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SYSTEM FOR CONTROLLED INTERMITTENT ILLUMINATION

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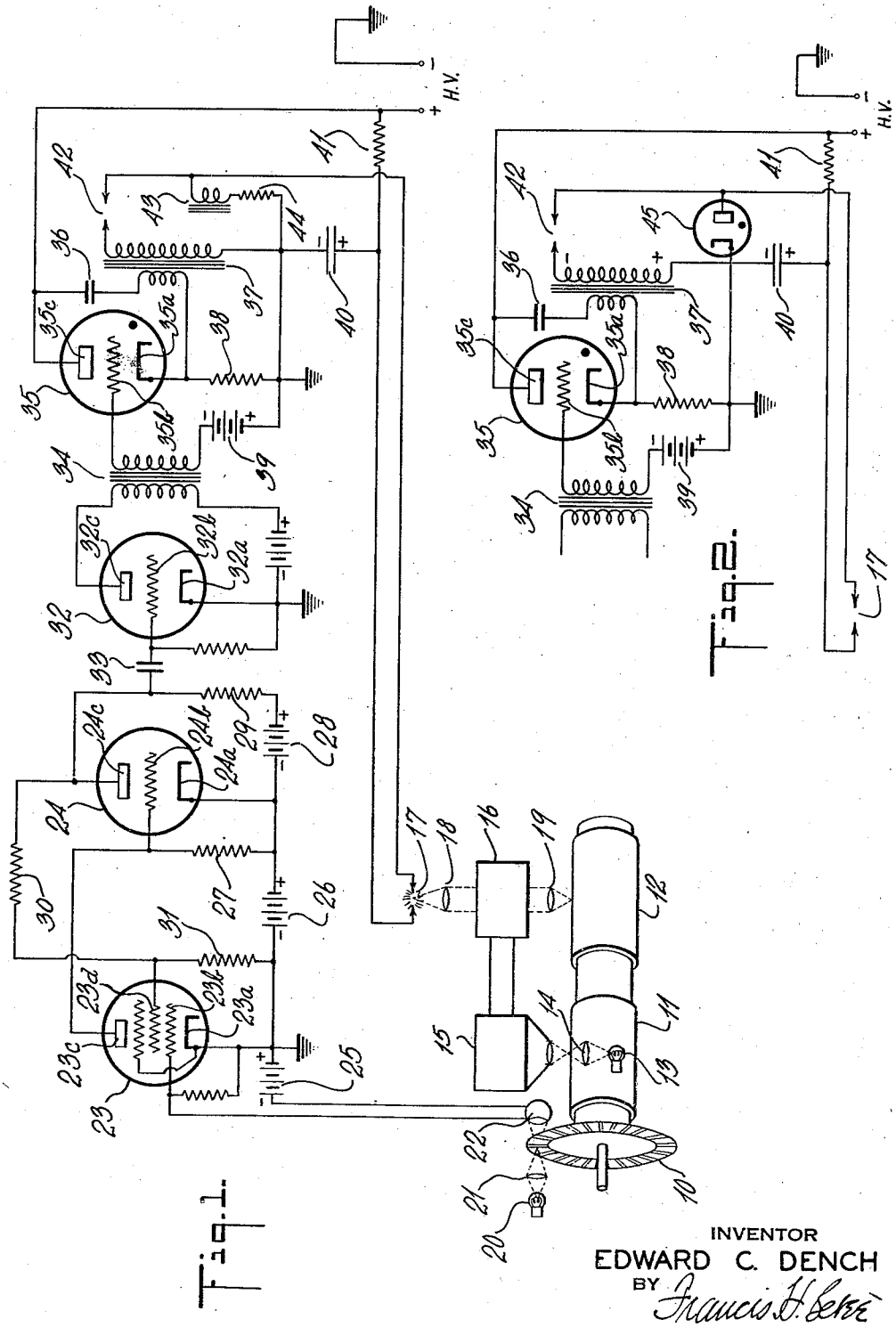


Fig. 1.

