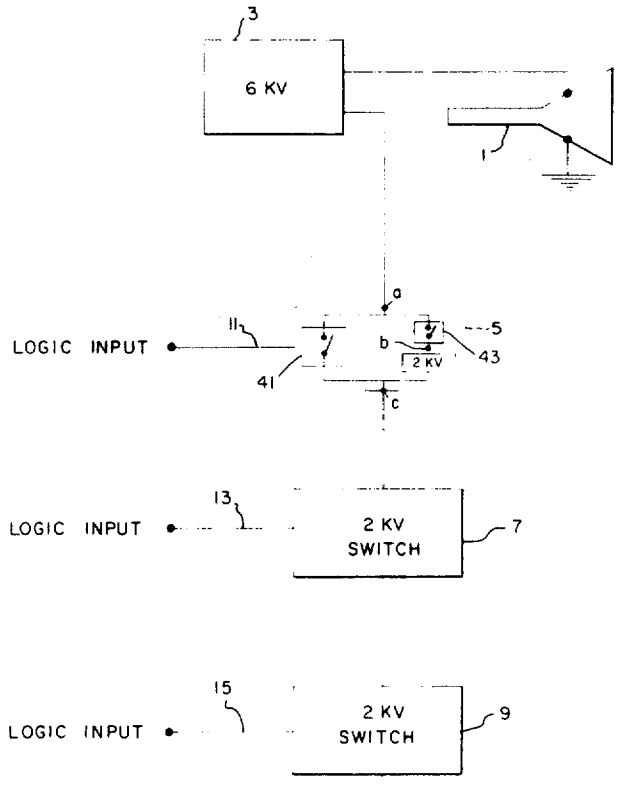
3,373,338	3/1968	Corey et al.	321/27 R
3,659,190	4/1972	Galluppi	323/22 T
3,723,855	3/1973	Shuleshko	323/25 X

Primary Examiner—Gerald Goldberg
Attorney, Agent, or Firm—Gerald K. Kita

[57] **ABSTRACT**

A voltage power supply for switching incremental voltages into and out of the circuit. The power supply includes a plurality of serially connected switch elements having series and parallel arms, one of the arms of each switch element being on and the other off, the arms being controlled by a logically controlled switching circuit. Each arm includes a plurality of serially connected semiconductor devices with a resistor across the emitter-collector circuit of each semiconductor device, the semiconductors being controlled by a transformer having plural secondary windings, each of the secondary windings controlling a different semiconductor in one arm.

