

Sept. 25, 1945.

P. W. BLACKBURN

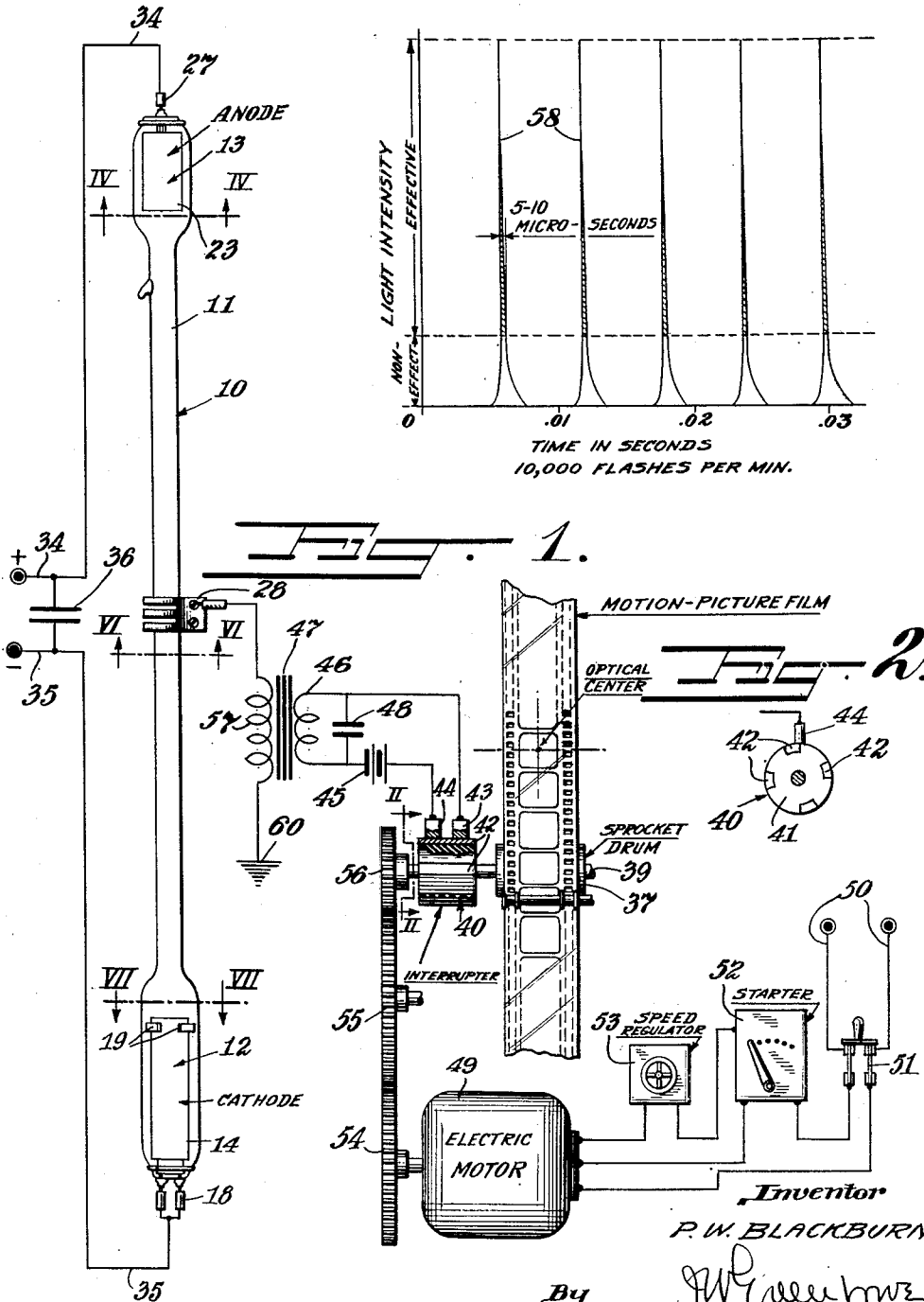
2,385,397

DISCHARGE LAMP AND APPLICATIONS THEREOF

Original Filed Jan. 21, 1937

2 Sheets-Sheet 1

FF. 3.