Fig. 2.

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SYSTEM FOR CONTROLLED INTERMITTENT ILLUMINATION

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This invention relates to a method and apparatus for producing intermittent illumination of controlled frequency. In particular, the invention is directed to a means for obtaining sharply defined, accurate dot structure in photographic reproductions for use in printing.

Photoelectric machines for preparing photographic reproductions for use in printing are all based on the same fundamental operations. These operations involve the scanning of the picture by one or more photocells, amplification of the signals from the photocells and control of photographic recording apparatus by means of the amplified signals. Since the reproduction must be "structured" or in the form of very fine dots, closely spaced and of varying size and shape, it is customary to interrupt the light emanating from the recording apparatus at a sufficiently high frequency to give the reproduction a "dot structure." (See "A Photoelectric Process of Halftone Negative Making" by H. E. Ives, vol. 15, pp. 96–109, August, 1927, Jour. Opt. Soc. A.)

Numerous methods are employed to accomplish this interruption, but it has been found that those methods which synchronize the interruption frequency with the traverse movement of the picture and the reproductions thereof (i. e. the scanning operation) are often desirable because lack of synchronization causes very uneven dot spacing and consequent unpleasant appearance of the picture. Although the light may be interrupted by commutators or flicker discs rotating in the path of the light and synchronized with the scanning mechanism, the results leave much to be desired because it is very difficult to obtain accurate synchronization, the inaccuracy appearing in the reproduction as a moiré, or faint, varying shift of the different lines of dots.

The problem of the moiré effect has been overcome by fastening the commutator or light interrupter directly to the cylinder which rotates the picture past the photocell, or if the picture is on a flat bed, the commutator is in the form of a straight strip mounted parallel to the direction in which the bed moves past the photocell. Instead of interrupting the recording light, the commutator interrupts a light to a second photcell which may be rigidly fastened to the same support as the scanning photocell. In this way the second photocell scans the commutator in exact synchronism with the first photocell as the first scans the picture, and the signal from the second photocell, suitably amplified, controls the light source of the photo-recording mechanism. This development has permitted the use of photographically prepared commutators of exceptional accuracy.

In utilizing such a photoelectric means for obtaining the light interruption, it is practical to have a source of light for the recording apparatus which can be varied electrically from substantially zero light up to full brilliancy many times a second in order to obtain clearly defined dots in the reproduction. The only kind of light source which has proven successful heretofore is the so-called "glow discharge" tube, because the light emitted by the ionized gases is essentially a function of the instantaneous current in the tube and therefore "follows" the rapid current fluctuations fairly well. The disadvantage of using glow discharge tubes is that the light emitted is relatively weak, or has low actinic power, so that the light must emanate from a wide area, rather than approximating a "point" source of light. Furthermore, photographic recording plates of high sensitivity or speed are necessary, with the result that the dots lack contrast and are not clear-cut.

This invention provides a light of high intensity, approximating a "point" source, and a method of interrupting the light at any practical speed desired. When used in the aforementioned recording circuits, it permits the employment of high contrast (i. e. low sensitivity) photographic film, with the result that the dot structure of the reproduction is unusually clear cut. The invention also includes an apparatus for generating the light and controlling it by electrical means. In particular the invention includes a novel "trigger" circuit for providing an alternating signal or electrical pulse having a steep wave front (although other known trigger circuits may be used), a novel discharge circuit for providing a high intensity source of light, and photoelectric means for controlling operation of the light.

The invention comprises the use of a spark discharge for generation of the light, inasmuch as an electric spark produces an intense light having a sharp build-up and cut-off. By means of the novel circuit involved the duration and intensity of the spark may be adjusted to suit the needs of its particular application.

Although the invention is equally useful for providing this type of intermittent light for any use or application whatever, it is especially designed for use with photoelectric scanning machines such as are employed in the reproduction of the "structured" negatives used in half

tone printing, and it will be described in relation thereto, with reference to the accompanying drawing, in which:

Fig. 1 is a schematic diagram of an apparatus embodying the invention, showing the electrical circuit; and

Fig. 2 is a schematic diagram showing a variation of part of the electrical circuit shown in Fig. 1.

