United States Patent

[11] 3,590,314

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[32] Priority **Feb. 11, 1968, Feb. 7, 1968**
[33] **Germany**
[31] P 16 22 323.7 and P 16 22 325.9

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[54] **ELECTRONIC FLASHLAMP APPARATUS HAVING A PLURALITY OF FLASH TUBES SUCCESSIVELY IGNITED**
14 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **315/151,** 315/122, 315/152, 315/159, 315/161, 315/186, 315/231, 315/313, 315/325, 328/70, 328/75
[51] **Int. Cl.** **G01j 1/18,** H05b 41/44
[50] **Field of Search** ..... 328/70, 75, 78, 79, 105, 106, 130; 307/311; 315/119, 121—124, 151—154, 159, 161, 186, 193, 210—215, 231, 313, 323—325, 241 P

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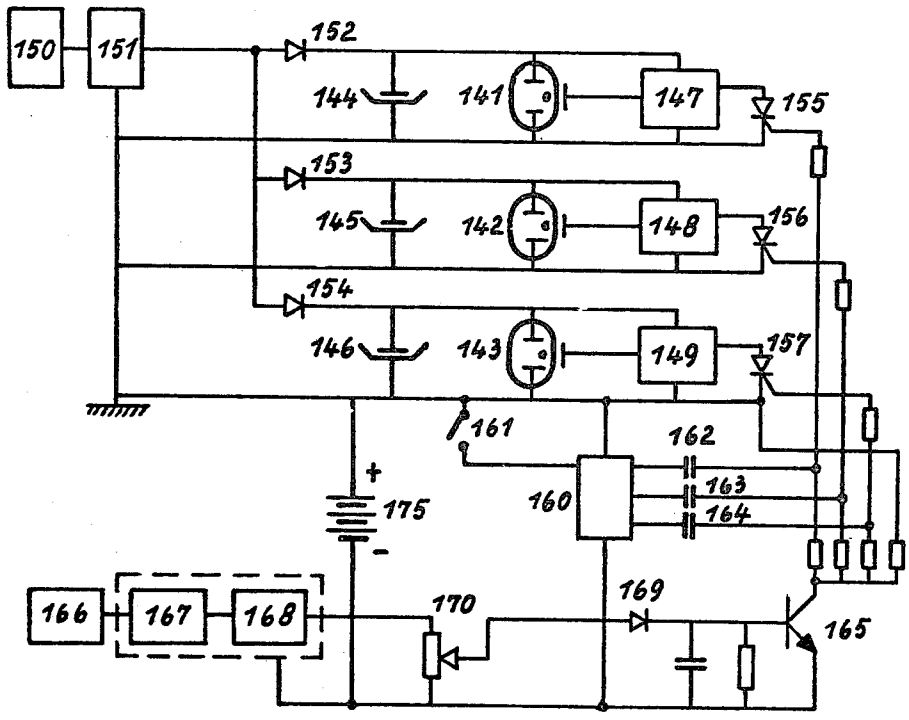
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Primary Examiner—Roy Lake
Assistant Examiner—E. R. La Roche
Attorneys—Charles Shepard and Stonebraker & Shepard

ABSTRACT: Electronic flashlamp apparatus, for photographic or other purposes, using a plurality of flash tubes fired in quick succession. A photo responsive circuit stops the firing sequence when the light produced by the tubes already fired has reached a cumulative total sufficient for the intended purpose, thus dispensing with further tube firing and saving the stored energy which would be used if further firing took place, the saved energy being available for use in subsequent firing operations. Several alternative circuit arrangements are described.



