Dec. 13, 1938. E. W. BOERSTLER 2,139,797

FLUORESCENCE DETECTING APPARATUS

Filed April 25, 1936 2 Sheets-Sheet 1

Fig.1

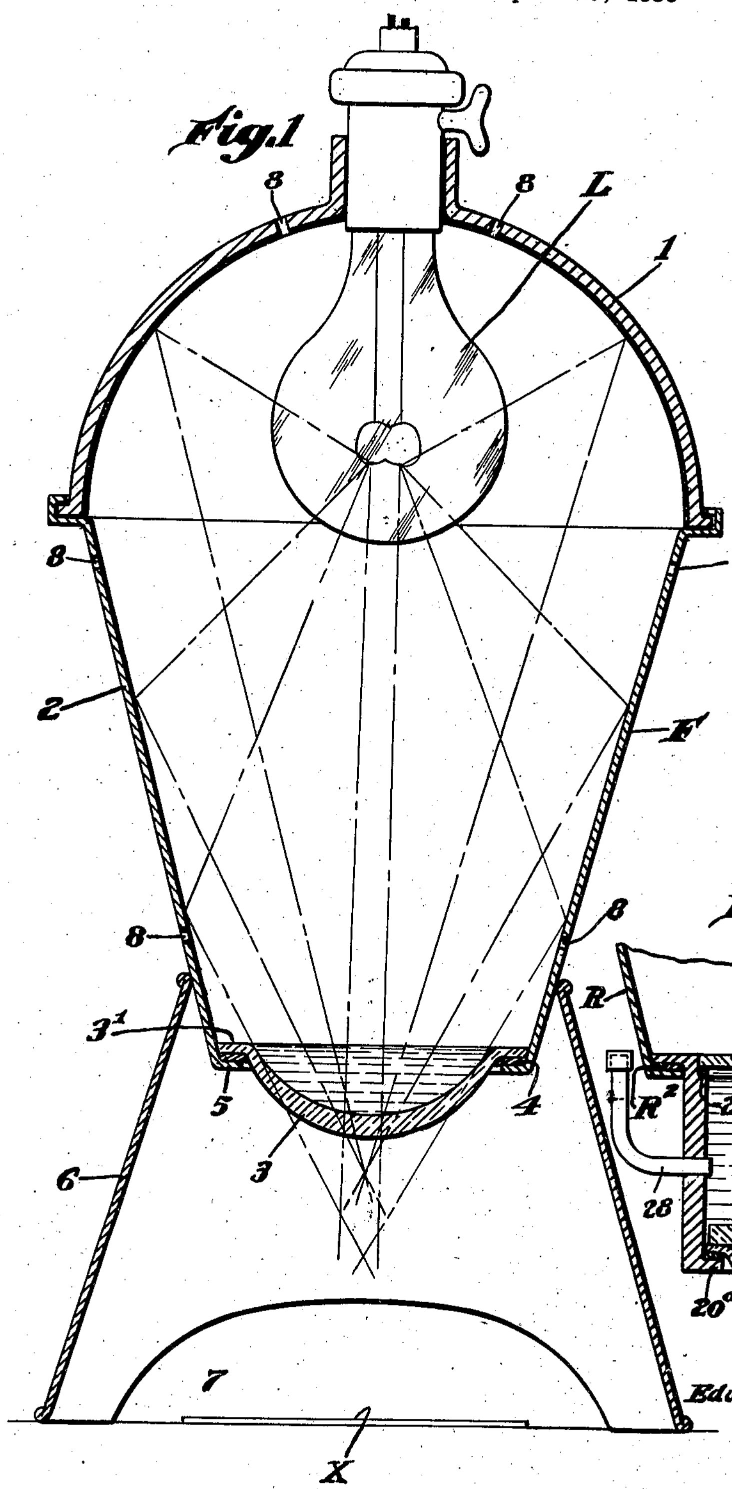
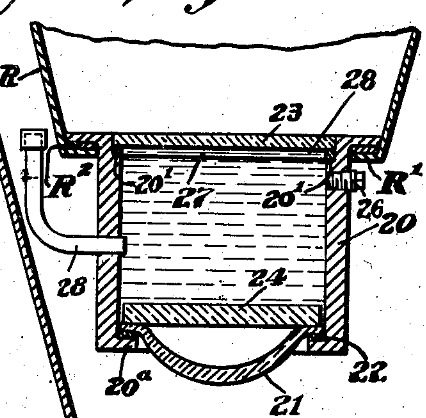


