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[54] DISCHARGE FLASH TUBE HIGH ENERGY SWITCH

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[21] Appl. No.: **30,385**

[52] **U.S. Cl.**.....**328/76,** 128/419 D, 307/252 H, 307/252 N, 315/208, 315/362, 328/210

[51] **Int. Cl.**.....**A61n 1/38**

[58] **Field of Search**.....315/84.5, 127, 161, 237, 238, 315/239, 240, 245, 363, 61, 63, 189, 197, 20 C, 208; 328/76, 125, 77, 79, 80, 84; 331/111; 317/9 R, 9 HV, 9 IB; 200/48 R; 313/197, 208; 250/208

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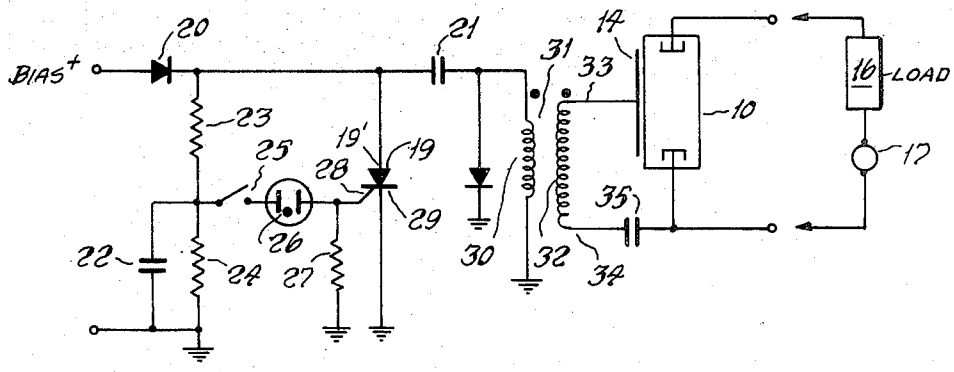
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[57] **ABSTRACT**

A high speed, high energy capacity switch system wherein a trigger pulse from an appropriate circuit is applied to the primary of a transformer. The secondary of the transformer may be connected across one of the main electrode terminals of a Xenon or Krypton gas tube and the control terminal thereof, or both terminals, may be isolated using a small capacitor. The main electrodes of the Xenon flash tube or Krypton gas tube are disposed in series with the power source and/or load which is to be controlled so that when the stepped-up trigger pulse is applied to the tube, it will fire and provide instant conduction of the power source current and remain in this state until the voltage and current thereacross fall below the value necessary to sustain conduction for a sufficient period of time. Additionally, there are disclosed a computer logic element wherein the switch is interposed in the memory core and the light output thereof is detected by a bank of photo diodes, a random color pattern generator wherein a series of light emitting diodes are connected in series with the switch, an overload protective device in which the current or voltage sensor controls the activation of the switch to short circuit the power source thereacross and other novel combinations.

