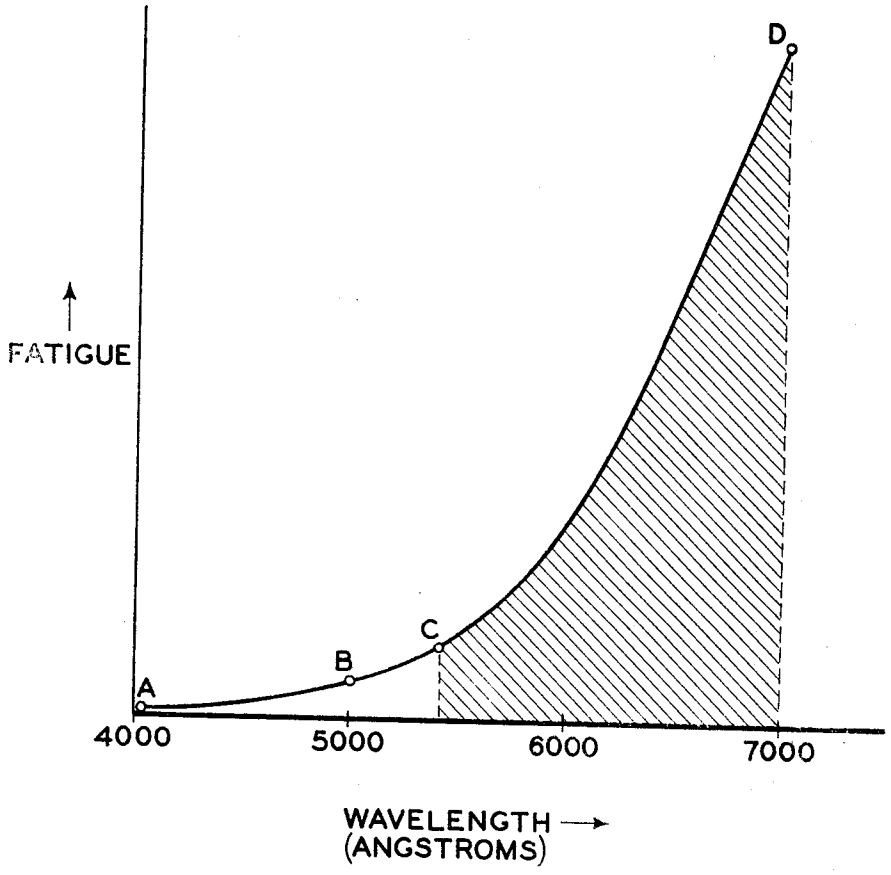
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PROCESS OF REDUCING FATIGUE IN PHOTOCONDUCTIVE GLASSES

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PROCESS OF REDUCING FATIGUE IN PHOTOCONDUCTIVE GLASSES

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ABSTRACT OF THE DISCLOSURE

A method of reducing fatigue in arsenic-selenium photoconductive layers which comprises uniformly charging the arsenic-selenium layer and exposing said layer to a source of electromagnetic radiation to form a latent electrostatic image thereon, while selectively filtering out radiation exceeding about 5400 to 6000 angstroms.

This invention relates to xerography and, in particular, to a method of reducing the fatigue effect in photoconductive glasses of the arsenic-selenium system. In the art of xerography, a xerographic plate containing a photoconductive insulating layer is first given a uniform electrostatic charge in order to sensitize its entire surface. The plate is then exposed to an image of activating electromagnetic radiation such as light, X-ray, or the like which selectively dissipates the charge in the illuminated areas of the photoconductive insulator while leaving behind a latent electrostatic image in the non-illuminated areas. This latent electrostatic image may be developed and made visible by depositing finely divided electroscopic marking particles on a surface of the photoconductive insulating layer. This concept was originally disclosed by Carlson in U.S. Pat. 2,297,691, and is further amplified and described by many related patents in the field.

Vitreous selenium remains the most widely used photoconductor in commercial xerography in that it is capable of holding and retaining an electrostatic charge for relatively long periods of time when not exposed to light and because it is relatively sensitive to light when compared to other xerographic plates. In addition, vitreous selenium has sufficient strength and stability to be reused hundreds or even thousands of times. Vitreous selenium, however, is susceptible to deleterious crystal growth when the plate is heated during operation. This crystal growth in selenium destroys the photoconductive insulating properties of the selenium, and places a limit upon the effective life of the selenium plate. Although the spectral response of selenium is satisfactory, it is exclusively limited to the blue or blue-green band of the visible spectrum. U.S. Pats. 2,803,542 to Ullrich and 2,822,300 to Mayer et al. both set forth methods of improving selenium plates by the incorporation of elemental arsenic in amounts up to about 50 percent by weight, to increase both the spectral response of the selenium and also greatly increase its photoconductive stability at elevated temperatures.

