United States Patent

Zoppoth

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[54] XEROGRAPHIC FUSING METHOD AND APPARATUS

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[52] **U.S. Cl.** **355/3,** 219/216
[51] **Int. Cl.** **G03g 15/00**
[58] **Field of Search**..355/3; 219/216

[56] **References Cited**

UNITED STATES PATENTS

3,187,162	6/1965	Hojo	355/3 X
2,844,123	7/1958	Hayford	355/16 X

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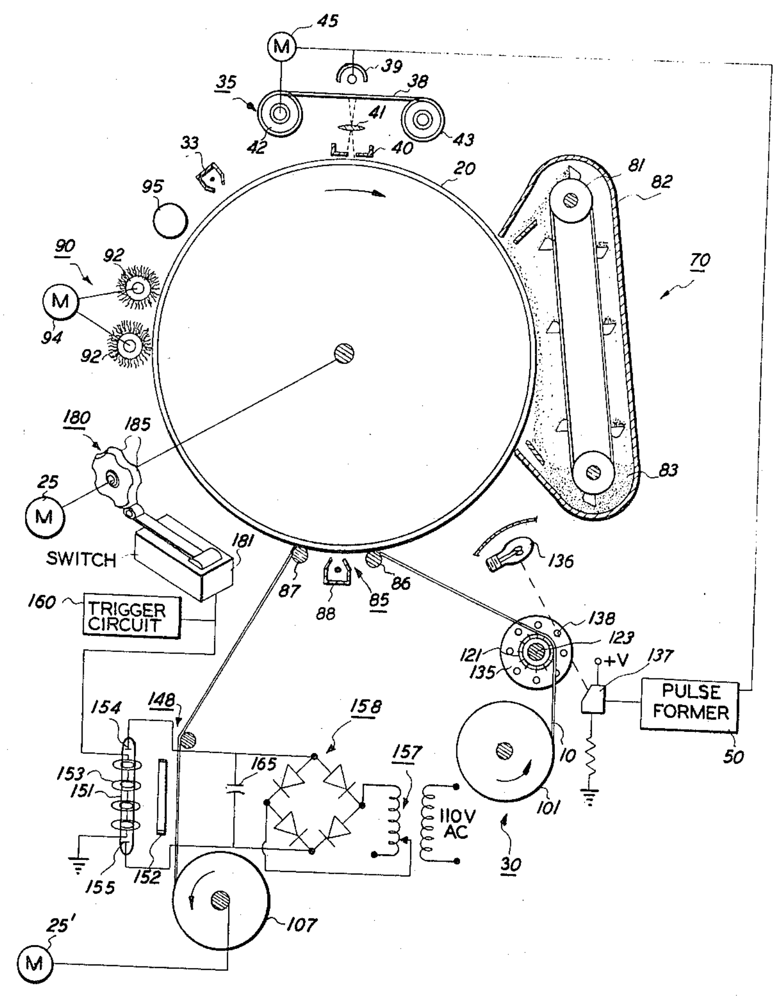
[57] **ABSTRACT**

This invention relates generally to xerographic method and apparatus for reproducing information on materials such as photographic film or the like and more particularly to method and apparatus for fusing electroscopic powder images to materials such as processed film and the like having photographic images thereon. The invention is characterized in that electroscopic powder images are fused to film material by exposing the images film material to selected wavelengths of radiation which are transmitted by an optical filter interposed between the film material and an intermittently activated source of short duration high intensity electromagnetic radiations.