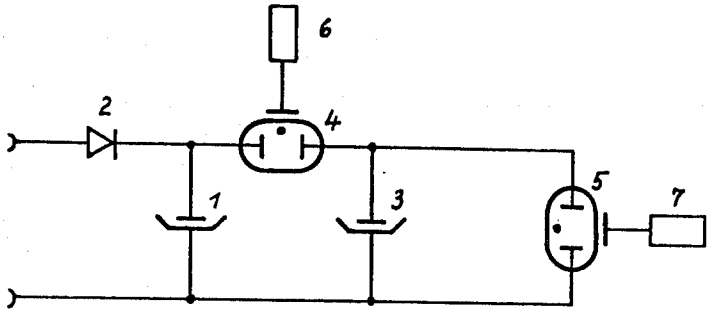


Fig. 1

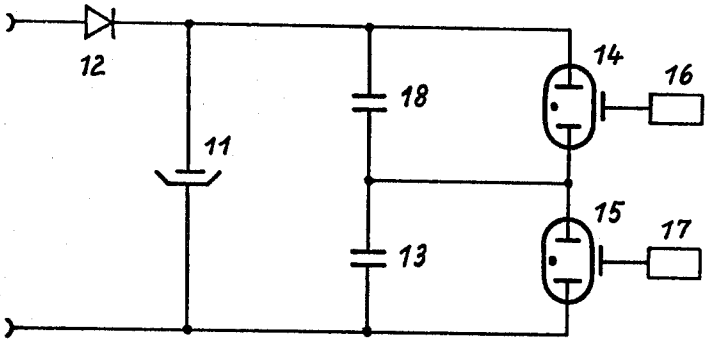


Fig. 2

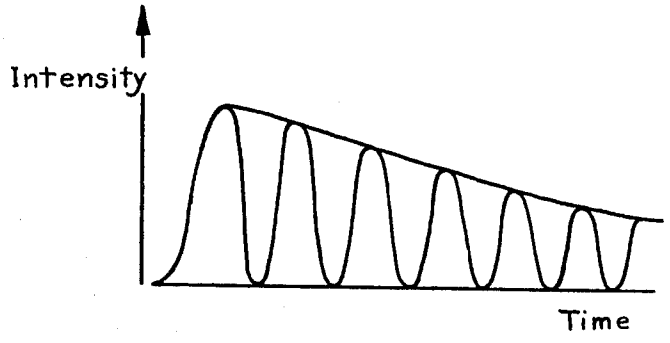


Fig. 3

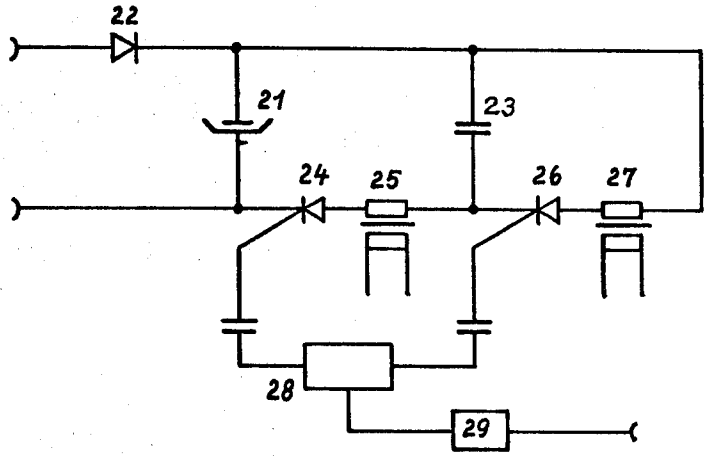


Fig. 4

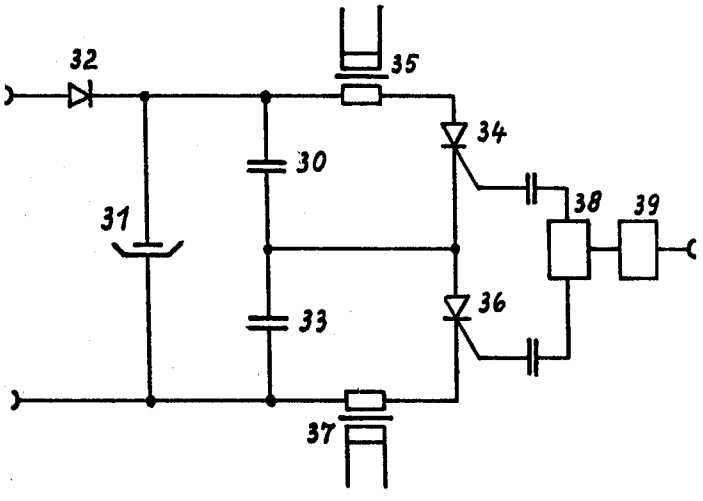


Fig. 5

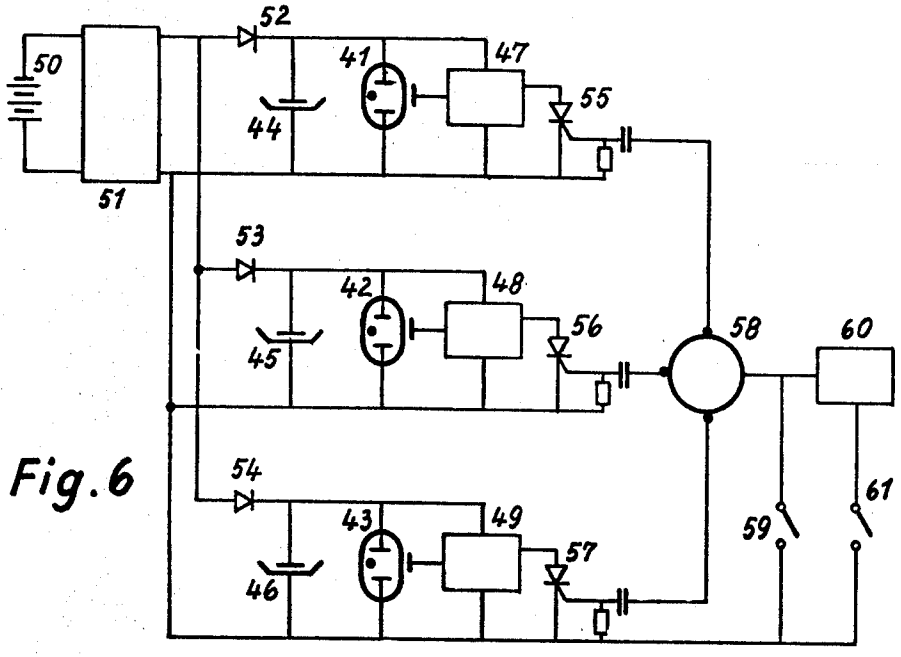

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Fig. 6

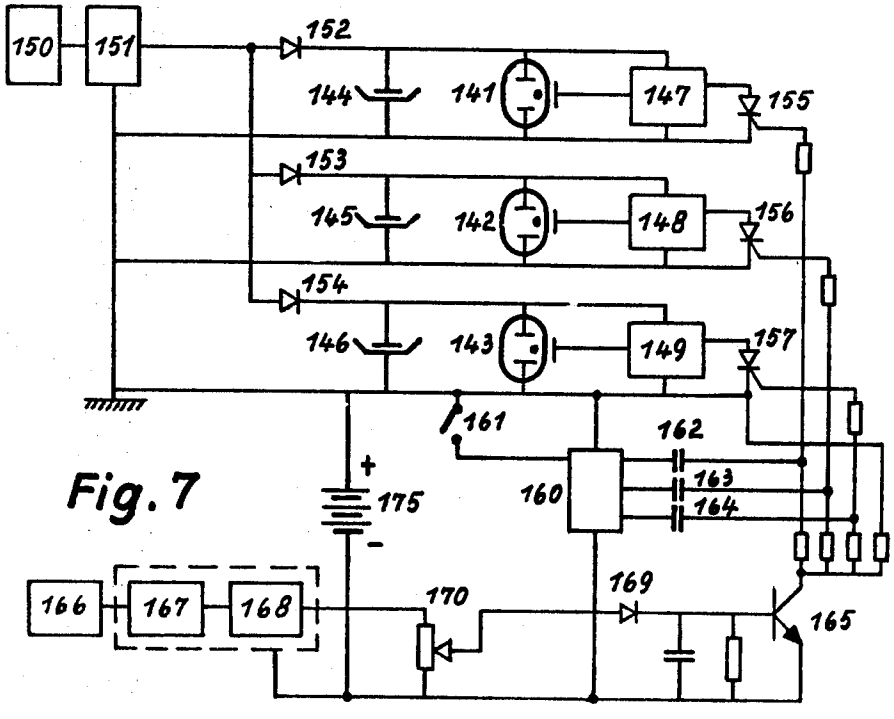

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Fig. 7

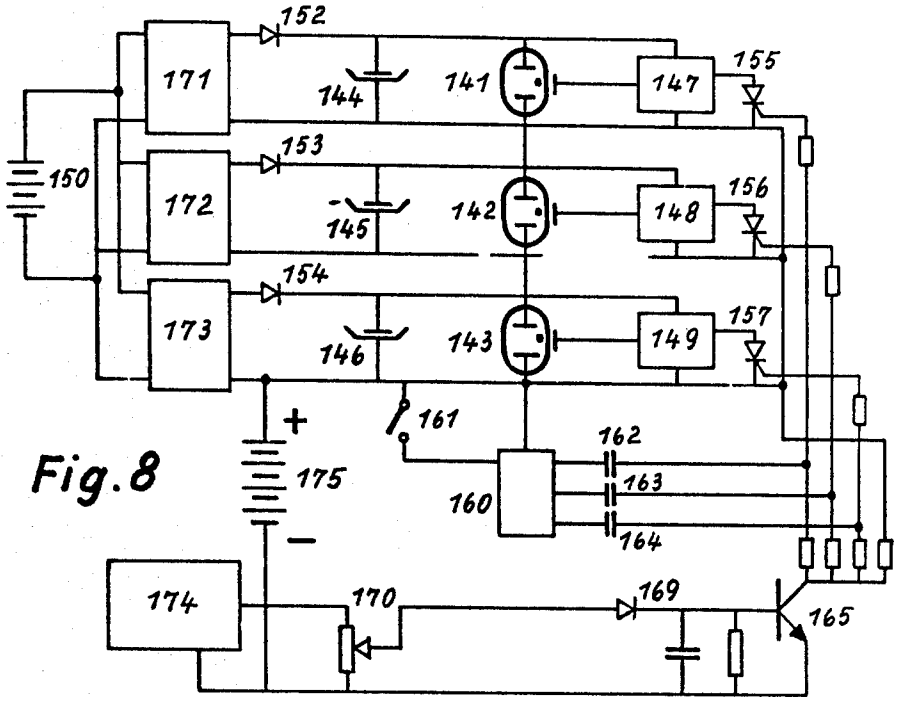

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Fig. 8

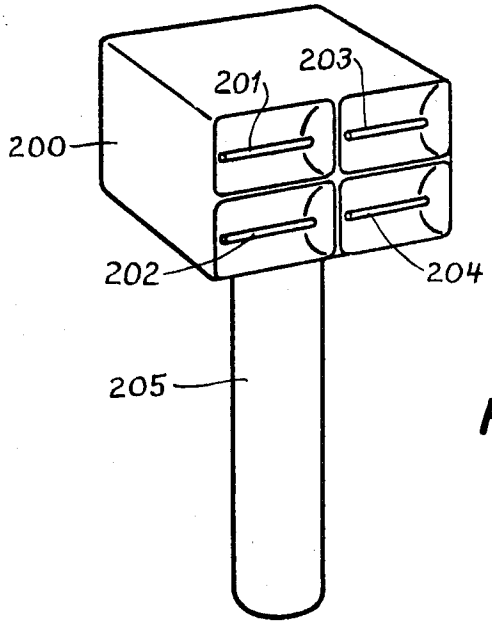

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Fig. 9

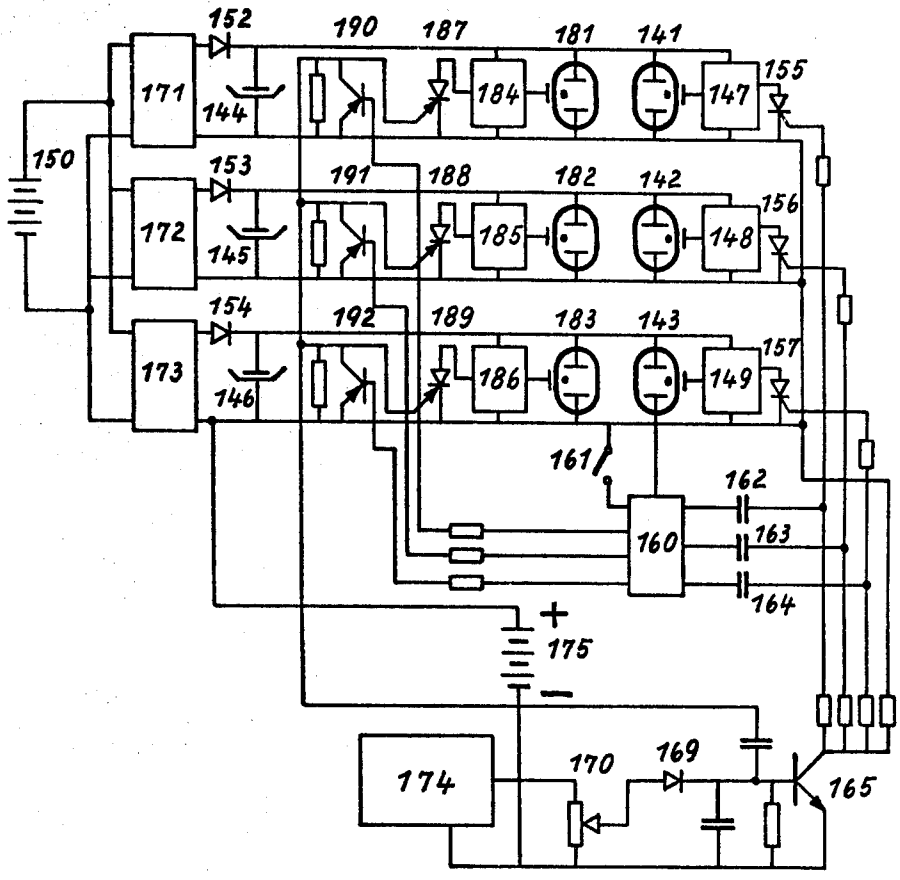

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Fig. 10

ELECTRONIC FLASHLAMP APPARATUS HAVING A PLURALITY OF FLASH TUBES SUCCESSIVELY IGNITED

BACKGROUND OF THE INVENTION

For photographic flashlight purposes and other purposes where intense light is needed for a limited time, it is known to use flash tubes which are electronically fired, and it is also known to employ a light-responsive circuit to terminate the flash when sufficient light has been produced to serve the intended purpose (e.g., sufficient light to make the desired exposure on a photographic film). Examples of such arrangements are the constructions disclosed in U.S. Pat. No. 3,340,426 to Elliot, granted Sept. 5, 1967, and in U.S. Pat. Nos. 3,350,603 and 3,350,604 to Erickson, both granted Oct. 31, 1967.

The present invention may be regarded as an improvement on the arrangements disclosed in the patents just mentioned, and the present disclosure proceeds on the assumption that the reader is already familiar with the patents just mentioned, so that features described in said patents or which will be obvious from said patents, need not be described in detail herein.

