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[54] **APPARATUS FOR CONTROLLING THE DISCHARGE OF A CAPACITOR**

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[58] **Field of Search** ..... 315/239, 241 R, 241 P

[56] **References Cited**

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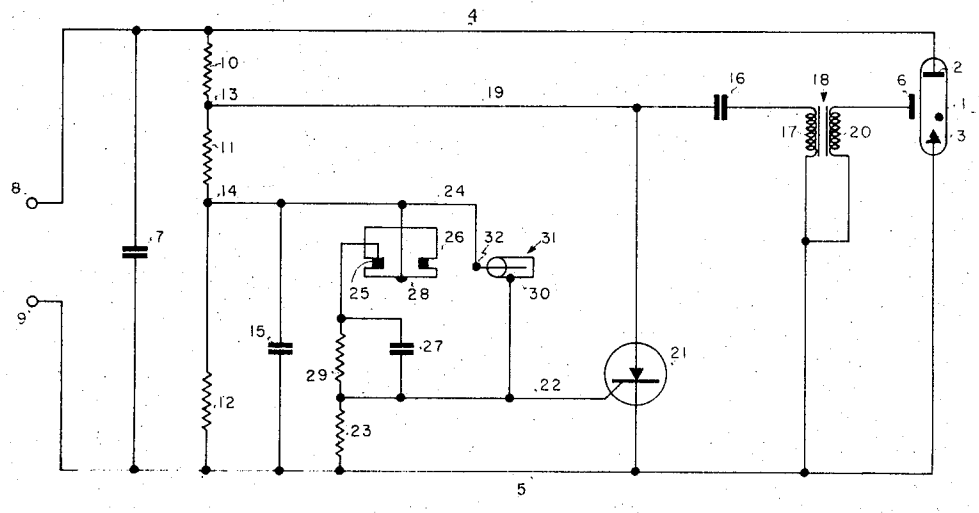
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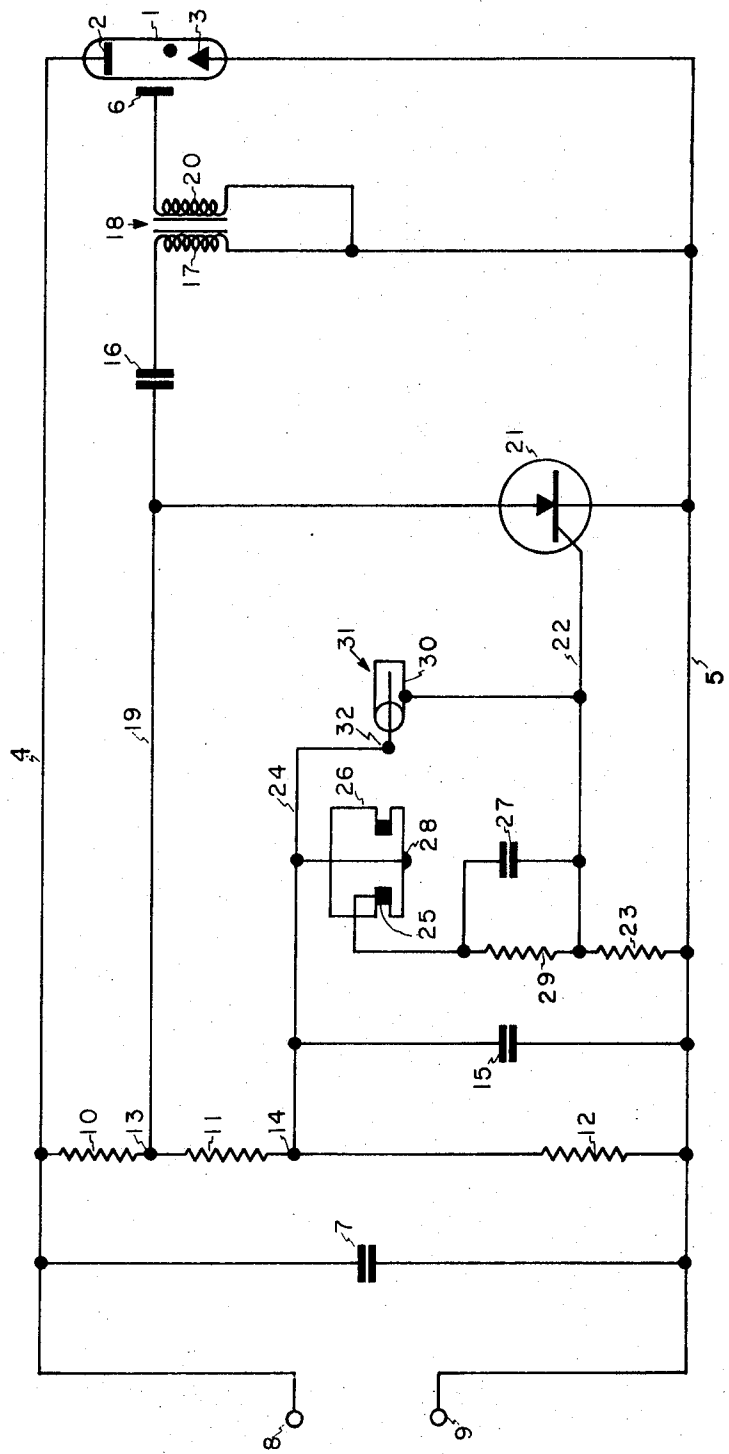
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[57] **ABSTRACT**