9 Claims, 3 Drawing Figures



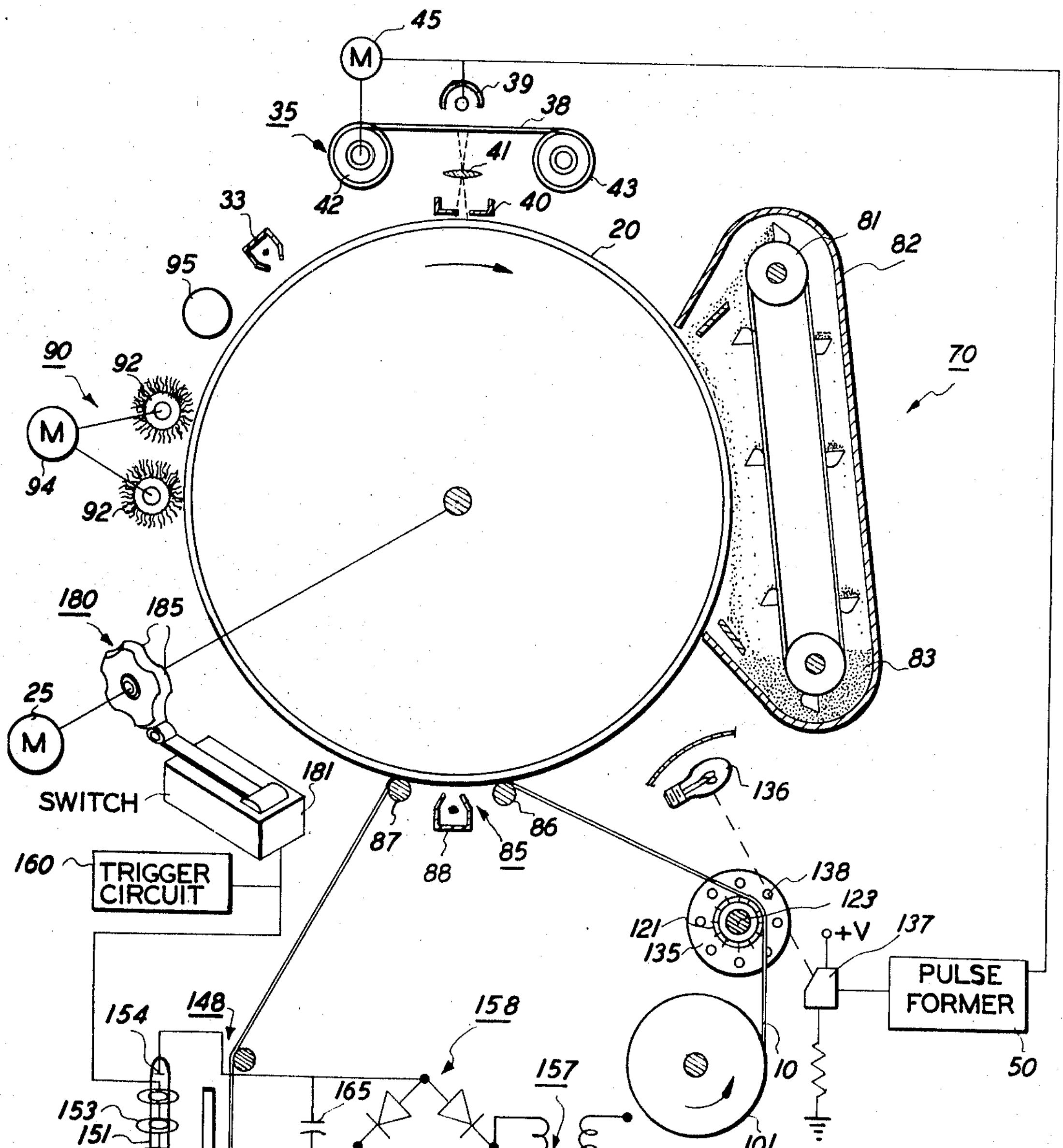
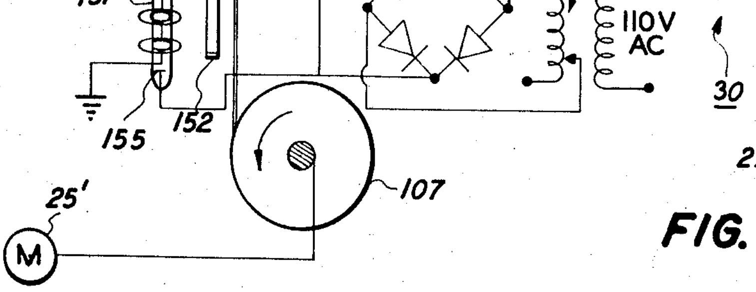



