

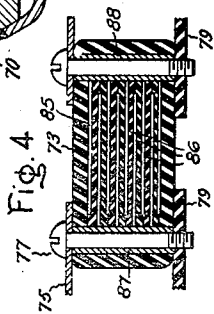
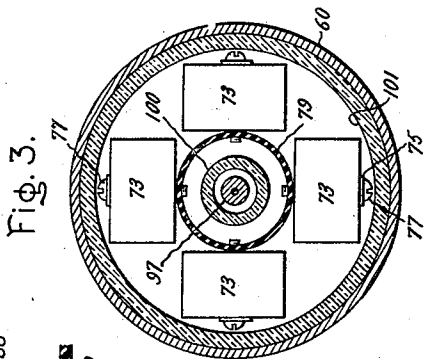
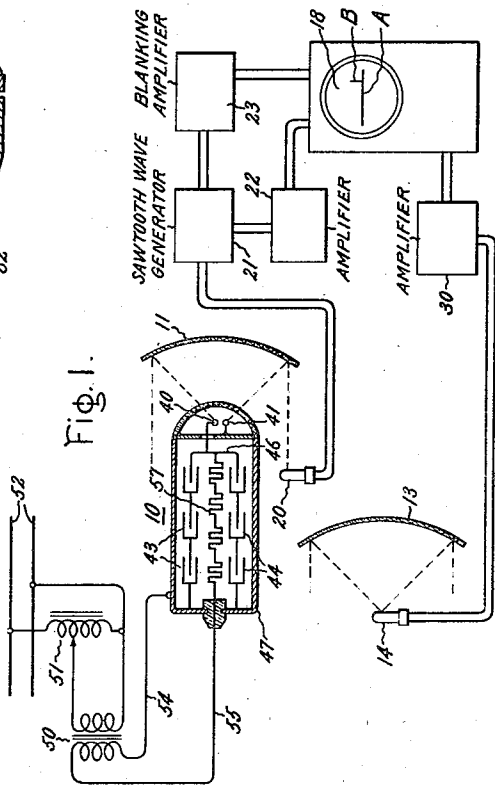
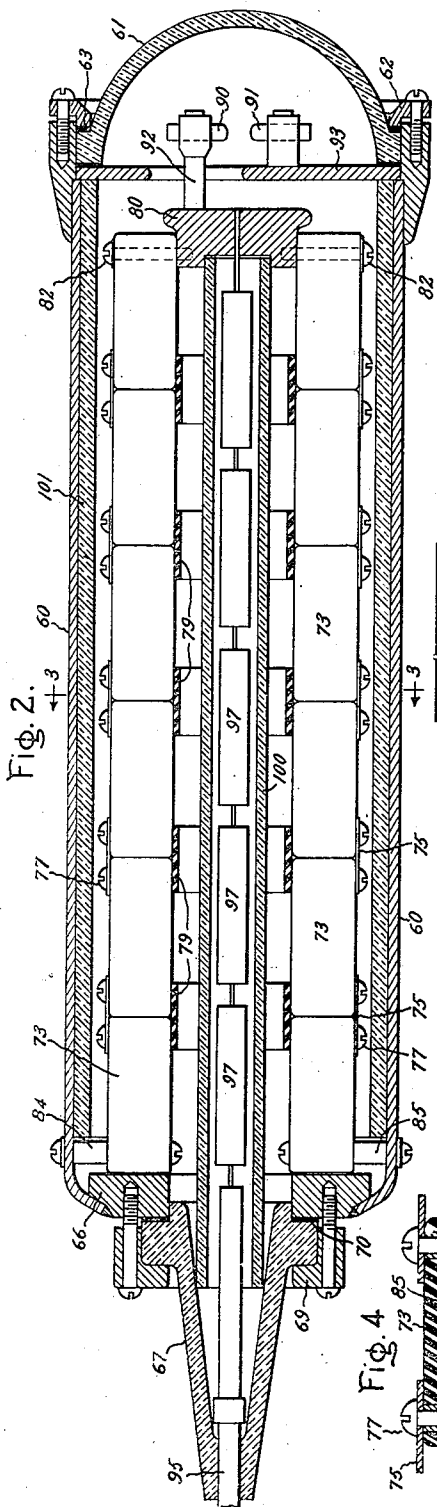
Oct. 8, 1946.