A flash tube triggering capacitor and triggering transformer primary winding are connected in series across power supply resistors to charge the capacitor. The anode-cathode circuit of an SCR is connected across the series combination of the capacitor and winding. A bypass capacitor, a bias resistor, and the terminals of a hot shoe are connected in series across one of the power supply resistors. The gate-cathode circuit of the SCR is connected across the bias resistor. The terminals of a PC connector are connected across the series combination of the hot shoe terminals and the bypass capacitor. The completion of an electrical path between either the hot shoe terminals or the PC terminals places a turnon voltage between the gate and cathode of the SCR and causes the latter to discharge the triggering capacitor into the winding to fire a flash tube.

9 Claims, 1 Drawing Figure





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APPARATUS FOR CONTROLLING THE DISCHARGE OF A CAPACITOR

CROSS-REFERENCE TO RELATED APPLICATION

Subject matter disclosed but not claimed herein is disclosed and claimed in the copending application of Robert H. Wallace Ser. No. 101,779 filed on even date herewith.

BACKGROUND OF THE INVENTION

The present invention relates generally to apparatus for actuating an electrical circuit upon the selective completion of either of two electrical paths, or upon the completion of one of these paths notwithstanding the concurrent existence of the other of the paths. Specifically, the invention relates to such apparatus wherein a charged capacitor is discharged into a load device upon the completion of an electrical path between the terminals of either one or the other of two pairs of terminals, or upon the completion of a path between the terminals of one of the pairs of terminals notwithstanding the concurrent presence of an already completed path between the terminals of the other of the pairs of terminals.

Apparatus is known in which the selective completion of an electrical path between one or another pair of terminals produces an electrical effect, such as the discharge of a charged capacitor into a load device. One example of such apparatus is the known photographic electronic flash unit which is provided with one pair of flash tube triggering or firing terminals in the form of the so-called PC connector, and with a second pair of flash tube firing terminals in the form of the so-called hot shoe. The completion of a path between either of these pairs of terminals, as is produced by the closing of camera shutter contacts connected between the terminals of that pair, causes the triggering capacitor of the triggering or firing circuit of the unit to be discharged into the associated triggering transformer and to fire the associated flash tube. It is necessary to provide such a unit with these two different forms of triggering or firing terminals in order to permit the unit to be used with, and to be fired by, both the type of camera in which the shutter contacts are connected to the terminals of a camera PC connector with which the terminals of the unit PC connector are designed to mate, and the type of camera in which the shutter contacts are connected to the terminals of a so-called camera hot accessory clip with which the terminals of the hot shoe of the unit are designed to mate when the unit is mounted and carried on the camera by means of this clip.

When a flash unit of the foregoing type is mounted by means of its hot shoe on the type of camera wherein the accessory clip is not provided with terminals, but is merely a single metallic element, an electrical path is continuously completed between the hot shoe terminals. In other words, the hot shoe terminals are continuously short-circuited in this situation. In order to prevent this path from continuously short-circuiting the firing circuit of the unit and thus taking the control of the firing away from the PC terminals of the unit, such known units have been provided with one or another of several different means for allowing the PC terminals to control the firing notwithstanding the concurrent short-circuiting of the hot shoe terminals by a terminalless accessory clip. These means have included manually or automatically operated switches for effecting the disconnection of the hot shoe terminals from the firing circuit of the unit when the PC connector is to be used, and arrangements which require the PC connector to be plugged back into the unit in order that the hot shoe terminals will be connected to the unit firing circuit. Another of such means has included two separate triggering capacitor circuits in the firing circuit of the unit, one for the hot shoe terminals and one for the PC terminals, each circuit including a separate triggering capacitor and charging resistor therefore. In each case, however, such means have unduly added to the size, complexity, and cost of the flash units employing these means.