Inventor
P. W. BLACKBURN

By

J. W. Greenhawz
Attorney.

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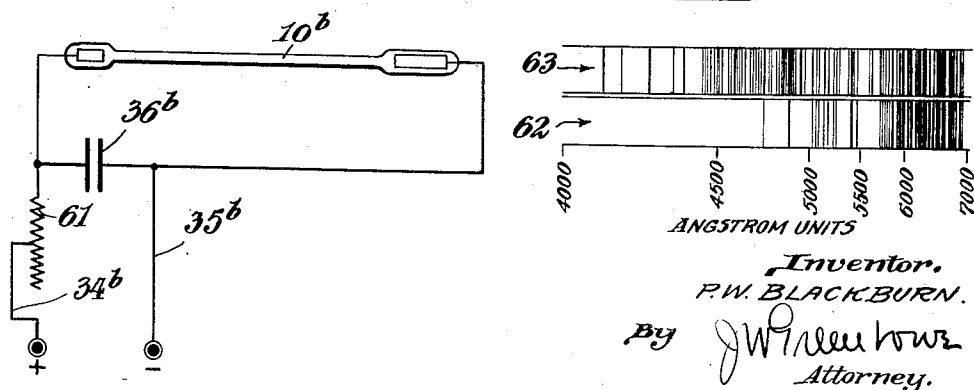
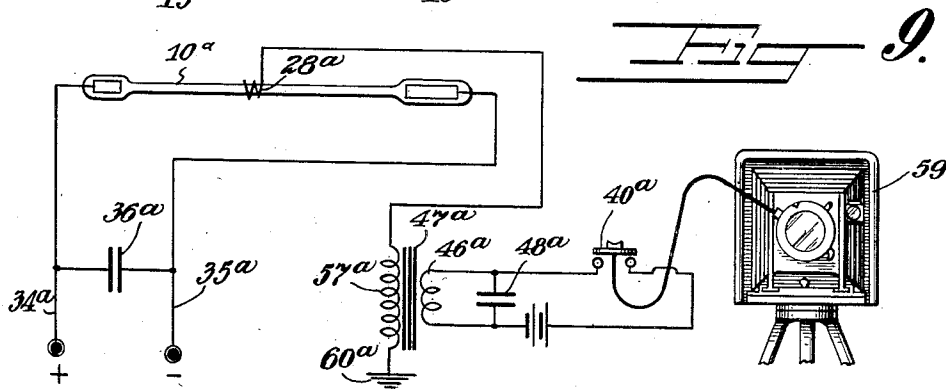
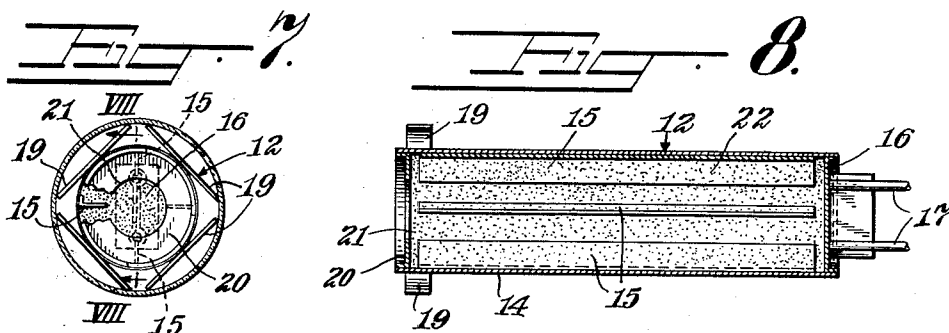
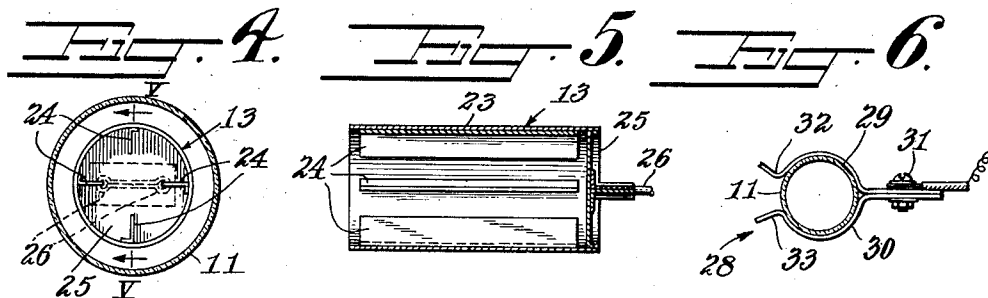
P. W. BLACKBURN

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DISCHARGE LAMP AND APPLICATIONS THEREOF

Original Filed Jan. 21, 1937

2 Sheets-Sheet 2



Inventor.
P. W. BLACKBURN.