10 Claims, 9 Drawing Figures



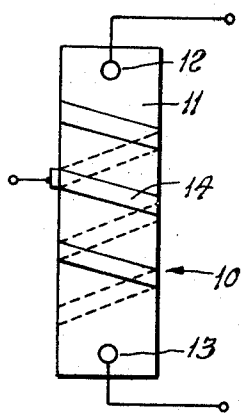


Fig. 1

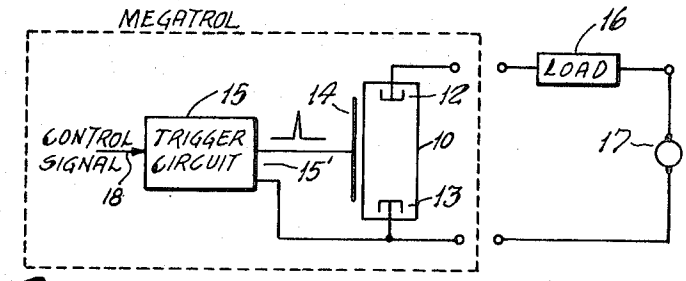


Fig. 2

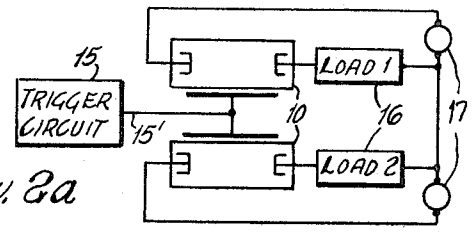


Fig. 2a

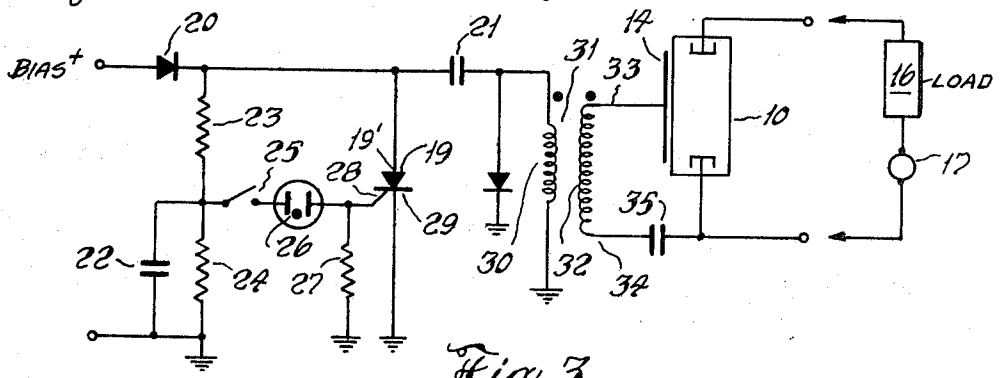


Fig. 3

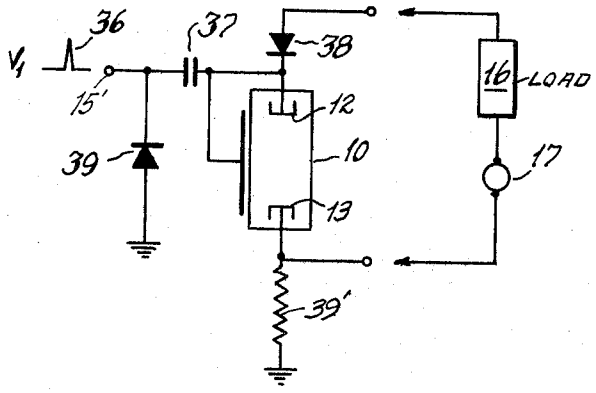


Fig. 4

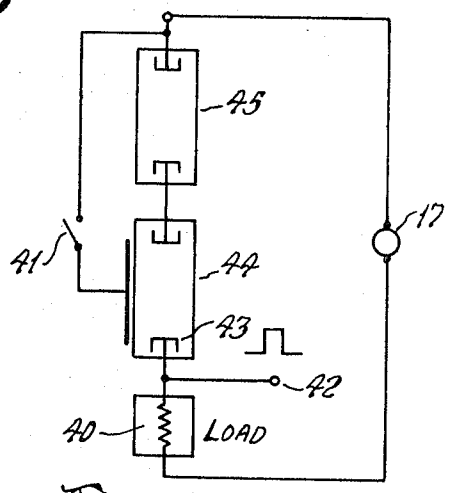


Fig. 5

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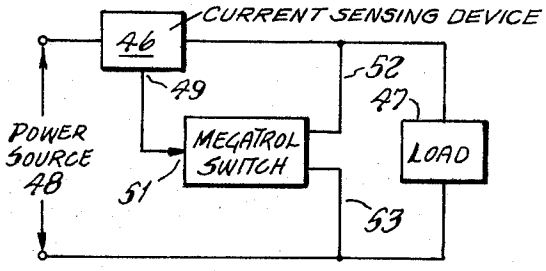