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2,409,030

LIGHT IMPULSE SYSTEM

Filed Dec. 22, 1941



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UNITED STATES PATENT OFFICE

2,409,030

LIGHT-IMPULSE SYSTEM

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Application December 22, 1941, Serial No. 423,984

10 Claims. (Cl. 315—59)

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The present invention relates primarily to improvements in apparatus for locating objects and measuring distances by the transmission and reflection of light-impulses, that is to say, by impulses of electromagnetic waves within the visible or near-visible range.

It is a primary object of the invention to provide in such apparatus an improved light-impulse generator which is capable of meeting the requirement that the duration of the generated impulses shall be a small fraction of the time required for the reflection of the impulses from an object positioned at any material distance from the impulse source.

It is a further object to provide a generator adapted to produce light-impulses of extremely high instantaneous intensity.

In the attainment of the foregoing objects an important feature of the invention consists in the use of electrodes adapted to sustain an intense spark-discharge in combination with a charge-storing agency which is of such character and which is so connected to the electrodes that the resultant circuit represents a discharge system of extremely small inductance. By alternately charging an appropriately constructed charge-storing agency and thereafter discharging it through the connected electrodes, it proves possible to produce light-impulses which have an effective duration of less than one-tenth microsecond but which are nevertheless of sufficient intensity to be reflected in detectable amounts from objects at a distance of many miles. Because of the extreme brevity of the impulses involved, the location of such objects can, with the assistance of a detecting system responsive to such impulses, be determined with an error of only a few feet, and even higher accuracies are possible under favorable conditions.

The features of the invention which we desire to protect herein are pointed out with particularity in the appended claims. The invention itself, together with its further objects and advantages, thereof may best be understood by reference to the following description taken in connection with the drawing in which Fig. 1 represents schematically a distance-measuring system suitably embodying the invention; Fig. 2 is a sectional view of a light-impulse generator of the type which characterizes the invention; Fig. 3 is a sectional view taken on line 3—3 of Fig. 2; and Fig. 4 is a cross-section of one of the condenser units of Fig. 2.

Referring to Fig. 1 there is shown a distance-measuring system which includes as its major

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elements a light-impulse projecting device, a device for receiving and detecting the projected light-impulses as they are reflected from a distant object, and means for visibly indicating the time required for the reflection of the light-impulses so as to provide a measure of the distance to the reflecting object.

The light-projecting device comprises in its general aspects a light-impulse generator 10 and a reflector 11 for focusing in a narrow beam the light radiations developed by the generator. The light-receiving means consists of a focusing mirror 13; preferably of parabolic form, and a light-sensitive agency 14, typically a photocell, arranged at the focal point of the mirror. The transmitting and receiving means are preferably oriented in the same direction and are arranged to have their orientation varied simultaneously both in elevation and in azimuth in order that the surrounding space may be scanned for reflecting objects such, for example, as distant aircraft.

The distance-indicating means comprises a cathode ray tube 18, of which only the screen portion is illustrated in Fig. 1. This tube is of conventional character and includes means for generating an electron beam and additional means for deflecting the beam in mutually perpendicular directions to cause a complex trace to be developed on the screen of the tube. The operation of the tube is controlled by means responsive both to the transmission and reception of light-impulses developed by the generator 10, the nature of the means used in this connection being explained more fully hereinafter.

In the use of the apparatus as so far described the generator 10 is actuated in such fashion as to cause it to produce a series of regularly spaced light-impulses of short duration. As each impulse is generated it is caused through the agency of a photosensitive element 20 (e. g. a photocell) to initiate a deflection of the electron beam of the cathode ray tube 18 in such a manner as to produce a horizontal trace A on the screen of the tube. This is accomplished through a saw-tooth wave generator 21 which is under the control of the photocell 20, and an amplifier 22 for applying the saw-tooth potential in amplified form to the horizontal deflecting electrodes (not shown) of the cathode ray tube. In order to protect the screen of the tube and for other reasons an auxiliary apparatus represented by the rectangle 23 is provided for blanking out the electron beam at intervals when the beam-deflecting means is not active and also during peri-

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ods when, after an initial deflection, the beam is being returned to its original starting point. The blanking means employed in this connection are conventional and do not require to be particularly described herein. The nature and function of devices serving this purpose are fully explained, for example, in "Cathode Ray Tubes" by M. Von Ardenne (Pitman and Sons, Ltd. London, 1939) pages 278 to 288.

