Aug. 29, 1961 J. R. M. GIRARD 2,998,548

VOLTAGE GENERATORS FOR FLASH LAMPS

Filed July 16, 1957 2 Sheets-Sheet 1

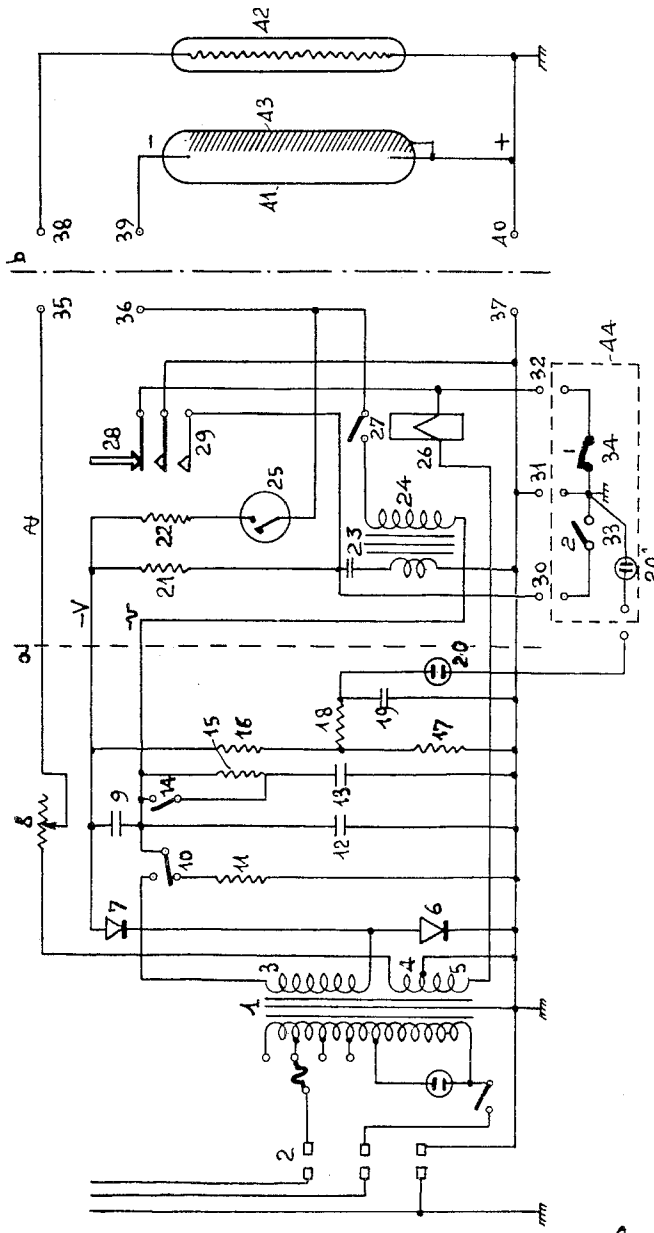

FIG. 1

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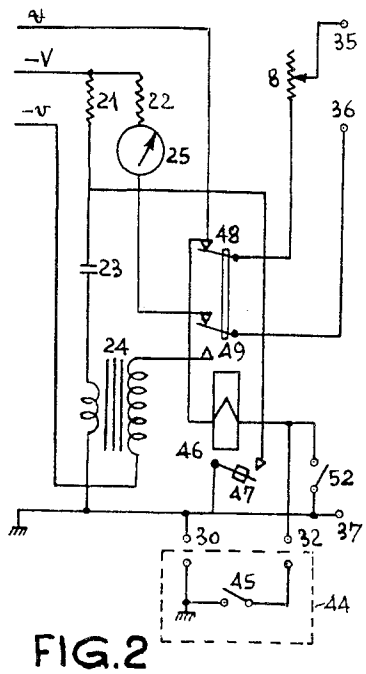