In said patents, when a flash tube is fired, the flash continues until it is extinguished by operation of a quench tube which is in parallel with the flash tube and which serves to short circuit the flash tube, thereby terminating the flash. Because of the short circuiting, all of the energy stored in preparation for the flash will be used up (e.g., the energy stored in a capacitor will be used up by complete discharge of the capacitor) even though perhaps only a third or a half of this energy was needed to produce a flash having the desired amount of light.

As distinguished from this, the present invention provides a plurality of separate flash tubes, preferably connected to a common source of stored energy, and a circuit arrangement for firing them in rapid sequence and for stopping the firing sequence when the successive flashes have produced the desired cumulative total of light. Thereby further discharge of energy from the storage device (e.g., a capacitor) is prevented, and the remaining energy in the storage device is available for use in a subsequent firing operation.

This arrangement results in less drain on the source of energy which is used in connection with the storage device. Thus for example, in the typical case where the source of energy is a battery and the storage device is a capacitor, the saving of energy which results from stopping the discharge of the capacitor when the desired amount of light has been produced, means that a smaller battery may be used to produce a given number of average flash operations over a period of time, thus resulting in lighter and more compact flash equipment which is more easily built into or mounted on a camera. On the other hand, if it is desired, with the present invention, to use a battery of the same size as before, the battery will last longer because there is less drain on the battery when taking a typical flash photograph. For similar reasons, the maximum light performance of the flash apparatus can be increased, using a battery and other parts which have the same dimensions as those used in the prior art.

It is, accordingly, an important object of the present invention to provide a generally improved and more satisfactory flash apparatus wherein stored energy not required for producing a flash of a desired light value is not discharged but is conserved for use at a subsequent flash operation.