Referring to Fig. 1, a light interrupter or commutator 10 is rigidly mounted on the end of a transparent cylinder 11 around which the picture is wrapped for reproduction. Mounted integrally with the cylinder 11 is a cylinder 12 which carries a photosensitive film on which the reproduction is recorded. Since the commutator 10 and the cylinders 11 and 12 are all mounted together on the same shaft, it is obvious that they will always remain in the same relative position or "in phase," regardless of variations in speed of rotation. The picture carried by the cylinder 11 is illuminated by a light 13 and lens 14, and scanned by a photoelectric apparatus 15 in conventional manner.

The recording light is furnished by discharge of a spark gap 17. The light from the gap 17 is passed through a light valve 16 and focused on the photosensitive film on the cylinder 12 by means of lenses 18 and 19.

The construction and operation of the scanning mechanism, including the cylinders 11 and 12, the apparatus 15 and the light valve 16 is according to standard practice.

By means of a lamp 20 and a lens 21 a beam of light is focused on the commutator 10 and against a photo-cell 22 which is connected to the input of an electronic "trigger" circuit or amplifying channel including a vacuum tube 23 containing a cathode 23*a*, a control grid 23*b*, an anode 23*c*, and a screen grid 23*d*, and a vacuum tube 24 containing a cathode 24*a*, a control grid 24*b* and an anode 24*c*. As shown in the diagram the tube 23 may also have a suppressor grid, but any of the commonly known multi-grid tubes may be used. The trigger circuit provides an alternating voltage having steep wave fronts as the input signal from the photocell 22 rises above, and drops below certain critical values.

The signal from the photocell 22, the energy for which is supplied from a battery 25, which alternates or fluctuates as the commutator 10 is rotated in the path of the beam of light, is impressed on the control grid 23*b*. As the grid voltage becomes less negative with respect to the cathode it must reach a certain critical value before current will flow (or increase in flow) from the cathode 23*a* to the anode 23*c*, which value is determined by the characteristics of the trigger circuit. When the voltage on the control grid 23*b* becomes less negative than this value the current flows from the cathode 23*a* to the plate 23*c* because of the difference in potential maintained by a battery 26. Flow of current through the anode circuit of the tube 23 causes the grid 24*b* to become more negative with respect to the cathode 24*a* because of the voltage drop across a resistance 27. When the grid 24*b* becomes more negative a current normally flowing from the cathode 24*a* to the anode 24*c*, supplied by a battery 28, is reduced or cut off, thus causing the potential of the anode 24*c* to become more positive because of the decrease in current flowing through a resistor 29 in the anode circuit of the tube 24. As the potential of the anode 24*c* becomes more positive the current through resistors 30 and 31 increases and the screen grid 23*d* becomes more positive (with respect to the cathode 23*a*) thus causing the current flowing through the tube 23 to rise abruptly to its maximum value once it has started increasing.

As the signal impressed on the control grid 23*b* becomes more negative and the current in the tube 23 decreases, the control grid 24*b* becomes more positive and the anode 24*c* becomes more negative due to increased flow of current through the tube 24 and the consequent voltage drop across the resistor 29. This causes the screen grid 23*d* to become more negative and thus aid the control grid in reducing the current through the tube 23. In this manner the current through the tube 23 is caused to decrease abruptly when the input signal has reached a critical negative value. Similarly the voltage appearing at the anode 24*c* fluctuates sharply in accordance with the current through the tube 23. Thus the trigger circuit transforms the fluctuating signal from the photocell 22 to an alternating voltage having very steep wave fronts, or resembling a wave of rectangular form.