6 Claims, 4 Drawing Figures



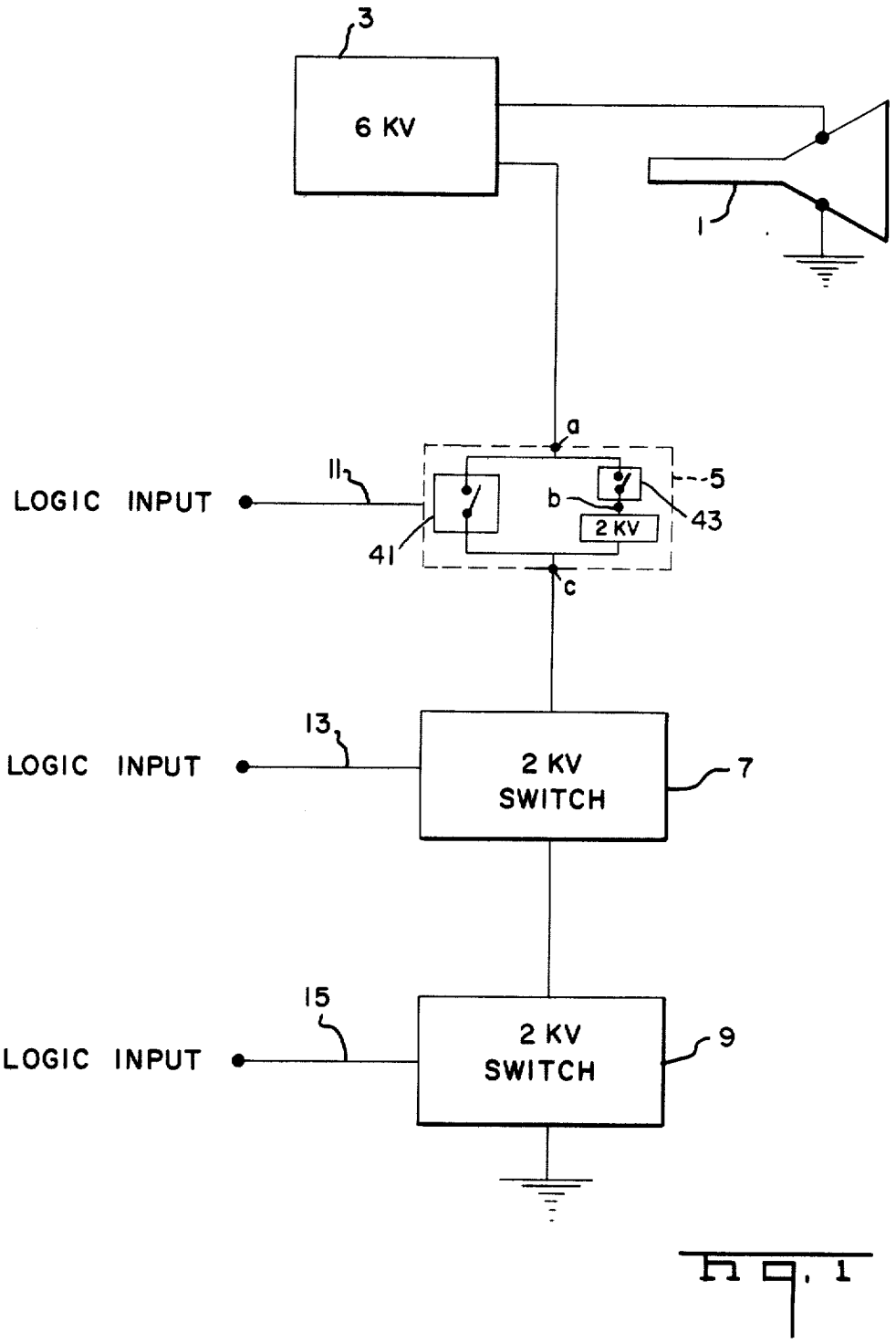

3
6 KV
1
a
11
LOGIC INPUT
5
b
43
2 KV
41
c
13
LOGIC INPUT
2 KV SWITCH
7
15
LOGIC INPUT
2 KV SWITCH
9

Fig. 1

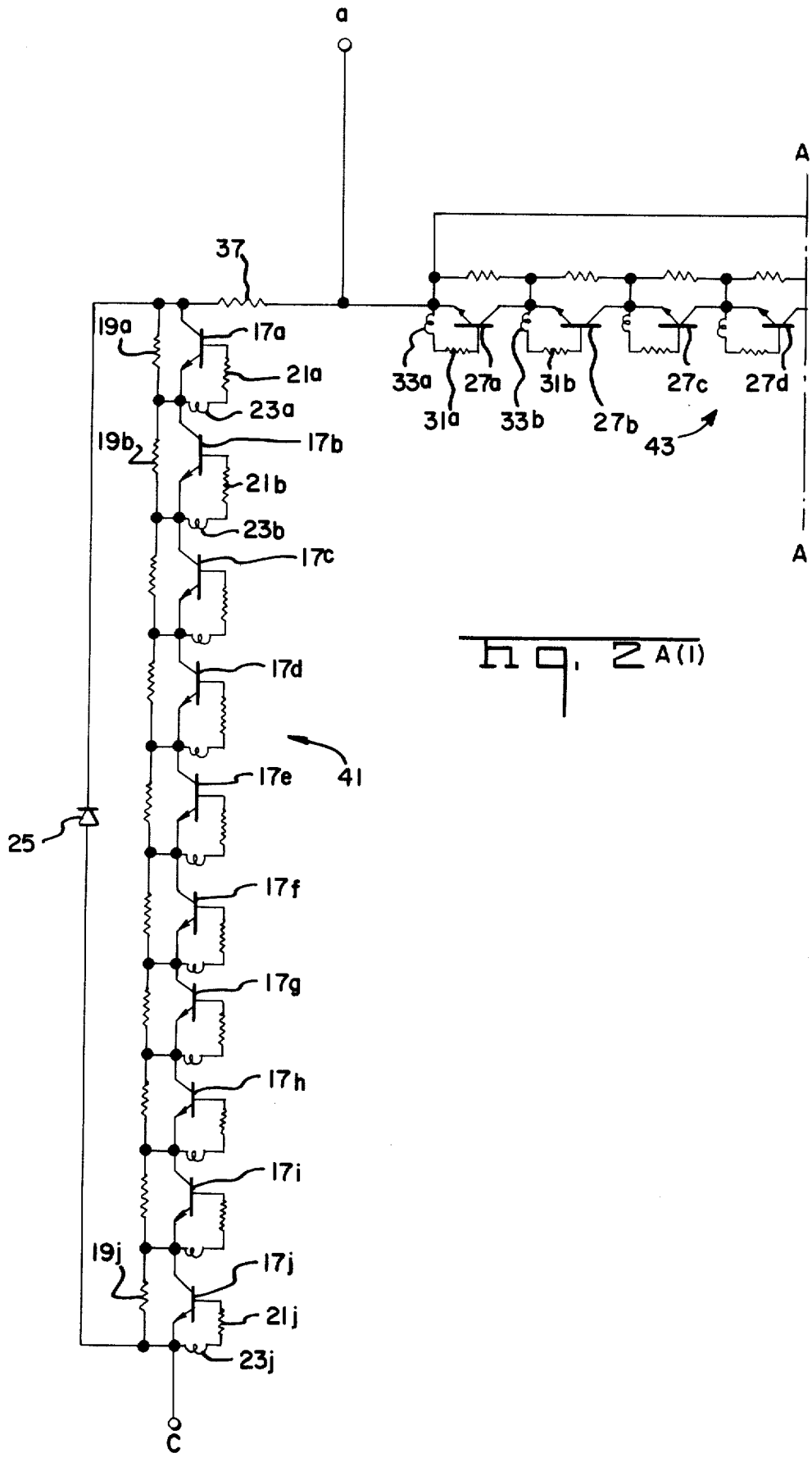

