AN ABSTRACT OF THE THESIS OF

Jamie Lindsay Shumway for the M.S. in Physics
(Name) (Degree) (Major)

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(Major Professor)

The design and details of construction of a recording type of microphotometer are given, and are accompanied by samples of the curves obtained.

To insure accuracy of construction and therefore reproducibility of results, a simple design was sought. Upon a bar pivoted near one end about a horizontal axis are fastened, concentrically about the pivot, two cylindrical arcs of appropriate radii, and suitable width, the smaller one serving as film holder and the larger as record holder.

An image of an illuminated slit is focused upon the film to be analyzed. The varying density of the lines upon the film allow varying amounts of light to fall upon a photoelectric cell connected to a wall galvanometer. Light reflected from the galvanometer mirror is focused upon a sheet of photographic paper fastened to the record holder.

A suitably slow motion in a vertical plane is imparted to the bar by a D.C. motor; this provides for a continuous record of galvanometer deflections in which the ordinates are proportional to the density of the lines on the original film, and the absissae to distances in the spectrum, the magnification of the latter being the ratio of the radii of the two arcs.

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A SIMPLE RECORDING MICROPHOTOMETER

by

JAMIE LINDSAY SHUMWAY

A THESIS

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Head of Department of Physics

In Charge of Major

Redacted for privacy

Chairman of School Graduate Committee

Redacted for privacy

Chairman of State College Graduate Council

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A SIMPLE RECORDING MICROPHOTOMETER

Introduction

A densitometer is a necessary part of the equipment of a spectrographic laboratory. The present thesis was undertaken to see whether the design of such an instrument of the recording type could be simplified sufficiently to enable it to be built at low cost.

The recording type was the only one considered, as the use of the visual type is tedious and conducive to eye fatigue. The principle of the recording instruments that are on the market is simple. The original photograph of the spectrum is moved across the image of an illuminated slit. As the photograph is moved, the lines on it absorb varying amounts of light, proportional to their density and width. The light transmitted is either collected by a lens or allowed to impinge directly on a photoelectric cell or some other form of radiometer. Most radiometers must be used in conjunction with a mirror galvanometer. A beam of light reflected from the galvanometer mirror produces a trace on a moving piece of photographic paper. As the galvanometer deflections can be made perpendicular to the direction of travel of the sensitized paper, the height of the trace will be inversely proportional to the densities of the lines on the original photograph. However, the ordinates of the trace are usually considered as 100 per cent for a clear space and 0 per cent for complete blackness, thus making it possible to regard the height of the lines as proportional to the intensities of the original spectral lines.

The present trend of development is away from the use of photographic paper for recording. Industry requires direct pen traces on a roll of coordinate paper operated at chosen speeds as this saves the time of processing and drying the paper and avoids any change in the dimensions of the paper due to wetting and drying. In these instruments the pen is often moved by an automatic balancing device applied to a potentiometer. It will be seen readily that such devices require great care in construction and therefore are high in cost.

Since spectral lines are very close together even when using a spectrometer of high dispersion, and since wavelength determinations depend on measuring the relative positions of lines, it is desirable that the trace be drawn at a definitely magnified scale. Commercial instruments use scales varying from 1:1 to 100:1. It is desirable to have some choice as to the magnification.

Much of the cost of commercial instruments is due to the devices for producing this magnification. Some of the devices used are: two lapped screws connected by a train of gears, a system of levers arranged in the form of a pantograph, a traveling camera, or even rotation of the galvanometer by a lever. These schemes all call for equipment and construction time that eliminate them from consideration in the present study.

Design and Construction

The design was dictated by decisions made concerning several factors discussed in the introduction. Photographic recording was adopted because it was cheaper. A Weston photronic cell was used because it was available and did not require a separate constant source of potential difference. For ordinary laboratory procedures magnifications from 4:1 to 10:1 are very useful; the ratio of 4:1 was decided upon for the initial instrument.

The greatest simplification made consists in the method of obtaining this magnification. The best way of assuring a fixed magnification, and therefore reproducible results, is to fasten the film holder and the record holder together rigidly and rotate them about a common center. In Fig. 1, F and R respectively indicate the film holder and the concentric record holder. They are attached to the iron bar BA rotatable in a vertical plane about an accurate bearing at B. The arc F is long enough to hold

