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AUTOMATED DATA ACQUISITION AND PROCESSING FOR A HOHLRAUM REFLECTOMETER

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SUMMARY

A computer and data acquisition board were used to automate a Perkin-Elmer Model 13 spectrophotometer with a hohlraum reflectivity attachment. Additional electronic circuitry was necessary for amplification, filtering, and debouncing. The computer was programmed to calculate spectral emittance from 1.7 to 14.7 μm and also total emittance versus temperature. Automation of the hohlraum reflectometer reduced the time required to determine total emittance versus temperature from about 3 hr to about 40 min.

E-4466

INTRODUCTION

Spectral emittance measurements between 1.75 and 14.7 μm have been made at NASA Lewis Research Center using a hohlraum (heated-cavity) reflectivity attachment for a Perkin-Elmer Model 13 spectrophotometer (ref. 1). The spectral emittance had to be calculated by hand from three strip chart recordings (a 100 percent curve, a 0 percent curve, and a sample curve) for each selected wavelength. To calculate the total emittance at a given temperature, the data would then have to be entered into a computer. Overall, the data-taking process was very tedious and time-consuming, but this was to be expected because of the vintage of the instrument (1955-spectrophotometer and 1959-hohlraum attachment).

In order to speed up the data-taking process, a data acquisition board was used to interface the spectrophotometer with a computer (fig. 1). The computer could calculate spectral emittance and total emittance immediately, greatly reducing the time required for the measurements. The hohlraum reflectometer is a widely used instrument for emittance characterization and since a large number of these vintage instruments exist, documentation of the automation improvement should be of widespread value to researchers who use this instrument.

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APPARATUS

Analog Signal

A Metrabyte DASH-8 12 bit A/D Data Acquisition Board was used with a Zenith IBM AT-compatible computer to read the data from the spectrophotometer. The analog voltage signal was taken from circuit board number 501, terminal number 7 of the spectrophotometer. At this point in the spectrophotometer circuit, the signal has just passed the filter and is about to enter the chart recorder. The analog reference was taken from circuit board 502, terminal number 8, which is the instrument ground.

The signal voltage was found to be less than 5 mV while the spectrophotometer was in use. Since the DASH-8 A/D converter accepted a ±5 V input with a resolution of 2.44 mV, the signal had to be amplified using the circuit shown in figure 2. The circuit consisted of a 741 op-amp as a noninverting low-pass amplifier with a gain of 1000. The filtering was necessary to remove the small spikes in the signal caused by the wavelength marker pulses for the chart recorder.

Before the circuit was first connected to the data acquisition board, the analog output was measured with a voltmeter and compared to the chart recorder readings. The spectral emittance of a test sample measured with the voltmeter and measured by the chart recorder (with the circuit disconnected) is shown in figure 3. The two curves were always within 0.02 emittance units of each other throughout the entire spectrum. This test confirmed that the correct terminals of the spectrophotometer were used. The small discrepancy between the two curves could be attributed to the limited reproducibility of the hohlraum data caused by the heating and cooling of the cavity. The uncertainty for spectral emittance measurements by the hohlraum reflectometer is ±0.02 (ref. 2).

Wavelength Marker Pulses

The spectrophotometer produces wavelength marker pulses, causing pips in the chart recorder reading. The pulses are produced every 10th division of the wavelength drum and also at the 95th division. The DASH-8 data acquisition board was operated in the interrupt mode (Mode 5), which allowed the A/D conversions to be positive-edge triggered by an external source. The problem therefore was to convert the wavelength marker pulses into suitable TTL clock pulses for the computer.

The wavelength marker pulses were taken from circuit board number 502 of the spectrophotometer, terminals number 4 and 2. The pulses were 70 V, and they were scaled down to 5 V by a voltage divider and follower circuit. It was necessary to use a circuit with a high input impedance because the wavelength marker pips on the chart recorder would have otherwise been affected.