It has been discovered that when photoconductive layers formed of glasses of the arsenic-selenium system are

used in xerographic applications they are subject to a high fatigue when exposed to strong light of certain wavelengths. Fatigue is measured by the dark decay rate, i.e., a high loss of apparent surface voltage per unit time in the absence of light. Although most commercial xerographic applications involve high speed drums which require relatively short cycling times, a high dark decay rate is particularly objectionable in xerographic applications where a simplified xerographic process is used which involves a cycling time exceeding those conventionally used in high speed commercial xerography. It can thus be seen that the present arsenic-selenium system would be unsuitable for xerographic applications which involve cycling times of sufficiently long duration such as 10 to 20 seconds or more.

It is, therefore, an object of this invention to provide an improved system for utilizing arsenic-selenium photoconductors which overcomes the above noted disadvantages.

It is a further object of this invention to provide a system utilizing arsenic-selenium photoconductors having improved fatigue properties.

It is another object of this invention to provide an arsenic-selenium xerographic plate which may be adapted to extend time use in a xerographic mode.

It is another object of this invention to provide an arsenic-selenium photoconductor having enhanced properties.

The foregoing objects and others are accomplished in accordance with this invention by providing a method of reducing fatigue in photoconductive glasses of the arsenic-selenium system such as those described in U.S. Pats. 2,803,542 and 2,822,300, by using only those wavelengths which yield a peak response. This concept is based upon the discovery that the fatigue effect appears to be wavelength dependent. It is, therefore, proposed to eliminate these undesirable longer wavelengths and include only those which yield a peak response and thus reduce fatigue to a bearable level. This is accomplished by using an appropriate interference filter which cuts out the undesirable long wavelengths.

The advantages of this improved method will become apparent upon consideration of the following disclosure of the invention; especially when taken in conjunction with the accompanying drawing wherein:

The figure of the drawing is a graphical illustration showing the relationship between the wavelength and fatigue.

Referring to the drawing, the fatigue effect is plotted along the ordinate while the abcissa represents wavelengths typical for the arsenic-selenium system. The curve illustrates a relationship between fatigue and wavelength with reference character C denoting the point at which at longer wavelengths the fatigue effect reaches an intolerable level. It is the purpose of this invention to eliminate the hatched area from point C to point D on the graph by selectively filtering out this undesirable wavelength and thus reduce the fatigue to a bearable level simply by utilizing the effecteive wavelength from point A to point C.

A series of arsenic-selenium alloys ranging from 0 percent arsenic to 50 percent arsenic by weight were tested under varying conditions utilizing interference filters at

different wavelengths. Any filter which can block out selected wavelengths may be used. Typical filters useful in carrying out this invention are manufactured by Optics Technology, Inc. of Belmont, Calif. and are sold under the tradename: Set 60 Variable Band Pass Interference Filter Set. These filters were used in obtaining the data set forth in Tables I and II below, and can effectively filter out increments of 500 angstroms in any wavelength area. These filters are effective to block sidebands in the visible spectrum to less than 0.1 percent transmission. In carrying out the experiments set forth in Tables I and II, in order to effectively block out sidebands in the visible spectrum, a 2043 heat absorbing glass manufactured by the Pittsburgh Plate Glass Co., Glass Division Research Laboratories in Pittsburgh, Pa. was used in conjunction with the above mentioned filter in order that the filter mechanism effectively blocked, as near as possible, 100 percent of all wavelengths intended to be filtered or blocked.

Table I below illustrates various alloy compositions of arsenic-selenium in which a wavelength band of 5400 angstroms was first used, followed by values in excess of 5400 angstroms and increasing all the way out to the full spectral output of the lamp. The light source used in Table I was a Burton Lamp, obtained from the Burton Medi Equipment Company of Van Nuys, Calif. This is a 100 watt tungsten lamp Model 1200 which has a visible spectral output including wavelengths above and below 5400 angstroms, maintained at the voltage required to yield same output at 5400 as the 914 green lamp which also has a visible spectral output including wavelengths above and below 5400 angstroms of Table II, that is, 4.2×10^{12} photons/cm.^{2}/second at the charged surface.