Fig. 6

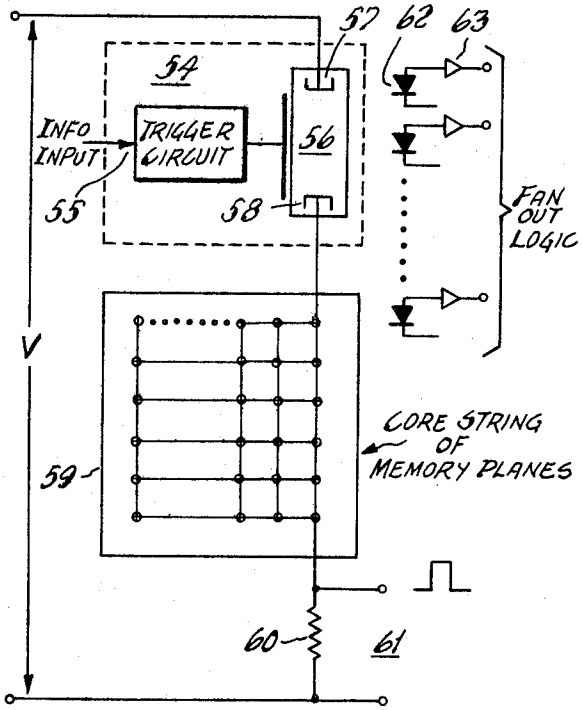


Fig. 7

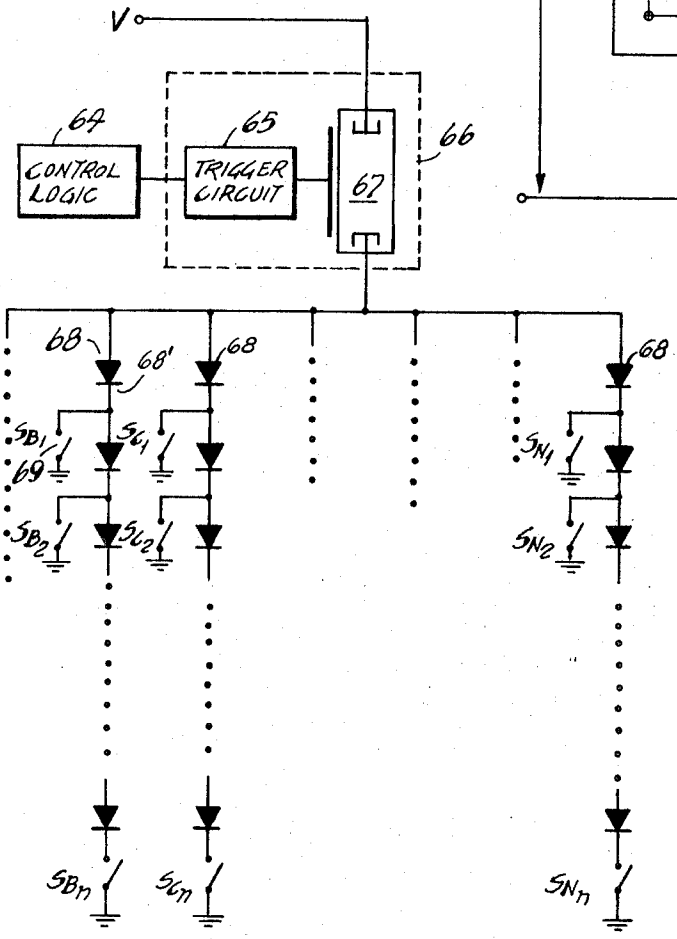


Fig. 8

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DISCHARGE FLASH TUBE HIGH ENERGY SWITCH

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to basic high speed, high energy capacity switches and more particularly pertains to an output as well as providing a power transfer function.

