

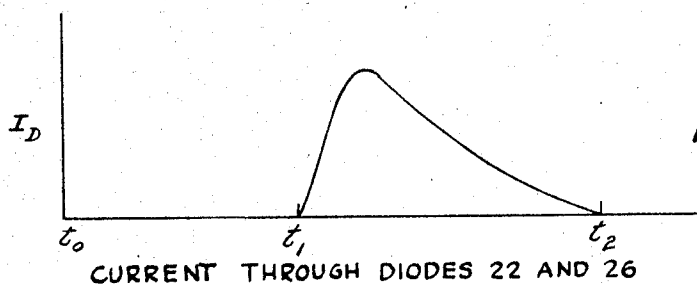
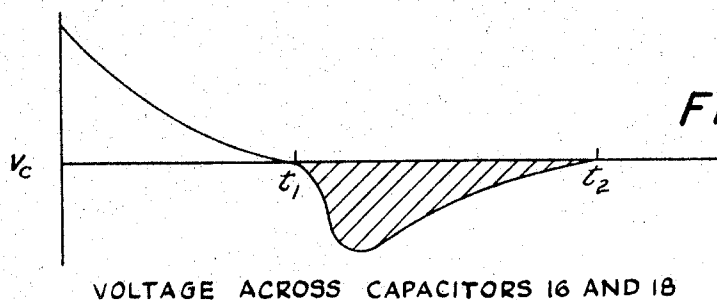
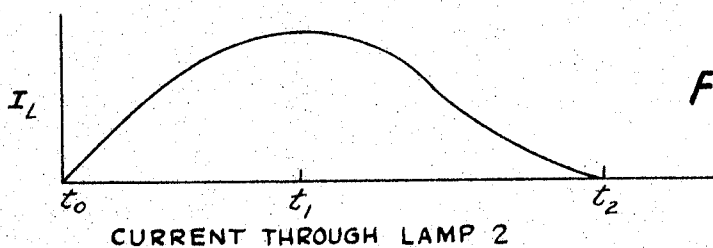
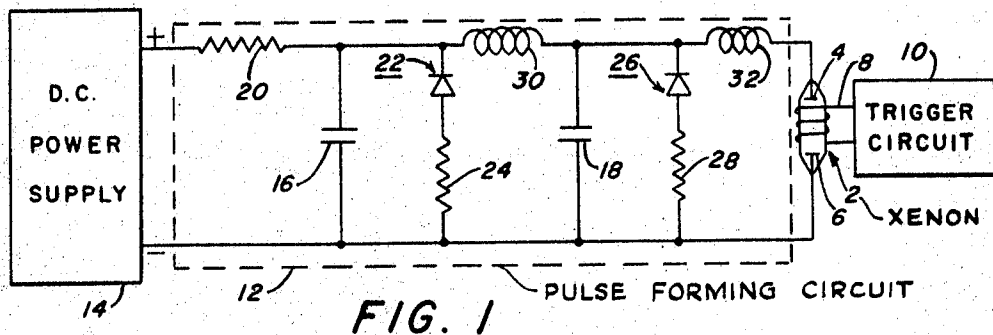
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FLASHLAMP FOR ELECTROSCOPIC TONER

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FLASHLAMP FOR ELECTROSCOPIC TONER

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5 Claims

ABSTRACT OF THE DISCLOSURE

A toner fusing flashlamp system wherein a pulse shaping circuit employs an asymmetrical current conducting device to provide a current bypass for a capacitive element thereby reducing the voltage reversal across this element as well as the flashlamp.

This invention relates generally to pulse forming circuits and, more specifically, to pulse forming circuits for gas flashlamps.

In xerographic reproduction, as described in U.S. Patent No. 2,297,691, issued to C. F. Carlson, a fixing step is required before a permanent copy of the image to be reproduced can be obtained. In this fixing step, the electroscopic toner as described in Wise's U.S. Patent No. 2,618,522, adhering electrostatically in imagewise configuration to a recording medium, such as ordinary paper, for example, is heated to such a degree that it melts and fuses with the fibers of the recording paper. This fused condition of the toner and the recording paper is then made permanent in a subsequent drying process thereby completing the fixing step.

The heating of the toner in the fixing step is preferably carried out in such a manner as to leave the recording paper substantially unaffected by the heat.

Also, this heating must be very rapid in order to accommodate a quick succession of recording sheets such as may be expected from a communications printer which records information on numerous small data-processing cards or the like.

In addition to the rapid heating cycle, the toner-fusing heat is preferably generated with a minimum energy input.

One method of providing sufficient heat for the toner is the use of a flash fuser which generally includes a gas lamp, such as a xenon lamp, and suitable optics to direct radiant energy from the lamp onto the surfaces of recording sheets as they are conveyed past the fuser.