Fig.2



Inventor
Edward W. Boerstler

By Attorney

FLUORESCENCE DETECTING APPARATUS

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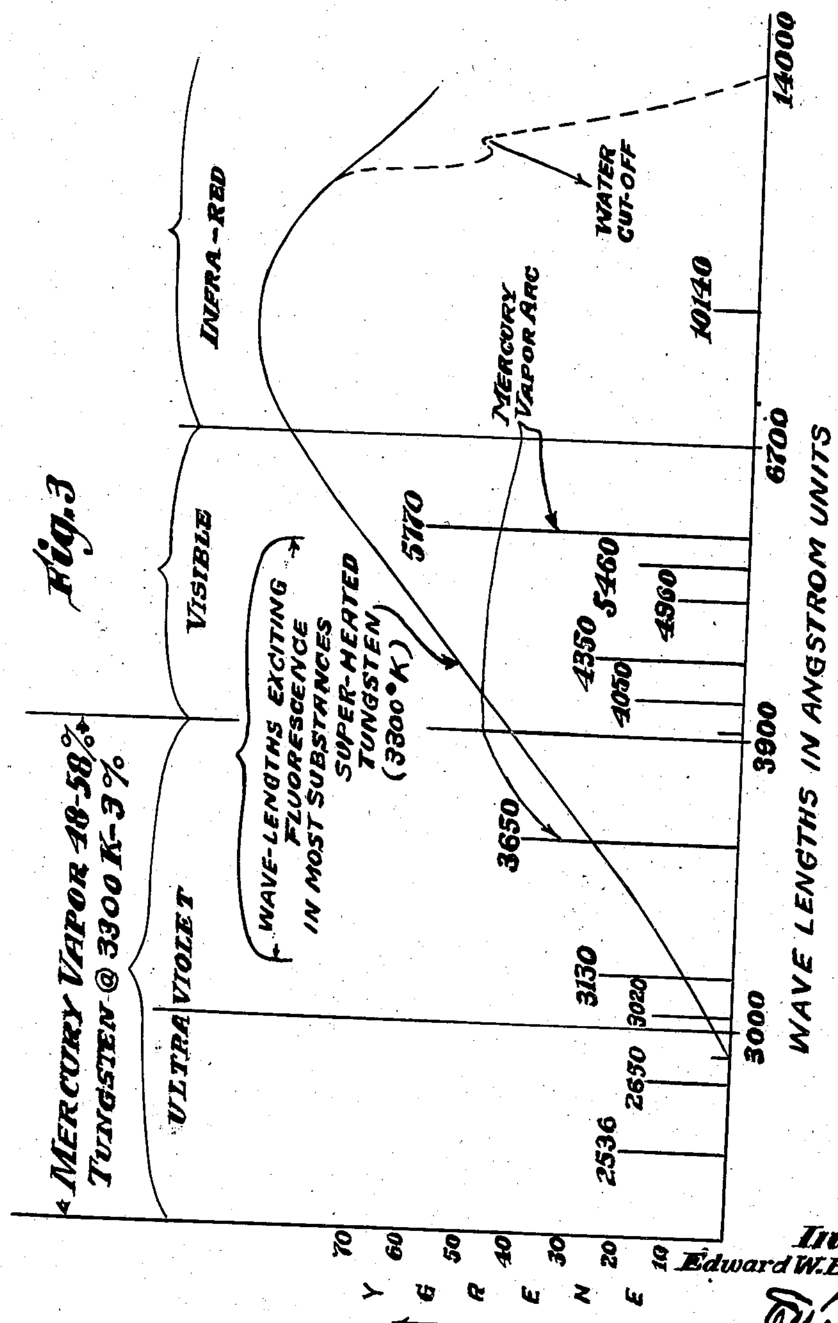

Fig. 3

Inventor
Edward W. Boerstler

By [signature]
Attorney

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FLUORESCENCE DETECTING APPARATUS

Edward W. Boerstler, Watertown, Mass.

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6 Claims. (Cl. 250—86)

By the utilization of rays of selected wave length, as in the so-called ultra violet, it has been determined that from certain sources fluorescent effects are attainable of potential practical value.