a
A
A
37
19a
17a
21a
23a
19b
17b
21b
23b
17c
17d
41
17e
25
17f
17g
17h
17i
19j
17j
21j
23j
C
33a
27a
31b
27c
27d
31a
33b
27b
43

Fig. 2A(1)

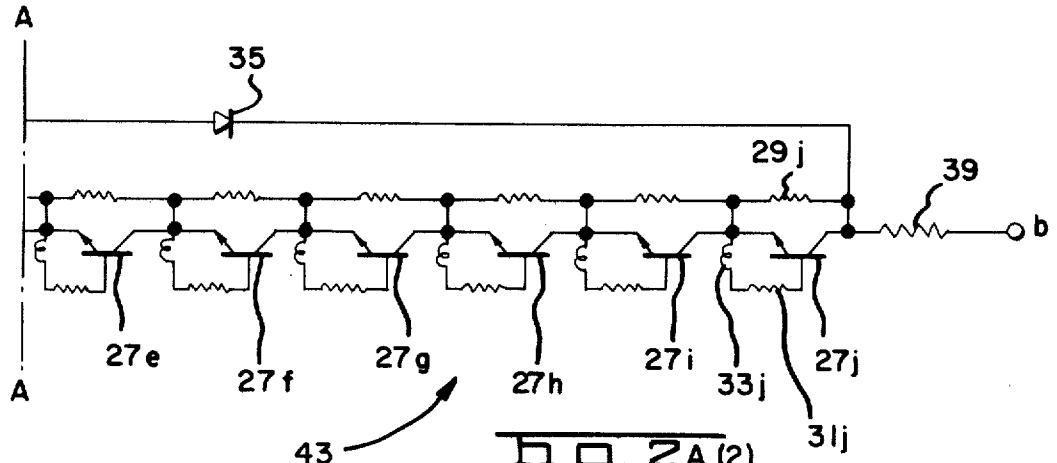


Fig. 2A (2)