It was soon discovered that debouncing of the pulses was necessary. The pulses were initiated by a microswitch operated by a notched cam on the wavelength drive screw of the spectrophotometer, and each pulse would clock the data acquisition board about five times. The pulses were debounced with a filtered Schmitt trigger circuit using a LM311 comparator. The complete wavelength marker pulse processing circuit is shown in figure 4.

Hohlraum Cavity

The hohlraum cavity was maintained at 600 °C with an automatic temperature controller. During a scan (7 min), the cavity heater would cycle once or twice. These power surges would cause the computer to be clocked about four extra times, and it would also cause large spikes in the spectrophotometer output. This problem was resolved by electrically isolating the cavity heater from the spectrophotometer.

SOFTWARE

The computer was programmed in BASIC to read and process the spectral data. First, the calibration data for the spectrophotometer was loaded into the computer, which enabled the conversion of the wavelength drum position into the wavelength. The program directed the user to run a 0 percent curve, a 100 percent curve, and a sample curve, with the computer reading the spectrophotometer output as it was clocked. Before each curve was run, the program included a 20 sec time delay to allow the instrument to stabilize. The raw data from the 0 and 100 percent curves was saved on a floppy disk, giving the user the option of running new 0 and 100 percent curves or retrieving the data from the previous run. Normally, the user would run new 0 and 100 percent data only for the first run of the day and use the saved data for the rest of the runs. After the sample curve was run the computer would immediately calculate spectral emittance $\varepsilon(\lambda)$ at each wavelength λ which it was clocked

$$\varepsilon(\lambda) = 1 - \frac{\text{sample} - 0 \text{ percent}}{100 \text{ percent} - 0 \text{ percent}}$$

The spectral emittance data would also be saved on the floppy disk.

Afterwards, the total emittance (e_T) at a given temperature T was calculated from the spectral emittance:

$$\varepsilon_T(T) = \frac{\int d\lambda \ \varepsilon(\lambda) \ f(\lambda,T)}{\int d\lambda \ f(\lambda,T)}$$

where $f(\lambda,T)$ is the blackbody distribution function. The integrals were done using the trapezoid rule for all the data points. The total emittance was calculated between 300 and 1100 K at 50 K intervals, and the results were saved on a disk.

The user was able to print tables or graphs of the spectral emittance or total emittance versus temperature. The graphs were produced using the "LINPLT" graphics program provided by Metrabyte.

CONCLUDING REMARKS

Automating the data acquisition and processing steps for the hohlraum reflectometer has dramatically reduced the time required to determine the spectral emittance and the total emittance versus temperature for a sample. Measuring, calculating, and graphing the spectral and total emittance could now be done in about 40 min instead of 2 or 3 hr. The increase in speed also improved the accuracy of the results because the calculations now involved many more data points.

REFERENCES

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2. Streed, E.R., et al.: Errors Associated with Hohlraum Radiation Characteristics Determinations. Measurement of Thermal Radiation Properties of Solids, J.C. Richmond, ed., NASA SP-31, 1963, pp. 237-252.