According to my present invention I contemplate a utilization of rays from selected sources to produce certain new and very definite results in the detection of fluorescent symptoms as in the diagnosis of disease, analysis of the physical and chemical construction of materials, in the detection of evidences of crime, or for other purposes as will be later discussed.

According to present usage the mercury vapor arc is a potent source of such irradiation. The mercury vapor lamp, either in quartz or glass, has been the recognized and accepted source heretofore of the rays generally used for exciting fluorescent phenomena. In either type such lamps are of high cost and require accessory electrical apparatus for their operation. In spite of these difficulties some are still of the opinion that since the percentage of ultra-violet radiation in the mercury vapor spectrum is admittedly higher than that of most other available sources, it should be the logical choice for producing fluorescent effects.

I have repeatedly demonstrated that although the ultra-violet spectrum of super-heated tungsten only comprises approximately 3% of the total radiant energy—as against the abnormally high percentage of 58% of some mercury vapor sources—fluorescent phenomena obtained by a properly filtered super-heated tungsten source (as in the present invention) are more reliable and brilliant than those obtainable with the mercury vapor or other known sources.

It is to be borne in mind that the ultra-violet spectrum of mercury is composed of isolated regional lines (the principal ones of which lie at 3650, 3130, 3020, 2967, 2804, and 2536 Angstrom units) whereas the ultra-violet spectrum of super-heated tungsten is a perfectly continuous band of radiations not found in the spectrum of any other known radiator.

When it is further considered that most substances, in which fluorescence may be excited by ultra-violet or other radiations, exhibit a maximum response of fluorescence at a discrete wave length, or within a relatively narrow band or bands of wave lengths, the superior nature and utility of the continuous spectrum of super-heated tungsten for producing such fluorescence will be understood. For example, while many materials are luminous, as shown by the mercury arc lamp their peaks of fluorescence may lie between the determined isolated ultra-violet waves of the mercury arc lamp and may not be appreciated or even discovered.

Other materials or substances may be luminous to ultra-violet rays which are not given off by the mercury arc lamp but respond brilliantly to wave lengths falling between the isolated mercury arc rays and which are included in the tungsten lamp radiations.

I have demonstrated such a continuous spectrum as given by the tungsten filament in many clinical or physiological experiments to be superior to those of discontinuous or broken spectra, even those of the carbon arc lamp or of the sun, the latter being broken by the multiplicity of absorption lines (commonly named the "Fraunhoefer lines").

Fluorescence has heretofore been regarded as little more than a scientific novelty, but its utility, as enhanced by such an apparatus as disclosed in the present invention, will aid many fields of endeavor and industry. For instance, in medical diagnosis many dermatological conditions may be discovered before they have become localized or defined so as to be clinical entities. The lesion of the common skin affection psoriasis, for instance, fluoresces bluish white, and in most patients examined discrete fluorescent areas of this color are noticed well distributed over the skin surface and scalp. This may serve as one index of prognosis or of the efficacy of the treatment used.

In chemical analysis the determination of minute variations in solution and solids may be detected quickly and cheaply. Often differences may be shown which have defied more elaborate methods. For instance, the superior nature of this apparatus may be shown in another and important field, namely, the detection of counterfeit paper currency.

With the filtered mercury vapor lamps no difference between spurious and genuine bills is discernible. With apparatus in accordance with my invention, a distinct difference may be instantly seen even by an untrained observer, both in the color of the papers as well as by a distinct bluish white fluorescence in the genuine bill, adjacent to large letters and numerals and surrounding the vignette, which fluorescence never appears in spurious currency.

This effect is doubtless due to substances expressed from the ink by the heavy pressure of Government presses into the fibres of the paper, which are not discernible in the bills made by the counterfeiter using small power or hand operated presses.

To make my invention available for use I will indicate herein schematically the source bases of such radiations as I propose and will discuss their uses.

The drawings indicate only diagrammatically the basis of practical lamp building for such uses. In these drawings I have shown in—

Fig. 1 a schematic sectional view of an apparatus according to my invention.

Fig. 2 is a modification of the same, and

Fig. 3 is a graph showing the respective energy lines of the mercury arc lamp and the tungsten.

In such an apparatus as I have indicated I provide a reflector 1 for concentrating the radiations from a lamp source L. This, according to my invention, comprises preferably a high temperature tungsten source of radiant energy (3300° K.) emitting an ultra-violet spectrum to approximately 3000 Angstrom units.

