

- [54] **TREATMENT OF LIGHT EMITTING FILMS TO EXTEND THEIR USEFUL LIFE**
- [75] Inventor: **Edwin J. Soxman**, Santa Barbara, Calif.
- [73] Assignee: **The Prudential Insurance Company of America**, Los Angeles, Calif.
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Primary Examiner—Roy Lake
Assistant Examiner—Siegfried H. Grimm
Attorney—Angus & Mon

[57] **ABSTRACT**

The method of driving, or of preconditioning, a vacuum-deposited light-emitting film of the type which comprises a binary compound of zinc and sulphur or selenium together with a manganese activator, so as to extend the useful life of the film. The voltage of the driving alternating current is raised so as substantially to maintain the initial luminescence of the film, and preferably is continuously raised, so as to accomplish the same. Also, this treatment may initially be given to the film and then discontinued, the film's useful life thereby having been extended beyond that life to which, without the treatment and at a constant voltage, its luminescence would have decayed to only one half of its initial value at that voltage.

5 Claims, No Drawings

TREATMENT OF LIGHT EMITTING FILMS TO EXTEND THEIR USEFUL LIFE

This invention relates to light emitting thin films of a class which comprise a binary compound of zinc and sulphur or selenium together with a manganese activator.

Light emitting films of the class described are generally known. They differ from compacted phosphor layers for the emission of light in that, instead of being compacted as a layer from powders, they are deposited in a vacuum so as to produce a monolithic layer which is thinner and more uniform. The problems of these two classes of layers are significantly different, and the solutions to the problems of one usually do not ordinarily suggest an effective solution to those of the other.

Light emitting films of the type which constitute the subject of this invention are characteristically rated for their life by determining an initial brilliance such as 10 foot lamberts, and determining the period of time at a constant alternating current driving voltage in which the luminous output will decline to one half its initial value, in this case 5 foot lamberts. In the past, the period of time during which under constant voltage excitation the luminescence would decrease by 50 per cent has been relatively short, and the utilization of these desirable films has accordingly been limited.

It is an object of this invention to provide a means for preconditioning, and also for driving, these films so as to optimize the luminescence thereof and also so as to extend the total life of the film at a higher level to a useful term which would exceed that which would otherwise expire merely in decreasing to half luminescence under constant voltage.

At this point it may be useful to emphasize the distinction between the term "life" as utilized in the prior art, wherein the term means the total time of excitation at a given frequency that it takes for the output luminosity to decline to one-half of what its value was when the film was first so excited, and the term "life" as used herein, wherein the film is even driven to produce luminescence at its full initial value. In the former situation, the experience is generally terminated, and the film discarded, upon reaching a value of luminescence one half that of the initial value. In the present invention, it will be found that at the end of its useful life the film will have been driven to a breakdown, i.e., the voltage applied will be sufficient to short across or otherwise destroy the film itself, but in the meantime it will have delivered luminescence quite close to or even equal to the said initial value. The total time to one-half brightness is sometimes called the "half-life" of the film when driven at a constant voltage. This is its useful life under these circumstances.

It has been found that, utilizing the present invention, a given film may have a useful life with substantially the initial luminescence and a useful life bordering upon two orders of magnitude greater than that which is attainable were the same film to have been driven in accordance with the prior art and permitted to decline to half-luminescence.

The method of this invention comprises driving, or preconditioning, a vacuum deposited film of the type which comprises a binary compound of zinc and sulphur or selenium together with a manganese activator, by exciting the same with a voltage such to main-

tain the initial luminescence of the film. According to a preferred but optional feature of the invention the voltage is continuously raised so as to accomplish the same.

According to another feature of the invention, this treatment may initially be made to a film and then discontinued, the film's useful life thereby having been extended beyond that life to which without the treatment and at a constant voltage, its luminescence would have decayed to one half its initial value at that voltage.

There is known in the art a light emitting film which consists essentially of a binary compound of zinc and either sulphur or selenium together with a manganese activator. A manganese activator is provided to give rise to luminous centers in the film and is deposited throughout the continuous film. The film will ordinarily be deposited upon a solid substrate such as a glass sheet or the like, and may or may not have other layers with it. As an example of a vacuum deposited film of this general class reference may be made to the presently co-pending application of Gordon N. Steele and Edwin J. Soxman, Ser. No. 748,046, filed July 26, 1968, now U.S. Pat. No. 3,560,784 entitled "Dark Field, High Contrast Light Emitting Display" which is assigned to the same assignee as the instant application. In the said application, there is shown a deposited thin film which is readily distinguishable by those persons skilled in the art from another class of luminescent devices based upon the compaction of a phosphor powder. This invention has no applicability to the latter, but only to the former.

In the class of device with which this invention is concerned, it has been conventional to rate the same by determining a reasonable level of luminescence, largely derived from experience, which ordinarily is on the order of 10 foot lamberts and determined a voltage which will produce this level of luminescence when the device is first driven, without prior excitation. The term "drive" relates to the excitation of a.c. voltage required to cause the luminescence which is a phenomenon well known to persons skilled in the art. The term brightness is frequently used herein to describe the level of luminescence, or brilliance. It is noted, and devices are rated accordingly, that utilizing a constant driving voltage, over a period of time the device will "age" so as to deliver gradually decreasing luminescence levels until finally it reaches one half the initial luminescence. This is sometimes called the "life" of a device of this class. The object of this invention is to extend the life of a film of this type beyond this "life" but still maintaining substantially the initial luminescence.