Another object of the invention is the provision of flash apparatus so designed and constructed that, as compared with prior flash apparatus of the same general character, a smaller battery may be used to produce an equal number of useful flashes over a period of time, or a battery of the same size may be used to produce a greater number of useful flashes.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings, incorporated herein by reference and constituting a material part of the disclosure and relating to an exemplary embodiment of the invention:

FIG. 1 is a circuit diagram of one form of the invention, using two flash tubes;

FIG. 2 is a diagram of an alternative circuit for two flash tubes;

FIG. 3 is a diagram of the ignition sequence;

FIG. 4 is a diagram of an ignition circuit for igniting two flash tubes in sequence;

FIG. 5 is a diagram of an alternative form of ignition circuit;

FIG. 6 is a diagram of a circuit for three flash units with a continuous ignition cycle;

FIG. 7 is a diagram of a circuit for three flash units with a fixed ignition sequence and with a photoelectric limiting system;

FIG. 8 is a diagram of a circuit similar to that of FIG. 7, but using separate transformers for the separate flash tubes;

FIG. 9 is a perspective view of a four-unit flash apparatus; and

FIG. 10 is a diagram of a further modification of the circuits shown in FIGS. 7 and 8.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to the form of the invention shown schematically in FIG. 1, this comprises a main capacitor 1 with a capacity of a few hundred microfarads, connected, via the diode 2, in the customary manner, with the main voltage supply, usually a direct-voltage concerter, to which the leads at the left end of the diagram go. The capacitor 3, having a capacity substantially less than that of the main capacitor 1 (for example, a capacity of a few microfarads) is connected to the capacitor 1 via the flash tube 4. A second flash tube 5 is connected with the capacitor 3, as shown.