FIG. 1

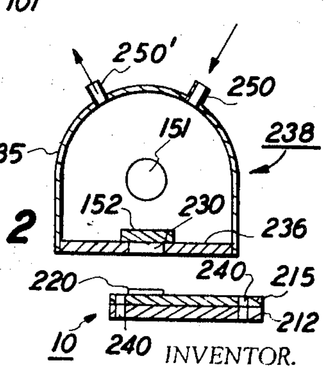


FIG. 2

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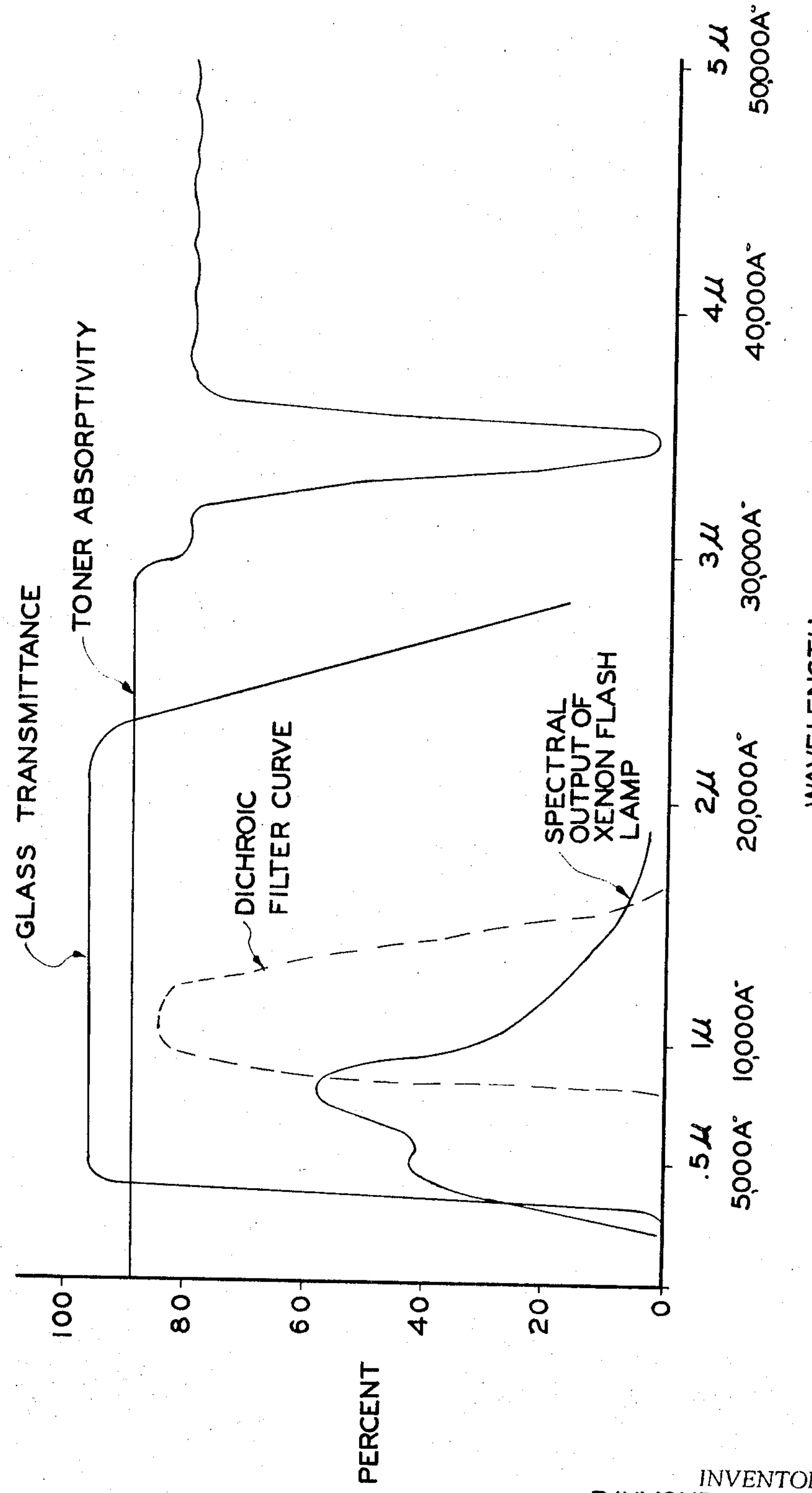

FIG. 3

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XEROGRAPHIC FUSING METHOD AND APPARATUS

After a photographic image has been produced on film it is often desirable to add additional information such as titling, coding, numbering, etc. In the past mechanical methods for adding information have been employed such as stamping the film with printing characters as the film is transported past a printing station on a conveyor transport. This technique is time consuming and requires laborious adjustments to insure proper registration between the printing characters and the prearranged marking areas on the film. This particular method has not proven entirely satisfactory.