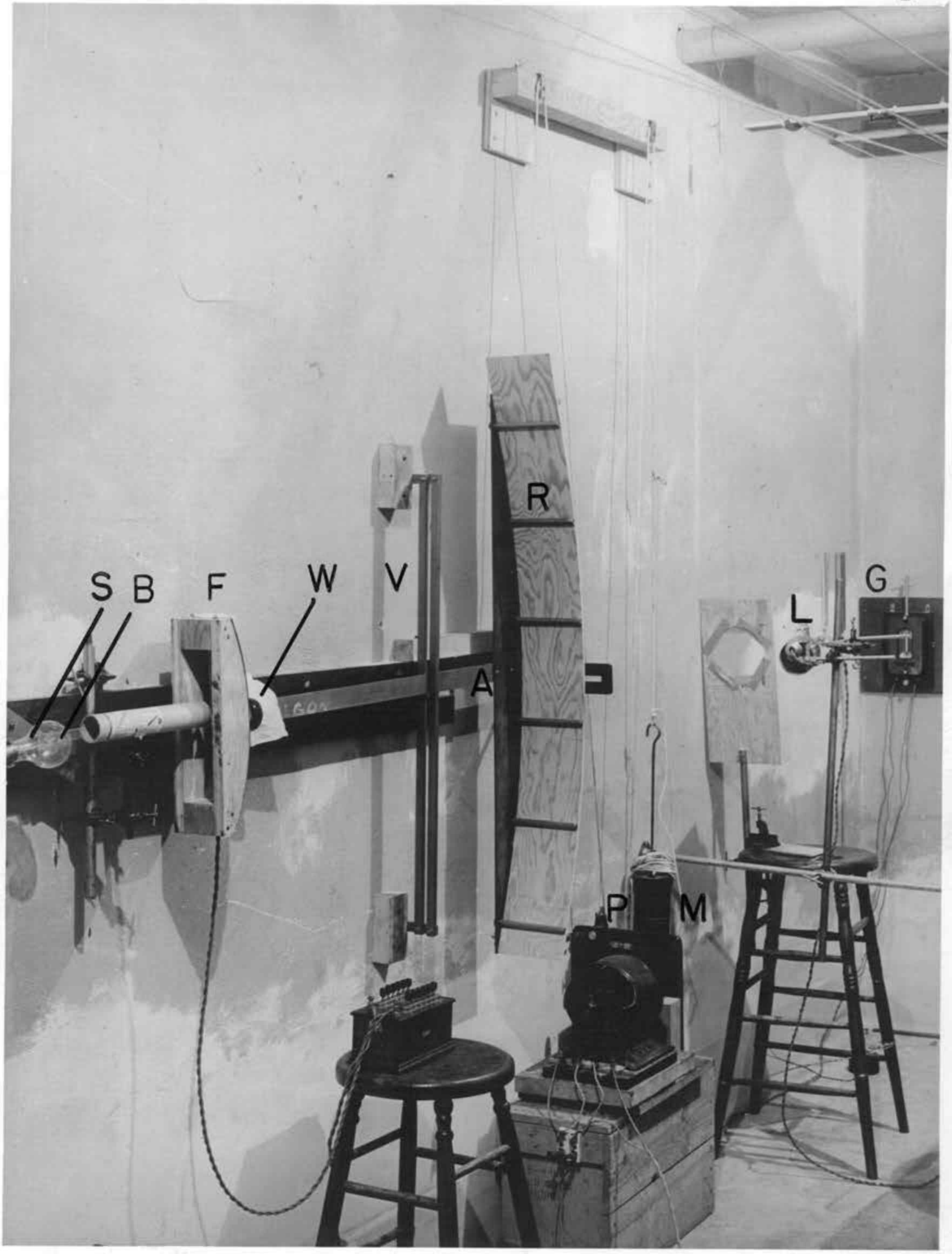

Fig. I

a 10 inch film and the arc R, a strip of photostat paper four times as long. The radius of F is 15, and of R 60 inches. F is made of sheet brass fastened to two plywood segments. The brass is four inches wide and is provided with a 1/4 inch slot along its length so that one spectrum on a film containing several may be illuminated. The source of light S is a 100 watt lamp, coiled coil cylindrical filament. Immediately in front of the lamp is a 1/16 inch horizontal slit. A lens of 2 inch focus images the slit on the film. The light that passes through the film impinges on the Weston photronic cell W. This cell is directly connected to a wall galvanometer, (L and N, type P), which in turn is shunted to reduce the deflections.

The record holder R is made of 1/4 inch plywood 6 inches wide bent around suitably spaced iron pegs in an iron plate. The galvanometer, G is illuminated by a lamp L similar to that which illuminates the film. The light is passed twice through a 65 inch focal length lens and finally focused on the sensitized paper by a horizontal cylindrical lens 5 inches long.

The apparatus is not quite counterweighted by means of the mass M and the pulley and sash-cord system shown in the photograph. Motion is imparted by rotating the pulley P by means of a D.C. motor and a reducing gear having a ratio of 60000:1. As the end A of the bar is lowered, the sash cord wraps itself around the plyboard arc R, thus imparting uniform angular motion to the apparatus. During the motion the apparatus is guided by two vertical ways, V.

