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# A Modulated-Beam Microdensitometer

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## Introduction

The employment of barrier layer cells in microdensitometers designed for use in spectrochemical analysis has found considerable favor, as indicated by the fact that this type of photosensitive element has been incorporated into three commercially available instruments: the Vincent and Sawyer (1) microphotometer manufactured by the Leeds and Northrup Company, and the Jarrel-Ash and Hilger instruments. Sensitive galvanometers are employed in all three of these densitometers. There seems to be no case in which such an instrument has been equipped with an amplifier in order to improve the precision of the higher density readings, presumably because the low internal resistance of the barrier layer cell is not conducive to amplification.

However, development in recent years of the General Motors breaker-type amplifer (2), designed to match low input impedances, has simplified the problem of amplifying such photocurrents. The present paper is concerned with the use of such an amplifier on a microdensitometer. In the course of this investigation the principle of modulated-beam operation was ultimately adopted.

## Preliminary Experiments

The General Motors amplifier used in this work had been previously modified for use with a Perkin-Elmer Model 12C infrared spectrometer (3), and was used in this form throughout the investigation. This instrument became available when the above-mentioned spectrometer was converted to Model 13.

Before any attempts were made to use this amplifier in conjunction with densitometric measurements, some preliminary experiments were conducted in order to investigate the behavior of this instrument in the amplification of barrier layer cell output at levels of luminous flux comparable with those anticipated in the proposed application. In this work the external input circuit of the amplifier consisted of a 5-ohm resistor connected across the terminals of the barrier layer cell. The output voltage was measured with a vacuum-

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tube voltmeter. Excessive zero drift and random fluctuations, due to thermal and induced electromotive forces arising in the input circuit, were encountered.

Although some improvement could have been effected by careful design and construction of the input circuit, a simpler and more foolproof solution appeared to be that of modifying the densitometer for modulated-beam operation.

This latter alternative seemed even more attractive, inasmuch as most of the necessary equipment was readily available, having been obtained from the same source as the amplifier.

## Description of the Modulated-Beam Densitometer

The additional items salvaged from the 12C spectrometer which have found application in this work are the 7-cycle light chopper and breaker assembly, and the filter circuit. The light beam in the microdensitometer is interrupted periodically by the light chopper.

The pulsating photo-current of the barrier layer cell is amplified and fed into the breakers which operate synchronously with the chopper. These breakers rectify the a.c. component of the amplified signal, and convert the d.c. component into a.c. This final d.c. component, freed from a.c. by means of a low-pass filter, is measured with a potentiometer.

The densitometer employed in this work was constructed at the State University of Iowa (4). The optical system, similar to that of the Hilger instrument, was altered only by a change in the type of lamp and installation of the light chopper. The lamp is a 6-volt battery operated Mazda 2331 automobile headlight bulb of the prefocussed type. The chopper, of blackened aluminum, is of half-cylindrical form and is so mounted on the shaft of the chopper and breaker assembly that its rotation is about the axis of the bulb. Since the lamp and chopper are completely enclosed, there is no modulation of the intensity of extraneous light, and thus, extraneous light has no effect on the response of the instrument.

The external circuit of the amplifier is essentially the same as that used in the preliminary experiments, with the exception that a 22-ohm resistor replaces the 5-ohm resistor used previously. This value represents a compromise between noise level and maximum ratio of amplifier output to luminous flux.

The external output circuit, shown in Figure 1, is essentially that used in the 12C spectrometer, with the following exceptions: the 220-ohm resistor $R_1$ has been added, $R_4$ has been increased from 50 to 270 ohms, $R_8$ from 500 to 900 ohms, and $R_9$ has been decreased from 250 to 100 ohms.

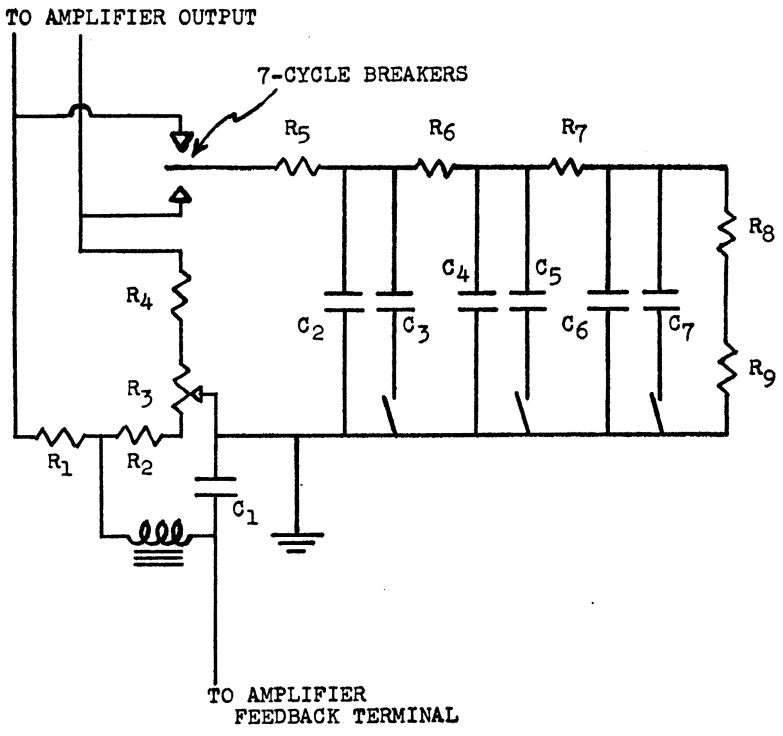


Figure 1. External Output Circuit

For densities in the range 0-1 the voltage across $R_9$ is measured, while the combined drops across $R_8$ and $R_9$ are used for the density range 1-2. A Leeds and Northrup student potentiometer and a rugged box galvanometer have been found satisfactory for these measurements, using only the slidewire of the potentiometer. The span voltage across the slidewire is adjusted to 10 mv., and the densitometer slit and amplifier gain are adjusted so that the clear-plate voltage across $R_9$ is 10 mv.

## Performance and Discussion

Densities have been measured with this instrument as precisely in the range 1-2 as in the lower 0-1 range. The precision is approximately $\pm 0.01$ at a density of 2.

No zero drift has been observed, but the expectation that the instrument would not respond to extraneous light, such as that encountered in a normally lighted room, has not been fully realized. This is apparently due to overloading the amplifier on half of the chopper cycle.

Finally, it should be pointed out that this arrangement would be well suited for use on a recording densitometer, since the circuits were originally designed for recorder application.

**Literature Cited**

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