When the current supply is switched on, the capacitor 1 is charged up to its capacity. The capacitor 3 is without charge at this time. The ignition of the flash tubes 4 and 5 is effected by ignition impulses of the ignition appliances schematically shown at 6 and 7, and further described below.

When the ignition device 6 is operated, the flash tube 4 is ignited. The ignition of this tube completes the circuit between the main capacitor 1 and the capacitor 3, so that the capacitor 3 now becomes charged. The tube 4 supplies only a short light impulse, since this tube is extinguished when the capacitor 3 is charged up approximately to the potential of the capacitor 1. The duration of the flash emitted by the tube 4 is determined by the capacity of the capacitor 3 and the internal resistance of the flash tube 4. The second flash tube 5 can now be ignited by operation of the ignition device 7, as a result of which the capacitor 3 is discharged through the tube 5, resulting in a flash. At the conclusion of this flash, when the capacitor 3 is substantially completely discharged, the capacitor 1 can again be partially discharged through the first flash tube 4 (by operating the flash ignition device 6) and so on, the flashes of the two tubes 4 and 5 alternating with each other in rapid sequence, until the storage capacitor 1 is empty or the ignition impulse sequence is interrupted. By suitable timing of the impulse sequence, it is possible to insure that the flash sequence need last no longer than the direct discharge of the storage capacitor 1, as may be seen from FIG. 3. The number of flash impulses for each total discharge of the storage capacitor 1 is determined by the capacity ratio between the capacitors 1 and 3.

From what has been said above, those skilled in the art will understand that the system can be used in conjunction with an impulse generator with facilities for disconnecting the impulses, for the control of the flash tube output. In conjunction with an impulse pickup of which the impulse sequence is adjustable, it is possible to obtain a stroboscopic effect. That part of the charge of the capacitor 1 which is left unused in each case is preserved, and thus is still available the next time the apparatus is used.

FIG. 3 illustrates diagrammatically the cumulative effect of the sequential series of flashes. The ordinate represents light intensity, and the abscissa represents time.

FIG. 2 shows a circuit which is similar in general to that of FIG. 1, but different in some details. In FIG. 2, parts which correspond to parts in FIG. 1 are indicated by the same reference numerals increased by 10, so that the main storage capacitor shown at 1 in FIG. 1 is indicated at 11 FIG. 2, the diode 2 of FIG. 1 is indicated at 12 in FIG. 2, and so on. In addition to the capacitor 13 (corresponding to the previous capacitor 3) there is also another capacitor 18. The various parts are connected as shown, and it is seen that, depending upon whether the flash tubes are conducting (creating a flash) or nonconducting, the capacitors may be regarded as being sometimes in parallel and sometimes in series with the flash tubes.

A high tension transformer or other suitable source is connected, via the diode 12, to the main storage capacitor 11, and serves to charge this capacitor. The capacitors 13 and 18 (each of substantially smaller capacity than the capacitor 11) are also charged. When the ignition device 16 fires the tube 14, the capacitor 18 is discharged through the tube 14, and at the same time the capacitor 13 keeps its charge or, if previously discharged, is recharged by the capacitor 11. Then upon the ignition of the tube 15 by operation of the ignition device 17, the capacitor 13 discharges through the tube 15, and at the same time the storage capacitor 11 charges the previously discharged capacitor 18. The flashes thus continue alternately, first one tube and then the other, as long as the firing or ignition devices 16 and 17 continue to operate, or until the charge from the storage capacitor 11 is used up. If the firing of the tubes stops before the charge on the storage capacitor 11 is used up, the remaining charge is saved, and is available for subsequent use at another flash operation. It will be noted that in this system illustrated in FIG. 2, the loading of both flash tubes 14 and 15 is symmetrical, assuming that the two capacitors 13 and 18 are of the same capacity. It will also be noted, both with respect to the arrangement in FIG. 1 and the arrangement in FIG. 2, that at no time is the storage capacitor 1 or 11 short circuited, as is done in certain prior art devices, the prior art arrangement resulting in complete dissipation of the entire stored charge, each time the flash apparatus is used.

If the impulse sequence is to be concentrated in a shorter period, of the same order of magnitude as the normal discharge of the storage capacitor, difficulties arise owing to the fact that the ignition capacitors have to be charged up within very short periods of a few microseconds, which are extended by drop resistors and the efficiency of the current source. Use is therefore made of an ignition apparatus which is adapted to the purpose in view, and which is free of the disadvantages mentioned.

One constructional version of such ignition apparatus is illustrated in FIG. 4. A storage capacitor 21 is charged, from the current source, through the diode 22. Its capacity can be made great enough to insure that it will be sufficient for the total ignition impulse sequence. The charging takes place before the commencement of the flash, so that sufficient time is available. The actual ignition capacitor 23 can be charged in a very short time via the thyristor 24 and the ignition transformer 25. In this process, a high tension impulse occurs in the high tension secondary side of the transformer 25. In known manner, this high tension impulse produces the firing or ignition of the particular flash tube with which the transformer 25 is associated.