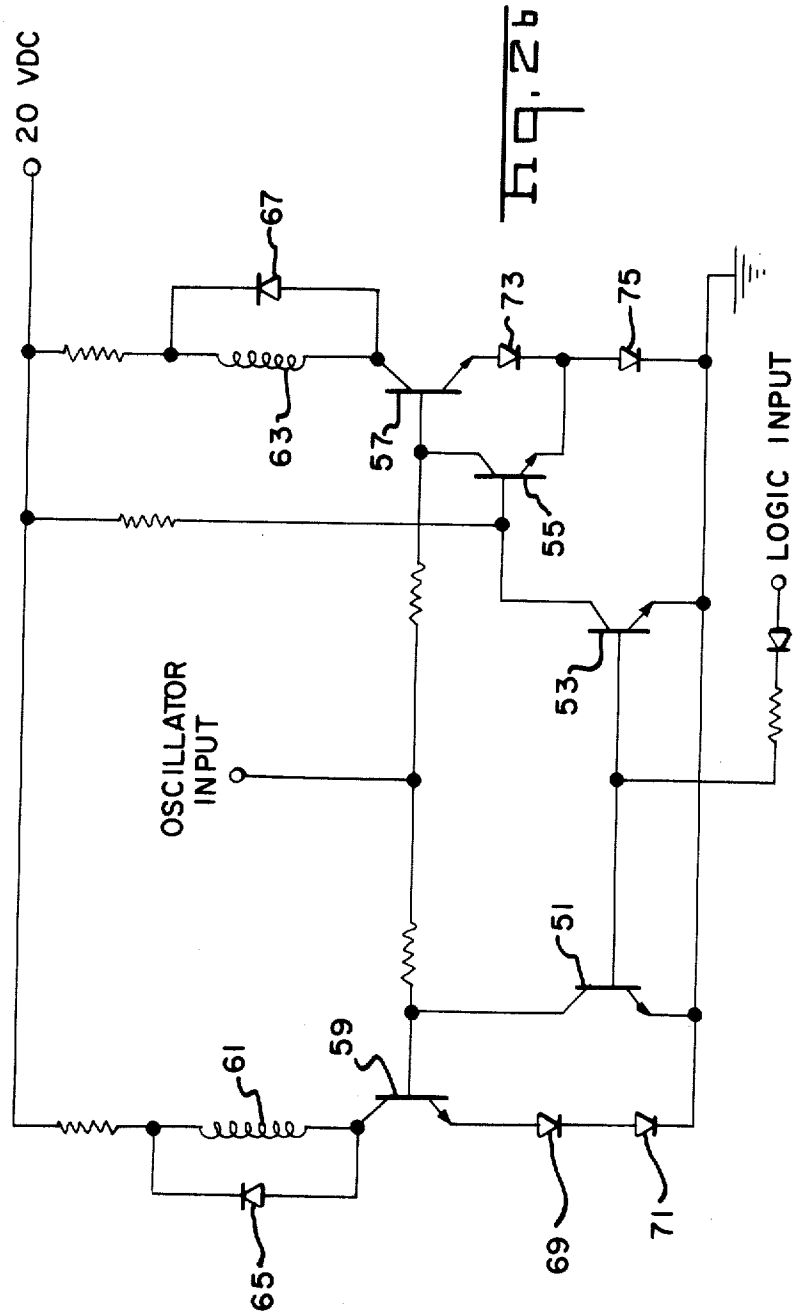

20 VDC
67
63
57
73
75
55
53
LOGIC INPUT
OSCILLATOR INPUT
51
59
61
65
69
71

Fig. 2b

SWITCHABLE HIGH VOLTAGE POWER SUPPLY

This is a continuation of Ser. No. **327,273** filed Jan. **29, 1973** now abandoned.

This invention relates to a switchable high voltage power supply and, more specifically, to a power supply for providing high voltage power and capable of switching to different voltage levels and at a rapid rate.

High voltage power supplies capable of switching between voltage levels several thousand volts apart in the area of the ten kilovolt range in a short time period have known application, one such application being in color cathode ray tubes of types known in the art and discussed in U.S. Pat. No. 3,659,190 of Galluppi and the references discussed therein. The potential use of such cathode ray tubes has been recognized, however, it is necessary to provide a rapidly switchable power supply in the kilovolt range before the commercial use of such cathode ray tubes becomes practical. While the prior art has attempted to provide power supplies as discussed above, it is always desirable to provide such power supplies having faster switching rates.