FIG.2

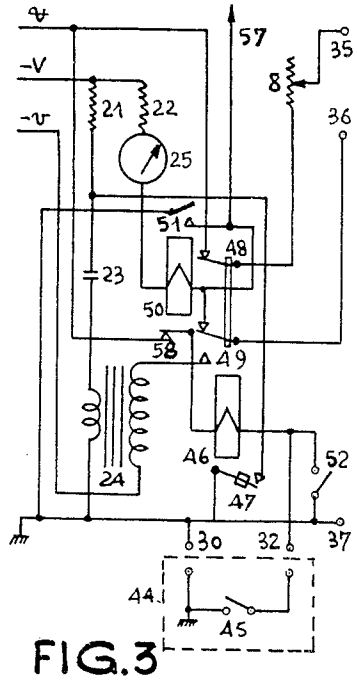

FIG.3

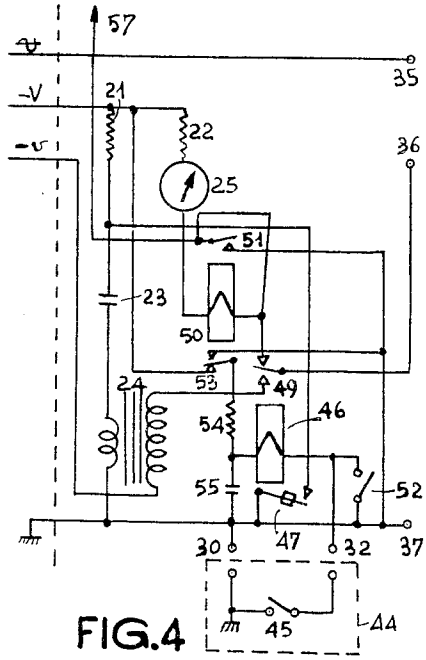

FIG.4

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2,998,548

VOLTAGE GENERATORS FOR FLASH LAMPS

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Claims priority, application France July 21, 1956
23 Claims. (Cl. 315—205)

The present invention concerns improvements in or relating to voltage generators for the control of flash tubes in such devices incorporating same for photographic purposes and more particularly for making photographs in endoscopic devices for the industry and the medical art, wherein the flash tube is introduced within a probe which is driven into the cavity to be inspected therefrom. Such an endoscopic probe may further incorporate an optical system, though this latter may be placed elsewhere in an independent probe when required. The inspection and photographic probe may further incorporate an inspection lamp for instance of an A.C. supply low voltage kind.

A flash tube for such uses must necessarily be of quite restricted dimensions and consequently drastic conditions have been imposed for the manufacturing and design thereof to the tube manufacturer so that it presents a short useful life, especially with respect to its ageing characteristic, which imposes to the user to supply it for flashing with a voltage rapidly increasing with respect to the life of the said tube. In such a respect, the nominal voltage for which a voltage generator for controlling such a tube has been provided is quickly overreached and this occurs in an unpredictable period of time for the user. The user is thus obliged to change the flash tube after some dozens or hundreds of flashes, which presents two main drawbacks: on the first part and quite obviously, it increases the cost of the photographs and on the second part it impedes the security and flexibility of operation of the complete device (as generally, the replacement of the tube, together with the probe containing it must be made during a series of inspections). This latter drawback is of special importance in endographic operations and more particularly in the medical art in an apparent way.

In such a case further it will often be required to introduce the probe containing the flash tube into natural cavities (or surgically made ones) filled with a conducting liquid, as for instance for an endography of the bladder. It is thought of importance in this respect that the user of the voltage generator also dispose of some means for checking the insulation of the flash tube, viz. of the high D.C. lead thereto.

Similar drawbacks are also encountered in the use of such miniaturized flash tubes in microphotography equipment.

The purpose of the invention is to provide improved voltage generators for the control of small-sized flash tubes wherein the said drawbacks are largely overcome.

