

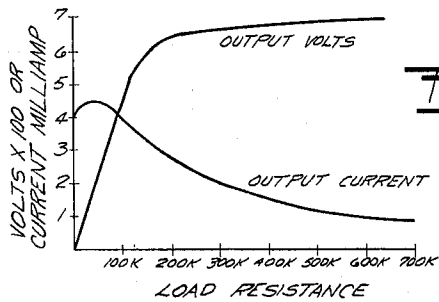
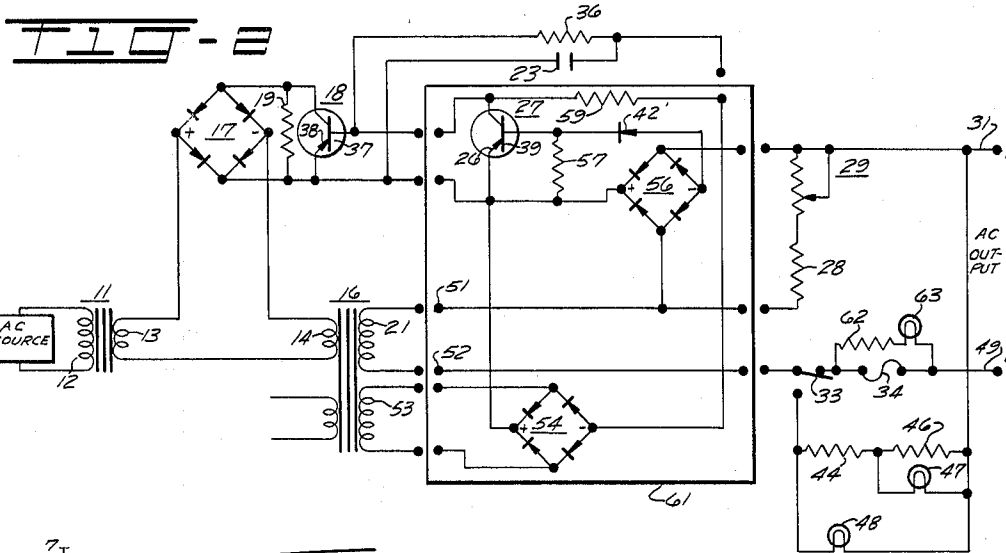
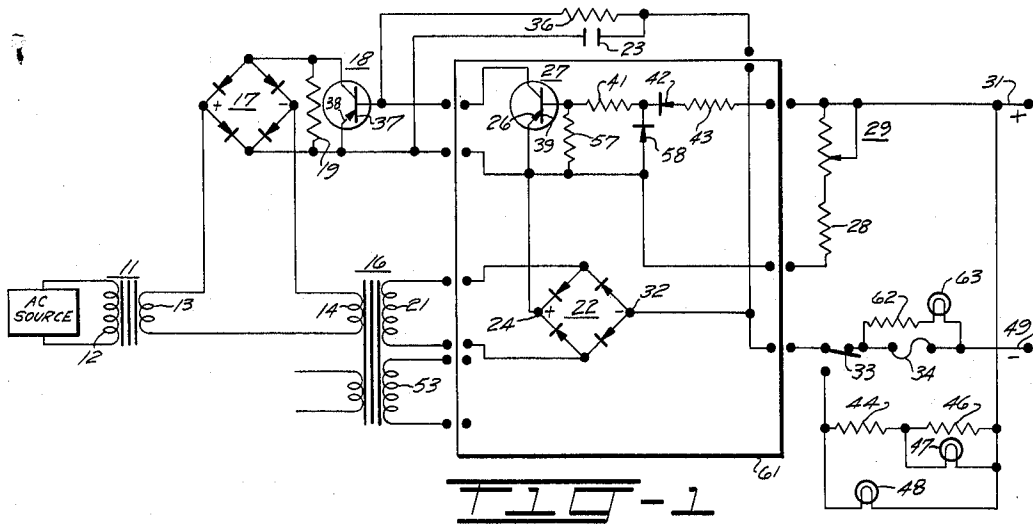
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CURRENT LIMITED VOLTAGE SUPPLY

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CURRENT LIMITED VOLTAGE SUPPLY

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9 Claims. (Cl. 321-18)

This invention relates to voltage supply apparatus and particularly to improved current limited voltage supply apparatus.