By *J. W. Greenhow*
Attorney.

Patented Sept. 25, 1945

UNITED STATES PATENT OFFICE

2,385,397

2,385,397

DISCHARGE LAMP AND APPLICATION THEREOF

Phillip W. Blackburn, Yonkers, N. Y., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Original application January 21, 1937, Serial No. 121,383. Divided and this application November 28, 1940, Serial No. 367,512. In Canada December 16, 1937

5 Claims. (Cl. 315-227)

This application is a division of my application Serial No. 121,383, filed January 21, 1937, now patent No. 2,246,486, dated June 17, 1941.

This invention relates to discharge lamps and more particularly to such furnishing instantaneous flashes of light of high intensity, which may be synchronized with the movement of an object to be photographed or inspected.

In my application Serial No. 733,156, filed June 30, 1934, now patent No. 2,168,861, dated August 8, 1939, I disclosed a stroboscopic lamp comprising an elongated envelope with an electrode at each end and the portion between said ends elongated and reduced in section, the anode being so formed that the light output from said lamp could be directed therethrough and the lamp used like an ordinary flashlight. The present invention relates to an improvement in a lamp of that general type and the method of operation and use thereof.

An object of my invention is to provide a stroboscopic lamp comprising an envelope with a filling of a monatomic gas or gas mixture at such a high pressure that it will not operate on an applied direct current voltage, a grid being employed to act as a trigger to ionize the gas and allow a discharge through said lamp of very high intensity for the production of very strong flashes of light.

Another object of my invention is to provide a lamp supplied from a source of direct current and including a condenser operating in parallel therewith, whereby, when an associated grid is energized for ionizing the contained gas, said lamp is operated by discharging the condenser with the instantaneous development of a very strong flash of light of exceedingly short duration.

A further object of my invention is the operation of a lamp containing a monatomic or a mixture of monatomic gases at such a high intensity that the light obtained therefrom is changed from that having a line spectrum characteristic of the gas, to that having a band spectrum, resulting in the production of substantially achromatic light.

A still further object of my invention is the production of a lamp suitable for motion picture work in which a relatively high potential is required for starting, but in which the drop-out potential is low so that an associated condenser is well discharged and short, intense flashes obtainable, the frequency of said flashes being limited by the charging of the condenser, said lamp having a relatively long life when only a moderate number of flashes per second, as would be suitable for motion-picture work, are required.

Other objects and advantages of the invention, relating to the particular arrangement and construction of various parts, will become apparent as the description proceeds.

Referring to the drawings illustrating my invention, the scope whereof is defined by the appended claims:

Figure 1 is an elevational view of one embodiment of my lamp associated with means for taking motion pictures.

Figure 2 is a detailed sectional view on the line II-II of Figure 1, looking in the direction of the arrows.

Figure 3 is a diagram illustrating the relationship between current flow and time, as well as the character of the light flashes which may be obtained from my lamp.

Figure 4 is a transverse sectional view on the line IV-IV in Figure 1, looking in the direction of the arrows.

Figure 5 is a longitudinal sectional view on the line V-V of Figure 4, looking in the direction of the arrows.

Figure 6 is a transverse sectional view on the line VI-VI of Figure 1, looking in the direction of the arrows.

Figure 7 is a transverse sectional view on the line VII-VII of Figure 1, looking in the direction of the arrows.

Figure 8 is a longitudinal sectional view on the line VIII-VIII of Figure 7, looking in the direction of the arrows.

Figure 9 is a diagram corresponding to Figure 1, but showing how a lamp embodying my invention may be employed in the taking of a still picture.

Figure 10 is a diagrammatic representation of another way in which my lamp may be operated.

Figure 11 is a representation of the spectra of light which are obtainable when using my lamp.

Referring now to the drawings in detail and first considering the embodiment of my invention illustrated in Figures 1 to 8, inclusive, there is shown a stroboscopic lamp 10, provided with a sealed envelope 11 of glass or other suitable vitreous material. If it is desired to use the lamp for supplying actinic light, said vitreous material is preferably quartz or glass pervious to the light or radiations desired.