Another approach to the problem has been to expose the film to superimposed identifying information simultaneously with the initial exposure. Subsequent processing therefore produces both the original subject matter and its identifying code simultaneously. However, this approach has the disadvantage of not being able to add information after the raw film stock has been processed.

Techniques for adding information after processing by other than mechanical means have been employed. One such method includes coating the emulsion in the marking areas with a protective coating such as paraffin and impressing photoengraved dyes containing the information onto the coating. This displaces the coating and exposes the emulsion in image configuration. Thereafter the emulsion is removed by allowing an etching agent such as sodium hypochlorite to act upon the exposed parts of the emulsion. However this approach has the disadvantage of being expensive and time consuming in that additional processing is required.

Probably the most desirable and efficient approach has been the utilization of the xerographic process. One such technique is disclosed in Carlson patent U.S. Pat. No. 2,297,691, in which a powder image of a thermoplastic resin is applied to the film in the marking areas. While it is conventional to fuse xerographic images to a support base by means of heat sufficient to soften the resin, this fusing method has heretofore been unsatisfactory with the use of film in which the film base is itself heat sensitive. In practice it has been found that when fusing heat is applied, the film emulsion is scorched and discoloration occurs, and the film base may become warped and distorted. As a result when employing xerography it has been necessary to utilize a solvent vapor which plasticizes the powder image but which leaves the film base unaffected. Because of the problems in handling a vapor and the expendable nature of a vapor it is desirable to use alternative methods to vapor fixing of powder images such as heat fusing.

Accordingly, it is an object of my invention to provide improved method and apparatus for fusing electroscopic toner images rapidly onto a film base without incurring damage to the film base.

It is another object of my invention to provide improved method and apparatus for fusing electroscopic toner images rapidly onto a film base without incurring damage to the previously formed images contained thereon.

Another object of my invention is to provide improved method and apparatus for flash fusing electroscopic toner images rapidly onto a film base.

Another object of my invention is to provide improved method and apparatus for fusing electroscopic toner images rapidly onto a film base by effectively controlling the amount of radiation which is applied to the toner images and film base.

These objects are attained by exposing a film base having electroscopic powder images thereon to selected wavelengths of radiation transmitted by an optical filter from an intermittently activated source of short duration high intensity electromagnetic radiations. Other objects of the invention will become readily apparent to those skilled in the art when read in connection with the following detailed description and drawings wherein:

FIG. 1 is a schematic sectional view of a drum type xerographic machine illustrating one embodiment of the invention;

FIG. 2 is a diagrammatic sectional view of a flash fusing station according to one embodiment of the invention, and

FIG. 3 is a diagram of curves showing the spectral output of a Xenon flash lamp with quartz envelope, toner absorptivity, the filtering effects of a dichroic filter, and the transmittance of another type of glass which may be used for the envelope of the flash lamp.

FIG. 1 illustrates one embodiment of an apparatus utilizing a controlled flash fusing technique. As shown therein referenced information is recorded on a film web **10** to identify image frames thereon. The information to be recorded is exposed to a uniformly electrostatically charged xerographic drum generally designated **20** through exposure station **35** producing an electrostatic image of the information. The image then contained on the drum is developed and transferred to web **10** at transfer station **85**. Thereafter the transferred information is fused to the web at a fusing station generally designated **148**.

The automatic xerographic reproducing apparatus employed herein, the detailed operation of which is more fully set forth in U.S. Pat. No. 3,049,968, includes a xerographic drum **20** which is coated on its outer surface with a layer of photoconductive insulating material such as vitreous selenium and is rotated about its axis in the direction of the arrow by a motor **25**.

A charging apparatus **33** is provided for placing an initial charge on the drum **20**. Charging apparatus **33** may comprise an array of one or more corona discharge electrodes extending transversely across the surface of drum **20** and energized from a high potential source.

