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(54) DISCHARGE FLASH APPLIANCE

(71) We, FRANKE & HEIDECHE G.M.B.H. a German Body Corporate, trading as ROLLEI-WERKE FRANKE & HEIDECHE, of 196 Salzdahlumerstrasse, Braunschweig, Germany, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a photographic electronic discharge flash apparatus for photo-electric control of the delivered light output of the flash tube discharge in dependence upon the measurement of the light reflected from the subject.

In this case at every shot the unused part of the charge in the storage capacitor is dissipated. In order to avoid this and in order to adapt the energy consumption to the actual requirement, the storage capacitor was divided into several part capacitances, so that the appliance could be switched manually to partial or full power. If then an effective saving of electrical work is to occur and at the same time it is to be ensured that the photographic exposure is correctly lit, before every exposure the requisite part power must be estimated very precisely.

It has already been proposed to bring about a partial power withdrawal automatically in a manner in which the capacitor was discharged step by step alternately through two flash tubes, the pulse sequence of an ignition pulse generator being broken off after the desired light power was reached. According to another proposal a plurality of complete flash units consisting of storage capacitors, flash tubes and ignition devices was provided, which were ignited in continuous sequence through an ignition pulse distributor.

In both cases at least two flash tubes were necessary and in other respects too a high expenditure had to be tolerated; admittedly then the dissipation of unconsumed electric

work was prevented or at least limited to the unconsumed part energy of the last ignited stage, provided that the initially mentioned photo-electric interruption of the flash discharge was used in order to obtain a precise light quantity regulation.

It is also known to utilise the pulse generated on reaching of the settable threshold value for the ignition of a short-circuit device for the flash tube, for example of a thyatron or thyristor, whereby the flash tube discharge is suddenly terminated. In this case the storage capacitor is necessarily completely discharged, so that regularly a more or less large part of the energy is uselessly dissipated.

In order to adapt the energy consumption to the actual requirement, the storage capacitor was divided into several partial capacitances, so that the appliance could be switched over manually to a partial power or to full power. In that case before every exposure the requisite power had to be ascertained precisely, if on the one hand a power dissipation was to be avoided but on the other hand it was to be ensured that the requisite light output is also reached.

The object of the invention is to solve the same problem of the automatic partial power switching with the same energy saving, but without the high expense, while the appliance requires only one single flash tube.

According to the invention there is provided an electronic flash apparatus including a single flash tube, a main capacitor and a plurality of additional capacitors arranged to be automatically and sequentially connected into circuit with the flash tube for determining the luminous intensity of the flash photoelectric control means for detecting the luminous intensity of the flash reflected back by the subject and for providing a control signal, and electronic switch devices associated respectively with said additional capacitors for receiving directly or indirectly

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said control signal to effect or prevent connection of one or more of the additional capacitors with the flash tube thereby to determine the luminous intensity of the flash discharge in accordance with a preset threshold value of the luminous intensity.

The invention will now be described by way of example with reference to the accompanying drawings in which:—

Figure 1 is a circuit diagram of one form of the invention in which successive connection of the additional discharge capacitors takes place.

Figure 2 shows a modification of the previous example in which the connection of the capacitors is controlled by an integrating photo-electric pulse generator.

Figure 3 shows a further modification having a photo-transistor for the control of the capacitor connection and

Figure 4 is an embodiment including an inductance member for controlling the connection of the capacitors.

In the arrangement shown in Figure 1 the flash tube 1 is represented with the usual ignition electrode 2. The actual ignition device does not differ from the arrangements known for this purpose. The ignited flash tube 1 can be extinguished prematurely by short-circuiting. As a short-circuit member there serves for example a thyatron 3, the ignition electrode of which is in connection (via lead 4) with the photo-electric measuring device which produces an ignition pulse for the thyatron 3 on reaching a settable threshold value of the reflected light. In a modification the thyatron 3 may be replaced by a thyristor 3'.

Such measuring devices are known and are not further described herein. The total capacitance of the storage capacitor is divided in the example of embodiment into three capacitors 5, 6 and 7, which can be charged through the supply lead 8 and through the diodes 9, 10 and 11, respectively. The capacitor 5 is connected through the diode 12 with the flash tube 1, the capacitors 6 through the thyristor 13 and capacitor 7 through thyristor 14 and resistor 27 to the tube 1. On ignition of the flash tube 1 firstly the capacitor 5 discharges through the flash tube.