The envelope 11 is preferably filled with a rare inert monatomic gas, such as neon at a pressure of about 32 millimeters of mercury, some variation, however, being permissible, say from 25 to 32 millimeters. In the present embodiment, it is intended that no mercury shall be included in the envelope, in order to provide for a more uniform operation of the lamp.

The envelope 11 is elongated and its end portions formed of sufficient size to contain a voltage-activated cathode 12 and an anode 13, that portion of the envelope or tube 11 between said electrode-containing end portions being preferably so elongated and reduced in diameter, as shown, that the ratio between the internal di-

ameter of the attenuated portion of the envelope and the length of said portion is within the range between $\frac{1}{30}$ and $\frac{1}{50}$. In one embodiment of my invention, I have secured good results in making the overall length of the envelope 4 feet 4 inches, the length of the restricted portion 3 feet, and the outside diameter of said restricted portion approximately 1 inch, thereby giving an inside diameter to said restricted portion of approximately $\frac{7}{8}$ ". I do not, however, wish to be limited to these specific dimensions.

The cathode of the tube is desirably cup-shaped as shown in detail in Figures 7 and 8. It may be of nickel about 0.1" in thickness, generally cylindrical, and about 7" long and 2" in diameter. The sides of the cylindrical portion 14 of the cathode 12 are desirably reinforced, and the effective electron emission area increased, by longitudinally extending angular members 15 of nickel having their short legs welded in place, as illustrated, and their about $\frac{1}{2}$ " legs extended inwardly. The outer end of the cathode is desirably closed by the plate 16 from which extend one or more conductors 17 connecting with the medium bi-post base 18 which may be employed.

The cathode is desirably centered and braced with respect to end portions of the tube by straight pieces of nickel 19, the intermediate portions of which are welded to the outer surface of the cylindrical portion of the cathode, and the ends of which engage the inner surface of the end portion of the envelope 11 which receives the cathode. In order to facilitate starting and operation of the tube, the interior of the cylindrical portion 15 of the cathode is desirably coated with material 22, initially composed of material such as the carbonates of barium and strontium, which is decomposed during manufacture to give an active electron emissive material. The inner end of the cylindrical portion 14 of the cathode is desirably partly closed by a nickel plate 20 provided with a central aperture 21, desirably about 1" in diameter, which restricts the discharge in cross section near the cathode and avoids a tendency to sputter said electron-emission material 22.

The anode 13 may be of similar construction, but about 3" shorter than the cathode 12, and on account of being shorter, no bracing means at its inner end is required, nor need any electron emission material be applied to the inner surface of the cylindrical portion 23 of the anode 13 or the reinforcing angles 24 thereof. The outer end of the cylindrical portion 23 is closed by means of a plate 25, from which extend conducting means 26 to the medium bipost base 27, which may be employed. The inner end need not be partly closed.

In order to operate such a lamp as just described for the production of intense flashes of light of very short duration, a grid 28 is employed. Said grid may be either internal or external and serves as a trigger for initiating the discharge. The construction of the illustrated form of grid 28 is shown in detail in Figure 6. Said grid 28 comprises merely a pair of relatively short plates 29 and 30 secured together by bolts 31, and each provided with fingers 32 and 33 bent to partially surround a short length of the attenuated portion of the envelope 11. The trigger is actuated by supplying current, from a source of high voltage or frequency, to ionize the gas filling in the envelope 11.

Direct current of relatively high potential, but not high enough to cause a discharge, is applied to the terminals 18 and 27, by means of conduc-

tors 34 and 35 from a suitable source. With a lamp such as specifically described, the potential may be about 1,000 volts. Inasmuch as the average power supplied to the tube is small, on account of the shortness of the flashes, only about $2\frac{1}{2}$ amperes being drawn on the average, it is possible to employ storage batteries for the purpose. With a lamp in which the attenuated portion is $\frac{1}{4}$ " in diameter and 1 foot long, I may use the same voltage with good results, but only drawing from 70 to 75 milliamperes.