Exposure station **35** may include a master film strip **38** containing information to be recorded, flash lamp **39**, lens **41**, and aperture **40**. Film strip **38** is supported between a supply reel **43** and a takeup reel **42** which is intermittently driven by stepping motor **45**. Both lamp **39** and motor **45** are energized by signals from pulse former **50** which receives an input signal responsive to the advance of web **10** as will be hereinafter more fully explained. The signals are synchronized so as to energize motor **45** and advance film strip **38** after each exposure from flash lamp **39**. The particular information contained in a given frame of film strip **38** is illuminated by a flash from lamp **39** and through lens **41** and aperture **40** is projected onto xerographic drum **20**, thereby exposing the drum.

As the drum **20** is rotated, exposed portions thereon are developed at developing station generally designated **70**. A conveyor **81** operating in housing **82** lifts developer material **83** from a supply at the bottom of the housing to above drum **20** and releases it onto the drum over which the developer material cascades until returning to the bottom of housing **82**. The developer material preferably comprises a mixture of relatively large carrier particles and small carbon black pigmented thermoplastic resin toner particles as described in U.S. Pat. Re. No. 25,136. As developer material **83** cascades over the drum, the toner particles are detached from the carrier particles and deposited onto the surface in accordance with the latent images thereon thus forming visible images.

Continued rotation of drum **20** advances the developed images thereon to transfer station, generally designated **85**, at which the electroscopic powder images are transferred to web **10**. At the transfer station web **10** is held in contact with drum **20** by a pair of pressure rollers **86** and **87**. A second corona charging device **88**, similar to corona charging device **33**, places a transfer charge on the web effecting the transfer thereto.

A drum cleaning and discharge station, generally designated **90**, is provided for cleaning and discharging the drum after transfer. A pair of cleaning brushes **92** driven by a synchronous motor **94** remove any toner particles remaining on the drum. A source of illumination **95** exposes the drum thereby dissipating any residual charge remaining thereon prior to commencing the next cycle.

Transport assembly, generally designated **30**, serves to systematically advance film web **10** thereby insuring transfer of the developed images in registration with the appropriate marking areas along the film. Web **10** is advanced from supply spool **101** to a takeup spool **107** by means of a motor **25'**. Between supply spool **101** and pressure roller **86**, the web **10** passes over idler sprocket **121**, or other suitable friction drive means rotatably mounted on shaft **123**. Timing disc **135** having a diameter somewhat larger than that of idler sprocket **121** is mounted in juxtaposition and rotatable therewith. A plurality of apertures **138** in uniform angular relationship are radially spaced about timing disc **135**. Axially disposed on opposite sides of timing disc **135** is a lamp **136** and a photocell **137**. Lamp **136** and photocell **137** are positioned such that radiation emitted from lamp **136** may be received by photocell **137** through apertures **138**. The angular spacing of apertures **138** about timing disc **135** corresponds to the spacing between marking areas on web **10**. Thus as web **10** is advanced, sprocket **121** and timing disc **135** rotate, thereby intermittently aligning an aperture **138** with lamp **136**, and photocell **137**. A signal thus received by photocell **137** from lamp **136** is transmitted to pulse former **50** which generates a pulse thereby energizing lamp **39**. This timing arrangement insures synchronized exposure of the drum **20** with advancement of the web **10**.

After transfer, web **10**, having an image thereon, is advanced to fusing station **148** located intermediate pressure roller **87** and takeup reel **107**.

With reference to FIG. **2**, fusing station **148** includes lamp **151**, a housing comprised of a reflector portion **235** and a base portion **236**, and filter **152**.

Flash lamp **151** may be of a type which when energized produces electromagnetic radiations. Typical flash lamps which are commercially available and are suitable for this purpose are filled with a gas such as Xenon, Argon, mercury or mixtures thereof. Such lamps are capable of emitting radiation outputs of wavelengths in the range of 2,000 angstroms to 24,000 angstroms. In practice a Xenon flash lamp has been found to work particularly well. Normal pulse widths for this lamp are on the order of from 100 microseconds to 2 miliseconds to provide the high repetition discharge rate desired. Operating voltages suitable for this purpose range from about 800 volts to about 2,500 volts. The spectral curves available for this particular lamp start at about 2,000 angstroms and extend to about 18,000 angstroms peaking in the short infrared range or at about 8,000 angstroms.