A voltage drop then occurs on the thyristors 13 and 14, so that the capacitors 15 and 17 are charged up through the capacitors 16 and 18 respectively. The series resistance of the capacitor group 17, 18 and of the resistor 20 is greater than the resistance of the capacitor series 15, 16 and the resistor 19, so that the charging up of the capacitors takes place at different rates.

The trigger diodes 21 and 22 are connected between these voltage dividers 15, 16 and 17, 18 and the thyristors 13 and 14. The thyristors 25 and 26 lie in parallel with the

capacitors 15 and 17. The resistors 27 and 28, which are in series with the discharge circuit of the thyatron 3, lie in the switching circuit of the thyristors 25 and 26. The voltage dividers 15, 16, 19 and 17, 18, 20 are so dimensioned that after the ignition of the flash tube 1, towards the end of the discharge of the first capacitor 5, the switching voltage is reached on the trigger diode 21 and the thyristor 13 is triggered, so that the discharge of the capacitor 6 is instigated. Towards the end of the discharge of the capacitor 6 the thyristor 14 is triggered by the trigger diode 22 and thus the discharge of the capacitor 7 is initiated.

If during the discharge of the capacitor 5 the photo-electrically controlled ignition of the thyatron or tube 3 becomes effective, then due to the discharge current of the tube 3 a voltage drop occurs on the resistors 27 and 28, which effects ignition of the thyristors 25 and 26 and thus short-circuits the capacitors 15 and 17, so that the trigger diodes 21 and 22 cannot become effective. Thus when the flash discharge, after reaching the requisite luminous intensity, is interrupted by ignition of the tube 3 or of the thyristor 3', in fact the residual energy of the flash capacitor 5 is dissipated, but the connection of the further capacitors 6 and 7 is prevented. If the flash discharge is interrupted in the same way while the capacitor 6 is already being discharged, then the connection of the third capacitor 7 is prevented. The diode 12 prevents the wasteful charging up of the capacitors 6 and 7. The same also applies to the thyristors 13 and 14. The parallel resistors 23 and 24 prevent inverse charging of the capacitors 15 and 17 in the recharging operation.

The current flowing through the tube 3 on ignition is very high, so that for generation of the requisite control voltage for the thyristors 25 and 26 only small resistances 27 and 28 become necessary to produce the requisite voltage drop, so that their influence upon the resistance of the extinguishing tube circuit 3 is immaterial.

The circuit of Figure 2 will now be described. The flash tube 1 is provided with the usual ignition electrode 2. The actual ignition device does not differ from the arrangements known for this purpose. The same also applies to a photo-electric measuring device which integrally measures the light reflected from the subject and at the moment when the illumination exceeds a settable threshold value generates a pulse which interrupts the flash discharge. Such devices are known and are not described herein. The total capacitance of the appliance is divided in the example of embodiment into the three capacitors 5, 6 and 7, which can be charged up through the supply lead 8 and through the diodes 9, 10 and 11.

The capacitor 5 is connected through the diode 12 with the flash tube 1, the capacitors 6 and 7 through the thyristors 13 and 14. On ignition of the flash tube firstly the capacitor 5 discharges through the flash tube 1.

A voltage drop then occurs on the thyristors 13 and 14, so that the capacitors 15 and 17 are charged up through the capacitors 16 and 18 respectively. The series resistance of the capacitor group 17, 18 and of the resistor 20 is in this case greater than the resistance of the capacitor series 15, 16 and of the resistor 19, so that the charging up of the pairs of capacitors takes place at different speeds.

The trigger diodes 21 and 22 are connected to the capacitors 15 and 17. The thyristors 25 and 26, which are connected with the photo-electric measuring device and controlled by the measurement pulse, are in parallel with the capacitors 15 and 17. The voltage dividers 15, 16 and 19 and 17, 18 and 20 are so dimensioned that after the ignition of the flash tube 1 towards the end of the discharging of the first capacitor 5 the switching voltage of the trigger diode 21 is reached and the thyristor 13 is triggered, so that the discharge of the capacitor 6 is instigated. Towards the end of the discharge of this capacitor 6 the thyristor 14 is triggered by the trigger diode 22 and thus the discharge of the capacitor 7 is initiated.