The output from the trigger circuit is applied to an amplifier circuit including a tube 32 containing a cathode 32*a*, a grid 32*b* and an anode 32*c*, by impressing the voltage of the anode 24*c* on the grid 32*b* through a condenser 33. The condenser 33 is necessary to isolate the voltage on the anode 24*c*. In the tube 32 and its related circuits the signal is amplified in a conventional manner. A transformer 34, which is in the anode circuit of the tube 32, transforms the fluctuating signal with steep wave fronts into separate voltage impulses corresponding to the change in voltage of the output of the tube 32.

The transformer 34 is connected to a spark discharge circuit including a gas discharge tube 35 containing a cathode 35*a*, a grid 35*b* and an anode 35*c*. The tube 35 is preferably a mercury vapor tube of the class known as thyratrons. In the anode circuit of the thyratron 35 is a condenser 36 connected in series with the primary winding of a step-up transformer 37 which may be of the type commonly known as an auto ignition coil. Due to the voltage applied across the cathode 35*a* and the anode 35*c* (e. g. about 1000 volts) the condenser 36 becomes charged. As the impulse from the transformer 34 swings the grid 35*b* in a positive direction the thyratron 35 becomes conducting and the condenser 36 discharges through the thyratron 35 (due to the flow of current from the cathode 35*a* to the anode 35*c*). Due to the flow of current through a resistor 38 in the cathode circuit the potential from the cathode 35*a* to the anode 35*c* is permitted to drop sharply to a very low value. In order to extinguish the thyratron 35 and to permit the grid 35*b* to resume control it is necessary to cut off the current from the cathode 35*a* to the anode 35*c*. Since the condenser 36 and the primary winding of the transformer 37 form an oscillatory circuit (completed through the thyratron 35) the thyratron 35 is extinguished when the oscillatory current passes through zero, whereupon the grid 35*b* resumes control. A battery 39 provides sufficient negative bias on the grid 35*b* to keep the thyratron 35 extinguished until the positive impulse from the transformer 34 is received. Upon cut off of the current through the thyratron 35 the condenser 36 becomes recharged and the circuit is ready for the next discharge. The discharge of the condenser 36 through the primary of the transformer 37 generates a very high volt-

age of short duration in the secondary winding of the transformer 37.

The high voltage supply to the anode 35c also charges a condenser 40 in series with a resistance 41. The condenser 40 is normally charged with the anode supply voltage of the thyratron 35 and is prevented from discharging across the spark gap 17 because a higher voltage is required to break down the resistance of the gap. The very high voltage impulse which is generated in the secondary winding of the transformer 37 is sufficient to break down the resistance of both the gap 17 and an auxiliary spark gap 42, thus causing the condenser 40 to discharge through the gap 17. Since the secondary winding of the transformer 37 is necessarily of very high impedance, another path must be provided for the discharge of the condenser 40 in order that the discharge may be short enough to generate an intense light in the gap 17. This is provided by a small inductance 43 in series with a resistance 44 across the gap 42 and the secondary winding of the transformer 37. The purpose of the inductance 43 is to prevent by-passing of the gap 17 when the gap 42 discharges, and the resistance 44 may be used to control the duration of the discharge of the condenser 40. The resistance 41 prevents short-circuiting of the high voltage supply when the gap 17 discharges. The gap 42 is necessary to permit the voltage generated in the secondary winding of the transformer 37 to reach the maximum possible, as otherwise the inductance 43 and resistance 44 would tend to by-pass the voltage surge from the transformer 37, resulting in insufficient voltage appearing across the gap 17 to initiate the discharge.

Means other than the inductance 43 and the resistance 44 may be used to by-pass the secondary of the transformer 37. For example, a high voltage gaseous rectifier 45 (shown in Fig. 2) may be employed. However, the direction in which the gap 42 discharges must be such as to discharge the condenser 40 or else the rectifier 45 will by-pass both gaps.