2. Description of the Prior Art

In the field of electronic and electrical switching it has been the general practice to employ a variety of special devices such as relays, contact switches, manual and remote, thyratrons, solid state elements such as silicon controlled rectifiers. Such devices have been found unsatisfactory in that they are limited in their current and voltage capacities and speed of operation. This is particularly true in the case of both the SCR, where limiting values of current and voltage exist due to the physical characteristics and the necessity of dissipating large heat accumulations, and for gas tubes such as the Thyratron where, although high currents can be accommodated, voltage and switching time limitations exist as well as the fact that the ignition and sustaining voltages are fixed parameters. These two devices, although extensively applied, are essentially unidirectional in conduction; thus they are not interchangeable for all applications with standard switch elements and do not have both switch terminals isolated. Relays and contact switches are clearly slow acting devices and subject to periodic breakdown when operating at high voltage and current. Moreover, none of these elements in and of themselves provide any secondary output or indicia of their operation, a useful output, where, a multifunction switch is necessary without additional elements or equipment. Those concerned with the development of switches and elements have long recognized the need for a high capacity, fast acting, bidirectional, and multipurpose switch. The present invention satisfies this requirement.

SUMMARY OF THE INVENTION

The general purpose of this invention is to provide a switch that has all the advantages of similarly employed prior art devices and has none of the above described disadvantages. To attain this, the present invention provides a unique arrangement of an Xenon or Krypton flash tube whose main electrodes are connected in series with the load or line to be switched while a control pulse is applied between the control terminals thereof. One control terminal being any surface proximate the glass envelope of the tube which may be raised to the necessary ignition potential. Novel combinations and applications of the present invention include the use of photo diodes to detect the light output of the Xenon or Krypton tube when triggered in conjunction with a computer memory core to provide a high fanout logic element. A random pattern generator wherein, the tube is connected in series with a plurality of parallel banks of light emitting diodes which are individually controlled by logic switches while the tube trigger circuit is activated by control logic. An overload protective device wherein, a sensing element is provided in series or in parallel with the circuit to be protected and the switch is applied across the power source so that when the sensing element initiates an output indicating an overload, this output triggers the switch to short circuit across the power source. In pulsed radar and sonar the switch is interposed between the transmitter/receiver and the radiating component with the switch control signal supplied as the pulse command from the T/R.

An object of the present invention is to provide a high speed, high capacity, reliable, inexpensive, bidirectional switching device which can readily be applied to a multitude of applications.

Another object is to provide a switch capable of operating under conditions of high current and high voltage while having an extremely short transit time.

A further object is the provision of a device for switching extremely high wattage with a minimum loss in efficiency through the use of only minimal control power.

Still another object is to provide a gaseous switch capable of operating over a plurality of ignition or firing potentials, while handling high level energy.

A still further object is the provision of a switch device which provides a secondary output in another form or medium that may be utilized in conjunction therewith.

An additional object is to provide a reliable, direct, fast acting, inexpensive overload protective device.

Another object is the provision of a random pattern generator, a computer logic device and a control for both radar and sonar systems.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective of a Xenon flash tube with a control electrode disposed thereon;

FIGS. **2** and **2***a* are block diagrams of embodiments made in accordance with the principle of this invention;

FIG. **3** is a schematic diagram of an embodiment of the instant invention;

FIGS. **4** and **5** illustrate novel trigger circuits for the switch;

FIG. **6** is a block diagram of an overload protector employing the switch of the instant invention;

FIG. **7** is a diagram of a logic circuit embodying the invented switch;

FIG. **8** is a block diagram of a random pattern display generator.

In the illustrated embodiment of FIG. **1** a gas discharge tube **10** filled with Xenon or Krypton gas enclosed in a glass envelope **11** (or other suitable enclosure) has therein a pair of main discharge electrodes **12** and **13**. A control terminal or electrode **14** can assume a variety of shapes and positions since all that is necessary is to provide a short duration voltage across the gas to the main electrodes. This can be accomplished by affixing an electrical conductor proximate to or on the envelope **11**. Wrapping a wire therearound or an electrically conducting tape **14**, or a thin layer of conducting paint applied directly to the envelope, will provide sufficient potential to break down the gas and initiate the main discharge. The type of control element employed depends on the tube use so that where light

