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PROCESS FOR SCANNING PHOTOGRAPHIC SLIDES OF LASER LIGHT SCATTERING WITH A TRANSMISSION DENSITOMETER

Don Newburry

Abstract

Non-symmetric variations in photographic slides of polarized laser light scattering experimental results are difficult to see. This paper explains a process developed for measuring the light density at points throughout the slide area using a transmission densitometer, so an accurate description of the laser light scattering may be obtained. A slide was tested using the described process and the results are presented. The results turned out well, but there were some errors introduced by the instability of the densitometer and by human error in reading the chart recorder output.

Introduction

Photographic slides of polarized laser light scattering experimental results are small in physical size and the nonsymmetric variations in light density are difficult to see. Therefore, an accurate method of scanning a slide, measuring the light density at points throughout the slide area, and digitizing the results was the goal of this project. Once obtained, the data can then be manipulated in any manner for study and presentation. For example, the constant intensity curves for any values of light intensity may be plotted on a percentage basis (i.e., 90% of max, 80% of max, and so on). These, in turn, give an accurate description of the laser light scattering as registered by the photographic film.

Thus, the purpose of this report is to describe just such a procedure. Throughout this project a Fisher Biotech 910 Transmission Densitometer (FB 910 - Fig. 1) was used along with a Kipp and Zowen Chart Recorder. The procedure for setting up the equipment and scanning a slide will be described along with the process for taking the data from the scan and converting it into distances for making plots.

Setup

The basic setup of this densitometer experiment was straight forward. Figure 1 also contains a photo of the setup. The recorder (reading 0 to 10 mV, max) was hooked up to the densitometer, and the SCAN/INTEGRATE switch was set to SCAN. At this point the equipment was ready to run with the exception of a warm-up period. In order to scan a slide, the lightest part of that slide was placed over the light source, and the ZERO knob was adjusted to a maximum value (100%). Then the slide was moved so the darkest portion of that slide was placed over the same light source, and the SPAN knob was adjusted to a minimum (0%). The carriage drive can then be turned to either low or high (the only choices), and the densitometer will scan down the object in a straight line.

The FB 910 operation had to be modified in order to scan the complete photographic slide. Two problems had to be overcome. First, due to the dark nature of photographic slides, the densitometer initially would not read in the dark regions of the slide. Two things were done in order to correct this problem. The first was to remove the narrow band optical filter that came with the densitometer and replace it with a broad band optical filter which could

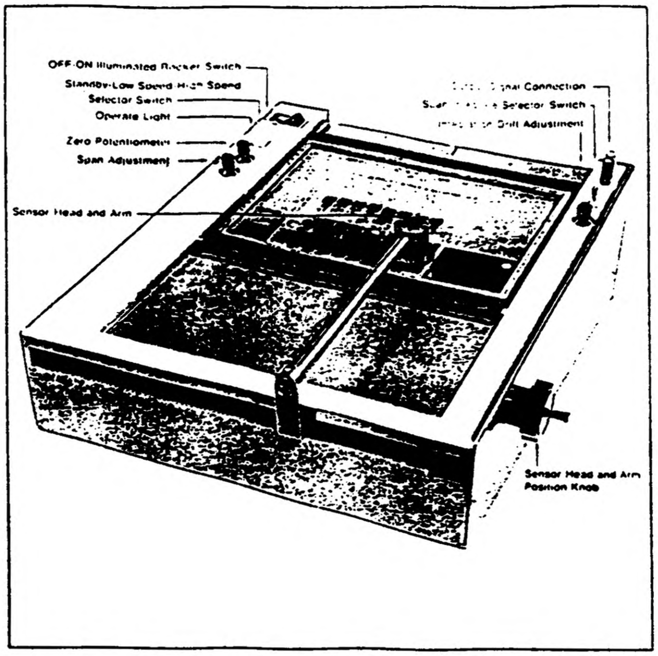

Figure 1a: FB 910 with labeled external controls.