By means of the above circuit an intense light, which may be of extremely short duration and which approximates a point source, may be supplied to any device such as a photorecording mechanism. Although a photoelectric frequency control of this light is shown, as this means is the most convenient for the accurate control necessary in recording operations of the kind described, it is not essential to the operation of the circuit. For example, any source of fluctuating voltage or voltage impulses which is sufficiently strong to swing the potential of the control grid 23b each side of the critical values may be used. Likewise, the spark discharge need not be employed to illuminate a scanning machine recording mechanism, but may supply the intermittent illumination for many different devices and uses, such as stroboscopic applications. Also, if the tube 23 has other grids than the control grid 23b and the screen grid 23d, the feedback from the tube 24 may be made to such other grids instead of the screen grid 23d. Any type of light sensitive element may be used for the photocells shown, with appropriate circuit changes which are well known in the art.

The photoreproduction system described above is especially designed for the preparation of structured negatives (or positives) of photographs to be used in half tone printing and like processes. However, the system is equally applicable to the reproduction of facsimiles and other images, and such are included by the term "picture" as used in the claims.

I claim:

1. In a system for the reproduction of pictures by photoelectric scanning and recording thereof on a photosensitive film, means for generating a regular dot structure in the reproduction, which comprises an intermittent source of light to which the photosensitive film is exposed, said source of light consisting of a regularly timed electric spark and a light valve between said spark and said photosensitive film.

2. In a system for the reproduction of pictures by photoelectric scanning and recording thereof on a photosensitive film, means for generating a regular dot structure in the reproduction, which comprises a timed electric spark to which the photosensitive film is exposed through a light valve, and discharging means for said spark in accordance with a predetermined regular timing, said discharging means comprising an illuminating spark gap across which said spark discharges, a condenser connected across said spark gap, means for charging said condenser, and means for breaking down the resistance of said spark gap in accordance with a timed voltage impulse.

3. In a system for intermittent illumination, a device for causing a spark discharge in accordance with a received signal, which comprises a high-voltage step-up transformer, means for supplying a voltage impulse to the primary of said transformer, an illuminating spark gap, a condenser connected across said illuminating spark gap, means for charging said condenser, a second spark gap connected between one side of said illuminating spark gap and the secondary of said transformer, and means for by-passing said second spark gap with respect to the discharge of said condenser across said illuminating spark gap but not by-passing said illuminating spark gap with respect to the discharge of the secondary of said transformer across both of said spark gaps.

4. Device as claimed in claim 3 in which said means for supplying a voltage impulse to the primary of said transformer comprises, in combination, a gaseous electronic valve containing a cathode, a grid and anode, a condenser and the primary of said transformer connected in series across said anode and said cathode, and means for charging said condenser.

5. Device as claimed in claim 3 in which said means for by-passing said second spark gap comprises an inductance connected from the common side of said spark gaps to the secondary of said transformer.

6. Device as claimed in claim 3 in which said means for by-passing said second spark gap comprises a gaseous electronic valve connected between the common side of said spark gaps and the secondary of said transformer so as to permit the flow of current in said electronic valve upon discharge of said illuminating spark gap and to prevent the flow of current in said electronic valve from the discharge of said second spark gap.

7. Device as claimed in claim 3 in which said means for supplying a voltage impulse to the primary of said transformer comprises, in combination, a gaseous electronic valve containing a cathode, a grid and anode, a condenser and the primary of said transformer connected in series across said anode and said cathode, and means for charging said condenser, and in which said means

for by-passing said second spark gap comprises an inductance connected from the common side of said spark gaps to the secondary of said transformer.

8. In a system for intermittent illumination, a device for causing a spark discharge in accordance with a received signal; which comprises a high-voltage step-up transformer, means for supplying a sharp voltage impulse to the primary of said transformer comprising a gaseous electronic valve having a cathode, a grid and an anode, a first condenser and the primary of said transformer connected in series across said cathode and said anode, means for charging said first condenser, and an electronic amplifying channel adapted to produce a voltage impulse having steep wave fronts; an illuminating spark gap, a second condenser connected across said illuminating spark gap, means for charging said second condenser, a second spark gap connected between one side of said illuminating spark gap and the secondary of said transformer, and means for by-passing said second spark gap with respect to the discharge of said second condenser across said illuminating spark gap but not by-passing said illuminating spark gap with respect to the discharge of the secondary of said transformer across both of said spark gaps.