It has been determined that by appropriate management of the voltage applied to the film in its early life, the conditions in its subsequent life can be favorably affected. Accordingly, in the conduct of this invention, the voltage is selected to produce the desired initial luminescence and then the luminescence is observed and the driving voltage is raised so as to maintain the said luminescence. Surprising and unpredictable results are obtained by this means.

In a number of tests, which because the real times may be so very long, have involved films with relatively short decay times, it has been found, for example, that films which, if untreated according to the present invention and simply driven with a constant voltage to their life aforesaid, would decay to one half their initial

luminescence in ten minutes, when treated by the technique of this invention will last up to 500 or 600 minutes. By extrapolation, and by various tests, it has been found that extensions of times on these and other very much longer lived films utilizing this invention may be on the order of about two orders of magnitude, namely about 100 times the life which would have been obtained under former circumstance decaying to half luminescence, but still maintaining full luminescence all the time. Such lives are forecast to be such as 10,000 hours, thousands of times longer than would be expected.

According to this invention in its presently preferred embodiment, the driving voltage is continuously raised to maintain the luminescence. However, there are times when this may not be convenient, and in that event a periodic raise in voltage will do well enough for some purposes. For example, it is found that the primary requirement for raising the voltage to overcome the decaying effect will occur in the first five per cent of the time involved in the life of the film. During that time, the increases in voltage might be relatively frequent and of relatively larger amounts. The increments of time and voltage need not be equal in this time to compensate, although, of course, they may be. However this may be, certainly the voltage will be raised well within the time to which the luminescence would have been reduced to the said one half value and preferably within about five per cent of that period of time so as to hold the variation from the initial luminescence to relatively small increments.

For reasons which are not completely understood, the greatest rate of change in voltage is required in the early stage of the aging process and thereafter it becomes relatively less important, which is to say that the decline in luminescence is most pronounced at first. Thereafter, the rates diminish, and the largest proportion of the effect is attained early in the treatment. Age, in this case, means not calendar age, but the amount of time under which the film has undergone excitation. Accordingly, the major correctional requirements occur early in the life of the film, and if terminated thereafter, a significantly improved film will still result.

Accordingly, it will be found that most of the advantages of this invention can be provided even before the sale or use of the film by subjecting it to an initial experience of increasing the voltage to maintain the initial luminescence, for a significant period of time but which is only a small fraction of the projected total life, and thereafter to operate the film as desired, even including and maintaining it at a constant voltage, because then it will be found that the luminescence will fall off at a decreased rate compared to what it would have been had this prior aging experience not been undergone.

One is inclined to ask the desideratum on which the initial luminescence is determined, because it would seem desirable to operate as close to the breakdown voltage as possible in preconditioning and operating

the cell. The problem here, of course, is that in a production type film, it is difficult to tell when one is close to breakdown, and often one finds out that one was close to breakdown only after undergoing the experience. Accordingly, the initial values referred to herein are those which are determined by those persons skilled in the art of light-emitting films to determine a safe value to operate the films over a respectable period of time. As aforesaid, a 10-foot lambert light output has been found to be quite sufficient under most circumstances. However, in the preconditioning suggested by this invention, one could apply voltages greater than those needed to produce the said initial value, so long as this level is prudent relative to the other conditions.

This invention thereby constitutes a manner of preconditioning a light-emitting film to extend its life during its use, and also a method of driving the film without preconditioning so as to extend its life to an optimal value with a luminous output at least equal to the initial level.

This invention is not to be limited by the embodiments shown by the foregoing specification but only in accordance with the accompanying claims.

I claim:

1. The method of treating an electroluminescent film of the class comprising a binary compound of zinc, and either sulphur or selenium, together with a manganese activator, which film has been vacuum deposited upon a solid substrate, and is subjected to an alternating current excitation voltage to produce light, said film having an inherent initial brightness when first subjected to a given excitation voltage, and an inherent total time of excitation, called "half-life" during which its brightness declines to one-half of its initial brightness when driven at the said given voltage, said method having as its objective the preconditioning of the said film so as to produce after said treatment a film having a longer half-life, comprising: exciting the film with the said given voltage, and for a substantial period of time maintaining a greater exciting voltage thereon so as to maintain the brightness at the value of the initial inherent brightness.

2. The method of claim 1 in which said voltage is continuously raised so as to maintain said initial brightness.

3. The method of claim 1 in which said voltage is continuously raised from time to time, the voltage and time increments not necessarily being equal, but the brightness produced by the film never being less than the said one half value.

4. The method of claim 3 in which the attained brightness is maintained to within five per cent of the initial brightness.

5. The method of claim 1 in which the said voltage is raised initially to a value to produce brightness in excess of the said initial brightness, but at a value prudently below that which would cause breakdown of the film.

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