The Relation Between Intensity of Chemiluminescence and Depth of the Luminescing Solution

Evans W. Cottman, Madison

As the depth of a chemiluminescent solution is increased, the amount of radiation per unit area is greater and the light appears brighter. This is to be expected, as the radiation is being emitted from all points throughout the solution. The present studies were undertaken in an attempt to ascertain to what extent the intensity of the luminescence increases with depth of the luminescing solution. The determinations were made by photographic methods, employing a photoelectric densitometer.

The essential apparatus used, will be designated as a "depth wedge." A side view of this is shown in figure 1. It consists of a wedge shaped chamber A, 3″ deep by 4″ long. This is painted black on the inside.
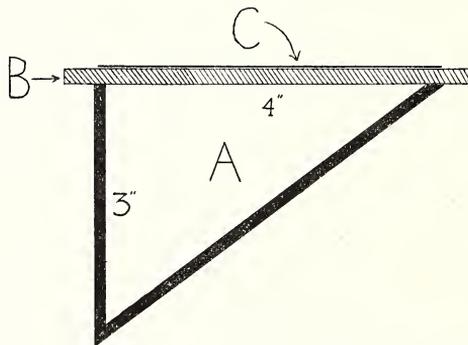

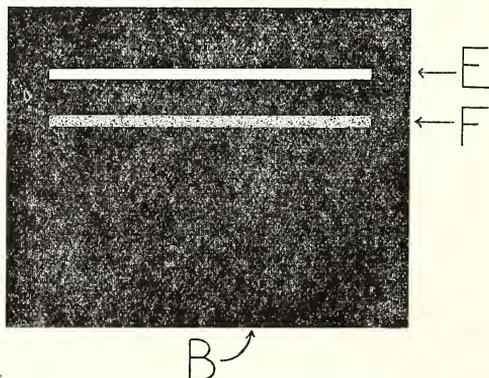Fig. 1. Sectional side view of depth wedge.

Fig. 2. Top view of masked glass plate covering depth wedge.

Over the open top of this chamber is placed a glass plate B. The film C is placed in proper position over B, during exposure. The top view of plate B is shown in figure 2. The top surface is completely masked with black paper except for the two 4″ slits E and F. These slits exactly fit over the 4″ length of chamber A. Over slit F is secured a strip of exposed film having a low, but uniform, density. Proper guides must be provided for placing film C, while working in the dark, in the correct position with respect to A, E and F.

The photographic exposure was carried out as follows: Chamber A was filled to overflowing with distilled water. A small quantity of Chemglo[1] was added and stirred continuously during the exposure. Plate B was set in place over chamber A. Film C was then placed in proper position and exposed 30 seconds. The results of this exposure are shown in E′ and F′ of figure 3. These correspond to the slits
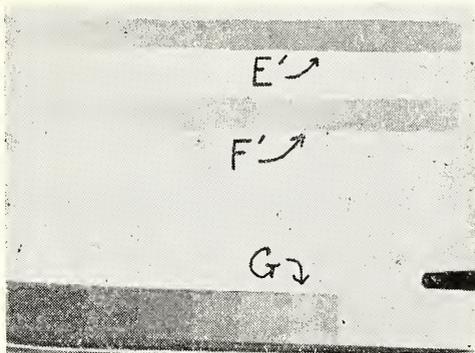

Fig. 3.   Photograph of density wedges (E′ and F′) and densigram G.

E and F of figure 2. They will be here designated as "density wedges."

Both these density wedges clearly show the increase in density corresponding to increase in depth of solution. However, it is necessary to translate these densities into relative intensities of the light, as produced by various depths of solution. This requires that the characteristic or H & D curve be ascertained. A simple procedure was devised for obtaining the H & D curve for any film bearing other photographic data. Since the film will bear its own individual H & D data, a standardized developmental technique will be unnecessary.