The light-impulse receiver 14 is connected through suitable amplifying apparatus (comprised within the rectangle 30) to the vertical deflecting plates of the cathode ray tube 18. Consequently, upon receipt of reflected waves by the receiver, a secondary deflection of the beam is produced at an instant dependent upon the time required for the reflection of the transmitted light-impulse from the distant object toward which the transmitting and receiving means are directed. This deflection produces on the screen of the cathode ray tube a trace B which is transverse to the trace A and the relative location of which provides an indication of the distance of the reflecting object.

A light-impulse system of the type so far described possesses an advantage over detecting systems which employ other types of electromagnetic waves in that it may be made very highly directional in character because of the possibility of optically focusing the propagated light rays in a narrowly confined beam. However, considerable difficulty exists in providing a light-impulse generator capable of developing impulses which are of sufficiently short duration to permit the system to function in its intended manner and which at the same time have a sufficient intensity to permit the detection of impulses reflected from objects at a distance of several miles. In this connection it is particularly important that the duration of the generated light-impulse shall be a small fraction of the time required for the reflection of the impulse from the object under surveillance. If this condition is not fulfilled, a clearly defined indication cannot be obtained on the screen of the cathode ray tube because of swamping of the trace produced by the reflected signal through the effects of radiations proceeding directly from the transmitting apparatus.

Another factor which is important to the successful operation of a system of the type under consideration consists in the possibility of obtaining light-impulses having a very steep wave front, that is to say, a very abrupt rise from zero light intensity to maximum light intensity. For example, if distance measurements are to be made with an error of less than 50 feet, the light-impulse generating system must be of such character as to produce an impulse which attains its maximum value in a time less than that required for light waves to travel about 25 feet. In view of the tremendous velocity of light, this obviously signifies a very steep wave front indeed.

The requirements stated in the foregoing are very satisfactorily fulfilled by the use of a light generator of the character illustrated in Fig. 1. This comprises a pair of mutually spaced electrodes 40, 41 adapted to be intermittently supplied with discharge current from a high capacity charge-storage agency. In the arrangement shown in Fig. 1 the charge-storage agency is illustrated as comprising two banks of series-connected condensers 43 and 44, which banks are connected in parallel across the electrodes 40 and

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41. One terminal of the condenser assembly is indicated as a bridging conductor 46 and the other terminal comprises the wall structure of a conductive container 47 which closely surrounds the condenser assembly. Electrode 40 is directly connected to the terminal 46 and the electrode 41 is supported from one end of the cylinder 47 as indicated.

For the purpose of charging the condenser assembly there is provided a high voltage transformer 50 which is connected through a regulating inductance 51 to an alternating current supply source 52. The secondary of the transformer 50 is connected to the terminals of the condenser assembly through conductors 54 and 55, the conductor 55 being insulatingly sealed through the wall of the container 47 and being in series with an interference suppressing resistor 57 which connects to the condenser terminal 46.

In the operation of the system thus provided the condenser assembly is charged at each cycle of the alternating potential supplied from the transformer 50. The electrodes 40 and 41 are so adjusted that the gap between them can break down just before the condensers attain maximum charge, whereby one discharge is produced during each full cycle of potential reversal. Because of the extremely low inductance of the circuit in which the condensers and the electrodes are included, the resultant spark between the electrodes is of extremely short duration. Moreover, since all the energy of the condensers is discharged within this very brief interval of time, the intensity of the resultant light-impulse is extremely high, reaching in some cases 50,000 watts of peak output or even higher. These advantageous results are a function of the nature of the light-generating apparatus employed, and for this reason it is desirable to consider in somewhat greater detail the construction of a particular light generator which we have successfully used. Such a generator is represented in Figs. 2 and 3 of the drawing.