The particular lamp illustrated may comprise a gas filled quartz tube containing two electrodes **154** and **155**, one sealed at each end thereof. To energize the lamp there is provided a trigger coil **153** encircling lamp **151** intermediate the two electrodes. Trigger coil **153** is coupled to a trigger circuit **160**, such as a simple relay circuit or controlled rectifier circuit, which when activated provides a suitable high voltage pulse to the trigger coil **153**. This pulse through the coil **153** generates a high magnetic field in the lamp thereby causing ionization of the gas within, between electrodes **154** and **155** to which is applied a potential. The potential applied to electrodes **154** and **155** is obtained from a 110 volt AC power supply which is stepped up by transformer **157** and then rectified in a bridge rectifier **158**. Capacitor **165** is charged to an initial potential dependent on the parameters of the circuit, prior to ionization of the gas in lamp **151**. Upon ionization, the lamp presents a low impedance across the electrodes **154** and **155** thereby striking a conductive arc discharging capacitor **165**. In practice a pulse forming circuit which produces a slow rise time with fast cutoff after peak, produces a flash in the lamp which is acceptable for fusing the toner images on the film. After discharge of capacitor **165** the gas in lamp **151** deionizes allowing a charge to be stored again in capacitor **165**. Switch **181** is coupled to trigger circuit **160** for actuating the flash lamp **151**. A multi-lobe cam **180** rotates in synchronism with drum **20** which cam actuates switch **181**. The spacing between cam lobes **185** is such as to provide triggering pulses in timed relationship with the advancement of drum **20** and film web **10**.

Flash lamp **151** is enclosed in housing **238** comprising reflector portion **235** and base portion **236**. An optical filter **152** overlays aperture **230** in base portion **236** of the housing to selectively pass only radiations from lamp **151** within a desired range of wavelengths as will be hereinafter more fully explained. Excess heat within the housing which may be generated by reflected wavelengths of radiation may be removed by means of a steady stream of air circulated past lamp **151** from an air conduit **250** located at one end of the housing which is connected to a compressed air source (not shown). An exhaust opening **250'** at the opposite end of the housing may be provided to allow the heated air within to escape.

FIG. **2** illustrates a cross section of film web **10** at the fusing station which is comprised of a base layer **212**, an emulsion **215** having been photographically processed to develop images therein and the electrostatically bound images **220** transferred thereto at transfer station **85**.

Base layer **212** may be comprised of any suitable material, such material including cellulose triacetate, estar, or cellulose acetate butyrate. The particular emulsion **215** on base layer **212** may likewise be comprised of any suitable material, silver halide being that which is most commonly utilized. Usually it is customary for the electrostatically bound images **220** to be placed along one edge of the film web, or adjacent to sprocket holes **240** if a web having such holes is utilized. It should be understood, however, that the toner image may be placed elsewhere on the web so long as the image areas are in the emission path emanating from the lamp. In any event the web is transported over the fusing station such that the images **220** are exposed to the selected wavelengths of radiation transmitted by filter **152**.

Filter **152** may be comprised of any suitable material which is adapted to reflect wavelengths of radiation in a specified range and to uniformly transmit wavelengths of a specified range.

While the characteristics of reflectivity, absorptivity, and transmissivity respective to the film base, emulsion and toner particles are not specifically known, it has been found that the relative values thereof are such as to obtain good fusion of the toner particles from wavelengths of radiation in the range of 3,000–8,000 angstroms without deleterious effects to the film base or emulsion.

In practice it has been found that without selective control of the wavelengths utilized, fusing of the toner particles is obtained during the short duration of lamp exposure, on the order of 1 millisecond, but scorching or bleaching of the emulsion occurs. On the other hand by utilizing the filter which selectively controls or reflects radiations having wavelengths longer than approximately 8,000 angstroms, fusion of the toner particles is obtained during the same duration of lamp exposure without bleaching or scorching the emulsion or adversely affecting the film base.