The step wedge G (Fig. 3), designated here as a "densigram", supplies the data for drawing the H & D curve of this film. The densigram was made as follows: A section of a step wedge having known densities was mounted on a glass plate. This will be here designated as "the standard wedge." The glass plate has the same dimensions as the film of figure 3, that is, $3\frac{1}{4}″$ x $4\frac{1}{4}″$. All the surface of the plate, except that part covered by the standard wedge, was masked with tin foil. The film,

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[1] Chemglo is a luminol preparation in powdered form. When added to water, it produces a blue luminescence of long duration.

which had already been exposed to the depth wedge, was placed on top of this plate, emulsion side down, in such a position that the unexposed portion of the film would be over the standard wedge. Exposure was made from a uniform source of illumination underneath the glass plate. The densities impressed upon the film will, of course, be in inverse ratio to those of the standard wedge. In the H & D curve, the densities of the steps of the densigram are plotted against the logs of the exposures which produced these densities. Exposure is the product of time and

TABLE I.—Data from which the H & D curve of figure 4 was drawn.

Step No.	Density of standard wedge	Log intensity of light transmitted through standard wedge	Density produced on densigram
1	1.11	8.89—10	0.17
2	0.94	9.06—10	0.21
3	0.78	9.22—10	0.28
4	0.63	9.37—10	0.38
5	0.49	9.51—10	0.50
6	0.38	9.62—10	0.61
7	0.29	9.71—10	0.71
8	0.23	9.77—10	0.77
9	0.18	9.81—10	0.84

TABLE II.—Relation of depth of solution to intensity of light emitted.

Density wedge No.	Position (inches)	Depth (inches)	Density	Log intensity	Relative intensity
1	0.1	0.225	0.225	9.100—10	0.126
1	0.2	0.300	0.245	9.150—10	0.141
1	0.3	0.375	0.265	9.195—10	0.157
1	0.5	0.525	0.315	9.273—10	0.187
1	0.7	0.675	0.370	9.354—10	0.230
1	1.0	0.900	0.430	9.432—10	0.270
1	1.5	1.275	0.500	9.510—10	0.324
1	2.0	1.650	0.550	9.566—10	0.368
1	2.5	2.025	0.560	9.577—10	0.378
1	3.0	2.400	0.570	9.586—10	0.385
1	3.5	2.775	No perceptible increase		
2	0.1	0.225	0.160	8.800—10	0.063
2	0.2	0.300	0.180	8.934—10	0.086
2	0.3	0.375	0,195	9.000—10	0.100
2	0.5	0.525	0.230	9.113—10	0.130
2	0.7	0.675	0.265	9.195—10	0.157
2	1.0	0.900	0.295	9.241—10	0.174
2	1.5	1.275	0.370	9.355—10	0.227
2	2.0	1.650	0.400	9.394—10	0.248
2	2.5	2.025	0.420	9.420—10	0.263
2	3.0	2.400	0.440	9.443—10	0.277
2	3.5	2.775	No perceptible increase		

light intensity. Since the time of exposure is the same for all of the steps, the density may therefore be plotted against the log of the intensity. The logs of the intensity of the light transmitted through the steps of the standard wedge, will be the reciprocals of the density of those steps. Exposure through the standard wedge produced the densigram shown in figure 3. The density of the densigram steps was measured, and from these data the H & D curve was drawn. The data are shown in Table I and the H & D curve is given in figure 4. The originals

Fig. 4. H and D curve of film of Fig. 3. Data are taken from Table I.
Fig. 5. Density wedge curves. Data are taken from Table II.

of figures 4 and 5 were drawn on cross section paper, which permitted a much more accurate reading of the curve, than is possible with the graphs shown here.

Density readings were then taken at a number of positions along each density wedge, and the depth of solution was calculated for each position. From these densities, the logs of the intensities were read from the H & D curve, and the intensity in each case was determined. Table II shows the data for both density wedges. The curves were drawn for the two wedges, intensity of the emitted light being plotted against depth of solution. These curves are given in figure 5.

Summary

1. The greater the depth of a chemiluminescent solution, the greater will be the apparent brightness of the light.

2. The effect of depth upon the intensity of chemiluminescent solutions was studied, and quantitative measurements of this effect were made, using photographic procedure.

3. A simple method is presented for obtaining the H & D curve of any individual film carrying other photographic data.