If during the discharge of the capacitor 5 the photo-electric control system becomes effective, then the generated extinguishing pulse ignites the thyristors 25 and 26, whereby the capacitors 15 and 17 are short-circuited, so that trigger diodes 21 and 22 cannot become effective and accordingly the capacitors 6 and 7 are not discharged. If the extinguishing pulse is fed to the thyristors 25 and 26 only after the capacitor 6 is already switched on, then the connecting-in of the third capacitor 7 is prevented.

Admittedly in this case the capacitors discharged in succession in each case are completely discharged, so that no sudden interruption of the flash discharge in the tube 1 takes place. However, with appropriately graduated capacitance values the overexposure which can thereby possibly occur is slight. If an exact adaptation of exposure is to be achieved, in addition a short-circuit tube 3 can be connected in parallel with the flash tube 1 and can be ignited simultaneously with the thyristors 25 and 26 by the ignition pulse of the photo-electric measuring device and thus suddenly interrupts the flash discharge in the tube 1.

In Figure 3 a variant is illustrated which differs from the above examples as regards the light-measuring arrangement. Otherwise the assembly is substantially the same as in Figures 1 and 2, so that the same references are also used for conforming parts.

The photo-transistor 31 is connected to the trigger diode 21. On ignition of the flash tube 1, that is in the discharge of the capacitor 5, a voltage drop occurs on the thyristors 13 and 14, so that on reaching of the breakdown voltage the trigger diodes 21 and 22 are switched on. At the same time the photo-transistor 31 is also supplied with voltage, until on reaching of the breakdown voltage of the trigger diode 21 the voltage collapses. Thus measurement is effected within a predetermined time. If the brightness is very great, then the trigger voltage on the thyristors 25 and 26 is reached earlier than the breakdown voltage of the trigger diode 21. Thus the capacitors 15 and 17 are short-circuited and a further rise of the voltage on the trigger diodes 21, 22 is prevented. In the case of less brightness the trigger voltage on the thyristor 25 is reached later than the breakdown voltage on the trigger diode 21. The desired switching points can be adjusted by the resistors 32 and 33. The relatively very small resistors 27 and 28, when using a short-circuit tube 3, should generate a voltage drop by which the thyristors 25 and 26 are ignited, in order to prevent a renewed rise of the voltage on the trigger diodes 9 and 10 when the short-circuit tube 3 is ignited.

Here again by appropriate graduation of the partial capacitances it is possible to achieve such an accurate light quantity regulation that the use of an additional short-circuit element 3 (thyristor or thyatron) and of the pertinent photo-electrically integrating measuring additional part becomes superfluous.

The automatic successive connection, initiated by the discharge of the main capacitor, of additional capacitances is directly interrupted or made ineffective by the pulse tripped on reaching of the threshold value of the photo-electric measuring device. This pulse can also be used additionally for the ignition of the extinguishing tube or of the extinguishing thyristor. If however the capacitances of the main and additional capacitors are graduated in a quadratic series in accordance with the increase of the power requirement as the square of the subject range, such a favourable power adaptation is already achieved that it is possible to dispense with the additional short-circuit member, without an unnecessary dissipation of energy having to be tolerated on that account. Apart from the avoidance of unnecessary losses of energy dissipation, the invention also has the advantage that the energy of the flash tube is supplied by stages, that is to say even in the case of the maximum power requirement the full capacitance does not have to be conducted through the flash tube in one single discharge, so that with equal maximum loading of the flash

tube it is possible to achieve greater total light outputs.

In the examples of embodiment described above the division of the storage capacitance into three capacitors 5, 6 and 7 is represented. It is obvious that a division into a larger number of partial capacitances is possible.

Since the power requirement of a flash appliance increases as the square of the subject, a quadratic graduation of the capacitance sizes is advisable. Thus in the case of a six-stage division the following capacitance series would occur:

15 $1+1+2+4+8+16$
and a total capacitance of 480uF would have to be divided up as follows:
15 uF+15 uF+30 uF+60 uF+120 uF+240 uF.