It has also been the practice in the above-described known flash units to connect the hot shoe and the PC terminals directly in circuit with the triggering capacitors of the units. As a result, the supply voltage which charges the triggering capacitors is present between the hot shoe and PC terminals of these units. Since such terminals, particularly those of the hot shoe, can be touched by the user of the unit, and since the noted voltage appearing between these terminals is sufficiently high to give at least an unpleasant electrical shock to one so touching these terminals, the foregoing practice has resulted in an undesirable shock hazard condition being present in such units.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved form of capacitor discharging apparatus of the type last described which does not require any mechanical switching devices or any manually operated means for controlling the connection of one of two pairs of terminals to a capacitor discharging circuit, and does not require the use of separate charged capacitors or circuits and charging resistors therefore for each pair of controlling terminals, in order to permit one of the pairs of terminals to retain control of the discharging of the capacitor in the presence of a maintained electrical path between the other of the pairs of terminals. A further object of the invention is to provide such improved apparatus wherein the voltage between said terminals is kept at a sufficiently low level that no shock is felt by one who may contact these terminals. A more specific object of the invention is to provide such improved capacitor discharging apparatus in photographic electronic flash apparatus which thus does not require any of the aforementioned previously known means in order to permit PC terminals to retain control of the firing of the flash tube in the presence of a sustained path between hot shoe terminals, and which does not present between any of such terminals any voltage which is sufficiently high to shock one who may touch these terminals.

In accomplishing the foregoing and other desirable objects, the improved apparatus provided in accordance with, and embodying, the present invention includes the connection of a bypass capacitor in series with a first pair of terminals, such as the hot shoe terminals of photographic electronic flash apparatus, which are connected between circuit points of the apparatus. These points are connected to the low voltage control or gating connections of a control device or switch, such as a silicon controlled rectifier, the controlling or switching portion of which is connected across the series combination of a charged capacitor, such as a flash

triggering capacitor, and a load device such as a flash triggering transformer. Said points are thus ones between which the completion of an electrical path causes the control device to discharge the charged capacitor into the load device.

Upon the completion of a path between the terminals of said first pair of terminals, a path is completed only temporarily between said points which causes the control device to discharge the charged capacitor into the load device. The completion of a path between a second pair of terminals, such as PC connector terminals, which are also connected between said points, also causes the control device to discharge the charged capacitor into the load device, even though there may already be the aforementioned path between the terminals of said first pair of terminals. A resistor is connected across the bypass capacitor to discharge the latter in the absence of a path between said first pair of terminals. The connection of said terminals to said low voltage circuit prevents the appearance on said terminals of any voltage of sufficient magnitude to shock one who may touch said terminals.

BRIEF DESCRIPTION OF THE DRAWING

A better understanding of the invention may be had from the following detailed description when read in connection with the accompanying drawing, wherein the single FIGURE is a schematic circuit diagram of photographic electronic flash apparatus embodying capacitor discharging means according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The flash apparatus or unit illustrated in the drawing FIGURE is one in which the flash tube of the unit is fired upon the completion of an electrically conductive or electrical path or connection, herein referred to as a path, between either the terminals of a hot shoe of the unit, or the terminals of a PC connector of the unit. Further, the completion of a path between said PC terminals fires the flash tube notwithstanding the concurrent presence of an already completed path between the hot shoe terminals.

To the end of providing such operation, the illustrated unit includes a flash tube **1** having main electrodes **2** and **3** which are connected, respectively, to supply conductors **4** and **5**. The tube **1** also has a triggering electrode **6**. The conductors **4** and **5** are connected across the usual flash storage capacitor **7**, and to respective supply terminals **8** and **9**. The latter connect the capacitor **7** to the usual capacitor charging means, not shown, which may well be of the type disclosed in the Schmidt et al. U.S. Pat. No. 3,310,723. Voltage dividing resistors **10, 11,** and **12** are connected in series between the conductors **4** and **5**, the resistors **10** and **11** having a common junction **13**, and the resistors **11** and **12** having a common junction **14**. A capacitor **15** is connected across the resistor **12**.