A high potential breakdown test is commonly applied to electrical apparatus during the production process. Basically, a breakdown test requires a specified high potential source connected in series with a current flow detector for a minimum period of time across predetermined points of the circuitry under test. The detector indicates excess leakage current and in the case of an automatic test set, stops the progress of the set upon encountering a defect. The internal impedance of the voltage source and the current flow detector must be relatively low to preclude undesirable variation in the applied potential due to internal regulation of the supply.

The combination of high potential and low internal resistance could conceivably result in an undesirable working condition for an operator testing electrical apparatus unless precautions are taken. Actually, in many test applications a choice has been made between a safety cage or shield of some kind to isolate the product from the operator and a current limiting resistor inserted in the test circuit to lower the current to a safe value. The former method meets test requirements but involves higher costs and reduced operator efficiency. On the other hand, the latter method limits the output current in an economic manner but reduces the applied potential due to the voltage drop in the current limiting resistor.

An object of this invention is to provide a new and improved current limited power supply for high voltage breakdown testing.

Another object of this invention is to provide an improved means for meeting breakdown test requirements without the necessity of shielding the test product or risking shock hazard to the operator.

A further object of this invention is to provide a power supply having a current limiting transistor shunt circuit which operates to decrease the conductivity of a saturated transistor in a low voltage area resulting in an increase of impedance for the entire supply circuit with the desired current limiting action.

In accordance with the general features of this invention, a voltage power supply comprises a source of alternating current, a step-up transformer, a rectifier and a first transistor connected in series between the source and the input of the transformer, and a second transistor coupled to the output of the transformer and shunting the input of the first transistor, the biasing circuit of the respective transistors being such that normally the first transistor is saturated and the second transistor is low conducting. On increase of load current in the output of the transformer to a predetermined magnitude, the conductivity of the second transistor is increased lowering the conductivity of the first transistor while increasing its impedance.

In general detail, a current limited power supply for high voltage A.C. or D.C. breakdown testing comprises an A.C. input and a high potential output with an adjustable current limit. In operation, a saturated first transistor provides a relatively low impedance path from the secondary of a step-down transformer to the primary of a high potential step-up transformer. When a preset output current is reached, a second transistor in the high potential side of the step-up transformer shunts the first

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transistor, reducing its conductivity. This increases the impedance of the primary circuit of the high potential transformer and results in an increase of impedance for the entire circuit with the desired current limiting action. The subject power supply maintains the output voltage within a required test range while limiting the output current to a value considered non-hazardous from an operator standpoint. The regulation occurs in the low voltage side of the step-up transformer thereby permitting control of a high voltage output in a relatively low voltage area.

Other objects and advantages will be apparent when considered in conjunction with the accompanying drawing, wherein:

FIG. 1 is a schematic view of a voltage supply embodying a D.C. application of the invention;

FIG. 2 is a schematic view of a voltage supply embodying an A.C. application of the invention; and,

FIG. 3 is a graphical representation illustrating the output characteristics of the current limited voltage supply described herein.

With reference to the drawings, a step-down transformer 11 reduces the 110-volt 60-cycle alternating current input 10 to the primary winding 12 to 55 volts in the secondary winding 13. Of course, it is understood that transformer 11 may be omitted if a low voltage source is available or if the circuit components are designed to handle the 110-volt input. As seen in the embodiment of FIG. 1, this alternating current is supplied to the primary winding 14 of a second transformer 16 in series with a bridge rectifier 17. The emitter-collector circuit of a transistor 18 connected across the rectifier 17 provides a low impedance series path through the rectifier 17 when conductive. This permits practically unimpeded current flow for alternating current from transformer 11 through the primary 14 of the 540 volt high voltage step-up transformer 16. A 25,000-ohm resistor 19 in parallel with the transistor 18 reduces the transistor's limiting effect so that the short circuit current is not reduced to a point where test apparatus short detection relays (not shown) do not operate. The purpose of the rectifier 17 is to permit uni-directional flow through the transistor 18.

The current from the secondary 21 of the step-up transformer 16 is rectified by a bridge rectifier 22 and filtered by the one microfarad capacitor 23. The positive side 24 of the high voltage rectifier output is connected to the emitter 26 of transistor 27 and through the series connected 500-ohm resistor 28 and limit adjusting potentiometer 29 to the positive output terminal 31 of the supply. The negative side 32 of the high voltage rectifier output is connected through the normally closed contacts of the test key 33 and through fuse 34 to the negative output terminal 49 of the supply. The negative output 32 of the high voltage rectifier 22 is also connected through the 70,000-ohm resistor 36 to the base 37 of transistor 18 to bias it to conduction.