The construction shown in Fig. 2 comprises an elongated container of which the principal part is in the form of a metal cylinder 60. This cylinder is closed at one end by means of a semi-spherical glass window 61 which is secured to the extremity of the cylinder by means of a clamping ring 62. Suitable gasket material 63 is provided in connection with the edge of the window part 61 to assure that the resultant joint shall be of gas-tight character. The end of the cylinder 60 remote from the window 61 is closed by the combination of a heavy annular ring 66, which is welded to the cylinder, and a tapered insulator 67 held in vacuum-tight relation with respect to the ring 66 by means of a clamping ring 69 and a gasket joint 70. The resultant gas-tight enclosure is filled with a gas under pressure. As will appear more clearly at a later point, it is the main function of the gaseous filling to provide a suitable atmosphere for a light-producing discharge to be produced within the enclosure. For the purposes of the present invention it is preferred to use in this connection nitrogen or one of the rare gases such as argon or neon, pressures of from one atmosphere up to 100 pounds per square inch being suitable.

Within the metal cylinder 60 and extending longitudinally with respect to it there is provided a charge storage system in the form of an assembly of condensers 73. These condensers are arranged in four rows or charge-storing units 75 which are positioned symmetrically with respect

to the axis of the cylinder 60 (see Fig. 3) and the individual condensers of which are connected in series by means of bridging straps 75 extending between adjacent terminals of the condensers. The screws or bolts 77 which are employed to secure the bridging straps 75 to the condenser terminals may advantageously extend through the condenser structure so as to facilitate mounting the various condensers on insulating mounting rings 79 positioned within the condenser assembly.

One terminal of each of the condenser rows is connected to a centrally positioned conductive body 89 which thus provides a common connection point for the condenser assembly as a whole. This connection may be made, for example, by means of bolts 82 which are respectively in contact with the terminals of the end condensers of each row and which extend into screw-threaded engagement with the metal body 80. The cylindrical casing 60 is made to serve as a common connection point for the other end of the condenser assembly by connecting it to the terminals of the condensers at the extremities of the various condenser rows as indicated at 84.

Each of the condensers 73 is preferably made of a flat electrode construction (as distinguished from a spirally wound construction) so that the internal inductance of each condenser is inherently small. The preferred construction is illustrated in Fig. 4 which shows on an enlarged scale a longitudinal section of one of the condensers 73, the thickness of the internal elements being greatly exaggerated for purposes of clarity. The condenser includes a large number of interleaved metal electrodes 85 which are suitably formed of aluminum foil and which are separated by mica sheets 86. Every other electrode is in contact with a metal bushing 87 while the alternate electrodes connect with a bushing 88, the two bushings providing externally accessible terminals for the condenser. The active parts of the condenser are encased in an insulating substance such as a synthetic resin.

The arrangement of the condensers within the cylinder 60 is such that the various condenser rows are relatively close to the internal surface of the cylinder. Since the cylinder provides the return path for current flowing from the terminal 80 through the condenser assembly, the loop inductance of the complete circuit measured between the terminal 80 and a closely adjacent point on the cylinder 60 is very low. This circumstance is made use of in connection with the present invention by mounting discharge electrodes 90 and 91 in direct electrical connection with the condenser terminal 80 and with the metal cylinder 60, the first such connection being through a short conductive rod 92 which extends outwardly from the terminal 70 and the second connection being through an apertured metal wall part 93 which is in direct contact with the end of the cylinder 60. By virtue of this disposition of the parts the entire condenser discharge circuit, including the electrodes 90 and 91, is of extremely small inductance (in a particular case about .05 microhenry as compared with a capacity of .01 microfarad for the condenser bank). Accordingly, once the condensers are charged, they may be abruptly discharged through the electrodes to produce an intense spark of remarkably short duration (i. e. less than one microsecond).

The electrodes 90 and 91 may suitably be constituted of a low work function metal, such as

aluminum. When they are so constituted and when employed in a gaseous discharge medium, such as nitrogen, argon or neon, breakdown between them may be caused to occur automatically whenever the impressed voltage exceeds a value readily attainable with a condenser assembly of the type illustrated. In a particular case, it has been found possible to produce successive discharges by repetitively charging the parallel connected condenser banks to a voltage on the order of 10,000 to 20,000 volts. The impulse discharges thus resulting prove to be of highly luminous quality, yielding in some cases a peak intensity of 50,000 watts or more.