The invention will be fully described with respect to the accompanying drawings, wherein FIG. 1 shows a first illustrative example thereof, whereas FIGS. 2 to 4, inclusively, show certain possible modifications of part of the voltage generator of FIG. 1. These embodiments consider the case wherein the flash tube 41 is incorporated in an inspection probe, the mechanical arrangement of which is not shown, but which also includes a conventional inspection lamp 42, though this is not imperative per se. The control connections from the voltage generator will at least partly pass through certain switching contacts related to the operation of a photographic camera which is diagrammatically shown as the block 44. In the respect of the connections of the three members, voltage generator proper, probe and camera, reference may be

had to my co-pending application Ser. No. 578,524, now Patent No. 2,867,209, wherein I appear as a co-inventor with M. M. Foures and De Montard and wherein is disclosed a complete medical purpose endographic device.

In FIG. 1, the dot-and-dash line *b* indicates the separation of the voltage generator (on the left-hand side) and the probe (on the right-hand side). The separation between the voltage generator and the camera is apparent per se in all figures through the corresponding terminals thereof.

In the shown example, the ionization control electrode 43 of the tube 41 is connected to the ground and consequently the positive pole of the voltage generator will also be connected to the ground. Such a reversal is not imperative per se, specially for industrial or microphotography equipment.

The ionization control electrode may advantageously be made as a thin metallization applied to the external surface of the bulb of the tube. From a pure electrical point of view, this gives a capacity value which is better matched to the control than when the electrode 43 is separated from the said wall of the bulb. The thickness of dielectric is merely that of the glass wall of the tube and the surface of the said electrode 43 may be made as wide as possible, but having a window for the flash light to the subject to be illuminated therewith. Such a metallization further may be made highly reflecting to the light and, further even, it may be so established so as to provide a color component of light spectrum favorable to the substantial correction of color temperature of the subject. Finally, the said metallization may be so provided as to be sealed around the periphery of the opening in the probing tube in order to reinforce the air-tightness of this part of the probe.

Referring back to the voltage generator proper, and FIG. 1 of the drawings, the input transformer 1 of the generator presents two secondary windings 3 and 4—5. The secondary winding 3 is used for the supply of the flash voltage part proper, and the other winding, the midpoint of which is connected to the ground, is used through an adjusting potentiometer 8 for the supply of the inspection lamp 42, in part 4 thereof, for the control of a relay 26, FIG. 1, or 46, FIGS. 2 to 4, in part 5 thereof. This relay will in accordance to the invention serve for a purpose which will be later explained. When required, parts 4 and 5 may be made identical.

When a circuit-inverter contact 10 is placed in the upper position thereof (with respect to the drawing), the device is activated, and a rectifier cell 6 ensures the charge of certain condensers, only one of which, 12, will be considered as existing for this first explanation. The said condenser 12 has a relatively high value and it may be an electrochemical capacitor. Between the upper terminal of said condenser and the ground is then established a rectified voltage $-v$ (for instance and for pure illustration, $-v=-180$ volts). When the inverter contact 10 is brought back to the lower position thereof, the condenser 12 will discharge through a resistance 11 for disabling the generator when no flash has been produced once the generator has been conditioned to such an operation by the said charging of 12.

A second rectifier cell 7 is simultaneously effective for ensuring the charging of a further condenser 9 in series with the condenser 12 according to one feature of the invention. Across the terminals of this series assembly of condensers is thus created a higher voltage $-V$ (for illustrative purposes solely, this value may then be -360 volts, the arrangement acting as a voltage doubler).

The voltage across the condenser 12 is applied to the secondary winding of an induction coil 24 which will transmit this voltage to the flash tube when a connection

is established between the terminals 36 and 39 (output from the generator to input to the probe) and this will be made when a contact 27 of a relay 26 is closed.