Transistor 27 functions as a shunt from the base 37 to the emitter 38 of transistor 18 to reduce the base current to transistor 18 whenever it becomes necessary to increase the impedance of the circuit in order to limit the output current. The base 39 of transistor 27 is connected through the 100-ohm resistor 41, the Zener diode 42 and through the 500-ohm resistor 43 to the positive output terminal 31 of the power supply. The 100-ohm resistor 57 provides a cutoff bias path for the transistor 27 and a diode 58 is provided to short the high potential discharge from the filter capacitor 23 when the output is shorted. Current drawn from the circuit causes a potential drop across resistor 28 and the limit adjusting potentiometer 29. The circuit parameters are selected to maintain the

output current in a non-hazardous region and to minimize the potential between the positive rectifier output 24 and the power supply positive output terminal 31. When the illustrated circuit is adjusted, the total resistance of resistor 28 and potentiometer 29 is approximately 1000 ohms. As a consequence, the potential difference between the rectifier output 24 and the output terminal will be one volt per milliampere drawn from the circuit.

In operation, transistor 27 remains at cutoff and permits transistor 18 to be saturated until the potential difference across resistor 28 and potentiometer 29 exceeds 4.7 volts due to a current drain exceeding 4.7 milliamperes. This value is selected as a current limit since 5 milliamperes is considered non-hazardous for operators. At this point, the 4.7 volt Zener diode 42 acts as a voltage regulator source and conducts providing a forward bias for the base 39 of transistor 27. As the current drain increases still further, transistor 27 becomes more conductive until it saturates. As the conductivity of transistor 27 increases, the current available to the base 37 of transistor 18 is reduced until the latter becomes cutoff.

Decreasing the conductivity of transistor 18 is equivalent to increasing the impedance of the primary circuit of the high potential transformer 14 and results in an increase of impedance for the whole circuit. Transistor 18 is a power transistor with a 90-volt emitter to collector breakdown voltage and relatively low cutoff leakage. Therefore, it is capable of withstanding the peaks of the rectified 55 volts which is blocks when cutoff and of increasing the impedance of the supply to limit the output to a safe value even though the load is a short circuit.

To adjust the power supply for the desired current limit, the test key 33 is depressed to switch the output of the supply to a test path composed of resistors 44 and 46 and indicator lamps 47 and 48. The potentiometer 29 is adjusted until the on lamp 48 is lighted and the off lamp 47 is not lighted. Circuit valves are selected so the power supply is properly set when the indicating lamps are in the aforementioned condition. A 10 milliamper fuse 34 is provided in the output 49 as a guard if the circuit should fail due to a faulty transistor. A serially connected resistor 62 and indicating lamp 63 are in parallel with fuse 34 to indicate such failure while limiting the power supply output.

FIG. 2 is a schematic representing the A.C. version of the current limited high voltage supply. Since its principle of operation and circuitry are similar to those of the D.C. counterpart, it is possible to use plug-in module units 61 for the circuitry peculiar to A.C. or D.C. operation. Therefore, the novel voltage supply described herein may be incorporated into a basic test circuit with removable module units 61 for variations in operating conditions.

The 540 volt A.C. output from the secondary 21 of the high voltage step-up transformer is not rectified in FIG. 2. One leg 51 is connected through resistor 28 and potentiometer 29 to the positive output terminal 31 of the supply. The other leg 52 is connected to the negative output terminal 49 through the normally closed contacts 33 of the test key through the fuse 34.

The 103 volt A.C. output from the secondary 53 of transformer 16 is rectified by a bridge rectifier 54 and utilized to provide the conductive bias for the base circuit of power transistor 27. Capacitor 23 is used to filter this bias circuit. A resistor 59 is connected in parallel with resistor 36 to increase the current to transistor 18. A bridge rectifier 56 is provided to convert the potential drop across resistor 28 and the potentiometer 29 to D.C. for application to the base 39 of transistor 27 through the Zener diode. The 3.9 volt Zener diode 42' operates at a lower voltage value than the D.C. Zener diode 42 to allow for the additional potential drop in the bridge rectifier 56.

The curves in FIG. 3 show a negligible variation in applied potential with increasing current drain as the load resistance is decreased until the preset limit is approached. At this point, the internal impedance of the source increases sharply to limit the current to the preset value. The limit chosen for the preferred embodiment is five milliamperes which is considered not hazardous and is ample for breakdown potential.