emission is a factor, a wire or transparent tape is selected. It should be noted that as in most gaseous discharge tubes, a particular voltage between the main electrodes is required to sustain ignition or firing after the control terminal has activated or fired the tube. Recent developments in Xenon and Krypton flash tubes have included what can be generally termed as "-doping." Various of these techniques have lead to the fabrication of a series of tubes which can sustain ignition at different currents and potentials. These parameters can be selectively determined in the manufacture of the tubes and, tubes can be obtained having sustaining voltages from approximately 50 volts to tens of thousands of volts. Tubes of this type are manufactured and available from the Xenon Corporation, Medford, Massachusetts and are fully described in their brochures on linear Xenon flash tubes designated as Novatron series 100, 200, 400 and 600. By combining, with the Xenon discharge tube **10**, a source of ignition voltage and sufficient main electrode voltage the tube can be made to fire or ignite and emit a high light intensity very close to that of natural sunlight. In the embodiment of FIG. **2**, a trigger circuit **15** has its output **15'** connected between the control terminal **14** and one main electrode **13** while the two main electrodes are connected across the series combination of a load **16** and an electrical power source **17**. Many circuits are presently available to provide a relatively narrow pulse and any of these are suitable for the purpose of supplying ignition potential. For selective "firing" the trigger circuit must be activated and a control signal input **18** thereto has been shown. This control signal can be provided through the action of a manual or electronic switch. In operation, when the load **16** and power source **17** are connected across the Xenon tube and the trigger circuit **15** activated, the tube fires and conducts therethrough the load current. The trigger circuit which may include the control signal source and the Xenon discharge tube in combination comprise a switch module which will be referred to hereinafter as the "Megatrol." In essence, the Megatrol is controlled in a manner similar to a relay or a silicon controlled rectifier. In order to close the main switch "contacts" a small amount of energy is applied to the control terminal permitting current to flow from the power supply through the load. As in the SCR, the main switch "contacts" reopen when the (voltage) current through the switch is insufficient to maintain conduction, but, unlike the SCR, current can flow in either direction (bidirectional). Once the Megatrol is extinguished it will not turn on again until the control terminal is activated. It is capable of controlling vast amounts of power through only minute control levels. For example, the Megatrol switch can easily hold off voltages in excess of 10,000 volts and conduct thousands of amperes while exhibiting an extremely high switching speed. FIG. **2***a* shows one possible multipole switch arrangement wherein another tube has been added to the module so that two or more loads can be simultaneously controlled.

An operative embodiment of the blocks of FIG. **2** is illustrated in FIG. **3** where a bias voltage is supplied to the anode **19'** of an SCR **19** through a diode **20**. Since the SCR **19** is "off" the bias voltage will cause capacitor **21** to charge to the desired level. Simultaneously capacitor **22** will be charged to a level established by the voltage divider comprising resistors **23** and **24**. When switch **25** is closed the neon gas tube **26** will breakdown permitting current to flow through resistor **27** to ground and apply a voltage at the gate **28** of SCR **19** causing the SCR to short capacitor **21** to ground through its cathode **29**. This discharges the capacitor and abruptly changes the voltage at the primary winding **30** of step-up transformer **31** which is coupled to the secondary **32** and provides a sufficient voltage pulse at the control terminal **14** to ignite the Xenon tube **10**. The secondary has one end **33** thereof connected to the control terminal **14** and the other end **34** connected through capacitor **35** to one of the main Xenon electrodes. It has been found that this capacitor **35** in the secondary circuit provides proper operation, reliability and improved results. More important, the capacitor electrically isolates the switch terminals from the control circuitry. Once conducting the load current, the Xenon tube will continue conducting until it is extinguished by a decrease in (current) energy therethrough.

In certain applications and conditions the applied voltage V is insufficient to breakdown the tube and initiate ignition. Considering FIG. **4**, a voltage pulse **36** is injected through capacitor **37** to the main electrode **12** thus applying a voltage $V + V_1$, which is sufficient to start ignition. Diode **38** blocks the positive pulse from the source of power while diode **39** absorbs the negative transient which passes through capacitor **37** when the tube switches "on." FIG. **5** indicates another novel trigger circuit wherein two discharge tubes are connected in series between the power source **17** and the load **40**. A switch **41** is connected between the power source and a trigger input **42** to main electrode **43** of Xenon tube **44**. With this switch **41** open no current will flow since the source voltage V is not great enough to breakdown both tubes **44** and **45** in series. However, when the switch is closed tube **44** will start conducting and will effectively lower its impedance so that the voltage across tube **45** will be sufficiently high to fire it and cause conduction in an avalanche mode. It should be noted that on conduction the voltage drop across tube **44** is practically zero due to the low conduction resistance.