When the ignition capacitor 23 becomes fully charged, the thyristor 24 is extinguished. The ignition capacitor 23 can now be discharged through the thyristor 26 and the transformer 27, which produces a high tension impulse in the high tension secondary side of this transformer 27, thereby igniting or firing the particular flash tube with which this transformer 27 is associated. This process can be repeated continuously, firing first one tube and then the other, if a generator causing the thyristors 24 and 26 to be switched on at the desired intervals is used for controlling them. The generator, schematically shown at 28, may comprise, for example, a multivibrator (astable flip-flop), which can be caused to oscillate by releasing a blocking device. By a control apparatus schematically shown at 29 (e.g., a timer) preceding the generator 28, the number of high tension ignition impulses given off by the ignition device can be limited. Alternatively, instead of limiting the firing as a function of time, it can be limited by the use of an integrating photoelectric luminous-density measuring device of a form known per se, such for example as the devices referred to in the prior patents above mentioned, which will cut off the operation of the generator 28 when the cumulative light resulting from the series of flashes reaches a given cumulative total, which total may be variable or adjustable.

A second version of ignition apparatus is shown in FIG. 5. This is similar in general to the ignition apparatus shown in FIG. 4, but differs in details. Two ignition capacitors 30 and 33 are provided, in a symmetrical circuit analogous to the symmetrical flash tube circuit illustrated in FIG. 2. Except for the provision of this second ignition capacitor, the parts in FIG. 5 which correspond to parts in FIG. 4 have been given the same reference numerals raised by 10, so that the storage capacitor shown at 21 in FIG. 4 is indicated at 31 in FIG. 5, the diode 22 of FIG. 4 is shown at 32 in FIG. 5, and so on. It is believed that further explanation of the circuit in FIG. 5 is unnecessary.

The invention is not limited to the use of only two flash tubes. Any desired number, three or more, may be employed, as illustrated in FIGS. 6—10.

Referring to FIG. 6, a number of equivalent flash units are provided, each having its own flash tube, flash capacitor, and ignition circuit. Three flash tubes are indicated at 41, 42, and 43, having respective flash capacitors 44, 45, and 46, and respective ignition circuits shown schematically at 47, 48, and 49. The capacitors 44, 45, and 46 are charged from the battery 50, through the direct voltage transformer 51 and the diodes 52, 53, and 54. The ignition circuits 47, 48, and 49 are controlled through the respective thyristors 55, 56, and 57, which are connected with the ignition impulse distributor 58, which consists of a ring selector circuit of a kind already known per se. At each contact produced by the synchrocontact 59, the ignition impulse is passed on to the next flash unit, so that the flash units are individually ignited in turn and continuously. By short circuiting the ignition impulse distributor 58, it is also possible for all of the flash tubes, if necessary, to be ignited simultaneously.

In the case of the two tube arrangements shown in FIGS. 1 and 2, the total of the separate flashes that can be obtained is controlled by the capacity of the storage capacitor 1 or 11. In the arrangement shown in FIG. 6, however, the total flash output that can be obtained upon a single operation of the flash apparatus is the sum of the individual flash outputs of the individual tubes, each determined by the capacity of its individual capacitor 44, 45, or 46. As the flash cycle can be produced a number of times in succession, a multiple of the single cycle light output is available, if the direct voltage converter is of the required efficiency and if the time sequence of the flashes is appropriately adapted to the time required for recharging the individual capacitors. In order to speed up the recharging of the individual capacitors and thereby allow the cycle to be repeated more rapidly, it may be advisable to provide each capacitor with its own individual charging converter, as described below in connection with FIG. 8.

To produce the impulse sequence, the above-mentioned contact 59 can be replaced by an impulse generator 60, with an operating contact or switch 61. This impulse generator 60 may, for example, comprise a number of univibrators, known per se, connected to each other in such a way that the rear flank of a univibrator impulse in each case actuates the following univibrator, so that the flash units are ignited in succession. The sequence can thus be either compressed or extended in time, as desired.

In FIG. 7, there is illustrated a circuit similar to that described above in connection with FIG. 6, but modified to provide for automatic photoelectric illumination control. For the sake of clarity, corresponding parts in FIG. 7 are identified

by the same reference numerals used in FIG. 6, with the addition of 100 to each. Thus the flash tubes indicated at 41, 42, and 43 in FIG. 6 are indicated at 141, 142, and 143 in FIG. 7, and so on. Corresponding parts in FIG. 7 which operate in the same way as in FIG. 6, therefore need no further description.

The ignition impulse distributor 58 of FIG. 6 has been eliminated in the arrangement shown in FIG. 7, as the impulse generator 160, when the contact 161 is actuated, always ignites the tubes 141, 142, and 143 in the same order, starting with the tube 141. It is particularly advantageous to have the outputs of the individual flash appliances graduated in a quadratic series, for example 1, 2, 4, 8, and 16, if for example five flash tubes are used. If a single transformer is used, common to all the capacitors, the respective capacities of the capacitors would be graduated according to the same series. If separate transformers for the respective flash tube circuits are used, the respective voltages supplied by the respective transformers may be graduated according to the same desired series, rather than graduating the capacities of the capacitors.

The graduation according to the quadratic series enables the illumination to be advantageously adapted to the various different distances of the subject from the flash apparatus, as the higher powers are required only in the case of greater distances, and increase with the square of the distance. By slightly advancing the ignition of the respective stages, in comparison with the number of stages required according to measurement, it is possible to insure that the ignition will not be inadequate at any point over the entire range.

The ignition circuits 147, 148, and 149 of the flash tubes 141, 142, and 143 are actuated by the thyristors 155, 156, and 157. When the contact 161 is actuated, the impulse generator 160 is set in operation, and this emits a sequence of three positive impulses (or more, if more than three tubes are used) which, in succession and via the capacitors 162, 163, and 164, control the thyristors 155, 156, and 157, and thus control the corresponding ignition circuits 147, 148, and 149. The impulse generator may consist, for example, of three univibrators, in which case the first univibrator, in known manner, actuates the next univibrator by the rear flank of the resultant impulse, after it has been set in operation, and so forth. The retardation can be individually adapted to the duration of the flash, particularly when different flash units are employed. Thyristors 155, 156, and 157, however, can only be set in operation if the transistor 165 is blocked, which is the case as long as the exposure has not yet reached the preselected level.