The mere negative voltage across 9—12 is applied through a resistance 21 to a small impulse condenser 23 which is placed in series with the primary winding of the said induction coil 24. The other end of the said primary winding is connected to the ground. Between the resistance 21 and the condenser 23 is branched off a lead to a terminal 39 of the generator. When the equipment is placed in operative condition, this terminal 39 connects to a switch contact 33 within the photographic camera 44, for instance, the said contact 33 being normally open at rest. The condition of the said contact is dependent upon the action of the operator when this latter actuates the photographic camera which, previously and through a contact 34, has produced the energization of the relay 26 and consequently the closing of the work contact 27 of the said relay. When contact 33 closes, the discharge circuit for condenser 23 through the primary winding of the induction coil is closed and this condenser is abruptly discharged therethrough. The magnetic core of the said coil is made of a material able to introduce a further deformation of the overvoltage pulse which is thus produced in the primary winding. Consequently an overvoltage pulse appears in the secondary thereof, which is able to start the flash of the tube 41. On the other hand, the previous closing of the contact 27 could not start such an action as the voltage $-v$ was insufficient in the value thereof for starting the flash. As soon as the flash tube is initiated however, the condenser 12 discharges and maintains the flash through the hereinabove defined circuit to the tube 41.

The technical interest of such an arrangement may be stated as follows, considering first that the elements 7 and 9 are omitted and consequently the condenser 23 only controlled by the $-v$ voltage which may be applied to the secondary winding of the induction coil 24 from the condenser 12. Considering a determined value of this voltage $-v$, the designer will be limited to a certain optimum embodiment of the induction coil 24 according to the present state of the technology in such coils. As viewed from the flash tube, this voltage $-v$ must be as small as possible though the overvoltage initiating the discharge therein (and due to the discharge of 12) must present a wide range of possible values for ascertaining the correct operation of the said discharge with respect to any ageing condition of said flash tube, which condition always necessitates an increased initiating voltage with respect to the time. An increase of the said initiating voltage would only be possible from an increase of the value of the capacitor 23, but this is not desirable since the overvoltage coefficient does not increase much as the time constant of the circuit increases with this value of capacity. Further a high pulse capacity corresponds to a very hot temperature of the spark at the light synchronization contact 35 which may easily be destroyed thereby.

The provision according to the invention for charging the condenser 23 to a voltage quite higher than the value required for the maintenance of the discharge of the flash tube once this discharge is initiated enables the required effect to be obtained without introducing such subjections as mentioned above in the normal operation of the device. The energy stored in a condenser increases according to a law of square value of the voltage across the condenser, and consequently there is a possibility of obtaining an abrupt discharge initiation of the flash tube, even in a aged condition thereof, and consequently a first increase of the useful life of such a flash tube. The voltage which maintains the discharge of the tube, once it has been initiated may on the other hand be limitated to a value avoiding premature destruction thereof, and from this results a further increase of the said useful life.

The voltage $-V$ is shown in the described and illustrated example as obtained from a voltage doubling circuit. It must be understood that this is only an illustrative way for embodying the invention and other arrangements may be used instead as, for instance, the arrangement which would charge two distinct condensers charged from separate circuits (from separate secondaries of the input transformer 1).

In the diagram, a further condenser 13 is shown in association to the "main" condenser 12 for enabling an adjustment by the operator of the intensity of the flash when he will think it advisable. Of course, several condensers such as 13 could be provided in the generator and controlled in the same way. Each one of the said additional or adjusting condenser 13 is charged in parallel with the condenser 12 through a resistance 15 from the lead $-v$ and the ground. When the operator wishes to render such an adjustment condenser effective for the control of the flash, he places the contact 14 in the condition thereof which short-circuits the said resistance 15, so that the condenser discharges simultaneously to the condenser 12. When the operator does not wish such a result, he places the contact 14 in the shown open-condition and the time constant of the series-network 15—13 is then so high as not to interfere with the discharge of the condenser 12 during the time interval of the flash.