The use of the Megatrol in conjunction with a sensing circuit to provide overload protection is shown in FIG. **6**. A current sensing circuit **46** is connected in series with the load **47** across the power source **48**. This circuit **46** which can be selectively adjusted to provide an output at terminal **49** only when the current therethrough exceeds a particular limit. This output is applied to the control terminal **50** of the Megatrol **51** or to operate the switch **25** of FIG. **3**. The main electrodes of the Xenon tube of the Megatrol **51** are connected by wires **52, 53** across the load **47** so that when an excessive or overload current is detected the Megatrol will be fired or "turned on." Since the Megatrol is an extremely low impedance device when conducting and capable of passing very high currents, it effectively absorbs all the current directed toward the load and short circuits it thereby protecting the load circuitry from damage. Additionally, the speed of switching permits protection of loads incapable of withstanding short duration overloads. Since the Megatrol shorts the power

source the protector therein, usually a circuit breaker, will react while the load is already protected. It has been found that the above described device effectively protects motors, generators, high power semi-conductors, vacuum tubes, etc.

In the embodiment of FIG. 7 the multifunction logic device includes the Megatrol **54** which receives digital information at the trigger circuit input **55**. The Xenon tube **56** has its main electrodes **57** and **58** connected in series with a core string on a memory plane **59**, a load resistor **60** and source V. With the digital input at the control terminal, the Megatrol switches "on" thereby providing a signal to the memory cores and an output at **61** across the resistor **60**. Simultaneously, the Xenon tube of the Megatrol emits a light signal which is detected by a bank or logic array of photo-diodes **62** and signal amplifiers **63** which are arranged to perform a logic function of a computer in a fanout logic. Such photo-diodes are readily available from the Hewlett-Packard Co. and described in their brochure "Pin Photodiode;" series 5082–4200, Technical data 1 October, 1968, and from G. E. Co. in their brochure 55. 46, 8/67. In addition, the logic device can be employed in various machines which require logic control functions such as printers, assemblers, typewriters for computer output and analog to digital converters.

In the random pattern generator of FIG. **8**, a control logic **64** provides the activation signal to the control terminal **65** of Megatrol **66** whose tube **67** is connected in series with a supply of voltage V and an array of parallel columns each having therein in series light emitting diodes **68**. These diodes are of the type which emit light when current is passed through them. One suitable diode is available from Monsanto Co. under Gallium Arsenide Semiconductors and described in their brochure, catalog No. 1, October 1968. Each diode is provided with a switch **69** connected between its cathode **68'** and ground so that the condition of these switches will set a selectable pattern for the entire array. Thus, the Megatrol, will supply programmed energy for the diode array whose elements are selectively activated.

It should be understood, of course, that the foregoing disclosure relates to only preferred embodiments of the invention and that numerous modifications or alternations may be made therein without departing from the spirit and the scope of the invention as set forth in the appended claims.

I claim:

1. A high speed, high energy capacity switch for switching a load in series with a source of electrical energy comprising

a gas filled bidirectional discharge flash tube having a pair of main electrodes and a control terminal for initiating the firing of said tube,

a trigger circuit for providing a high voltage pulse, connected between said control terminal and one of said main electrodes,

means for activating said trigger circuit to provide said pulse, whereby when said load and source are connected across said main electrodes said switch will control the energy therethrough.

2. The switch according to claim **1** wherein said gas is Xenon.

3. The switch according to claim **1** wherein said gas is Krypton.

4. The switch according to claim **1** further including a plurality of discharge tubes each having said trigger circuit connected between its control terminal and one of its main electrodes and having a different series load and source connected across its said main electrodes, whereby said switch is a multipole switch for controlling simultaneously a plurality of independent loads.