The firing means for the tube **1** include a triggering capacitor **16** which is connected in series with the primary winding **17** of a triggering transformer **18** between a conductor **19**, which is connected to the junction **13**, and the conductor **5**. The transformer **18** also has a secondary winding **20** which is connected between the triggering electrode **6** and the conductor **5**.

The anode of a silicon controlled rectifier (SCR) **21** is connected to the conductor **19**, while the cathode of the SCR **21** is connected to the conductor **5**. The gate of the SCR **21** is connected to a conductor **22** which is connected through a resistor **23** to the conductor **5**. A conductor **24** is connected to the junction **14**.

A first terminal **25** of a hot shoe **26** is connected in series with a bypass capacitor **27** to the conductor **22**, while a second terminal **28** of the hot shoe **26** is connected to the conductor **24**. A resistor **29** is connected in parallel with the capacitor **27**. The value of the resistor **29** is made to be many times greater than the value of the resistor **23**. A first terminal **30** of a PC connector **31** is connected to the conductor **22**, while a second terminal **32** of the connector **31** is connected to the conductor **24**. Although the connector **31** is shown and described herein as being of the PC type, it is noted that the connector **31** could as well be of any of the many other types of shutter contact connectors which are used in the photographic field.

In the manner described in the aforementioned Schmidt et al patent, the storage capacitor **7** is normally maintained in a charged state by the aforementioned capacitor charging means, whereby a suitably high voltage is normally maintained between the conductors **4** and **5**. By virtue of the connection of the triggering capacitor **16** and the winding **17** in series between the conductors **19** and **5**, and hence across the resistors **11** and **12**, the capacitor **16** also is normally maintained in a charged state.

When the SCR **21** is turned on or made conductive, the charged capacitor **16** is effectively connected across the winding **17**. This causes the capacitor **16** to discharge into the winding **17**. This, in turn, fires the flash tube **1**, in the manner described in said Schmidt et al. patent. The tube **1** then continues to conduct until, due to this conduction, the charge on the capacitor **7**, and hence the voltage between the conductors **4** and **5**, drop sufficiently to cause the tube **1** to become extinguished and the SCR **21** to turn off. Thereafter, the capacitors **7** and **16** recharge to be ready for the next turn-on of the SCR **21**.

The SCR is turned on, and becomes conductive, upon the completion of a path between the conductors **22** and **24**. The ways in which such a path may be completed will now be described. In this connection, it is noted that the hot shoe terminals **25** and **28** and the capacitor **27** are connected in a first series circuit between the conductors **22** and **24**, while the PC terminals **30** and **32** are connected in a second series circuit between the conductors **22** and **24**.

When the illustrated flash unit is to be used with and fired by a camera, not shown, of the type provided with a hot accessory clip-that is, a flash unit mounting clip having terminals connected to the camera shutter contacts — the usual procedure is to mount the unit onto the camera by engaging the hot shoe **26** with the accessory clip. This causes the camera shutter contacts to be connected between the hot shoe terminals **25** and **28**. When a photograph is to be taken by the camera, the shutter thereof is actuated, which causes the shutter contacts to close and to complete a path between the terminals **25** and **28**. Since the bypass capacitor **27** does not have a charge at this time, the completion of the path between the terminals **25** and **28** effectively completes a path between the conductors **22** and **24**. This effectively causes the existing voltage across the

resistor 12 and the capacitor 15 to appear across the resistor 23 between the gate and cathode of the SCR 21. This voltage is sufficient to turn on the SCR 21. As noted above, the turning on of the SCR 21 causes the capacitor 16 to discharge into the winding 17, thereby firing the tube 1.

Since the camera shutter contacts usually stay closed only momentarily, the capacitor 27 usually acquires only a small charge under the foregoing conditions. When the camera shutter contacts open, any charge which has accumulated on the capacitor 27 is disipated by the resistor 29. As soon as the capacitors 7 and 16 become charged once more following the termination of the conduction of the tube 1 and the SCR 21, the unit is ready to be fired again by the next closure of the shutter contacts and completion of the path between the terminals 25 and 28.

When the illustrated flash unit is to be fired by means of the PC connector 31 instead of by the hot shoe 26, the connector 31 is connected to the camera shutter contacts so that the latter are connected between the terminals 30 and 32. This may be done by means of the usual shutter cord, not shown. This use of the PC connector 31 is required when the associated camera is not provided with a hot accessory clip, or when it is desired, for one or another reason, to support the flash unit in a manner other than by engaging the hot shoe 26 with an accessory clip.

