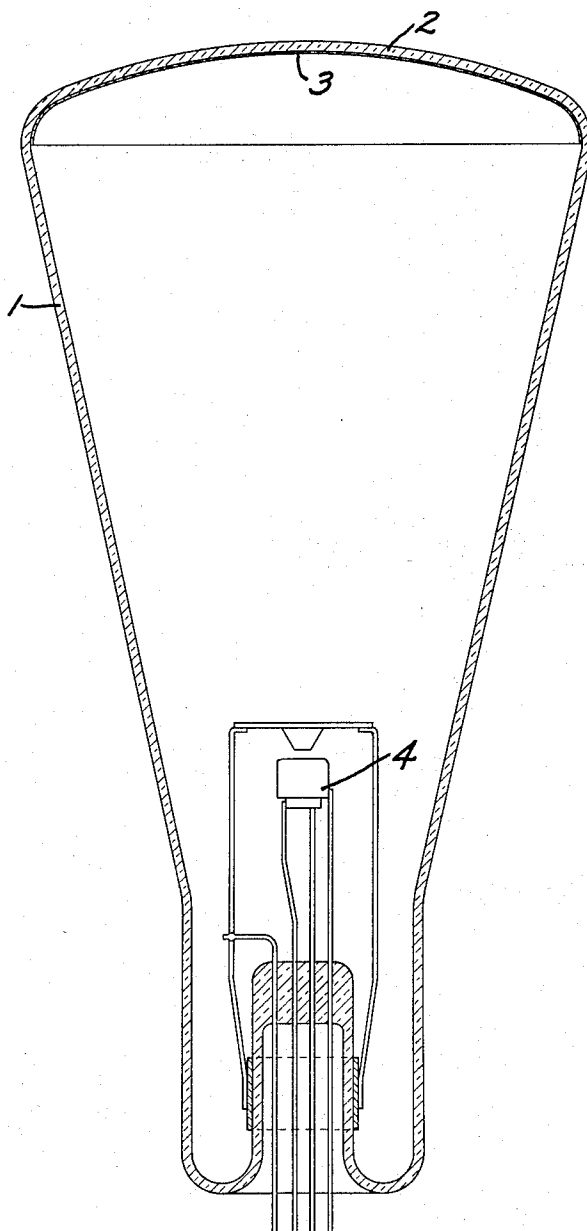


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R. H. VARIAN
FLUORESCENT SCREEN
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INVENTOR,
RUSSELL H. VARIAN.
BY *Lippincott & Metcalf*
ATTORNEYS.

UNITED STATES PATENT OFFICE

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FLUORESCENT SCREEN

Russell H. Varian, San Francisco, Calif., assignor
to Farnsworth Television Incorporated, a corporation of California

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3 Claims. (Cl. 250—27.5)

My invention relates to a fluorescent screen and more particularly to a screen formed by the use of admixed fluorescent materials, having complementary colors, the fluorescent light obtained from the mixture closely approaching white.

Among the objects of my invention are: to provide a fluorescent screen giving an approximately white light when bombarded by cathode rays; to provide a fluorescent screen formed by the admixture of fluorescent materials having complementary colors; to provide a fluorescent screen formed of an admixture of fluorescent materials, the color obtained under bombardment of the admixed materials being whiter than the color of any of the separate ingredients; to provide a method of forming a fluorescent screen from an admixture of activated and nonactivated fluorescent materials without causing the nonactivated materials to become activated; and to provide a composite material giving a brilliant, contrasty and nearly white fluorescent response under the bombardment of a beam of cathode rays.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of the invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawing:

The figure is an elevational view of a cathode ray tube having deposited therein the screen of my invention.

Various fluorescent materials behave in different and usually unpredictable manners under bombardment by cathode rays. Many different colors are produced. The efficiency of energy conversion varies widely in the various materials, and it has been found that there are, roughly, two classes into which fluorescent materials may be divided. The first are those materials which fluoresce weakly or not at all unless activated by the addition of a small amount of other material, usually combined by the use of heat. Such activated materials usually have a time lag, the fluorescence being followed by a period of phosphorescence which may, in some cases, last for a relatively long time.

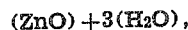
The second group of materials gives a response to the eye that is practically instantaneous, which, in my opinion, indicates that the light produced is practically all fluorescence, there being little or no phosphorescence following. I have found the latter nonactivated materials are usually active only in an exceptionally pure state, even minute

quantities of impurities inhibiting proper fluorescent response.

My invention, broadly, comprises a fluorescent screen which is an admixture of one of the activated type of materials with one of the nonactivated materials, preferably utilizing two such materials which are complementary in fluorescent color so that the response from the admixed materials is substantially white light. I prefer to use a mixture of activated zinc borate and nonactivated zinc sulphide.

As to method, I prefer to activate the material which needs activation to give a proper response in the presence of a relatively large amount of heat, to cause the proper combination of the two materials necessary for activation to take place. I then prefer to mix the nonactivated material with the activated material and withhold from the mixture thereafter all heating which might be sufficient to cause any of the activator used in conjunction with the first material to combine with the second material. In the formation of my preferred mixture for the production of a substantially white light, I prefer to utilize activated zinc borate to produce the yellow light component. Manganese dioxide is preferred as an activator. The response of activated zinc borate, while not instantaneous, is sufficiently fast and has a time lag which is unimportant within the time periods used in the reproduction of television images. The material gives a bright greenish yellow to orange yellow fluorescence as bright as the best willemite, and gives also excellent contrast between light and shade.