In accordance with the present invention, there is provided a high voltage power supply capable of switching between several preselected voltages in the kilovolt range at an even faster rate than is presently possible in the prior art with equipment of relatively lower cost. Briefly, the above is accomplished by providing a basic voltage source and a plurality of switchable voltage sources in series therewith, the sources being switchable into and out of the circuit by logic circuity which is not electrically referenced to the sources. Each source includes a pair of legs, one leg being "on" when the other is "off". In one of the two states, the source adds a voltage in series with the basic source and in the other state, the source places a short circuit between ground and the low voltage side of either the basic source of another switchable source. Each leg is operated by constantly pulsing the elements therein at a rapid enough rate so that the output appears flat.

It is therefore an object of this invention to provide a high voltage power supply which is rapidly switchable between voltage levels.

It is a further object of this invention to provide a relatively inexpensive switchable high voltage power supply.

It is a yet further object of the invention to provide a switchable high voltage power supply where the switching control is not electrically referenced to the switched elements.

It is a still further object of this invention to provide a switchable high voltage power supply wherein switched elements are switched into the circuit by a logic control.

The above objects and still further objects of the invention will immediately become apparent to those skilled in the the art after consideration of the following preferred embodiment thereof, which is provided by way of example and not by way of limitation, wherein:

FIG. **1** is a block diagram of a high voltage power supply in accordance with the present invention; and

FIGS. **2a** and **2b** comprise a circuit diagram of the contents of one of the switched elements of FIG. **1.**

Referring now to FIG. **1,** there is shown a cathode ray tube system using the switchable high voltage power supply of the present invention. The system includes a

cathode ray tube **1** having a ground terminal and a high voltage terminal connected to the power supply. The power supply includes a basic high voltage source portion **3** of, for example, 6 kilovolts in series with three switchable voltage sources designated as **5, 7** and **9.** Each of the sources **5, 7** and **9** has a logic input **11, 13** and **15** respectively, the signal on which determines whether the associated source will present a high voltage, for example 2 kilovolts, or a short circuit thereacross. This operation will be discussed in detail hereinbelow. In the embodiment of FIG. **1,** 6Kv, 8Kv, 10KV or 12KV can be switched across the tube **1,** this voltage being rapidly variable from one one of the above noted voltages to any other of the above noted voltages. It is, of course, understood that though three switchable voltage sources are shown, any number can be used. In addition, any voltage desired can be provided by the sources, **3, 5, 7** and **9.**

Referring now to FIG. **2***a*, there is shown the controlled portion of a switchable source of FIG. **1.** The controlled portion includes a plurality of series connected transistors **17***a* to **17***j* forming one leg **41** thereof, each transistor having a resistor **19***a* to **19***j* across its emitter-collector circuit and a series circuit composed of resistors **21***a* to **21***j* and winding **23***a* to **23***j* in the base-emitter circuit of each transistor. A diode **25** is connected across the series circuit composed of the emitter-collector circuits of transistors **17***a* to **17***j*. The other leg **43** of the controlled circuit is identical and includes a series circuit composed of transistors **27***a* to **27***j*, each transistor having a resistor **29***a* to **29***j* across its emitter-collector circuit. A series circuit composed of resistor **31***a* to **31***j* and winding **33***a* to **33***j* is connected in the base-emitter circuit of each of transistors **27***a* to **27***j*. A diode **35** is connected across the series circuit composed of the emitter-collector circuit of transistors **27***a* to **27***j*. The number of transistors in each series circuit is determined by the voltage rating and rise and fall time characteristics of the transistors required for the voltage to be impressed thereacross. The resistors in the emitter-collector circuits are utilized to compensate for transistor leakage characteristics to provide equal voltage division. The resistors **37** and **39** are provided to limit current flow in the event of a short circuit. The diodes **25** and **35** provide protection for the transistors in the reverse direction. Diode **35** also provides a path for current flow in the event the voltage at the junction a is in excess of **2** kilovolts to clamp a at 2 kilovolts.