The inner surface of the reflector 1 as well as the inner surface of the wall 2 of the filter cell F are of reflective efficiency for the ultra-violet rays and may be simply and effectively rendered so as by a coating of an aluminum oxide finish. The rays are thus directed in a concentrated beam through a lens 3 forming the bottom of my filter cell F.

In the form shown in Fig. 1, I may provide for such bottom an opaque ultra-violet transmitting lens-like member 3. This may be sealed in position as by gaskets 4 disposed between its peripheral flange 3' and the inturned flange 5 formed at the bottom of the wall 2 of the filter cell F. By filling the bottom of the cell so defined with water or suitable filtering solution, I am able to protect the filter bottom or lens 3 against the destructive effects of such high concentrations of energy or heat as are developed by tungsten lamp source L. My lens 3 is preferably made of nickel oxide composition which, while permitting the free passage of the ultra-violet rays and a small amount of infra-red rays, shuts off the visible rays so that the space within the casing C is in darkness wherein the fluorescence resulting from the action of the ultra-violet rays on the material under test is readily apparent. Glass of nickel oxide composition is extremely fragile and cracks with the slightest amount of heat. The water however filters out the greater portion of the heat or infra-red rays produced by the tungsten lamp. In my particular combination of tungsten lamp, water filter, and visible ray filter, the fluorescence exciting ultra-violet rays are delivered on the material to be tested as a continuous band as distinguished from the spaced or separated rays from a mercury arc lamp.

It is known that fluorescent effects are amplified by the removal of the longer infra-red or heat waves, and this is done in my apparatus by the water filter or other filters which may be used such as nickel acetate and some colored substances. The removal of heat accentuates ultra-violet effect whereas the presence of heat quenches phosphorescence or fluorescence.

By combining the opaque filter 3 with desired depths of solutions, where solutions are used in plate of plain water, various effects can be attained, as for example, by different combinations of solid filtering members and bodies of fluid selectively pervious to predetermined divisions of the ultra-violet, visible and infra-red specturm.

The curvature of the filter wall 3 may be varied to give any desired lenticular effect in the combination.

The ultra-violet rays so concentrated and filtered are thus directed generally axially of the apparatus. As shown, the device is provided with a base or mount 6 which acts as a housing or shield for any specimen as X observed through the viewing aperture 7.

My device is preferably ventilated by apertures 8 through reflector and filter casing F disposed as desired.

Instead of providing filtering cells as indicated in Fig. 1 and as hereinbefore discussed, I may provide other forms in accordance with my invention. As indicated in the modified form of Fig. 2 I may provide the filter cell as a separate unit comprising a casing 20. This may be attached to the bottom flange R' of a wall R and sealed therein by a gasket R^2 as shown in Fig. 2. Such a construction can be produced in shapes or sizes for which lenses such as the roundel or filter wall 3 are not commercially available. The unit of Fig. 2 may readily be substituted for the roundel 3, of Fig. 1. The form of Fig. 2 is preferable in cases where the apparatus must lie in a horizontal or inclined plane, as it isolates the liquid filter and prevents the liquid from moving freely within the enclosure of the reflector 1 and filter F of Fig. 1, as would be the case if this apparatus were moved from a substantially vertical position.

In the unit assembly of Fig. 2 I preferably provide a top member 23 of ultra-violet transmitting glass or quartz supported and sealed by the gasket 27 on the shoulder 20' of the cell 20. Spaced beneath this member 23 is a filter 24 of opaque ultra-violet transmitting material such as nickel oxide composition which absorbs such portions of the visible spectrum as are to be eliminated.

To protect these fragile materials from overheating in the intense ray concentration from the tungsten source, I provide for the casing 20 a hollow glass or quartz lens or bottom member 21. This is sealed to the lower flange 20a of the casing 20 by a gasket 22. The filter 24 is preferably freely supported marginally on this flange but with sufficient clearance for circulation of the cooling fluid. This may be introduced through a plug or relief valve 26.

It is desirable that the filter unit be filled with water, and to care for the expansion resulting from the heat generated by the lamp L, I provide the expansion tube 28. This permits the cell to be filled "bubble free." With a full cell the lamp may be used in any desired position without interfering with its filtering or ray transmitting effectiveness.

In such an apparatus my invention provides for a wide variety of combinations of the solid or fluid filters to give the best results in the work to be done.