20 In an appliance having a guide number 18, such a six-stage division would already correspond to a graduation of $\pm 1/2$ diaphragm stop division.

The embodiment shown in Figure 4 will now be described. The flash tube 1 is provided with the usual ignition electrode 2. The actual ignition device does not differ from the arrangements known for this purpose. The total capacitance of the appliance is divided in the example of embodiment among the three capacitors 5, 6 and 7 which can be charged up through the lead 8 and through the diodes 9, 10 and 11. The capacitors 6 and 7 are connected with the flash tube 1 through the thyristors 13 and 14 and in parallel with the capacitor 5. Parallel with the thyristors 13 and 14 the capacitors 15, 16 and 17, 18 respectively are in series. The trigger 21 and 22 are connected to the capacitors 15 and 17. The thyristors 25 and 26, which are connected with the photo-electric control device, are in parallel with the capacitors 15 and 17. The control device consists of the series connection of a photo-transistor 31 with an inductance 32, the voltage divider 27, 28 and the capacitor 29, and is connected in parallel with the flash tube 1 and capacitor 5.

On ignition of the flash tube 1 firstly the capacitor 5 discharges. A voltage drop then occurs on the thyristors 13 and 14, so that the capacitors 15 and 17 are charged up through the capacitors 16 and 18. As soon as the switching voltages are reached on the trigger diodes 21 and 22, the thyristors 13 and 14 are triggered, whereby the discharge of the capacitors 6 and 7 is instigated.

The likewise charged capacitor 29 serves for the voltage supply of the photo-transistor 31. The photo-transistor measures the brightness reflected from the subject during a short interval which is determined by the charging of the capacitor 29. This time interval is substantially shorter than the time interval which must elapse until the capaci-

tors 15 and 17 have reached the switching voltage of the trigger diodes 21 and 22 and trigger the thyristors 13 and 14 and thus initiate the discharge of the capacitors 6 and 7 through the flash tube 1. The reflected light from the subject falling upon the photo-transistor 31 generates in the inductance 32 a voltage amplitude the level of which corresponds to the reflected brightness. This voltage amplitude triggers the thyristors 25 and 26, provided that their trigger voltage is exceeded. The capacitors 15 and 17 are then short-circuited, so that the switching voltage cannot be reached on the trigger diodes 21 and 22, and thus the switching through of the transistors 13 and 14 and the discharge of the capacitors 6 and 7 are suppressed.

As represented in the example of embodiment, the tapplings 33, 34, 25, 36 are provided on the winding 30 inductively coupled with the inductance 32 and are connected with the individual thyristors 25, 26, etc. If the voltage amplitudes tapped on these tapplings all exceed the switching voltages of the thyristors 25, 26, etc., then the connecting-in of the additional capacitors is entirely suppressed.

If the voltage amplitudes only partially exceed the switching voltages of the thyristors 25 and 26, then only those capacitors 6, 7 are connected in where the thyristors 25 and 26 were not switched on. As indicated in the drawing, any desired number of additional capacitors can be supplied. In place of the indicated tapplings of the winding 30 the different response sensitivities of the thyristors 25, 26 can also be achieved by appropriate voltage dividers, while all thyristors 25, 26 etc. are connected to the inductance 32.

Considered in time, immediately after the ignition of the tube 1 the light measurement is effected by the photo-transistor 31 and a voltage amplitude is generated the level of which determines the extent of the discharging of the capacitors 15, 17. Directly thereupon the thyristors 13, 14, etc. of the stages not discharged are triggered and the discharge of the capacitors 6, 7 etc. is initiated. The switching of the thyristors 25, 26 etc. takes place at the same time. Likewise the switching of the thyristors 13, 14, etc., unless by different dimensioning of the components, especially of the capacitance of the capacitors 15, 17, a chronological succession is to be effected or is desired.

In the case of arrangement of an appropriate number of capacitors with graduated capacitance values which are staged in quadratic series, thus for example 15 uF+15 uF+30 uF+60 uF+120 uF+240 uF, an appliance with automatic light intensity regulation can be assembled which with a guide member of 18 has for example a stage

accuracy of $\pm 1/2$ diaphragm stop. With a smaller number of stages or if there is a desire for it, in addition to the flash tube a short-circuit element such as a thyatron or a thyristor can be connected in parallel, which element is ignited by the ignition pulse of a separate photo-electric measuring device and thus breaks off the flash discharge when an adequate exposure is achieved and whereby, in a manner known *per se*, an exact light quantity regulation is possible. The resistors 23 and 24, which are connected in parallel with the capacitors 15 and 17, are to prevent inverse charging of these capacitors in the recharging of the appliance.