For this purpose, a photoelectric light transformer 166 is provided, which measures the light of the flash tubes 141, 142, and 143 which is reflected back from the subject being photographed. This measurement is integrated over time by an integrating device 167, and is conveyed, after being amplified by an amplifier 168, to a diode 169, as a threshold indicator. As soon as the threshold value has been reached, the transistor 165 is supplied with a positive impulse, and is thus rendered conductive. The control grids of the thyristors 155, 156, and 157 thus receive a negative bias voltage. The thyristors which up to that moment have not yet been ignited can then no longer be influenced by the impulse generator 160. The necessary negative potential is generated by an additional battery 175, or is branched off of the transformer 151. A potentiometer 170, connected between the amplifier 168 and the diode 169, is used for adjusting the sensitivity and for taking into account the film speed and any desired adjustable factor of the camera, such as the diaphragm aperture.

Another modification of the circuit is illustrated in FIG. 8. It is basically similar to the circuit described in connection with FIG. 7, and most of the parts are identified by the same reference numerals used in FIG. 7, so require no further explanation. The main difference is that, instead of having the individual capacitors charged from a single transformer 151 in FIG. 7, the individual capacitors 144, 145, and 146 are here (in FIG. 8) provided with individual transformers 171, 172, and 173, respectively. Also, the photoelectric measuring and integrating device indicated schematically at 166, 167, and 168 in FIG. 7, is here shown schematically as a single sensing unit 174.

Although only three flash lamps have been shown in the various arrangements illustrated in FIGS. 6—8, it will be understood by those skilled in the art that any desired number of flashlamps can be used, providing each of them with a capacitor, a firing or ignition circuit, an ignition controlling thyristor, and so on.

It is convenient and advantageous in practice to provide the flash apparatus of the present invention in a simple and compact unit which can be held in the hand of the photographer or can be mounted, if desired, on the camera body. Such a unit is illustrated somewhat schematically in FIG. 9, and comprises a casing or housing portion 200 containing the necessary capacitors and other circuit parts for controlling four separate flash tubes 201, 202, 203, and 204. A cylindrical extension 205 serves both as a handle for conveniently holding the flash unit in the hand of the photographer, and also as a housing containing the battery or batteries. Each flash tube is provided with an individual reflector of its own, as shown, the reflectors all being faced in the same direction. As the flash output of each individual flash tube need be only a fraction of the output of a normal flashlamp, the various individual flash tubes can all be accommodated in a compact unit, the dimensions of which need not exceed the dimensions of a conventional flash unit of the prior art, using conventional flashlamps. This applies particularly to the version illustrated in FIG. 6, where the total performance (that is, total amount of light produced) may be subdivided among several complete cycles repeated in rapid succession, so that each individual tube and its associated capacitor may be quite small and compact. In this form illustrated in FIG. 6, as well as in all of the other forms of the invention, the flash intervals can be kept so short that they are not perceptible as individual flashes, and they appear to be a single flash, even though actually made up of a number of flashes of different tubes occurring in rapid succession with the entire sequence possibly repeated a second or third time or more after each of the individual tubes has been fired once.

Another form of the invention is illustrated in FIG. 10. This is mainly the same as the form shown in FIG. 8, and corresponding parts are identified by the same reference numerals used in FIG. 8, so require no further description. The difference is that, in FIG. 10, each individual flash tube 141, 142, and 143 has its own individual means for terminating the flash at a variable point during what would otherwise be the duration of the flash, in case the required cumulative total of light has been reached at an intermediate point of the duration of the flash. This enables a closer control of the total light output produced upon a given actuation of the flash apparatus, than would be possible if each tube, once having been fired, would have to complete its own flash to the limit of the charge on its own individual capacitor.

The flash terminating device for each flash tube, in the arrangement shown in FIG. 10, is in the form of a quench tube, one for each flash tube, the quench tubes being shown at 181, 182, and 183, respectively. Each quench tube has its own ignition circuit or firing circuit schematically shown at 184, 185, and 186, respectively, these quench ignition circuits being actuated by thyristors 187, 188, and 189, respectively.

To insure that only the quench tube or switch tube 181, 182, and 183 which is associated with the flash tube which is flashing at that moment, can be ignited, the positive impulse occurring when the threshold value of light output is reached, is conveyed by the diode 169 to the thyristors 187, 188, and 189, through normally conductive transistors 190, 191, and 192, respectively, which are coupled to the impulse generator in such a way that the bases of these transistors normally have positive voltage. The control signal is thus short circuited and becomes inoperative. When the generator 160 supplies positive signals in succession to the thyristors, the grid transistors 190, 191, and 192 can at the same time be blocked in succession, in that the voltage, from the point of view of the impulses, drops at the base to zero or to a negative value. The

transistor in question is thus blocked, and the thyristor associated with it can be ignited by the control signal of the diode **169**. This operates the firing circuit of the associated quench tube (**181**, **182**, or **183**) and when the quench tube fires, it short circuits its associated flash tube and immediately stops the flash thereof, even though otherwise the flash might have continued for a somewhat longer time.

It is true that with this short circuiting arrangement of terminating the flash, the individual capacitor **144**, **145**, or **146** is thereby short circuited and fully discharged, so that some energy is lost. However, the total energy consumption is no greater than in the arrangements previously described in connection with FIGS. **6—8**, for if the flash of a particular tube had continued and had not been quenched at an intermediate point, it would have consumed all of the energy in its associated individual capacitor.