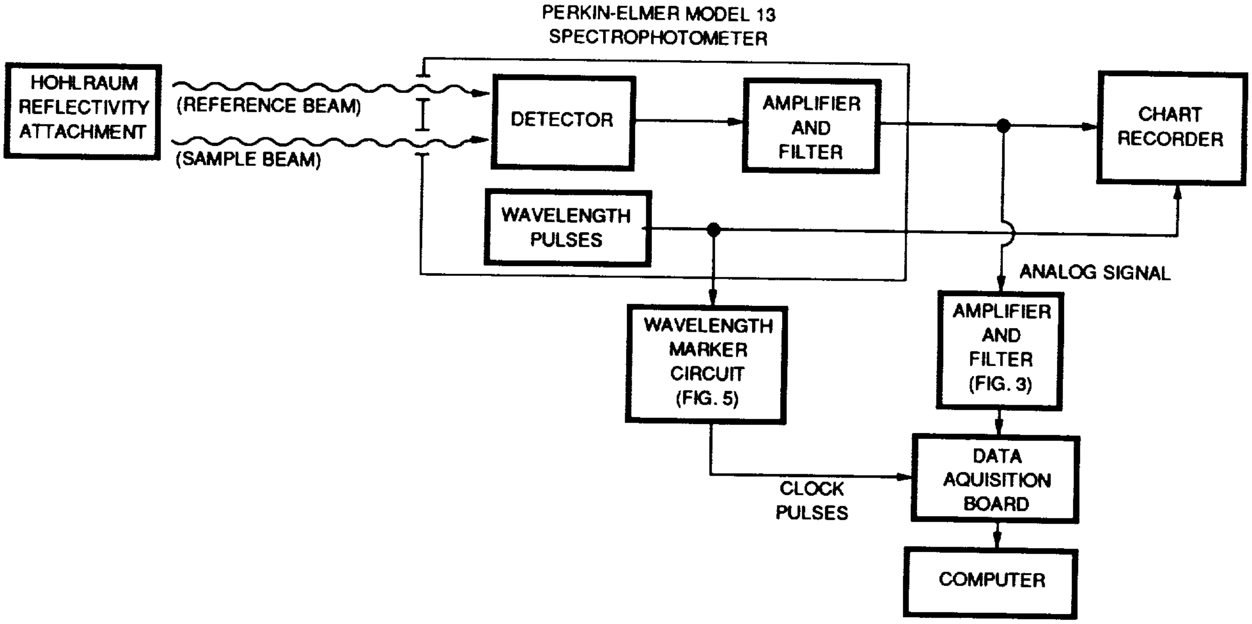

Figure 1. - Schematic of Spectrophotometer/Computer Interface.

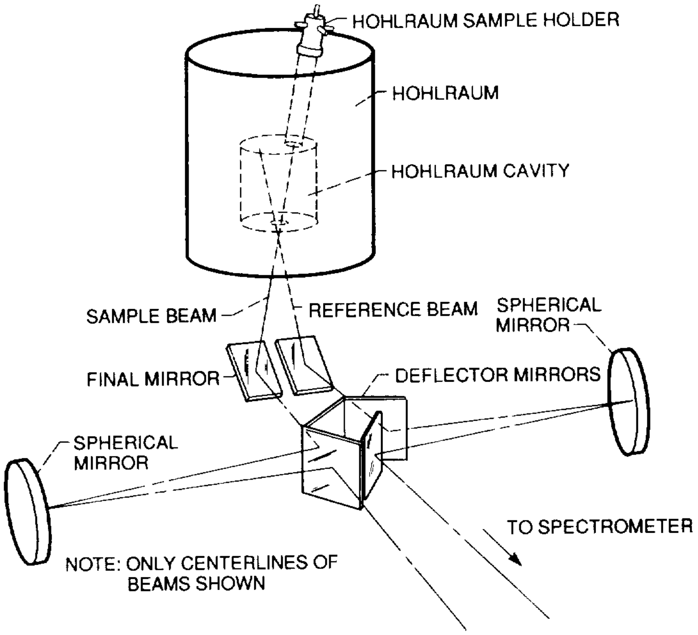

Figure 2. - Optical path of Hohlraum reflector.