In the generator which is shown in the drawing, further a relaxation circuit is provided as follows: between the lead $-V$ and the ground is placed a resistance bridge 16—17 and, from the intermediate connection point thereof is placed an integrating network 18—19, which is connected to the ground in the camera arrangement by a pair of serially connected neon tubes 20 and 20^1. Such a relaxation circuit plays two parts: in the first place, it ensures a visual control or display of the increase of the voltage during a charging time interval and in the second place, and mainly after a long period of rest of the device, it displays to the operator when this latter may actuate a flash under other correct conditions. The stopping of the relaxation indicates that a flash has really occurred, as in certain endoscopic processes the operator cannot see if the flash has or not been actually made by the control thereof. Of course, two neon tubes are serially connected so that the operator may look at either one (on the generator box or rather more often the neon tube on the camera) for being informed if the generator is in correct condition for the control of a flash therefrom. It must be understood that the recharging time interval after a control varies according to the energy which has been dissipated in the flash and which must be compensated before a new flash may occur in correct conditions thereof. From another point of view, the supply of the relaxation circuit from the higher voltage $-V$ is more efficient than if it were controlled by the smaller voltage $-v$. Two distinct relaxation circuits might be provided, one in the generator and one in the camera but apparently this will be a mere duplicate of what is shown and does not seem to be of interest.

In a voltage generator according to the invention further, the operator may check any time he may so wishes a measurement of the quality of the insulation of the leads of the flash tube and, more generally speaking, of the electrical leads of the probe with respect to the medium in which this probe is placed. For such a purpose, the higher voltage $-V$ is applied through a resistance 22 to a microamperemeter 25 connected to the terminal 36. The resistance 22 is of a very high value so that a casual short-circuit current would be maintained at a low value (for instance lower than 60 microamperes) but this resistance 22 has a small value with respect to the insulation resistance value of the leads. It will be of advantage to provide this microammeter 25 with a push-button for only connecting it in the said circuit at the time of measuring of the said insulation resistance, so that it

is out of circuit at the times of production of flashes which ensures the protection thereof against damage from the flash voltage operation.

For initiating a flash, the operator in the normal control from the photographic camera, operates contacts **33** and **34**. In the actuation of the camera, the said contact **34** closes first, so that the relay **26** is energized and the contact **27** thereof closes and then the closing of the contact **33** closes which produces the flash as herein above said. But the operator also may have a push-button **28**, which is an "open-flash" contact and the double inverter **29** of which is so made as to realize the same operations as the contacts **34** and **33** in the camera: when the push-button **28** is depressed, a first contact closes the energization circuit of relay **26** and then, once the contact **27** of the said relay closed, the circuit for discharging the condenser **23**.

The safety of operation of the voltage generator may then be further increased when required with recourse to one of the partial alternatives of the arrangement of FIG. 1 as disclosed in FIGS. 2 to 4 of the drawings. In the said alternatives a single contact, **45**, is useful in the camera, for activating a relay **46** substituted for the relay **26** of FIG. 1 in the voltage generator proper. The said relay **46**, when energized, will firstly open the insulation checking circuit which was made through the rest contact **49** thereof but, in the work condition of **49**, will close the discharge circuit of the pulse condenser **23** for starting the flash. A push-button **52** is substituted for the push-button **28** of FIG. 1, with the same action as **28**.

In the arrangements of FIGS. 2 and 3, the inverter contact **49** is mechanically coupled to a rest contact **48** which, when the relay **46** is at rest, controls the supply of the inspection tube **42** (FIG. 1) with the proper A.C. low voltage, from the output terminal **35** of the voltage generator, so that this lamp is automatically cut off during the energization of **46** and consequently during the occurrence of the flash. The filament of the said inspection lamp is then protected against a casual overvoltage induced within the supply circuit thereof by the high voltage discharge. Further the cut off of the inspection low voltage lamp is of advantage as the light therefrom tends to introduce an error in the color temperature of the photograph if maintained therethrough. Further again, the contact **49** when actuated opens the connection between the microammeter **25** and the terminal **36** so that a permanent indication of the insulation value of the leads may be ensured in any other time interval than those of the flashes.