The arsenic-selenium alloys, formed by conventional techniques at a thickness of about 20 microns on a flat conductive aluminum plate, are exposed at a distance of about 20 inches from said light source. Table I below illustrates the results for various compositions ranging from 0 to and including 50 percent arsenic.

Table II below illustrates the same test for a Xerox 914 green fluorescent lamp available commercially from Sylvania Corp., Cat. No. 122–P–25 exposed at 20 inches from the plate to be tested. The same samples as shown in Table I were tested under the 914 green lamp.

In Tables I and II the arsenic-selenium plate is first corona charged in the dark to a surface voltage V_o (positive polarity) dark decay, V_D, is then measured by means of an electrometer, the plate is then exposed to a selected bandwidth of the spectrum for 2 seconds and the light decay, dV_L, measured by means of an electrometer. This cycle is repeated at a given bandwidth of about 40 or 50 times to yield a constant or equilibrium value for dV_D and dV_L.

The initial reference point as shown in the tables is narrow band pass 100 angstroms half width at a wavelength of 5400 angstroms which is maintained by a pair of Corning color filters B–72 and 4–97 sold by the Corning Glass Co. of Corning, N.Y., used together with a Bausch & Lomb Std., 5400 angstrom interference filter to control the narrow band path at 5400 angstroms. This reading at 5400 angstroms gives a comparative base to which the other readings at different wave bands may be compared. The 5500 angstrom value is controlled by the cutoff filter of Optics Technology, Inc. along with the Pittsburgh Plate Glass filter which effectively cuts off all wavelength in excess of 5500 angstroms while exposing the given arsenic-selenium alloy to all visible wavelength up to and including 5500 angstroms under the tungsten lamp or 914 green lamp, as the case may be, in Tables I and II. Similarly, the value for 6000 angstroms is similiar to the conditions for 5500 angstroms only the bandwidth was increased 500 angstroms. The notation "Full Spectrum" in Tables I and II denotes that for this value the given alloy was exposed to the full spectrum of wavelengths for the particular light source which includes those below and above 6000 angstroms.

The symbol dV_L indicates the change in voltage with time or the loss in volts per second from the charged surface when the given alloy is exposed to the selected spectrum of light for 2 seconds. The values which are under the heading "Magnitude of Change" following dV_D and dV_L merely indicate the magnitude in change from one particular bandwidth to another with regard to increase in dark or light decay.

It can thus be seen in Tables I and II, as illustrated by the 50 percent arsenic-selenium alloy under either the tungsten or 914 green lamp, that in going from the controlled wavelength of 5400 angstroms out to 5500, increasing the spectrum to 6000, and finally followed by exposure to the full visible spectrum, that the dark decay rate increases drastically. Depending upon the composition, this fatigue effect as illustrated by the dark decay (dV_D), is particularly detrimental at values above about 5500 or 6000 angstroms depending upon the given alloy. From the data illustrated in the tables, it can be seen that for arsenic-selenium systems, if the wavelength is selectively filtered at values exceeding about 5400 to 6000 angstroms, high sensitivity can be attained while keeping the fatigue at bearable minimum.

The values for the light decay (dV_D) generally indicate that there is no significant increase in speed of discharge once a particular wavelength is reached. This wavelength is usually that at which the dark decay begins to reach the level at which it must be controlled by selective filtering (5400 to 6000 angstroms).

TABLE I.—TUNGSTEN LIGHT SOURCE

Composition (percent wt.)		Wavelength		dV_D	Magnitude	dV_L	Magnitude
As	Se	(Angstroms)	V_o	(volts/sec.)	of change	(volts/sec.)	of change
0	100	5,400	450	7.0		75	
		5,500	380	6.3	0.9×	1,160	16×
		6,000	450	7.5	1.1×	1,250	17×
		(1)	450	7.5	1.1×	2,000	27×
17	83	5,400	269	2.3		250	
		5,500	270	2.9	1.3×	2,350	9×
		5,400	258	1.3		250	
		6,000	265	2.9	2.2×	2,580	10×
		(1)	200	6.4	4.9×	2,580	10×
20	80	5,400	250	4.4		180	
		5,500	255	4.1	0.9×	1,530	8×
		6,000	250	4.4	1.0×	2,100	12×
		(1)	250	5.8	1.3×	2,750	15×
33	67	5,400	55	3.4		98	
		5,500	55	3.5	1.0×	578	6×
		5,400	70	3.4			
		6,500	70	3.3	1.0×	740	10×
		(1)	70	4.7	1.4×	750	10×
50	50	5,400	160	6.6		285	
		5,500	150	7.4	1.1×	1,350	5×
		5,400	190	4.9		310	
		6,000	190	7.4	1.5×	2,200	7×
		(1)	190	12.3	2.5×	2,250	7×

[1] Full spcetrum (no filter).