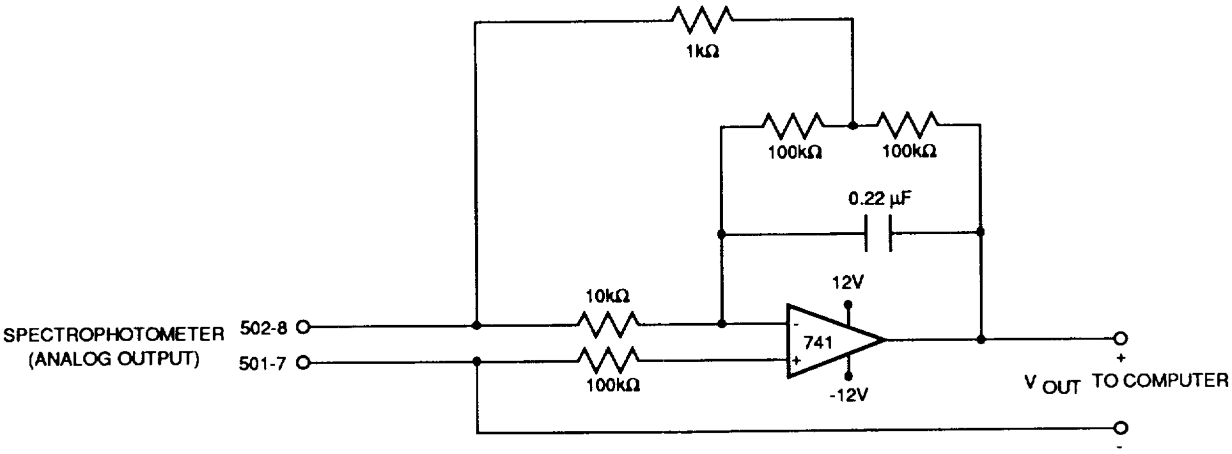

Figure 3. - Analog Signal Processing Circuit.

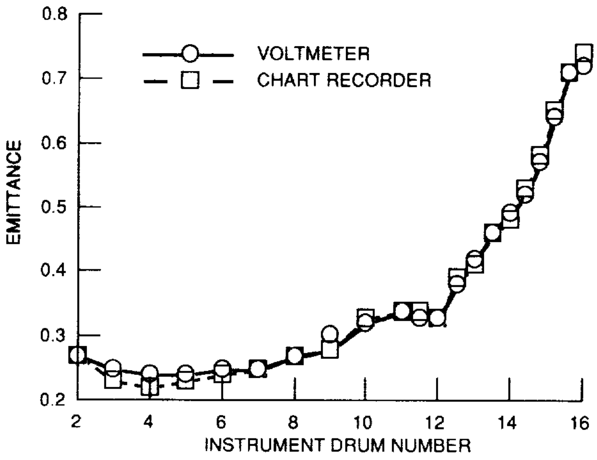

Figure 4. - Comparison of the circuit output with the chart recorder output.

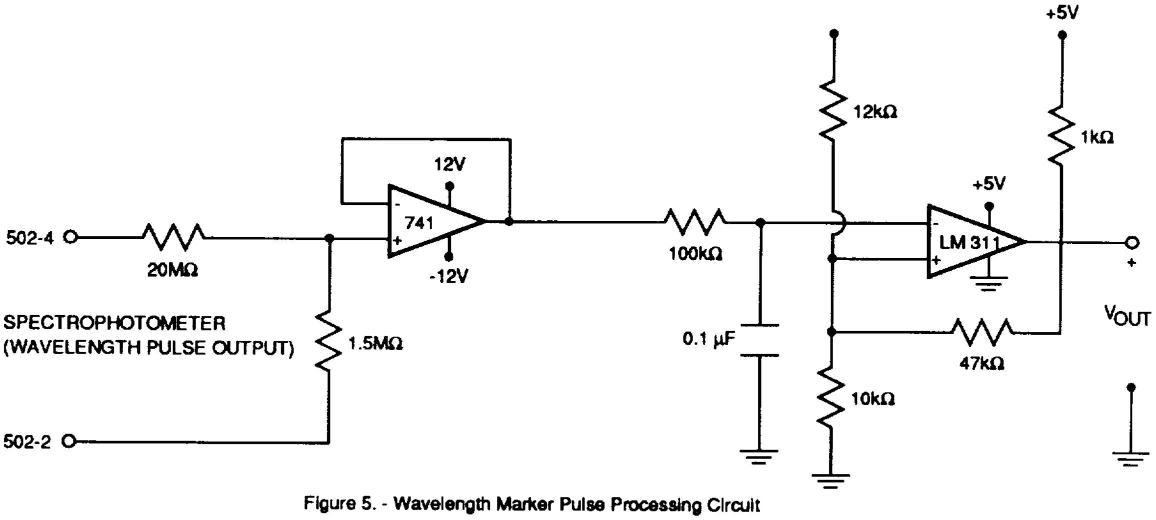

Figure 5. - Wavelength Marker Pulse Processing Circuit

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16. Abstract

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