The apparatus, its casing and reflectors will also be varied to meet the requirements of different conditions, as will readily appear to those skilled in this art and its practice.

The graph of Fig. 3 well illustrates the value of the tungsten lamp over the mercury arc lamp. So far as is known ninety percent of all fluorescent substances are activated within the wave length limits indicated (3150 A. u. to 4360 A. u. approximately). As indicated, the mercury vapor source has practically only five lines of any appreciable intensity within this range.

In the ultra-violet field of the mercury vapor spectrum the spaces or gaps between the ultra-violet bands are apparent. Any bodies having luminescent properties responding only within rays falling within the gaps are not apparent with the mercury vapor emanations.

As indicated in the graph, the tungsten filament spectrum appears as a fully continuous succession of all possible wave lengths and therefore the tungsten lamp rays will excite fluorescence in any body responding within the ultra-violet band of energy rays of the indicated wave lengths.

Where it is considered that each substance has a point or points of optimum wave length excitation, the superior value of the super-heated tungsten spectrum is obvious.

What I therefore claim and desire to secure by Letters Patent is:

1. Apparatus for detecting fluorescence comprising a high temperature tungsten filament lamp productive of rays of substantially full continuous spectrum value, a reflector, said lamp being disposed axially of said reflector, and an open-bottomed filter cell beneath said reflector and said lamp, an opaque ultra-violet transmitting lens forming a bottom for said cell, and a body of heat and light filtering liquid permissive of the passage of ultra-violet rays within said cell and of a depth covering said lens.

2. Apparatus for detecting fluorescence comprising a high temperature tungsten filament lamp productive of rays of substantially full continuous spectrum value, an encasement for said lamp including a reflector, said lamp being disposed axially of said reflector, and an open-bottomed filter cell beneath said reflector and said lamp, an opaque ultra-violet transmitting lens forming a bottom for said cell and sealed therein, a body of heat and light filtering liquid permissive of the passage of ultra-violet rays within said cell and of a depth covering said concave lens, and an open topped, open-bottomed support for said casing having inwardly inclined walls adapted to receive and grip the outer wall of said filter cell, said support providing a housing adapted to be placed over the material to be examined and having a sight opening in one wall thereof.

3. Apparatus for detecting fluorescence comprising a high temperature tungsten filament lamp productive of rays of substantially full continuous spectrum value, a reflector, said lamp being disposed axially of said reflector, and an open-bottomed filter cell beneath said reflector and said lamp, the inner walls of said cell having a coating of ultra-violet reflecting material, an opaque ultra-violet transmitting screen forming a bottom for said cell, a body of heat and light filtering liquid permissive of the passage of ultra-violet rays within said cell and of a depth covering said lens.

4. Apparatus for detecting fluorescence comprising a high temperature tungsten filament lamp productive of rays of substantially full continuous spectrum value, a reflector, said lamp being disposed axially of said reflector, and an open-bottomed filter cell beneath said reflector and said lamp, the inner walls of said cell having a coating of aluminum oxide, an opaque concaved surfaced lens forming a bottom for said cell and composed of nickel oxide composition, and a body of heat filtering liquid permissive of the passage of ultra-violet rays within said cell and of a depth covering said lens.

5. Apparatus for detecting fluorescence comprising a high temperature tungsten filament lamp productive of rays of substantially full continuous spectrum value, an encasement for said lamp including a reflector, and an open-bottomed filter cell beneath said reflector and said lamp and having an inturned flange on its bottom edge, an opaque concaved-surfaced ultra-violet transmitting lens forming a bottom for said cell and having a peripheral flange sealed to the flange of the filter cell, a body of heat and light filtering liquid permissive of the passage of ultra-violet rays within said cell and of a depth covering said lens, and ventilating apertures in said reflector and filter walls.

6. Apparatus for detecting fluorescence comprising a high temperature tungsten filament lamp productive of rays of substantially full continuous spectrum value, a dark chamber within which the object to be viewed may be suitably disposed, a reflector adapted to direct said rays into said dark chamber, an opaque vitreous filter in one wall of said dark chamber disposed to intercept the rays directed into said chamber and to filter the light waves therefrom while permitting the passage of ultra-violet rays to said chamber, and a body of liquid between said lamp and reflector and said filter for filtering the infra-red and other heat waves from said rays before they reach said filter while permitting the passage of the ultra-violet rays to said filter and said dark chamber.

EDWARD W. BOERSTLER.