This radiant energy is reflected by those areas of the recording sheets which do not bear toner, while the toner itself on the other areas of the recording sheets absorb the radiant energy in the form of heat which is sufficient to effect the desired fusing.

The circuits associated with the flash fuser lamp must be designed not only to operate efficiently and reliably, but also to operate in such a manner as to maximize their own usefulness as well as that of the fuser lamp. Under the condition of very rapid and sometimes random on-off operation, the life of the fuser lamp and associated circuit components can be very limited. This limited longevity is reflected in a commercial sense by unreliability, and frequent repair maintenance, including costly replacements.

Therefore, it is an object of the present invention to improve apparatus used in flash fusing electroscopic toner images.

Another object of this invention is to maximize the life of a flash fuser including its circuit components and flash lamp.

In addition, it is also an object of this invention to improve the efficiency and reliability of an efficient, reliable, flash fuser apparatus.

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These and other objects of the invention are accomplished in accordance with the principles of the present invention by simultaneously shaping the pulse waveform passing through a flashlamp and controlling the voltage reversal across this lamp. In one aspect of the invention, an asymmetrical current conducting device is utilized to provide a current bypass for a capacitive element thereby reducing the voltage reversal across this polarity sensitive element of the circuit as well as the flashlamp.

For a better understanding of the present invention as well as other objects and features thereof, reference may be made to the following detailed description of the invention to be read in connection with the accompanying drawings wherein:

FIGURE 1 illustrates schematically a preferred embodiment of the fuser apparatus in accordance with the present invention;

FIGURES 2A, B, and C illustrate explanatory waveforms helpful in understanding the operation of the apparatus of FIGURE 1.

As shown in FIGURE 1 the fuser apparatus includes a flashlamp 2 which may comprise a quartz tube filled with a suitable gas, for example, xenon gas, and contains two electrodes 4 and 6, one sealed at each end thereof. A trigger coil 8 encloses the tube of the flash lamp 2 intermediate the two electrodes 4 and 6. This coil 8 is coupled to a conventional trigger circuit 10, such as a simple relay circuit or controlled rectifier circuit, which when activated provides a suitable high voltage pulse to the trigger coil 8. This pulse through the coil 8 generates a high field in the lamp between the electrodes 4 and 6 to which is applied a voltage difference from the power supply thereby causing the gas in the tube to ionize a conductive arc between the flashlamp's electrodes. Upon ionization, the flashlamp presents a low impedance to the pulse forming circuit, generally designated by the reference numeral 12, which will be described in more detail hereinafter.

A conventional direct current power supply 14 provides a suitable voltage across the input terminals of the pulse forming circuit 12. This pulse forming circuit 12 functions not only to provide a pulse to the flashlamp 2 of such an amplitude and duration to maximize the life of the tube but also to effect the emission of radiant energy from the tube to achieve the desired degree of fusion between the toner and the fiber of the recording sheets.

Referring now to FIGURE 2 in addition to the circuit of FIGURE 1, it is seen that at an initial point in time before the triggering of the flashlamp 2, capacitors 16 and 18 are charged to an initial potential dependent upon the value of capacitance, the resistance of charging resistor 20 and time. In parallel with capacitor 16 are a series connected diode 22 and resistor 24. Similarly, capacitor 18 is paralleled by a series connected diode 26 and resistor 28. The diodes 22 and 26 are connected such that at the aforementioned initial point they are reversed biased and hence non-conducting. Between the junction of diode 22 and capacitor 16 and the junction of the capacitor 18 and diode 26 there is connected an inductor 30. Intermediate this latter junction and one electrode 4 of the flashlamp 2 is connected another inductor 32.

If, immediately after the aforementioned initial point is reached or at a time t_0 the flashlamp 2 is triggered, the capacitors 16 and 18 will commence to discharge through the inductors 30 and 32 and the low impedance of the ionized flashlamp 2. The current flow through the inductors 30 and 32 will follow a characteristic curve which is proportional the value of the inductances. The current through the lamp from the initial point t_0 is illustrated in FIGURE 2A for a typical embodiment in accordance with the present invention. It will be seen from this waveform

that the initial lamp current has a gradually increasing amplitude.