I prefer to produce zinc borate by mixing zinc oxide with boric acid in the proportions to give $\text{Zn}(\text{BO}_2)_2 + 3(\text{H}_2\text{O})$, to give $\text{Zn}(\text{BO}_2)_2$



or to give $\text{Zn}(\text{BO}_2)_2 \cdot 2(\text{ZnO}) + 3(\text{H}_2\text{O})$ or any proportions between these values. The proportions to produce $\text{Zn}_2\text{B}_2\text{O}_7 + 6(\text{H}_2\text{O})$ may also be used but the fluorescence is less brilliant. $\text{Zn}(\text{BO}_2)_2$ gives a greenish yellow fluorescence. $\text{Zn}(\text{BO}_2)_2 \cdot 2(\text{ZnO})$ is a clear yellow, while $\text{Zn}(\text{BO}_2)_2 \cdot 2(\text{ZnO})$ is a more orange yellow. It can be seen, therefore, from the above, that by mixing zinc oxide with the boric acid in the proper proportions, various shades of color may be obtained which, when combined with other materials as will be later described, will give a close approximation to white. In other words, the eventual color may be controlled by controlling the color response of one of the materials, in this case the zinc borate.

Whatever the formula decided upon, manganese dioxide is added to the zinc borate in a about 2.5% of the zinc oxide originally used. The amount, however, is not very critical, and I have found that good results can be obtained within the range of one half to three percent. The manganese dioxide, which is the preferred activator, is thoroughly mixed with the zinc borate and the resultant mixture is heated to a dull red heat, preferably for one half to one hour, until a combination and recrystallization takes place. The activated zinc borate thus produced may be finely ground and used as one of the ingredients of my screen.

It might be well to state here that I do not know the exact function of the manganese dioxide in the mixture, nor do I fully understand the exact kind of combination which takes place between the manganese dioxide and the zinc borate to produce the desired activation. I have found, however, that a simple physical mixture of manganese dioxide and zinc borate will not produce an activated material. The two must be heated together at a dull red heat for the activation to take place. Whether there is an actual chemical combination formed or whether the manganese dioxide becomes distributed throughout the zinc borate in colloidal form or not, I do not know. Hereafter and in the claims attached hereto the word "combination" is used to distinguish this intimate relation between the two substances in direct contrast to a simple physical mixture made without the application of continued heat. It is this feature and action of the activator which allows me to mix a nonactivated material with the activated zinc borate without having the nonactivated material contaminated or inhibited in its action by the activator used for the first substance. Even in materials which might not have fluorescence inhibited by the activator, the color might be changed to prevent the obtaining of the desired white light.

For the unactivated material I prefer to use zinc sulphide which has been repeatedly purified in various ways well known in the art. Such purified zinc sulphide fluoresces instantaneously and gives a brilliant response of sky blue light. Its performance, however, when activated with manganese dioxide is unsatisfactory, as it is unstable under the cathode ray. It is therefore important, when the zinc sulphide and the zinc borate are mixed together to form the eventual screen material, that none of the manganese dioxide enter into combination with the zinc sulphide.

I prefer to mix the activated zinc borate and the nonactivated zinc sulphide together in such proportions that a relatively white light is produced, it being apparent that in the mixture the particles of each separate material fluoresce with their own characteristic light, the resultant light being the true combination of the two. It is not practical to give here the exact percentages of each of the materials as these percentages will vary widely according to the composition and resultant color response of the zinc borate.

I prefer to thoroughly grind the materials either before or after mixing, or both, and make

a water suspension of the mixed materials. The coarser particles will settle to the bottom, and the supernatant liquid may then be decanted, allowed to settle, and the fine material thus obtained dried out for future use or the excess water may be evaporated and the material placed in the reservoir of a spray gun.

A cathode ray tube blank 1, preferably of the general form shown in the figure, has its viewing end 2 coated inside with the fluorescent material 3, preferably by a spray from the gun. The screen thus formed is then allowed to dry out. A cathode ray emitter 4 is then sealed in the opposite end of the tube which is then evacuated and otherwise processed and sealed off the pumps.

As practically all cathode ray tubes have associated with them glass envelopes, processing temperatures of the assembled tubes will not exceed 300-400° C. By being careful never to exceed this temperature, no combination of the activator used in the zinc borate takes place with the zinc sulphide, a temperature of 800-900° C. being apparently the most desirable temperature at which the activator combines with other materials. The tubes, therefore, may be thoroughly and completely baked out in processing without changing the desired characteristics of the screen.

The screen thus formed of composite materials has a time lag no greater than that of the zinc borate, but does give a brilliant light closely approximating white, the light differing in color from the light given off by either of the ingredients of the mixture separately excited.

There are several other admixtures of like character which will produce a light closely approaching white when fluoresced, acting in a manner similar to that of the preferred admixture as described above. These admixtures are given in the following table:

Yellow	Blue
Zn(BO ₂) ₂ CdSO ₄ CdSO ₄	ZnWO ₄ ZnWO ₄ ZnS

I claim:

1. In a cathode ray tube, a fluorescent screen comprising a chemical combination of manganese and zinc borate physically mixed with pure zinc sulphide.

2. The method of making a fluorescent screen material which comprises chemically combining an activator with a material fluorescent when activated in the presence of heat, and mixing the activated material with a nonactivated material at a temperature insufficient to cause the activator to activate the nonactivated material.

3. The method of making a fluorescent screen material which comprises chemically combining a manganese salt with zinc borate in the presence of heat, and mixing the material thus formed with pure zinc sulphide at a temperature insufficient to cause combination of the manganese and the zinc sulphide.

RUSSELL H. VARIAN.