In order to permit charging of the condenser assembly from an external voltage source, a lead-in conductor 95 is sealed through the extremity of the insulator 67, being connected to the terminal 80 within the sealed enclosure through the intermediation of a series of current-limiting resistors 97. A connection to the other terminal of the condenser assembly may obviously be made by affixing a conductor (not shown) to the surface of the metal cylinder 60 or any associated metal part.

In order insulatingly to separate the resistors 97 from the condensers 73 and thus to minimize the likelihood of undesired breakdown, an axially extending insulating cylinder 100 is interposed between them. A larger insulating cylinder, indicated at 101, is interposed between the condenser assembly and the inner wall surface of the metal cylinder 60 for a similar purpose.

The mode of use of a light-impulse generator of the character shown in Fig. 2 has already been explained in connection with the description of Fig. 1. In applying the generator of Fig. 2 to the system of Fig. 1 it will be understood that the electrodes 90 and 91 correspond to the electrodes 40 and 41, the condensers 73 to the condensers 43 and 44, etc.

A system of the character described is applicable to the detection and location of aircraft, to cloud height measurement, and to distance measurement generally. Under certain circumstances, it also has utility for marine purposes in making sub-surface observations, for example, in the detection and location of submerged submarines.

While the invention has been described by reference to a particular embodiment thereof, it will be understood that numerous changes may be made by those skilled in the art without departing from the invention. We, therefore, desire in the appended claims to cover all such variations as come within the true spirit and scope of the foregoing disclosure.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In a system in which light impulses are transmitted to a distant object and thereafter corresponding reflected impulses are received from said object in a time dependent upon the distance to the object, the combination which comprises a charge-storing agency, means for periodically charging the said agency, a spark-discharge type of light source, and circuit connections between the charge-storing agency and the light source for allowing the intermittent discharge of the former through the latter, said charge-storing agency and said circuit-connections being of such small inductance that the duration of each of the resultant light impulses is a fraction of the time required for reflection

of such impulses from the aforesaid distant object.

2. In a system in which light impulses are transmitted to a distant object and corresponding reflected impulses are thereafter received in a time dependent upon the distance to the object, the combination which comprises a charge-storing agency of small internal inductance, means for periodically charging the said agency, a pair of gas-immersed electrodes positioned in close physical proximity to the charge-storing agency, and direct conductive connections between the terminals of said agency and said electrodes for allowing the intermittent discharge of the former through the latter, the resultant discharge circuit being of such small inductance that the duration of each light impulse generated between the electrodes upon the occurrence of a discharge is a fraction of the time required for reflection of said impulses from the aforesaid distant object.

3. In a system in which light impulses are transmitted to a distant object and corresponding reflected impulses are thereafter received in a time dependent upon the distance to the object, the combination which includes an enclosing casing having a light-transmitting wall part, a charge-storing agency within the casing, means for periodically charging the said agency, a pair of mutually spaced electrodes within the casing adjacent to the said light-transmitting wall part and in close proximity to the charge-storing agency, and direct conductive connections between the charge-storing agency and the said electrodes for allowing the intermittent discharge of the former through the latter, the resultant discharge circuit being of such small inductance that the duration of each of the light impulses generated upon the occurrence of a discharge is a fraction of the time required for reflection of said impulses from the aforesaid distant object.

4. In a system in which light impulses are transmitted to a distant object and corresponding reflected impulses are thereafter received from said object in a time dependent upon the distance to the object, the combination which includes a condenser assembly arranged so that current flow is from end to end through the assembly, terminal means for the assembly at its respective extremities, a circuit including said terminal means for periodically charging the assembly, a conductive structure closely surrounding the assembly and extending lengthwise of it, a first sparking electrode having a direct conductive connection to the said structure near one end thereof, a second sparking electrode directly connected to the assembly terminal means which is near said one end of the conductive structure, and a connection between the remaining assembly terminal means and the other end of the conductive structure, the resultant loop circuit from the condenser assembly through the sparking electrodes being of such small inductance that the duration of each of the light-pulses generated by discharge of the assembly through the electrodes is a fraction of the time required for reflection of such impulses from the aforesaid distant object.