The inductors 30 and 32 limit the peak current which can be applied to the flashlamp 2. As the rate of current flow through the conductors begins to decrease, the energy stored in the magnetic field of the inductors commences to decay and the inductors begin to supply current to the lamp. In FIGURE 2A this point of operation corresponds to t_1 . Therefore, the stored energy in the inductors 30 and 32 is allowed to be dissipated in the lamp. The diode branches of the circuit paralleling the capacitors 16 and 18 are accordingly biased in the forward direction at time t_1 and provide a current bypass path for the respective capacitors. This low resistance path formed by the conducting diodes 16 and 18 reduces the extent to which the normally negative plates (in the drawing those plates connected to the negative terminal of the power supply 14) of the capacitors 16 and 18 go positive with respect to the other plates of these capacitors. This reduction in the amount of voltage reversal experienced across the capacitors will consequently effect a similar reduction in the voltage reversal across the electrodes 4 and 6 of the flashlamp 2.

The small amount of voltage reversal resulting across capacitors 16 and 18 can be further reduced by eliminating the low value resistors 24 and 28 shown in the circuit of FIGURE 1. These resistors can be utilized to limit the current through their respective diodes to prevent damage thereto. However, because of the short duration of the current flow through these diodes, these resistors 24 and 28 are to be considered optional. Suitable diodes of sufficient peak current handling capabilities can be obtained and may be used as a substitute for the series combinations of a diode and current limiting resistor. The current flow through the diodes is characteristically illustrated in the waveform of FIGURE 2C for a typical embodiment.

The characteristic voltage on the capacitors 16 and 18 of FIGURE 1 is illustrated in FIGURE 2B for a typical embodiment the cross hatched area representing the voltage reversal across these components as well as across the flashlamp.

When the voltage and current decrease to the extinguishing point of the lamp, the gas therein will deionize thereby terminating lamp conduction. At this point, represented by t_2 in the waveforms of FIGURES 2A, B, and C, the capacitors 16 and 18 in the pulse forming circuit 12 will recharge in preparation for the next fusing cycle.

This significance of the above described fusing apparatus in regard to increasing reliability, useful life, and operational desirability may be made more apparent when the following aspects are considered.

A flashlamp such as the one used in the above-described fuser is subject to cathode sputtering during reverse polarity excursion. As is known sputtering results in a blackening of the tube caused by a deposition of opaque evaporated metal from this electrode on the inside surfaces of the flashlamp tube. This blackening of the inner walls of the tube generally occurs around the cathode end of the lamp and can be traced to high peak currents and flashlamp temperatures along with ionic bombardment which create an erosion of this electrode, usually made of tungsten.

After continued sputtering over a period of time, this blackening enlarges in a direction toward the other end of the tube. It is evident that sputtering is undesirable since it effectively decreases the amount of radiant energy which passes through the tube wall of the flashlamp to the toner to be fused. As was noted in the discussion of the operation of the circuit of FIGURE 1, the pulse forming circuit 12 acts to limit the peak current to the lamp as well as to effectively shape the leading edge of the current pulse applied to the lamp. By making this edge of the current pulse of a gradually increasing nature

and limiting the amplitude of this pulse and hence sputtering, electrode erosion is reduced.

It can be readily appreciated that, if there is permitted a substantial voltage reversal across the flashlamp during the ionization period thereof, the electrodes in the flashlamp will effectively be interchanged, i.e., the cathode electrode becomes the anode electrode and vice versa. When the voltage reversal is sufficient to permit this interchange, sputtering is generated not only from the usual cathode electrode but also from the anode electrode thereby substantially increasing the total amount of sputtering in the flash tube.

The capacitors used in the circuit of FIGURE 1 may take the form of metalized energy storage capacitors, the metal plates of which tend to flex upon the occurrence of a voltage reversal thereacross. These capacitors present a very low resistance as well as inductance to the circuit and are desirable from the aspect of power conservation. However, after numerous voltage reversals, the metal plates tend to weaken and move closer to each other thereby altering the capacitance of the capacitor and shortening its useful life. By providing the bypass branch of the diode and resistor, or the diode alone, these undesirable voltage reversals are reduced to an acceptable minimum thereby maximizing the life of these capacitors. It is also appreciated that the use of polarized capacitors is also possible in the circuit of FIGURE 1 without exposing these capacitors to the damaging effect of excessive voltage reversals.

Because of the fact that a flash fuser must be able to have an operational cycle of such a frequency as two cycles per second, the reduction in any voltage reversal across the capacitors of the circuit in FIGURE 1 results in a more rapid recharging of these capacitors from the power supply 14 to make them available for the next fusing cycle.

In addition to the capacity for rapid recycling of the circuit in FIGURE 1, less energy is required from the power supply 14 to recharge the capacitors to the desired level after each fusing cycle.

In view of the aforementioned remarks, it is readily seen that a very efficient and reliable fusing apparatus has been disclosed in the form of the present invention. These superior results are achieved through the use of a unique pulse forming circuit which desirably shapes a current pulse to the flashlamp itself while at the same time reduces undesirable voltage reversals across the capacitive elements of the circuit as well as the flashlamp itself.