In the arrangements of FIGS. 3 and 4, an auxiliary relay **50** is used, the winding of which is serially connected with the microammeter **25**, for blocking automatically any possibility of discharge of the pulse condenser **23** and consequently of production of the flash tube, each time the insulation resistance falls under a predetermined value, even temporarily. This relay is in such a condition, energized and at **51** closes a self holding circuit to the ground and at **58**, FIG. 3, it opens the circuit of the relay **46** which cannot be energized thereafter even if one of the contacts **45** and **52** is again closed. The closing of **51** further applies a ground potential to a lead **57** connected to an alarm for the operator.

In the arrangement of FIG. 4 more particularly now, the safety of operation is still increased by the fact that the relay **46** can only be operated by the short pulse of discharge of a condenser **55** forming part of a series circuit including a resistance **54** and a condenser **55** to the intermediate point of which is connected the winding of the said relay **46**. The said network **54—55** is connected between the ground lead **37** and a contact **53** of relay **50**, so that **46** can only be operated if and when the relay **50** is at rest. When so controlled the relay **46** will only remain actuated during a few milliseconds, which is a time interval sufficient for taking a photograph. From another point of view, it is well known that an insulated sheath accepts a definite potential difference (for instance of the order of 4000 volts) permanently applied thereto but a much higher potential difference (for instance of the order of 16,000 volts) when the said difference is applied as a short duration pulse. In that lies the additional increase of safety since the relay **46** is only temporarily energized. If now the relay **50** is energized in the circuit of FIG. 4, responsive to a lack of insulation of the high voltage leads to the flash tube, the said relay cuts off the charging circuit of the condenser **55** by opening the lower contact **53**, and on the other hand, establish through the upper contact **53** a discharge circuit to the ground for the said condenser **55**, which consequently blocks any possibility of operation of the said relay **46**.

As an illustrative example of miniaturized flash tubes which may be used in arrangements according to the invention, one may citate the so-called TE 52 MAZDA flash tube.

Having now described and ascertained my invention, I declare that what I claim is:

1. A voltage generator for the control of a miniaturized flash tube for endographic and microphotographic equipment, comprising means for generating a first high D.C. voltage and a second high D.C. voltage of higher value than the first, means for initiating the discharge of the said flash tube from the second of the said D.C. high voltages and means for sustaining the said discharge in the said tube from the first of the said D.C. high voltages.

2. A voltage generator according to claim 1 and wherein the said means for initiating and sustaining a discharge in the said flash tube comprises in combination a magnetic core induction coil having a primary and a secondary winding, a condenser serially connected with the said primary winding, a connection to one armature of the said condenser from the said second D.C. voltage generating means, a connection from the said first D.C. voltage generating means to the end of the second winding of the said induction coil and a lead for connecting the said secondary winding from the other end thereof to the electrode of the said flash tube.

3. A voltage generator according to claim 2 and including a relay having a contact inserted in the said lead from the said secondary winding and means for energizing the said relay for activating the said lead with the secondary voltage from the said induction coil.

4. A voltage generator according to claim 3 and including pulse generating means for actuating said relay.

5. A voltage generator according to claim 1 and wherein the said high D.C. voltage generating means comprise a pair of condensers supplied from a source of alternating current through a corresponding pair of rectifier cells each connected to one of the armatures of the respective condensers, the other one of the said armatures being connected to a ground lead in the generator.

6. A voltage generator according to claim 5 and wherein the said condensers are serially connected with respect to each other in a voltage-doubler arrangement which acts as a voltage doubler for the higher D.C. voltage generated therein with respect to the lower one.