When a photograph is to be taken under the conditions just described, the camera shutter is actuated, which causes the shutter contacts to close momentarily and to complete a path between the PC terminals 30 and 32. This in turn completes a path between the conductors 22 and 24 which again applies the voltage on the capacitor 15 and the resistor 12 across the resistor 23 and between the gate and cathode of the SCR 21, thereby turning on the latter,discharging the capacitor 16, and firing the tube 1. Thereafter, when the capacitors 7 and 16 have become recharged following the termination of the conduction of the tube 1 and the SCR 21, the unit is ready to be fired again by the next closure of the shutter contacts and completion of the path between the terminals 30 and 32.

It is seen, therefore, that the conductors 22 and 24 constitute a pair of circuit points between which the completion of a path causes the charged capacitor 16 to discharge into the winding 17 to fire the flash tube 1.

It is often desired to mount the illustrated flash unit on a camera by engaging the hot shoe 26 with an accessory clip on the camera even though this clip is not a hot clip, but is merely a suitably-shaped piece of metal without any shutter contact or other terminals. Under these conditions, the PC connector 31 must be used to connect the camera shutter contacts to the flash unit. As noted previously herein, however, this practice causes the hot shoe terminals to be continuously short-circuited as long as the unit remains mounted on the camera. Specifically, the engagement of the hot shoe 26 with such a short-circuiting accessory clip causes a path to be completed between the terminals 25 and 28 which is maintained or sustained throughout the period in which the unit remains mounted on the camera. Were it not for the presence of the novel construction according to the present invention, this continuously completed path between the terminals 25 and 28 would result in the completion of a path between the conductors 22 and 24, and across the PC terminals 30 and 32, throughout said period, during which the terminals 30 and 32 would have no control of the firing of the SCR 21 and the tube 1, and the latter devices would be caused to fire repeatedly in an uncontrolled manner.

The novel construction of the illustrated device prevents such undesirable action, however. When the hot shoe 26 is placed in engagement with a short-circuiting accessory clip, a path is completed between the terminals 25 and 28, and, for the time being, between the conductors 22 and 24. This causes the SCR 21 and the tube 1 to fire once, in the same manner as occurs upon the closure of the shutter contacts when the hot shoe 26 is in engagement with a hot accessory clip.

In the present case, however, the sustained completion of the path between the terminals 25 and 28 causes the capacitor 27 to become charged, since this capacitor now remains connected in series with the resistor 23 across the capacitor 15 and the resistor 12. When the capacitor 27 becomes so charged, the voltage on the capacitor 15 and the resistor 12 now appears mainly across the capacitor 27 and the resistor 29. The result of this is that there is now insufficient voltage across the resistor 23 to turn on the SCR 21 when the voltages between the conductors 4 and 19 and the conductor 5 have risen to the values which would permit the SCR 21 to become conductive.

It is seen, therefore, that, when the capacitor 27 becomes charged, the path between the conductors 22 and 24 effectively disappears. Therefore, the completion of the path between the terminals 25 and 28 for a sustained or an extended period only temporarily completes a path between the conductors 22 and 24. Accordingly, the continued presence of the path between the terminals 25 and 28, due to the presence of the short-circuiting accessory clip, does not cause the flash tube 1 to be repeatedly fired in an uncontrolled manner, but allows the terminals of the PC connector 31 to control the firing of the flash tube 1 as before. Therefore, each subsequent completion of a path between the PC terminals 30 and 32 simultaneously completes a path between the conductors 22 and 24 and fires the flash tube as before, notwithstanding the concurrent presence of the path already completed between the hot shoe terminals 25 and 28 by the short-circuiting accessory clip.

When the hot shoe 26 is subsequently disengaged from the short-circuiting accessory clip, the capacitor 27 is suitably discharged by the resistor 29. Accordingly, the device is then returned to the condition wherein the completion of a path between either the hot shoe terminals 25 and 28 or the PC terminals 30 and 32 completes a path between the conductors 22 and 24 and causes the SCR 21 to turn on and the flash tube 1 to be fired.