Inasmuch as the instantaneous flashes of high intensity desired could not be secured from the prime source of power without unnecessarily increasing the capacity of said source, as well as the size of the conductors for supplying the momentary relatively enormous flow of current when the lamp flashes, I employ a condenser 36 in parallel with the lamp, as shown most clearly in Figure 1. The capacity of the condenser determines the amount of energy in each flash of light and because of this, it is necessary that the capacity of said condenser be proportionate to the size of the lamp. For a lamp as specifically described in which the overall length is 4 feet 4 inches, I have found that a condenser of about 90 microfarads capacity should be employed. With a smaller lamp, that is, one in which the attenuated portion is only 1 foot long and $\frac{1}{4}$ " in diameter, it is only necessary to use a 5 microfarad condenser. The life of such a lamp is as long as 200 hours when flashed not oftener than twenty-four times a second. The high current density in the lamp during flashes changes the spectrum of the gas so that a band spectrum results, superimposed on the line spectrum of the gas. With neon a pinkish-white light is obtained.

I will now describe a preferred manner of operating my lamp for taking motion pictures:

Associated with my lamp 10 is means for taking motion pictures comprising a sprocket drum 37, over which a motion-picture film 38 passes. Said drum is carried on a shaft 39, provided with an interrupter 40, formed as an insulating cylinder 41 with metal contact strips 42 inserted therein, and serving to periodically connect and disconnect the brushes 43 and 44, for making and breaking the circuit from the battery, or other source of direct current 45, through the primary 46 of high voltage coil 47 and condenser 48. The shaft 39 and associated interrupter and sprocket drum may be driven from an electric motor 49 supplied from a suitable source of power 50, through switch 51, starter 52, and speed regulator 53, by means of the gearing 54, 55, and 56. As an alternative, a suitable source of alternating current may be employed for actuating the trigger 28, instead of the battery 45, if desired.

In operation, the relation between the optical center of each separately exposable section of the film and the interrupter is such that the flash occurs each time a section of film, on which a picture is to be taken, is in picture-taking position with respect to the lens of the camera. In other words, the interrupter has caused the circuit to be broken through the coil 47, thereby resulting in a flash in the lamp 10 just when the particular section of film is in position with respect to the lens of the camera, as the break in such a circuit causes a collapse of the magnetic field in the high voltage coil 47, resulting in the development of high potential in the transformer secondary 57, one terminal of which is connected to the trigger 28 and the other grounded, as indi-

cated at 60, reducing the lamp resistance by ionizing the gas in the tube or envelope 11, and causing the instantaneous development of a flash of light of high intensity in said tube or envelope 11.

If the lamp 10 is the sole source of light in taking the motion pictures, it is clear that there is no necessity for any shutter, as the positioning of the film sections may be accurately synchronized with the flashing of the lamp 10, so that each time a film section comes into place it is exposed to the scene illuminated by an instantaneous flash of light from the lamp 10. This does not mean, however, that a motion picture camera with a shutter may not be employed, as it can be so synchronized with the arrangement disclosed that when the shutter is open and the film indexed and at rest, the lamp will be flashed and the picture taken. However, because of the extremely short duration of each flash, the film may be in motion continuously, as it will not travel an appreciable distance during a flash.

The manner in which the light flashes are delivered from the lamp 10, is clearly shown in Figure 3, which indicates that high intensity light flashes 58 are developed which rise to a maximum almost perpendicularly, and fade away nearly as rapidly, in accordance with the current flow through the lamp. In other words, as soon as the discharge of the lamp is initiated by the actuation of the trigger 28, the condenser 36 is immediately discharged with the development of an instantaneous current of very high intensity, which dies down almost as quickly as it rises, while the condenser is being discharged.

It will be understood that the effective portions of the current, for purposes of photography, are those above a certain value represented by the horizontal dotted line, and the current below that portion does not give an effective light. It will therefore be seen that the flashes, insofar as effectiveness is concerned, are very sharply defined and especially suitable for motion-picture work.