9. Device as claimed in claim 8 in which said means for by-passing said second spark gap comprises an inductance connected from the common side of said spark gaps to the secondary of said transformer.

10. In a system for the reproduction of pictures by photoelectric scanning and recording thereof on a photo-sensitive film, means for generating a dot structure in the reproduction in synchronism with the scanning of the picture, which comprises a light interrupter and a light sensitive element positioned to receive a beam of light interrupted by said interrupter, means for moving said interrupter in relation to said light sensitive element so that the interruption frequency of the light received by said light sensitive element is directly proportional to the rate of scanning, an electronic amplifier connected to said photocell, a spark discharge circuit controlled by said amplifier, and a light source for the photo-recording operation consisting of a spark gap the discharge of which is controlled by said spark discharge circuit.

11. Device as claimed in claim 10 in which said spark discharge circuit comprises a high-voltage step-up transformer, means for supplying a voltage impulse to the primary of said transformer, an illuminating spark gap, a condenser connected across said illuminating spark gap, means for charging said condenser, a second spark gap connected between one side of said illuminating spark gap and the secondary of said transformer, and means for by-passing said second spark gap with respect to the discharge of said condenser across said illuminating spark gap but not by-passing said illuminating spark gap with respect to the discharge of the secondary of said transformer across both of said spark gaps.

12. Device as claimed in claim 10 in which said electronic amplifier is adapted to produce a voltage impulse of steep wave fronts, and said spark discharge circuit comprises a high-voltage step-up transformer, a gaseous electronic valve having a cathode, a grid and an anode, a first condenser and the primary of said transformer connected in series across said cathode and said anode, means for charging said first condenser, an illuminating spark gap, a second condenser connected across said illuminating spark gap, means for charging said second condenser, a second spark gap connected between one side of said illuminating spark gap and the secondary of said transformer, and an inductance connected from the common side of said spark gaps to the secondary of said transformer.

13. Device as claimed in claim 10 in which said electronic amplifier has the characteristics of providing a sharp change of output for a critical level of input.

14. Device as claimed in claim 10 in which said electronic amplifier is a trigger circuit comprising a first electronic valve of the multi-grid type, a second electronic valve containing a grid, a connection between the first valve anode and the second valve grid, an impedance connected between said second valve grid and the second valve cathode, a source of potential connected so as to impress a positive potential on the second valve anode with respect to said second valve cathode, an impedance connected between said source of potential and said second valve anode, an impedance connected between said second valve anode and a first valve grid, an impedance connected between said first valve grid and the first valve cathode, and a source of potential connected so as to impress a positive potential on said first valve anode with respect to said first valve cathode; and said spark discharge circuit comprises a high-voltage step-up transformer, a gaseous electronic valve having a cathode, a grid and an anode, a first condenser and the primary of said transformer connected in series across said cathode and said anode, means for charging said first condenser, an illuminating spark gap, a second condenser connected across said illuminating spark gap, means for charging said second condenser, a second spark gap connected between one side of said illuminating spark gap and the secondary of said transformer, and an inductance connected from the common side of said spark gaps to the secondary of said transformer.

15. In a system for intermittent illumination, a device for causing a spark discharge in accordance with a received signal, which comprises an illuminating spark gap, a condenser connected across said illuminating spark gap, means for charging said condenser, a second spark gap connected between one side of said illuminating spark gap and a source of high voltage, and means for by-passing said second spark gap with respect to the discharge of said condenser across said illuminating spark gap but not by-passing said illuminating spark gap with respect to the discharge of the said source of high voltage across both of said spark gaps.

16. In a system for intermittent illumination comprising an illuminating spark gap, a condenser connected across said spark gap, and means for discharging said condenser comprising an auxiliary spark gap, synchronous means for causing said auxiliary spark gap to break down and transfer at least part of the voltage existing across said auxiliary gap to said illuminating spark gap to cause said illuminating spark gap to break down and discharge said condenser.

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