7. A voltage generator according to claim 3 and including testing means energized from said second high voltage generator means for testing the insulation condition of the high D.C. voltage leads to the said flash tube.

8. A voltage generator according to claim 7 and wherein the said insulation condition responsive means comprise a high value resistor serially connected with a microammeter in a galvanic circuit connection extending from the said second high voltage generating means and one lead of the said generator to a terminal for the said flash tube.

9. A voltage generator according to claim 8 and wherein the said series connection further includes a normally closed contact of the said discharge initiating relay.

10. A voltage generator according to claim 9 and wherein the said series connection further includes the

operating coil of a relay having a normally closed contact in the energization circuit of the said discharge initiating relay.

11. A voltage generator according to claim 10 and wherein the said discharge initiating relay is supplied for the energization thereof from a time constant circuit receiving the said second high D.C. voltage at one end thereof and comprising a condenser connected to the ground lead of the generator, and wherein the said relay controlled from the insulation condition of the flash high voltage lead has a further contact thereof for discharging the said condenser through a circuit external to the said discharge initiating relay winding.

12. A voltage generator according to claim 2 and wherein at least one relaxation circuit is included which is fed from the second high voltage generating means.

13. A voltage generator according to claim 12 and wherein the said relaxation circuit includes at least two neon tubes, one in the generator and one in the electrical circuit of the photographic camera associated therewith.

14. A voltage generator according to claim 3; and wherein the said discharge initiating means is controlled by a manually operated contact in the said camera for the control of the said relay, and wherein further an open-flash contact is provided on the voltage generator proper, for also actuating the said relay when required.

15. A voltage generator according to claim 5 and wherein at least one auxiliary condenser is provided for shunting during the charging thereof the one of the said pair of condensers which is supplied for the generation of the first of the said high D.C. voltage when required, and a manually operated contact controlling a time constant circuit to control the effectiveness of said auxiliary condenser in the flash initiating and sustaining operations of the said voltage generator.

16. A voltage generator according to claim 5, and wherein both the said high D.C. voltages are high negative voltages, and wherein the ionization electrode of the miniaturized flash tube is connected to the ground, for the operation of the complete equipment.

17. A voltage generator according to claim 16 and wherein the said ionization electrode is made as a metallization over the glass bulb of the said flash tube and which is light reflecting.

18. A voltage generator according to claim 3 and including an inspection A.C. supplied lamp associated with the said flash tube, and a supply circuit for this lamp completed through a normally closed contact of the said initiating discharge relay.

19. A voltage generator according to claim 10 and wherein a further contact of the said relay controls a supply circuit for an additional A.C. operated inspection lamp associated with the said flash tube in the equipment.

20. A control system for photographic apparatus including a photographic camera and an endoscopic probe containing a flash tube, said control system comprising a voltage generator for energizing said flash tube comprising first and second high voltage direct current sources, the second source being of a higher voltage value than the first, an induction coil having a magnetic core carrying a primary winding and a secondary winding, a condenser connected to be charged from the output of the second direct current source, a connection from the output of the said first voltage source to one terminal of the secondary winding, a connection from the other terminal of the secondary winding to at least an activating electrode of the flash tube, and contact means under the control of the actuation lever of the camera for closing a discharge circuit for said condenser through said primary winding.

21. A control system according to claim 20, and including a relay having a contact inserted in the connection from the secondary winding to the activating electrode of the flash tube, a second relay controlling the said contact, and an activating circuit for the said second relay completed through contact means actuated by the actuation lever of the camera.

22. A control system according to claim 20, wherein each one of the said direct current sources comprises a condenser charged through a rectifier from a common alternating current supply, said condensers being connected in series and one pole of one condenser being connected to ground.

23. A control system according to claim 20, wherein each one of the said direct current sources comprises a condenser, the said condensers being serially connected from the ground to a rectifier output lead, and a further rectifier output lead connected to the common point of connection of said condensers.

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