One of the two legs of the controlled circuit is always conducting and the other is simultaneously off. For this reason, each of legs **41** and **43** acts as a switch with one switch being open and the other closed. When leg **41** is closed, a short circuit is provided across the switch **5, 7** or **9** (FIG. **1**) whereas when leg **43** is closed a **2** kilovolt signal is placed across switch **5, 7** or **9** since a voltage source of 2 kilovolts or higher is placed across terminals *b* and *c* of FIG. **2***a*.

The circuit of FIG. **2***a* is controlled by the control circuit of FIG. **2***b*. The control circuit is operated by a logic input, shown in FIG. **1** as input **11, 13** and **15.** The logic input is either a "1" or a "0". With a "0" logic input, transistors **51** and **53** will both be off. This will cause transistor **55** to be turned on and turn off transistor **57.** Transistor **59** will be turned on by the oscillator input. Since transistor **59** is on and transistor **57** is off, current will flow from the source through primary

winding **61** of a pulse transformer, the secondary being coils **23***a* to **23***j*. This causes current to flow in leg **41** and not to flow in leg **43** of FIG. **2***a*, thereby providing a short circuit across leg **41**. The current through the coil **61** is a series of pulses caused by the output of a constantly running oscillator (not shown) which can be in the 30–1000 Khz range and is preferably 100Khz and is connected to the oscillator input. This provides pulses at such a rapid rate that it appears as a direct current, yet the legs **41** and **43** float relative to the control circuit.

If a "1" logic input is provided, transistors **51** and **53** will be on, thereby transistor **59** will be off, transistor **55** will be off and transistor **57** will conduct due to the oscillator input. For this reason, current will pass through coil **63** which is the primary winding of a second pulse transformer, the secondary being the coils **33***a* to **33***j*. For this reason leg **43** will conduct and leg **41** will be off, thereby providing a 2 kilovolt signal across terminals *a* and *c*. The diodes **65** and **67** handle current during collapse of the magnetic field at their respective coils. The diodes could be omitted. The diodes **69** and **71** are used to balance diodes **73** and **75** and to set the saturation level of transistor **59** higher than for transistor **51**.

It is appreciated that the circuit of FIGS. **2***a* and **2***b* is located in each of switches **5**, **7** and **9**, the ultimate voltage depending on the logic input to each of switches **5**, **7** and **9**. It is also noted that the frequency of the oscillator input in FIG. **2***b* is such as to provide a duty cycle to limit the rise and fall time of the transistors of legs **41** and **43** to provide a substantial direct current.

It can be seen that there has been provided a circuit which is simple and accomplishes the objects set forth hereinabove.

Though the invention has been described with respect to a specific preferred embodiment thereof, many variations and modifications will immediately become apparent to those skilled in the art. It is therefore the intention that the appended claims be interpreted as broadly as possible in view of the prior art to include all such variations and modifications.

What is claimed is:

1. A variable high voltage power supply comprising,

first and second voltage sources,

a first switch means including at least one semiconductor for connecting the first voltage source to the load when energized,

a second switch means including at least one semiconductor for connecting the first and second sources in series with the load when energized,

a source of oscillation,

a pair of transformer primary windings,

a pair of switches operative when rendered conductive, to apply the oscillations to the respective windings through unidirectional conducting means,

and control means for rendering one of the switches conductive and simultaneously rendering the other of the switches non-conductive,

the semiconductors of the first and second switch means being each provided with a respective secondary winding of the transformer connected between their control electrodes to control the energization.

2. A variable high voltage power supply according to claim **1**, wherein the pair of switches each includes semiconductor means.

3. A variable high voltage power supply according to claim **1**, wherein the other of said switches is normally energized and the one of the switches is normally deenergized.

4. A variable high voltage power supply according to claim **3**, wherein the pair of switches each includes semiconductor means.

5. A variable high voltage power supply according to claim **4** wherein the control means comprise semiconductor devices coupled to the semiconductor means and responsive to an applied pulse for rendering one of the semiconductor means conductive and the other of the semiconductor means non-conductive.

6. A variable high voltage power supply according to claim **1**, wherein each of the pair of switches comprises a transistor,

each of the primary windings being in the current path of a respective transistor,

the source of oscillations being connected to the base of each transistor.

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