TABLE II.—914 GREEN LIGHT SOURCE

Composition (percent wt.) As	Se	Wavelength (Angstroms)	V_o	dV_D (volts/sec.)	Magnitude of change	dV_L (volts/sec.)	Magnitude of change
0	100	5,400	380	3.8		13	
		5,500	415	5.4	1.4X	146	11X
		6,000	390	5.4	1.4X	145	11X
		(1)	380	5.3	1.4X	210	16X
17	83	5,400	255	1.3		55	
		5,500	250	1.8	1.4X	300	6X
		6,000	270	2.2	1.7X	345	7X
		(1)	255	2.3	1.8X	450	8X
20	80	5,400	285	3.2		53	
		5,500	290	5.1	1.4X	270	5X
		6,000	285	4.4	1.4X	310	6X
		(1)	285	4.6	1.4X	375	7X
33	67	5,400	65	3.4		30	
		5,500	60	3.2	1.0X	120	4X
		6,000	70	4.0	1.2X	155	5X
		(1)	65	3.1	1.0X	165	6X
50	50	5,400	170	4.0		70	
		5,500	170	4.7	1.2X	300	4X
		6,000	160	5.8	1.4X	340	5X
		(1)	155	5.7	1.4X	420	6X

[1] Full spectrum (no filter).

Xerographic plates having a photoconductive layer comprising an alloy of vitreous selenium and arsenic may be prepared by well-known conventional techniques such as those set forth in the above mentioned Ullrich and Mayer et al. patents. Such techniques briefly involve forming an alloy of selenium and arsenic by melting the appropriate amount of arsenic and selenium together in a temperature range of approximately 750 to 900° F. The resulting alloy is then evaporated under vacuum conditions onto any suitable electrical conductive support means.

The method set forth in the present invention is normally used in a xerographic mode which includes the basic steps of forming a latent electrostatic image and developing said image.

By way of example; a xerographic plate comprising a 20 micron photoconductive layer of a 50 percent arsenic-selenium alloy is corona charged to a potential of 190 volts over its entire surface. The plate is then exposed to a 100 watt tungsten light source at a distance of about 20 inches for about 2 seconds to form a latent electrostatic image on the surface of said plate. The light is selectively filtered to allow wavelengths of only up to 5400 angstroms to impinge on the surface of the plate. The latent electrostatic image is then developed by cascading a developer bath of toner particles and carrier beads over the surface of the plate. The image is then transferred to a sheet of paper and permanently fixed by heat fusing. This method yields a sharp copy of the original image.

Although specific components and proportions have been stated in the above description of the preferred embodiment of this invention, other suitable materials and procedures such as those listed above may be used with similar results.

For example, any suitable conductive substrate may be used, such as aluminum, brass, stainless steel, conductively coated plastic or glass, etc. Similarly, the thickness of the photoconductive layer may be in any suitable range consistent with good xerographic imaging such as from about 20 to 150 microns. In addition, other materials or procedures may be used which synergize, enhance or otherwise modify the properties of the photoconductive alloy treated by this invention.

Other modifications and ramifications of the present invention would appear to those skilled in the art upon reading the disclosure. These are intended to be included within the scope of this invention.

What is claimed is:

1. A method of reducing light fatigue in the arsenic-selenium system which comprises uniformly charging the surface of a photoconductive layer comprising a vitreous arsenic-selenium alloy, exposing said layer to a source of visible activating electromagnetic radiation having a spectral output including wavelengths above and below about 5400 angstroms to form a latent electrostatic image thereon while selectively filtering out from said source radiation exceeding about 5400 angstroms.

2. The method of claim 1 wherein the arsenic is present in amounts up to about 50 percent by weight.

3. The method of claim 1 wherein the latent electrostatic image is developed to make it visible.

4. A method of forming an electrostatic image which comprises:

(a) providing a photoconductive layer comprising arsenic and selenium;

(b) substantially uniformly electrostically charging siad layer;

(c) exposing said layer to a filtered source of visible activating electromagnetic radiation having a spectral output including wavelengths above and below about 5400 angstroms to form a latent electrostatic image wherein wavelengths in excess of about 5400 angstroms are filtered out;

(d) developing said latent image; and

(e) repeating said charging, exposing and developing steps at least one additional time, whereby said layer remains substantially free from fatigue effects.

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