5. A light impulse generator comprising an enclosing casing, a charge-storing agency within the casing, a pair of mutually spaced electrodes within the casing in proximity to the charge-storing agency, a light-transmitting wall part incorporated in said casing adjacent to the said electrodes, and low inductance conductors direct-

ly connecting the terminals of the charge-storing agency to the respective electrodes, whereby the said agency is enabled, upon charging, to create between the electrodes a light-producing spark of extremely short duration.

6. A light-impulse generator comprising a condenser assembly of hollow elongated configuration, terminal means for the assembly at its respective extremities for permitting charging and discharging of the assembly, a conductive structure closely surrounding and extending from end to end of the said assembly, a first sparking electrode having a direct conductive connection to the said structure near one end thereof, a second sparking electrode cooperatively spaced with respect to the first electrode and directly connected to the assembly terminal means which is near said one end of the conductive structure, and a connection between the remaining assembly terminal means and the other end of the conductive structure, whereby the loop circuit through the condenser assembly and the conductive structure provides a low inductance discharge path from the assembly to the said sparking electrode.

7. A light-impulse generator comprising a condenser assembly of elongated hollow configuration, said assembly including a plurality of capacitive units arranged so that current flow is lengthwise through the assembly, terminal means for the assembly at its respective extremities, a conductive casing closely surrounding and extending from end-to-end of the assembly, a first sparking electrode having a direct conductive connection to the said casing near one end thereof, a second sparking electrode cooperatively spaced with respect to the first electrode and directly connected to the assembly terminal means which is near said one end of the casing, and a connection between the remaining assembly terminal means and the other end of the said casing, whereby the loop circuit through the condenser assembly and the casing provides a low inductance discharge path from the assembly through the said sparking electrodes.

8. A light impulse generator comprising an assembly of charge-storing units extending parallel to a common axis, said assembly having at one end thereof a common connection point to which the adjacent extremities of the various charge-storing units are connected, a conductive structure closely surrounding the assembly and extending from end-to-end thereof, said structure providing a common connection point for the various charge-storing units at the end of the assembly remote from the first-named connection point, cooperatively spaced electrodes located adjacent to said first-named connection point, a direct conductive connection between one of said electrodes and said first-named connection point, and a direct conductive connection between the other electrode and an adjacent point of said conductive structure, the resultant discharge path from the said assembly through the electrodes being of such small inductance that the assembly is enabled, upon charging, to create between the electrodes a light-producing spark of extremely short duration.

9. A light impulse generator comprising a gas-filled metal casing having a light-transmitting window at one end thereof, an assembly of charge-storing units within said metal casing and extending longitudinally thereof so that current flow through the assembly is lengthwise of the casing, said units having a common connection point at

the end of the casing adjacent the said window and a complementary common connection point for the other end of the assembly being provided by the casing itself, a pair of mutually spaced electrodes within the casing and in proximity to the said window, a first conductive means connecting one of said electrodes directly to said first-named common connection point, and a second conductive means connecting the other electrode directly to the wall of the casing, whereby a low inductance current path is provided between the charge-storing assembly and the electrodes.

10. A light impulse generator comprising a gas-filled metal casing having a light-transmitting window at one end thereof, an assembly of charge-storing units arranged in hollow configuration within the casing and extending longitudinally thereof so that current flow through the assembly is lengthwise of the casing, said units having a common connection point at the end of the casing adjacent to the said window

and a complementary common connection point for the other end of the assembly being provided by the casing itself, conductive means sealed through said casing at the end thereof remote from said window and extending longitudinally of the casing within said charge-storing assembly, said conductive means connecting with the assembly at said first-named common connection point and serving as an element of a supply circuit for charging the assembly, a pair of mutually spaced electrodes within the casing and in proximity to the said window, a first conductive member connecting one of said electrodes to said first-named common connection point, and a second conductive member connecting the other electrode directly to the wall of the casing, whereby a low inductance discharge circuit is provided between the charge-storing assembly and the electrodes.

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