It is understood that the waveforms of FIGS. 2A, B, and C are not intended to be actual representations for the pertinent currents and voltages. However, they are intended to show relative waveshapes and occurrence in time.

While the invention has been described with reference to the circuit disclosed herein, it is not confined to the details set forth since it is apparent that certain electrical equivalent components may be substituted for the components of the preferred circuit without departing from the scope of the invention. Thus, for example, although two capacitors and two inductors are disclosed in the preferred embodiment of FIGURE 1, it is readily apparent that the capacitances and inductances may be lumped into a single inductance and capacitance with a single diode branch in parallel with the capacitance forming a current bypass path therefor.

As previously mentioned, the current limiting resistors in the diode branches are optional and may be eliminated by a discrete selection of the diodes to be used.

Therefore, it is intended that this invention cover such modifications or changes as may come within the scope of the invention as defined by the following claims.

What is claimed is:

1. An electroscopic toner fuser apparatus comprising:
 - (a) lamp means for emitting electroscopic toner heat-

- ing radiation when triggered in response to a trigger signal;
- (b) a source of electrical energy;
- (c) capacitive means for storing an electrical charge of either of two polarities relative to said source; 5
- (d) a charging path means coupled between said source and said capacitive means for translating charging current to effect a charge storage thereby of one polarity;
- (e) a discharging path means coupled between said capacitive means and said lamp means for discharging said capacitive means through said lamp means when the latter is triggered; 10
- (f) a symmetrical current conducting means coupled in electrical parallel relation with said capacitive means for shunting current tending to effect a charge storage of said other polarity by said capacitive means; and 15
- (g) trigger means coupled to said lamp means for effecting the triggering thereof whereby said lamp is caused to emit heating radiation of sufficient intensity to effect fusing of toner material with the fibers of a recording paper in a xerographic reproduction apparatus. 20
2. An apparatus as defined in claim 1 wherein: 25
- (a) said charging path means includes a charging resistance element;
- (b) said capacitive means includes a capacitor;
- (c) said discharging path means includes an inductor; and 30
- (d) said asymmetrical current conducting means includes a diode.
3. An electroscopic toner fusing apparatus comprising:
- (a) two terminals adapted to be connected to a source of electrical energy; 35
- (b) capacitive means coupled to said terminals for storing electrical energy;
- (c) lamp means for emitting electroscopic toner heating radiation including an enclosed tube containing an ionizable gas, and at least two spaced apart electrodes; 40
- (d) triggering means cooperably juxtapositioned relative to said lamp means and responsive to a trigger signal for effecting ionization of said ionizable gas in the presence of a suitable electric field across said electrodes during a period of ionization; 45
- (e) inductive means coupled to said capacitive means for initially limiting current through said inductive means during said period of ionization;
- (f) polarity sensitive by-pass means coupled to said capacitive means for effecting a low resistance current path electrically parallel thereto during a terminal portion of said ionization period interval; and 50
- (g) Circuit means for individually coupling one of said electrodes to said inductive means and to said

by-means, respectively, whereby said lamp is caused to emit heating radiation of sufficient intensity to effect fusing of toner material with the fibers of a recording paper in a xerographic reproduction apparatus.

4. An apparatus as recited in claim 3 wherein:
- (a) said inductive means and said capacitive means include an inductor and capacitor, respectively; and
- (b) wherein said by-pass means includes a diode having two terminals, one of which is coupled to one of said electrodes by said circuit means and the other of which is coupled to the junction between said inductive means and said capacitive means.
5. An electroscopic toner fuser apparatus comprising:
- (a) two terminals adapted to be connected to a source of electrical energy;
- (b) a first capacitor coupled across said terminals;
- (c) first asymmetrical current conducting means coupled to one of said terminals and in electrical parallel relation to said first capacitor for selectively providing a low resistance path thereacross;
- (d) a circuit point;
- (e) a first inductor coupled between said first capacitor and said circuit point;
- (f) a second capacitor coupled between said circuit point and the other of said terminals;
- (g) second asymmetrical current conducting means coupled in electrical parallel relation to said second capacitor for selectively providing a low resistance path thereacross;
- (h) lamp means for emitting electroscopic toner heating radiation including an enclosed tube containing an ionizable gas, and at least two spaced apart electrodes;
- (i) a second inductor coupled between said circuit point and one of said electrodes of said lamp means;
- (j) conductive means for coupling the other of said electrodes of said lamp means to the other of said terminals; and
- (k) triggering means cooperably juxtapositioned relative to said lamp means for effecting ionization of said ionizable gas.

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