In the arrangement as described by way of example the connecting-in of the additional capacitors is effected by not short-circuiting the capacitors 15 and 17 which supply the trigger diodes 21 and 22 and trigger the thyristors 13 and 14 on reaching of the breakdown voltage. It is obvious that in place of this short-circuit switching for the capacitors 15 and 17 a positive switch-on control is also possible, such that a switching on takes place in place of a switching off of the trigger diodes 21 and 22 or their working capacitors 15 and 17.

Thus with every flash a practically constant flash duration is obtained. No flash duration regulation takes place, but a brightness regulation with constant flash duration. Since the measurement and control operation can be compressed into a very short time interval at the beginning of the flash discharge, an especially high security against extraneous flash is obtained for this arrangement, since an extraneous flash can influence the system only if it falls exactly into this very short time interval.

WHAT WE CLAIM IS:—

1. An electronic flash apparatus including a single flash tube, a main capacitor and a plurality of additional capacitors arranged to be automatically and sequentially connected into circuit with the flash tube for determining the luminous intensity of the flash, photoelectric control means for detecting the luminous intensity of the flash reflected back by the subject and for providing a control signal, and electronic switch devices associated respectively with said additional capacitors for receiving directly or indirectly said control signal to effect or prevent connection of one or more of the additional capacitors with the flash tube thereby to determine the luminous intensity of the flash discharge in accordance with a preset threshold value of the luminous intensity.

2. An electronic flash apparatus as claimed in claim 1, wherein the electronic switch devices prevent the sequential connection of the additional capacitors with the flash tube.

3. An electronic flash apparatus as claimed in claim 2, wherein the connection of the additional capacitors is prevented after the requisite total capacitance is reached.

4. An electronic flash apparatus as claimed in claim 2 or 3, wherein the connection in continuous sequence of the additional capacitors is prevented by the photo-electric control means for the termination of the discharge of the flash tube by short-circuiting of the discharge path.

5. An electronic apparatus as claimed in claim 2, 3 or 4, wherein the total capacitance is divided up into individual capacitances in such a way that the capacitances are graduated increasingly one after the other in a geometric quadratic sequence.

6. An electronic flash apparatus as claimed in any one of the preceding claims, in which the switch devices include thyristors connected to said additional capacitors and controlled through voltage-divider members, the voltage of which is tapped on ignition of the main capacitor, time-delay members being provided which determine the chronological sequence of the connections of the additional capacitors by the thyristors.

7. An electronic flash apparatus as claimed in claim 6, wherein the voltage divider members comprise a capacitor and a resistor of which each capacitor is connected in parallel with a further thyristor controlled by the voltage drop on further resistors which lie in the circuit of the photo-electric control means, the capacitors of said dividers being dischargeable by the further thyristors to prevent the ignition of the thyristors which are connected to said additional capacitors.

8. An electronic flash apparatus as claimed in claim 6, wherein the photo-electric control means is a photo transistor connected with diodes affecting the voltage drop on the thyristors connected to the additional capacitors.

9. An electronic flash apparatus as claimed in claim 1, wherein said electronic switch devices are controlled by an inductance member connected to the photo-electric control means for generating in the circuit a voltage signal, the amplitude of which is dependant upon the illumination of the subject, for effecting a simultaneous connection or discharge of a selected number of the additional capacitors according to a preset threshold value of the luminous intensity.

10. An electronic flash apparatus as claimed in claim 9, wherein associated respectively with the additional capacitors are short-circuit members having differing response sensitivities adapted to receive the voltage signal and to short-circuit one or more of the additional capacitors according to the amplitude of the voltage signal.

accuracy of $\pm 1/2$ diaphragm stop. With a smaller number of stages or if there is a desire for it, in addition to the flash tube a short-circuit element such as a thyatron or a thyristor can be connected in parallel, which element is ignited by the ignition pulse of a separate photo-electric measuring device and thus breaks off the flash discharge when an adequate exposure is achieved and whereby, in a manner known *per se*, an exact light quantity regulation is possible. The resistors 23 and 24, which are connected in parallel with the capacitors 15 and 17, are to prevent inverse charging of these capacitors in the recharging of the appliance.