The use of the SCR 21 permits the voltages which appear between the hot shoe terminals 25 and 28 and the PC terminals 30 and 32 to be so low as to make it impossible for anyone touching these terminals in any way to experience any electrical shock. Additionally, the use of the SCR 21 makes it unnecessary for either the hot shoe or the PC terminals, or the associated camera shutter contacts,to carry the extremely high peak triggering currents of the discharging triggering capacitor 16. A typical set of resistance values for the resistors 10, 11, 12, 23, and 29 which will provide the voltages necessary for producing these desirable conditions and

the hereindescribed operation are as follows, it being noted that these values are stated merely by way of illustration and example, and not by way of limitation:

Resistor **10** — 2.2 megohms
Resistor **11** — 910 K ohms
Resistor **12** — 100 K ohms
Resistor **23** — 10 to 25 ohms
Resistor **29** — 18 megohms

Assuming that the voltage between the conductors **4** and **5** is 360 volts when the capacitor **7** is fully charged, which is a typical voltage for flash devices of the type being described, the above-listed resistance values will give a voltage of approximately 100 volts between the conductors **19** and **5**, and a voltage of approximately 10 volts across the resistor **12** and between the conductors **24** and **5**. As a result, the maximum voltage which can appear between the hot shoe or the PC terminals for the foregoing values is 10 volts.

In summary, it is seen that the described apparatus according to the present invention fulfills the objects set forth hereinbefore by employing a bypass capacitor in connection with a hot shoe and a PC connector in a relatively simple flash tube firing circuit including an SCR which permits the terminals of the PC connector to control the firing of the flash tube even when the hot shoe terminals are short-circuited by a camera accessory clip. Moreover, said described apparatus provides the foregoing operation without the use of any mechanical switching devices, any manually operated means, or any duplicated triggering capacitors or capacitor charging resistors, and without placing on the hot shoe or PC terminals any voltage which could shock a user of the apparatus.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Apparatus for discharging a charged capacitor into a load device comprising

a first capacitor connected in series with a load device to a source of capacitor charging voltage,

normally open switch means connected across the series combination of said first capacitor and said load device and having first and second control connections between which the application of a control voltage causes said switch means to discharge said first capacitor into said load device,

circuit means connected to said control connections and including first and second circuit points between which the completion of an electrical path causes said control voltage to be applied between said control connections,

first and second terminals forming a first pair of terminals,

third and fourth terminals forming a second pair of terminals,

a second capacitor,

conductors connecting said first and second terminals and said second capacitor in a first series circuit between said points to temporarily complete an electrical path between said points at the time of the completion of an electrical path between said first and second terminals, and

conductors connecting said third and fourth terminals in a second series circuit between said points to complete an electrical path between said points at the time of the completion of an electrical path between said third and fourth terminals notwithstanding the concurrent presence of an already completed electrical path between said first and second terminals.

2. Apparatus as specified in claim **1**, wherein said first series circuit is connected to said source of voltage to cause said second capacitor to become charged upon the sustained completion of an electrical path between said first and second terminals.

3. Apparatus as specified in claim **2**, wherein a resistor is connected directly across said second capacitor to discharge the latter in the absence of an electrical path between said first and second terminals.

4. Apparatus as specified in claim **1**, wherein said source of voltage includes first, second, and third resistors connected in series across a storage capacitor, wherein said first capacitor and said load device are connected in a series circuit across the series combination of said second and third resistors, wherein said points are connected, respectively, to first and second conductors, and wherein said first and second conductors are connected in series with a fourth resistor across said third resistor.

5. Apparatus as specified in claim **4**, wherein said control connections are connected across said fourth resistor.

6. Apparatus as specified in claim **1**, wherein said first capacitor is the triggering capacitor of a photographic electronic flash apparatus having a hot shoe connector and a PC connector arranged for connection to camera shutter contacts, wherein said load device is the primary winding of a flash tube triggering transformer, wherein said first and second terminals are terminals of said hot shoe connector, and wherein said third and fourth terminals are terminals of said PC connector.

7. Apparatus as specified in claim **6**, wherein said source of voltage includes first, second, and third resistors connected in series across a flash storage capacitor, wherein said triggering capacitor and said primary winding are connected in a series circuit across the series combination of said second and third resistors, wherein said points are connected, respectively, to first and second conductors, wherein said first and second conductors are connected in series with a fourth resistor across said third resistor, and wherein a third capacitor is connected across said third resistor.

8. Apparatus as specified in claim **7**, wherein said switch means is a semiconductor device having anode, cathode, and gate electrodes, wherein said anode and said cathode are connected across the series combination of said second and third resistors, and wherein said gate and said cathode are connected across said fourth resistor.

9. Apparatus as specified in claim **7**, wherein there is included a flash tube having electrodes connected across said storage capacitor, and wherein said triggering transformer includes a secondary winding arranged in firing relationship with said tube.

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