5. A high speed, high energy capacity switch for switching a load in series with a source of electrical energy comprising:

a gas filled discharge flash tube having a pair of main electrodes and a control terminal for initiating the firing of said tube,

a step-up transformer having a primary and a secondary winding coupled between said control terminal and one of said main electrodes,

a first diode,

a first capacitor

a pair of bias terminals,

a first series loop having connected therein said bias terminals, said first diode, said first capacitor and said primary,

a pair of resistors forming a divider network connected between the junction of said first diode and said first capacitor and one of said bias terminals,

a second capacitor connected intermediate one of said pair of resistors and said one bias terminal,

a silicon controlled rectifier having a gate and its anode-cathode connected in parallel across said divider network,

a second switch,

a neon tube,

said second switch and said neon tube connected in series between said gate and the junction of said pair of resistors,

a third resistor connected intermediate said gate and said one bias terminal,

whereby when said load and source are connected across said main electrodes said second switch will control the energy therethrough.

6. The switch according to claim **5** further including a secondary winding capacitor connected intermediate said secondary winding and said one main electrode.

7. A high speed, high energy capacity overload protective device for a load connected across an electrical power source comprising:

a load,

an adjustable current sensing means connected in series with said load and having an output terminal for providing an output voltage when the current through said sensing means exceeds a selected limit,

a switch including,

a gas filled flash discharge tube having a pair of main electrodes and a control terminal for initiating firing of said tube, said main electrodes connected across said load,

a trigger circuit for providing a high voltage pulse connected between said control terminal and one of said main electrodes, and having an input terminal for activating said trigger circuit,

electrical means connecting said output terminal of said sensing means to said input terminal of said trigger circuit,

whereby when the current through said load exceeds said limit said sensing means will activate said trigger circuit and said switch will short circuit across said load and thereby protect the same.

8. A multifunction logic device comprising:
a switch including,
a gas filled, transparent envelope, discharge flash tube having a pair of main electrodes and a control terminal for initiating firing of said tube,
a trigger circuit for providing a high voltage pulse, connected between said control terminal and one of said main electrodes, for initiating said pulse, and having an input terminal for activating said trigger circuit
a core string on a memory plane
a load resistor
a source of voltage
a series loop having connected therein said source, said main electrodes, said core string and said load resistor,
a logic array of photodiodes means disposed to detect the light emitted by said discharge tube and arranged to perform a logic function in fanout logic when digital information is applied at said input terminal of said trigger circuit.

9. A random pattern generator comprising:
a switch including,
a gas filled discharge flash tube having a pair of main electrodes and a control terminal for initiating firing of said tube,
a trigger circuit for providing a high voltage pulse, connected between said control terminal and one of said main electrodes for initiating said pulse and having an input terminal for activating said trigger circuit,
an array of parallel columns, each column having connected in series therein,
a plurality of light emitting diodes and,
switch means connected across each of said diodes for selectively permitting activation thereof,
terminal switch means connected in series with the last diode in each column,
a source of voltage
means connecting in series said source, said main electrodes and said array,
a source of control logic having its output connected to said input terminal of said trigger circuit,
whereby said control logic will activate said Megatrol switch and selectively light said diodes in a predetermined pattern.

10. A high speed, high energy capacity switch for switching a load in series with a source of energy comprising in combination:
a gas filled discharge flash tube having a pair of main electrodes and having a control terminal for initiating the firing of said tube,
a first diode,
said first diode being coupled in series with the load and energy source and the serial connection being coupled across said electrodes.
a high voltage pulse source,
means for actuating said pulse source coupled thereto,
means coupling said pulse source to said flash tube,
said coupling means comprising a capacitor having one side coupled to said pulse source and the other side coupled to one of said electrodes and to said terminal,
a second diode coupled to said pulse source,
a resistor coupling said diode to the other of said electrodes,
said first diode acting to block said pulse source from said energy source, and
said second diode acting to absorb transients from said capacitor when said tube switches on.

* * * * *