In the arrangement as described by way of example the connecting-in of the additional capacitors is effected by not short-circuiting the capacitors 15 and 17 which supply the trigger diodes 21 and 22 and trigger the thyristors 13 and 14 on reaching of the breakdown voltage. It is obvious that in place of this short-circuit switching for the capacitors 15 and 17 a positive switch-on control is also possible, such that a switching on takes place in place of a switching off of the trigger diodes 21 and 22 or their working capacitors 15 and 17.

Thus with every flash a practically constant flash duration is obtained. No flash duration regulation takes place, but a brightness regulation with constant flash duration. Since the measurement and control operation can be compressed into a very short time interval at the beginning of the flash discharge, an especially high security against extraneous flash is obtained for this arrangement, since an extraneous flash can influence the system only if it falls exactly into this very short time interval.

WHAT WE CLAIM IS:—

1. An electronic flash apparatus including a single flash tube, a main capacitor and a plurality of additional capacitors arranged to be automatically and sequentially connected into circuit with the flash tube for determining the luminous intensity of the flash, photoelectric control means for detecting the luminous intensity of the flash reflected back by the subject and for providing a control signal, and electronic switch devices associated respectively with said additional capacitors for receiving directly or indirectly said control signal to effect or prevent connection of one or more of the additional capacitors with the flash tube thereby to determine the luminous intensity of the flash discharge in accordance with a preset threshold value of the luminous intensity.

2. An electronic flash apparatus as claimed in claim 1, wherein the electronic switch devices prevent the sequential connection of the additional capacitors with the flash tube.

3. An electronic flash apparatus as claimed in claim 2, wherein the connection of the additional capacitors is prevented after the requisite total capacitance is reached.

4. An electronic flash apparatus as claimed in claim 2 or 3, wherein the connection in continuous sequence of the additional capacitors is prevented by the photo-electric control means for the termination of the discharge of the flash tube by short-circuiting of the discharge path.

5. An electronic apparatus as claimed in claim 2, 3 or 4, wherein the total capacitance is divided up into individual capacitances in such a way that the capacitances are graduated increasingly one after the other in a geometric quadratic sequence.

6. An electronic flash apparatus as claimed in any one of the preceding claims, in which the switch devices include thyristors connected to said additional capacitors and controlled through voltage-divider members, the voltage of which is tapped on ignition of the main capacitor, time-delay members being provided which determine the chronological sequence of the connections of the additional capacitors by the thyristors.

7. An electronic flash apparatus as claimed in claim 6, wherein the voltage divider members comprise a capacitor and a resistor of which each capacitor is connected in parallel with a further thyristor controlled by the voltage drop on further resistors which lie in the circuit of the photo-electric control means, the capacitors of said dividers being dischargeable by the further thyristors to prevent the ignition of the thyristors which are connected to said additional capacitors.

8. An electronic flash apparatus as claimed in claim 6, wherein the photo-electric control means is a photo transistor connected with diodes affecting the voltage drop on the thyristors connected to the additional capacitors.

9. An electronic flash apparatus as claimed in claim 1, wherein said electronic switch devices are controlled by an inductance member connected to the photo-electric control means for generating in the circuit a voltage signal, the amplitude of which is dependant upon the illumination of the subject, for effecting a simultaneous connection or discharge of a selected number of the additional capacitors according to a preset threshold value of the luminous intensity.

10. An electronic flash apparatus as claimed in claim 9, wherein associated respectively with the additional capacitors are short-circuit members having differing response sensitivities adapted to receive the voltage signal and to short-circuit one or more of the additional capacitors according to the amplitude of the voltage signal.



11. An electronic flash apparatus as claimed in claim 9, wherein associated respectively with the additional capacitors are switch circuits having differing response sensitivities adapted to receive the voltage signal and to switch on one or more of the additional capacitors according to the amplitude of the voltage signal.
12. An electronic flash apparatus substantially as described with reference to any one

of the examples shown in the accompanying drawings.

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