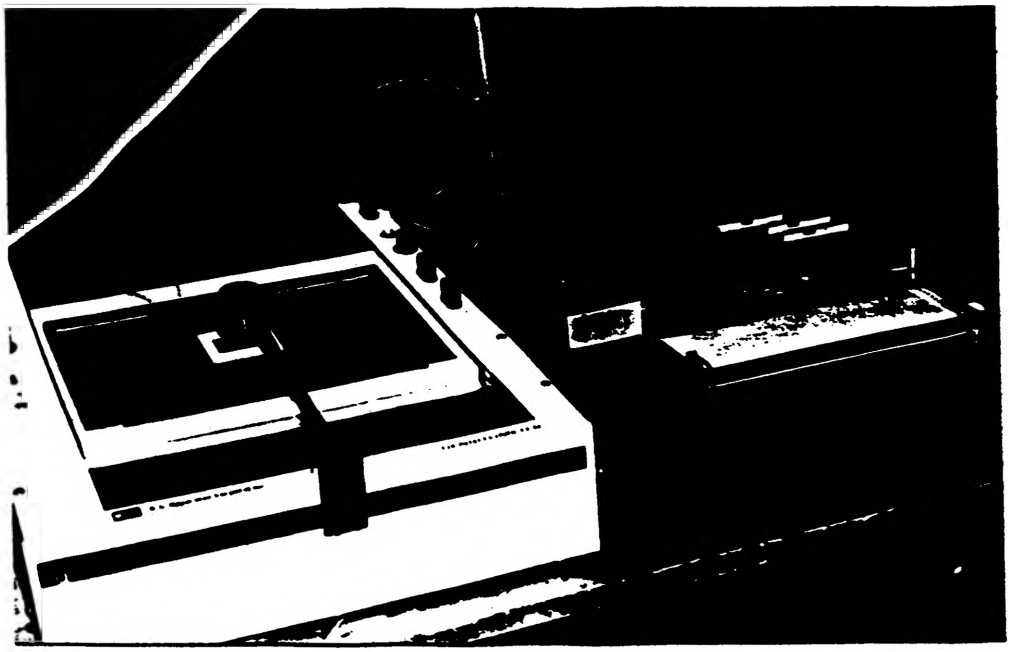

Figure 1b: Photograph of experimental set-up.

allow more red light to pass. The second action involved the light source of the densitometer; it is a tungsten filament light bulb which shines through an orifice. Initially, this orifice was a 0.05 mm in diameter circular hole and served as a point source. This orifice was the smallest obtainable from the manufacturer. so we assumed it would be the best size for very accurate results. However, the small source did not provide near enough light to penetrate the photographic slides. Therefore, larger and larger orifices were tried until the 0.4 mm point source produced the desired results (i.e., response to light variations throughout the slides).

Another problem with the FB 910 was the warm up time. When testing various slides, it was noticed that as time went on the magnitude of the output dropped, even if the same portion of the slide was being scanned repeatedly with all other settings fixed. Although the instruction manual for the densitometer stated it only needed 15 minutes to warm up, this was not found to be the case. A test was run over a 10 hour period of time with the densitometer simply scanning the same point. That is, the scanning mechanism was disconnected. During this test the densitometer was turned on (a cold start) and the chart recorder was set at the speed of 1 mm/minute. The results show that it took the densitometer at least 2.5 hours to reach a stable value. (See Figure 2.)

Another problem which was discovered was that the densitometer should be warmed up with nothing between the light source and the photodetector. An obstructed view keeps the photodetector from becoming fully warmed up. This causes error in the readings as of function of time as the photodetector does warm up during operation.

In order to test the long term stability of the scanner, while taking data, a slide was scanned vertically 20 times along the same line without changing any of the other settings. After the 20 scans, it could be seen on the chart recorder that the output magnitude of the last scan had dropped off approximately 5% from the output magnitude of the first scan. The cause of this error was still unknown. Further, after 20 scans the output continues to decrease. Therefore, this must be kept in mind when taking data of more than 20 scans and a data adjustment incorporated into the data to account for this drop.

Process

Since the scanner operates in only a straight line in the vertical direction, a method had to be developed in order to scan the entire slide. This was accomplished by starting at the left side of the slide, scanning down the slide, moving the light source and sensor head to the right (essentially the same as moving the slide to the left), and repeating the process across the whole slide. Depending upon how accurate the data needed to be and how much the slide varied in the horizontal direction, the distance between scans could be set as needed.

In order to determine the distances being scanned some operational procedures had to be developed. The motion in the horizontal direction was controlled by an unregistered knob on the machine. Therefore, a horizontal measurement standard had to be established. To accomplish this, the knob was marked at every 90 degrees. Then a Moire pattern (60 lines per inch) was scanned in the horizontal direction by turning the knob and keeping track of the number of revolutions. The peaks and valleys of the output were used to judge precisely where to start and stop counting the revolutions. Once this was finished the actual distance on the Moire pattern was measured and was divided by the number of revolutions. Thus the horizontal scale came out to be 2.5 mm/rev. of the knob.