Referring now to the embodiment of my invention illustrated in Figure 9, there is shown a stroboscopic lamp 10^a embodying my invention, connected to a source of power by means of conductors 34^a and 35^a in parallel with a condenser 36^a, as in the previous embodiment. In the present embodiment the lamp is connected for taking an ordinary "still" photoflash picture by means of a camera 59. For that purpose, a grid 28^a is employed on the lamp 10^a connected to one terminal of the secondary 57^a of a high-voltage coil 47^a, the other terminal of said secondary being grounded, as indicated at 60^a, as in the previous embodiment. In the present embodiment, the primary 46^a of the high-voltage coil 47^a is connected to a battery, or other source of direct current 45^a, and a condenser 48^a through a key or switch 40^a operable simultaneously with the shutter of the camera 59, so that, when the key is depressed, the condenser and high-voltage coil are charged, and, when released, the shutter is opened to expose the sensitized medium, such as a film or plate, and the lamp flashed for illuminating the object to be photographed. It will be understood that the connection between the shutter and the lamp should be such that the flash is exactly timed to correspond with the exposure of the sensitive medium in the camera. Alternating current trigger actuating means may be substituted for the battery 45^a, as in the previous embodiment.

Figure 10 shows a circuit in which there is no trigger for operating my lamp 10^b. In this case,

the direct current supply, to which the lamp is connected by means of conductors 34^b and 35^b, the condenser 36^b being in parallel as heretofore, is sufficiently high so that a constant break down of the tube would occur if there were no condenser or resistance in the circuit. However, since a condenser discharge is required for satisfactory operation of the lamp, the rate of charging the condenser can be timed, by a proper value of the resistance 61, so that a flash will occur immediately after the condenser is fully charged. It will therefore be seen that by varying the resistance 61, we can time the flashes as desired, as if a trigger were employed, with the exception that the timing is not quite as easily controlled.

Figure 11 illustrates two spectra obtainable when using a lamp embodying my invention. The lower spectrum 62 is of the kind of light obtainable when operating my lamp continuously without a condenser, or other means for producing spaced flashes. In this event the lamp may be operated with a voltage of 1500 and an input current of 2 amperes, the spectrum of the light produced corresponding with that of the filling gas. Inasmuch as I prefer to employ neon, the spectrum is characteristic of that gas.

The upper spectrum 63, illustrated in Figure 11, is that produced when using a condenser, as previously described, for obtaining intense flashes of substantially achromatic light. This shows that the character of the light is changed as compared with the lower spectrum. Instead of having the lines substantially restricted to the red end of the spectrum, we obtain a considerable number of lines toward the violet end, so that substantially achromatic light is produced, which is suitable for photographic and other work requiring light having strong actinic properties.

In explanation of this unusual result, I might say that on account of discharging an enormous current through the enclosed neon gas, said current during a flash being of the order of thousands of amperes rather than units, the electrons of the gas atoms, through which the current passes, are displaced to a much greater extent than when only a small current is passed through the tube, so that momentarily the gas can be considered as dissociated or transmitted, resulting in the development of light vibrations having frequencies not normally attributable to the light developed from neon gas. The result is that a light having a broad band spectrum with superimposed lines is secured, as distinguished from the line or narrow band spectrum of the gas utilized.

In view of the foregoing it will be seen that I have devised a stroboscopic lamp which delivers instantaneous flashes of high intensity of very short duration, which flashes may be accurately spaced and synchronized with movements of associated parts, such as the exposable portions of the film of a motion picture camera, so that use is made of the flashes exactly when they are needed. It will be understood, however, that my lamp is also suitable for other purposes, such, for example, as a constant light source and as a flasher in a lighthouse or beacon.

It will also be seen that by the employment of an excessively intense discharge through the tube containing neon or other suitable gas, a continuous spectrum of substantially achromatic light is obtained, rather than the line spectrum of the gas, whereby such flashes have the desired actinic value for motion-picture and any other work. Because of the high current carried, short heavy

leads should, of course, be used between the condenser and lamp.

Although preferred embodiments of my invention have been illustrated and described, it will be understood that modifications may be made within the spirit and scope of the appended claims.

I claim:

1. In combination with a discharge lamp having an envelope, a pair of electrodes in said envelope, a source of high potential direct current connected to said electrodes, an adjustable resistance in series with said lamp, a condenser in parallel with said lamp, said source of direct current being of such a potential and the adjusted value of the resistance and that of the condenser being so related, that a discharge through said lamp occurs when the condenser is fully charged and terminates upon the condenser being discharged, the adjusted amount of resistance determining the frequency of the discharge, whereby said discharges may be synchronized with moving objects.