These results may be attributable to several factors. In practice, the film base is believed to have a high reflectivity to incident radiation whereas the toner particles are believed to have a low reflectivity. That is, the fraction of the incident radiation reflected from the surface of the film base is greater than that for the toner particles. The reflectivity of the dense dark emulsion areas likewise is believed to be relatively high but to a somewhat lesser extent perhaps than the unemulsified film base. The transmissivity of the film base is also believed to be greater than that of the toner particles. That is, the fraction of the incident radiation transmitted through the film base is greater than that transmitted through the toner particles. The transmissivity of the dark emulsion areas is also believed lower than that of the film base but perhaps greater than the toner particles. In addition, the film base is believed to have a very low absorptivity whereas the toner particles thereon have a relatively high absorptivity more nearly approaching that of a theoretical black body. That is to say, more of the incident radiant energy falling upon the toner particles is absorbed, or transformed into heat, than occurs in the film base. The absorbtivity of the dark or dense areas of the emulsion are likewise believed to be relatively high but to a lesser extent than that for the toner particles. It would appear therefore that a greater amount of heating occurs in the toner particles than in the emulsion or the film base since more radiation is absorbed by the toner particles than by the emulsion or by the film base.

It is generally known that the longer wavelengths of radiation produce a greater amount of heating in most absorbing bodies than do the shorter wavelengths. By controlling the wavelengths of radiation to which the toner particles, film base, and emulsion are subjected, the toner particles absorb radiation sufficient to produce heating to the point of fusion but the radiation absorbed by the film base and emulsion is insufficient to effect heating to the point of damaging or deleteriously affecting either the emulsion or film base in exposed areas.

Numerous optical filters are commercially available which are designed to selectively transmit only radiations in a particular range. A commercially available dichroic filter has been utilized with effective results. As shown in FIG. 3, the spectral output of the Xenon flash lamp with a quartz envelope ranges from about 2,000 to 18,000 angstroms, peaking in the short infrared range or at about 8,000 angstroms. The glass transmittance curve illustrates the spectral transmittance of another type of glass which may be used for the envelope of the flash lamp which does not transmit wavelengths below approximately 3,000 angstroms. The area under the dichroic filter curve illustrates that portion of the spectrum which is reflected by the filter ranging between approximately 8,000 and 16,000 to 17,000 angstroms. Although filters such as the dichroic filter do not reflect all wavelengths above approximately 8,000 angstroms, they nevertheless reflect all wavelengths in the upper ranges of an intensity sufficient to have deleterious effects on the film. The radiations emitted by the lamp above approximately 16,000 to 17,000 angstroms, which are beyond the capacity of the filter, are of such low intensity as to have no adverse effect on the film base or emulsion. As may be further observed from FIG. 3, the spectral output of the Xenon flash lamp which is utilized to effect fusing, ranges from about 3,000 angstroms to about 8,000 angstroms.

Thus, it may be seen that by the above description there is disclosed a novel method and apparatus for flash fusing xerographic images onto a film base without adversely affecting the image frames or emulsion contained thereon, and that this may be accomplished by selectively controlling the wavelengths of radiation to which the film base, the emulsion, and the toner images are subjected.

While the invention has been described with reference to the structure disclosed herein, it is not confined to the details set forth, and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims:

What is claimed is:

1. Apparatus for xerographically reproducing information on materials such as film or the like comprising:
- a photoconductive member adapted to receive input information,
- drive means for advancing said photoconductive member through a series of processing stations,
- charging means for applying a uniform electrostatic charge on said photoconductive member,
- exposure means for exposing and forming electrostatic latent images on said photoconductive member in accordance with the input information,
- means for developing said latent electrostatic images,
- transport means for advancing a film web containing image frames thereon,
- means for actuating said exposure means in a timed relationship with the advancement of said film web,
- means for transferring developed electrostatic images from said photoconductive member to said film web,
- a source of electromagnetic radiation adapted when energized to direct high intensity short duration radiations toward said electrostatic images on said film web,
- circuit means for providing actuating signals to said source of electromagnetic radiation,
- cam actuated switch means for activating said circuit means in a timed relationship with the advancement of said photoconductive member, and
- means interposed between said source of electromagnetic radiation and said electrostatic images on said film web for filtering out wavelengths of radiation within a selected range emitted by said source.