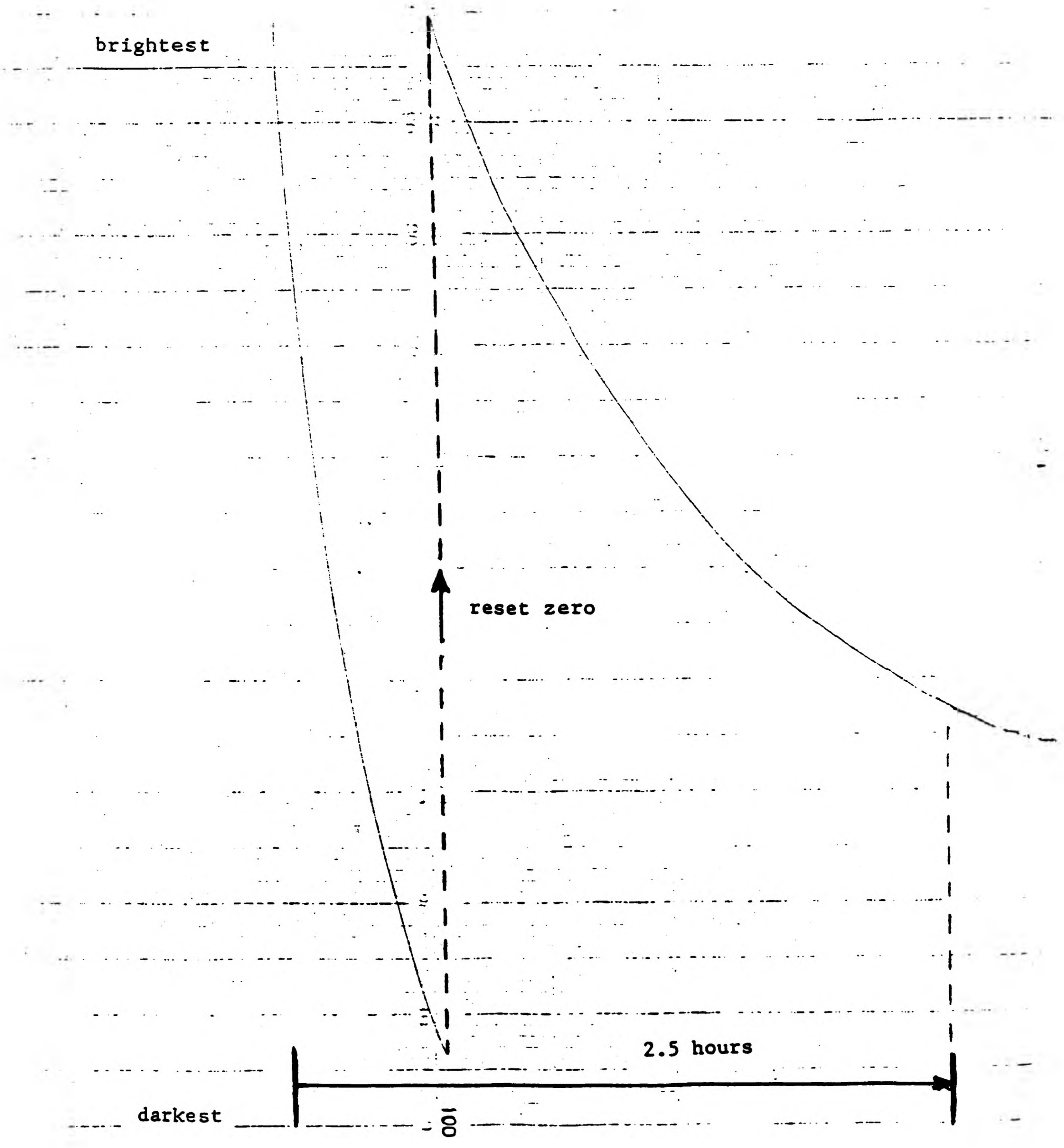

Figure 2: Chart recorder output of warm-up test.

In the vertical direction, the operational procedure was a bit more complicated. There were two motion aspects that needed to be considered: the recorder speed and the scanning speed. The scanning speed has two settings ("high - 2.2 in/min" or "low - 1.1 in/min"). These were verified by scanning a ruler of known length for a specified length of time. Since the recorder used metric distances, the scanning speeds were converted giving 0.932 mm/sec and 0.466 mm/sec, respectively. The scanning distance in the vertical direction was found by using the following definition:

R = the recorder speed in mm/sec
S = the scanning speed in mm/sec
$f = R/S$, which is the difference factor between the recorder and the scanner.

Therefore, the vertical distance on the slide is $-y$, (the scanner scans downward) and can be found from the distance travelled by the recorder along the time axis, d. Thus

$$-y = d/f$$

Using an easily recognizable position as a reference point, (the edge of the ruler for example), all the other vertical distances can be obtained with respect to it.

The brightness at each point could be measured directly off the slide at each point. By multiplying the maximum brightness by a percent, the value needed for that percent was given. Then everywhere that value occurred on the recorder charts could be found and used to plot a constant intensity curve.

Results and Conclusions

A slide was tested using the process described above, and the manipulated results are presented here. A plot was made for the relative brightness, z, equal to 20% of the maximum. (Fig. 3.)

Although the results turned out well for the test slide, there are some errors introduced by both the instability of the densitometer and by human error in taking the measurements. Also, the quality of the slide will effect the readings. Efforts are presently underway to pinpoint these errors and take corrective action. The results presented are encouraging. That is, the procedure presented outlines a reliable procedure of data acquisition from the slide. The results can, in fact, be presented as patterns which describe the scattering of laser light in a scattering medium.

Figure 3: Plot of relative brightness of 20% for the test slide