2. In combination with a discharge lamp comprising a hollow elongated vitreous envelope having a pair of end chambers connected by an intermediate portion about three feet long and seven-eighths of an inch inside in diameter, an electrode in each end chamber, one of said electrodes being hollow-cylindrical about seven inches long and two inches in diameter, and adapted to act as the cathode and the other being hollow-cylindrical about four inches long and two inches in diameter, and adapted to act as the anode, a source of approximately one thousand volts direct current connected to said electrodes, a condenser of about ninety microfarads capacity in parallel with said lamp, a grid intermediate said electrodes, adapted to act as a trigger, a high-voltage coil one terminal of whose secondary winding is grounded, means connecting the other terminal of said secondary winding to said grid, the primary winding of said coil being in circuit with a condenser and a source of direct current, and means for making and breaking the circuit to said primary winding comprising an interrupter, whereby said grid may be intermittently actuated and the lamp caused to emit intense flashes of light spaced at desired time intervals.

3. In combination with a discharge lamp comprising a hollow elongated vitreous envelope containing an inert monatomic gas free from mercury, and consisting of a pair of end chambers connected by an intermediate portion about three feet long and seven-eighths of an inch in diameter, an electrode in each end chamber, one of said electrodes being hollow cylindrical, about seven inches long, two inches in diameter, closed at one end, partially closed at the other end by an inwardly extending annular flange, adapted to act as a cathode, and reinforced by members angular in section, one leg of each member being connected to the inner surface of said cylinder and the other leg extending radially inward, said inner surface and legs being coated with electron emission material, and the other electrode being hollow cylindrical, about four inches long, two inches in diameter, adapted to act as an anode, and similarly reinforced, the pressure of the contained gas being about thirty-two millimeters, a grid intermediate said electrodes and adapted to act as a trigger, a source of approximately one thousand volts direct cur-

rent connected to said electrodes, a condenser of about ninety microfarads capacity in parallel with said lamp, a high-voltage coil one terminal of whose secondary winding is grounded, means connecting said grid to the other terminal of said secondary winding, the primary winding of said coil being in circuit with a condenser and a source of direct current, and means for making and breaking the circuit to said primary winding comprising an interrupter, whereby said grid may be intermittently actuated and the lamp caused to emit intense flashes of light spaced at desired time intervals.

4. In combination with a discharge lamp comprising a hollow elongated vitreous envelope, containing an inert monatomic gas free from mercury and at a pressure of about thirty-two millimeters, and consisting of a pair of end chambers connected by a relatively long attenuated intermediate tube, an electrode in each end chamber, one of said electrodes being a hollow cylindrical shell closed at one end, partially closed at the other by an inwardly extending annular flange, reinforced by members, angular in section, one leg of each member being connected to the inner surface of said shell and the other extending radially inward, said inner surface and legs being coated with electron-emission material, and said electrode as a whole being adapted to act as a cathode and nearly twice as big as the other electrode, said other electrode being similarly constructed and adapted to act as an anode, a grid for said electrodes and adapted to act as a trigger, a source of direct current connected to said electrodes, a condenser in parallel with said lamp, a high-voltage coil one terminal of whose secondary winding is grounded, means connecting said grid to the other terminal of said secondary winding, the primary winding of said coil being in circuit with another source of direct current, and means for making and breaking the circuit to said primary winding comprising an interrupter, whereby said grid may be intermittently actuated and the lamp caused to emit intense flashes of light spaced at desired time intervals.

5. In combination with a discharge lamp comprising a hollow elongated vitreous envelope containing an inert rare monatomic gaseous filling free from mercury and at a pressure of about thirty-two millimeters, and consisting of a pair of end chambers connected by a relatively long attenuated intermediate tube, an electrode in each end chamber, one of said electrodes being a hollow cylindrical shell, closed at one end, and with its inner surface coated with electron-emission material, said electrode being adapted to act as a cathode and larger than the other electrode, said other electrode being adapted to act as an anode, a grid for said electrodes and adapted to act as a trigger, a source of direct current connected to said electrodes, a condenser in parallel with said lamp, a high-voltage coil one terminal of whose secondary winding is grounded, means connecting said grid to the other terminal of said secondary winding, the primary winding of said coil being in circuit with another source of direct current, and means for making and breaking the circuit to said primary comprising an interrupter, whereby said grid may be intermittently actuated and the lamp caused to emit intense flashes of light spaced at desired time intervals.

PHILIP W. BLACKBURN.