In order to produce this quenching action, the respective quench tubes **181**, **182**, and **183** must have a relatively low impedance as compared with the impedance of their respective main flash tubes **141**, **142**, and **143**. This matter of the relative impedances of the tubes is known per se in the art.

This arrangement for extinguishing a flash tube at an intermediate point in its normal flash, if the required amount of light has been produced at that time, is particularly advantageous when a series of flash tubes are arranged in a quadratic series of light values, as above suggested. At the moment when sufficient light has been produced for purposes of the photograph being taken, if it happens to be a tube with a low light value (1 or 2, for example) which is then firing, it does not greatly matter whether the tube completes its normal flash or not. But if it is a tube with a higher light value (e.g., a light value of 8 or 16) which is then flashing at the moment that the desired total of light output has been produced, there might be serious overexposure of the photograph if the tube were allowed to continue through its complete normal flash. The present arrangement cuts off the flash at the proper point, avoiding overexposure.

Reference has been made above to a quadratic series of relationships such as 1, 2, 4, 8, etc. To avoid possible confusion or misunderstanding, it is pointed out that such a series is often called a geometrical series or progression, as well as a quadratic series or progression.

It is to be understood that the disclosure is given by way of illustrative example only, rather than by way of limitation.

I claim:

1. Flashlamp apparatus for photographic purposes comprising a series of associated flash tubes each powered by an individual capacitor, means for firing said flash tubes successively in rapid sequence, means for measuring and integrating the quantity of reflected light reaching the flashlamp apparatus from a subject being photographed, and means responsive to said measuring and integrating means for terminating the successive firing of said flash tubes when the integrated quantity of reflected light reaches a predetermined threshold value, so that further firing of flash tubes will not occur after said threshold value has been reached.

2. Flashlamp apparatus as defined in claim **1**, wherein each successive flash tube in the series produces, when flashed, a greater quantity of light than the preceding flash tube in the series.

3. Flashlamp apparatus as defined in claim **1**, wherein the light values produced by flashing the successive tubes have the relation to each other of an ascending quadratic series.

4. Flashlamp apparatus as defined in claim **1**, further including means responsive to said measuring and integrating means for terminating a particular flash then in progress when said threshold value is reached during the progress of a particular flash.

5. Flashlamp apparatus, particularly for photographic purposes, comprising a plurality of flash units each including a flash tube, a capacitor individual to that flash tube, and ignition circuit means including a thyristor for controlling the ignition circuit means, impulse generating means for activating said thyristors successively in turn, and means for interrupting effective operation of said impulse generating means, said means for interrupting effective operation of said impulse generating means including a threshold indicator (**169**), a transistor (**165**) operatively connected to said indicator and rendered conductive when a threshold value is reached, and connections from said transistor to said thyristors for supplying control grids of the thyristors with a negative bias voltage when said transistor is conductive, to prevent impulses from being passed through said thyristors.

6. A construction as defined in claim **5**, wherein said means for activating said thyristors in turn includes a ring selector impulse distributor.

7. A construction as defined in claim **5**, wherein said means for activating said thyristors in turn includes an ignition impulse generator and an ignition impulse distributor in series with each other.

8. A construction as defined in claim **5**, further including a photoelectric light transformer responsive to light reflected from a subject illuminated by said apparatus, and an integrating device responsive to said photoelectric light transformer, said threshold indicator being operatively connected to and responsive to said integrating device.

9. A construction as defined in claim **5**, wherein each of said flash units is provided with a special direct-voltage transformer (**171**, **172**, **173**).

10. A construction as defined in claim **5**, in which each of said flash units produces, when flashed, a different light value from that produced by the other units, the light values of the respective light units in the order in which they are respectively flashed being arranged in a geometric progression.

11. A construction as defined in claim **5**, further comprising a separate quench tube connected in parallel with each of said flashlamps and serving, when ignited, to short circuit the flashlamp with which it is connected in parallel, thereby to terminate any flash then in progress in the flashlamp with which it is connected, and means responsive to light reflected from a subject illuminated by said flashlamps for igniting the quench tube of at least a flashlamp in which a flash is then in progress and for concomitantly interrupting effective operation of said impulse generating means so that further flashlamps will not be ignited, when the light reflected from said subject reaches a selected value.

12. A construction as defined in claim **5**, further comprising a separate quench tube connected in parallel with each of said flashlamps and serving, when ignited, to short circuit the flashlamp with which it is connected in parallel, thereby to terminate any flash then in progress in the flashlamp with which it is connected, and means responsive to light reflected from a subject illuminated by said flashlamps for igniting the quench tube of at least a flashlamp in which a flash is then in progress, when the light reflected from said subject reaches a selected value.

13. A construction as defined in claim **12**, in which said means for igniting the quench tube ignites only the quench tube of a flashlamp in which a flash is then in progress, without igniting the quench tube of any flashlamp in which a flash is not occurring.

14. Flashlamp apparatus for photographic purposes comprising flash tube means, a series of individual capacitors for powering said flash tube means, means for causing said capacitors to fire said flash tube means in a series of successive flashes in rapid sequence, means for measuring and integrating the quantity of reflected light reaching the flashlamp apparatus from a subject being photographed, and means responsive to said measuring and integrating means for terminating the successive firing of flashes when the integrated quantity of reflected light reaches a predetermined threshold value, so that further firing of flashes will not occur after said threshold value has been reached.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,590,314 Dated June 29, 1971

Inventor(s) Achim Krusche

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover sheet [32] the priority date "Feb. 11, 1968" should read -- Feb. 1, 1968 --.

Signed and sealed this 19th day of December 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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