2. The apparatus as set forth in claim 1 wherein said means interposed between said source and said film web includes an optical filter adapted to reflect wavelengths of radiation which produce excessive heating of said film web and to uniformly transmit wavelengths of radiation sufficient to fuse said electrostatic images to said film web without producing excessive heating of said film web.

3. Apparatus for flash fusing electroscopic powder images on photographically processed films or the like comprising:
- a source of electromagnetic radiation,
- a housing surrounding said source,
- means for advancing film material having electroscopic powder images thereon past said housing in close proximity to said source,
- means for intermittently activating said source to produce short duration high intensity electromagnetic radiations,
- means for exposing said film material to electromagnetic radiations emitted by said source, and
- means interposed between said source and said film material for selectively controlling the wavelengths of radiation to which the film material and powder images are subjected.

4. Apparatus for xerographically reproducing information on materials such as film or the like comprising:
- a photoconductive member adapted to receive input information,
- drive means for advancing said photoconductive member through a series of processing stations,
- charging means for applying a uniform electrostatic charge on said photoconductive member,
- exposure means for exposing and forming electrostatic latent images on said photoconductive member in accordance with the input information,
- means for developing said latent electrostatic images,
- transport means for advancing a film web containing image frames thereon,
- means for actuating said exposure means in a timed relationship with the advancement of said film web,
- means for transferring developed electrostatic images from said photoconductive member to said film web,
- a source of electromagnetic radiation adapted when energized to direct high intensity short duration radiations toward said electrostatic images on said film web,
- circuit means for providing actuating signals to said source of electromagnetic radiation,
- cam actuated switch means for activating said circuit means in a timed relationship with the advancement of said photoconductive member, and
- means interposed between said source of electromagnetic radiation and said electrostatic images on said film web for filtering out wavelengths of radiation including an optical filter adapted to transmit wavelengths ranging from approximately 3,000 A to approximately 8,000 A.

5. Apparatus for flash fusing electroscopic powder images on photographically processed films or the like comprising:
- a source of electromagnetic radiation,
- a housing surrounding said source comprising means to expel excessive heat generated by said radiation source,
- means for advancing film material having electroscopic powder images thereon past said housing in close proximity to said source,
- means for intermittently activating said source to produce short duration high intensity electromagnetic radiations,
- means for exposing said film material to electromagnetic radiations emitted by said source, and

means interposed between said source and said film material for selectively controlling the wavelengths of radiation to which the film material and powder images are subjected comprising an optical filter adapted to reflect wavelengths ranging from approximately 7,500 A to approximately 17,000 A.

6. Apparatus for flash fusing electroscopic powder images to a support means comprising:

means adapted to intermittently generate a source of electromagnetic radiation, and

means adapted to selectively control the wavelengths emanating from said source of electromagnetic radiation whereby said selected wavelength radiation fuses said powder images to said support means.

7. Apparatus for flash fusing electroscopic powder images to a support means comprising:

means adapted to intermittently generate a source of electromagnetic radiation having a short duration and high intensity, and

means interposed between said source of electromagnetic radiation and said support means adapted to selectively control the wavelengths emanating from said source of electromagnetic radiation whereby said selected wavelength radiation fuses said powder images to said support means.

8. Apparatus for flash fusing electroscopic powder images to a support means comprising:

means adapted to generate a source of electromagnetic radiation having a short duration and high intensity,

means for advancing said support means in close proximity to said source of electromagnetic radiation and in synchronism with the actuation thereof, and

means adapted to selectively control the wavelength emanating from said source of electromagnetic radiation whereby said selected wavelength radiation fuses said powder images to said support means in predetermined areas.

9. Apparatus for flash fusing electroscopic powder images on photographically processed films or the like comprising:

a source of electromagnetic radiation,

a housing surrounding said electromagnetic radiation source,

means for advancing film material having electroscopic powder images thereon past said housing in close proximity to said electromagnetic radiation source,

means for intermittently activating said electromagnetic radiation source to produce short duration high intensity electromagnetic radiations,

means for exposing said film material to electromagnetic radiations emitted by said electromagnetic radiation source, and

means interposed between said electromagnetic radiation source and said film material comprising an optical filter adapted to reflect wavelengths of radiation which produce excessive heating of said film material and to uniformly transmit wavelengths of radiation sufficient to fuse said electroscopic powder images to said film material without producing excessive heating of said film material.

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