It is to be understood that the above described arrangements are simply illustrative of the principles of the invention. Numerous other arrangements may be readily devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

What is claimed is:

1. A current limited voltage supply comprising:

a source of low potential alternating current, a first and a second transistor, each having an emitter, a collector and a base, the emitter-collector circuit of the second transistor being connected across the emitter-base circuit of the first transistor, means coupled to the first transistor for converting the low potential alternating source current to a high potential output current,

rectifying means connected in series with the low potential source, the emitter-collector circuit of the first transistor and the potential converting means, said transistor circuit providing a low impedance path through the rectifying means when conductive, and means responsive to an increase in output current to a predetermined value for forward biasing the base of the second transistor to shunt the base to emitter circuit of the first transistor thereby increasing the impedance of the first transistor and limiting the output current of the supply to a predetermined magnitude to permit transistorized control of a high potential at a low potential point in the voltage supply circuit.

2. A voltage power supply comprising:

a source of alternating current, a step-up transformer, a rectifier and a first transistor connected in series between the source and the low voltage input of the transformer, a second transistor coupled to the high voltage output of the transformer and shunting the input of the first transistor, and

a biasing circuit for each transistor, said circuits being such that normally the first transistor is conducting and the second transistor is non-conducting but on an increase of the load current in the output of the transformer to a predetermined magnitude the second transistor becomes conducting and causes the impedance of the first transistor to be increased thereby limiting the output current of the transformer to permit transistorized control of a high potential at a low potential point in the power supply circuit.

3. A voltage power supply in accordance with claim 2 wherein:

the biasing circuit of the second transistor includes a voltage regulated source conducting when the output current reaches a predetermined limit to forward bias the base circuit of the second transistor to reduce the current in the base circuit of the first transistor thereby controlling the current flow through the primary of the step-up transformer and thus limiting the high potential output voltage.

4. In combination:

a source of low potential alternating current, a first transistor and a second transistor, each having an emitter, a collector and a base, the emitter-collector circuit of the second transistor being connected across the emitter-base circuit of the first transistor, a first rectifying means connected in series with the

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- source and having the emitter-collector circuit of the first transistor connected thereacross, said transistor circuit providing a low impedance path through the rectifying means when conductive,
- means in series with the first rectifying means for converting the low potential alternating current to a high potential,
- a second rectifying means coupled to the high potential output of the step-up converting means, said rectifying means having a positive and a negative output side,
- a positive and a negative output terminal,
- a plurality of circuit paths from the positive side of the second rectifying means, a separate path going to the emitter of the first transistor, to the emitter and the base of the second transistor and to the positive output terminal,
- a plurality of circuit paths from the negative side of the second rectifying means, a separate path going to the base of the first transistor to normally bias said first transistor and a separate path going to the negative output terminal, and
- a normally non-conducting voltage regulating device connected to the base of the second transistor and said positive output terminal, said device becoming conductive when the output current exceeds a predetermined magnitude to forward bias the base of the second transistor to shunt the base to emitter circuit of the first transistor thereby limiting the output current.
5. In combination with claim 4:
means providing a cutoff bias path for the second transistor, and
means for shorting the high potential discharge to the second transistor when the output is shorted.
6. In combination with claim 4:
means for adjusting the output current limit.
7. In combination:
a source of low potential alternating current,
a first transistor and a second transistor, each having an emitter, a collector and a base, the emitter-collector circuit of the second transistor being connected across the emitter-base circuit of the first transistor,
- a step-up transformer having a primary and a pair of secondary windings,
- a rectifier connected in series with the first transistor between the source and the primary winding of the transformer,
- a high voltage output path from one of the pair of secondary windings,

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- a biasing circuit for the second transistor connected to the other of the pair of secondary windings of the step-up transformer such that normally the first transistor is saturated and the second transistor is low conducting but an increase in the current in the output path of the transformer to a predetermined magnitude, the conductivity of the second transistor is increased causing the conductivity of the first transistor to be lowered thereby limiting the input current to the transformer.
8. A current limited voltage supply comprising:
a source of alternating current,
a step-up transformer having a low voltage primary winding and a high voltage secondary winding,
a rectifier and a first transistor connected in series between the source and the primary winding of the transformer,
a second transistor shunting the first transistor and being coupled to the secondary winding of the transformer to continuously monitor the current associated with the high voltage from the transformer secondary, said second transistor lowering the conductivity of the first transistor thereby limiting the input current to the transformer at a low potential point in the voltage supply circuit when the monitored current reaches a predetermined limit, and
an output circuit path from the transformer secondary, said path being connectible to a variable load to supply a high output voltage with a predetermined current limit.
9. A current limited voltage supply in accordance with claim 8 wherein:
the predetermined current limit is less than 5 milliamperes.

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