Results

Three sample spectra and traces are reproduced in Fig. 2. Z represents an arc spectrum of zinc, B of brass and C of copper. It is easy to recognize the prominent lines of the elements in their alloy.

Further Design

It is clear that other magnifications can be readily obtained by constructing additional arcs. The apparatus has been redesigned so as to be more compact, easier to operate, and at the same time yield a magnification of 8:1. Because of the compactness that is possible with this design, the whole apparatus may be made portable.

In Fig. 3 the only moving part is the film holder F to which is attached the mirror M directly over the bearing B. As the film holder rotates, the image of the slit formed by the source S and the lens A passes over the film. The transmitted light is received by the photronic

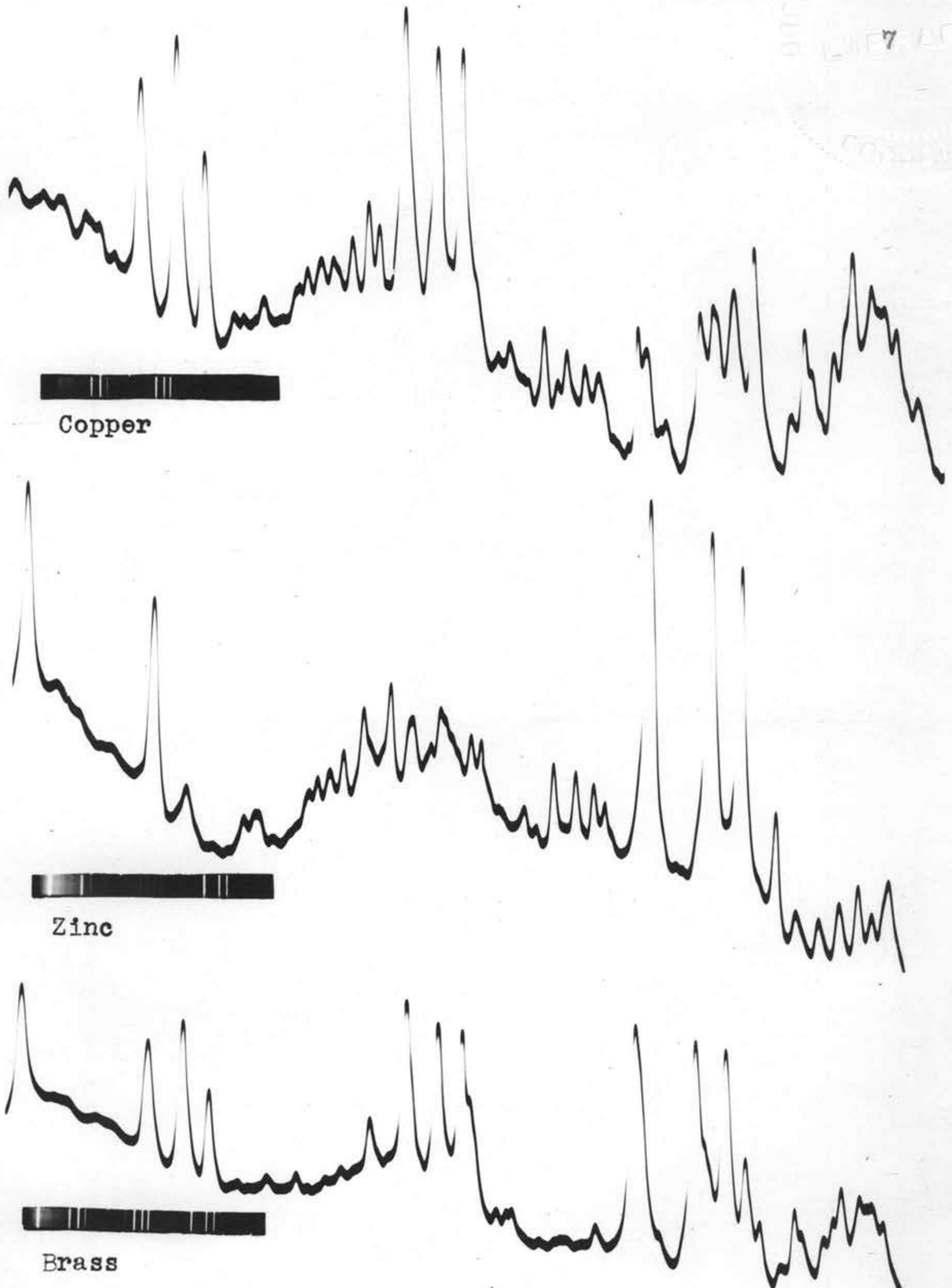

Fig. 2. Representative Traces and Prints From Original Photograph

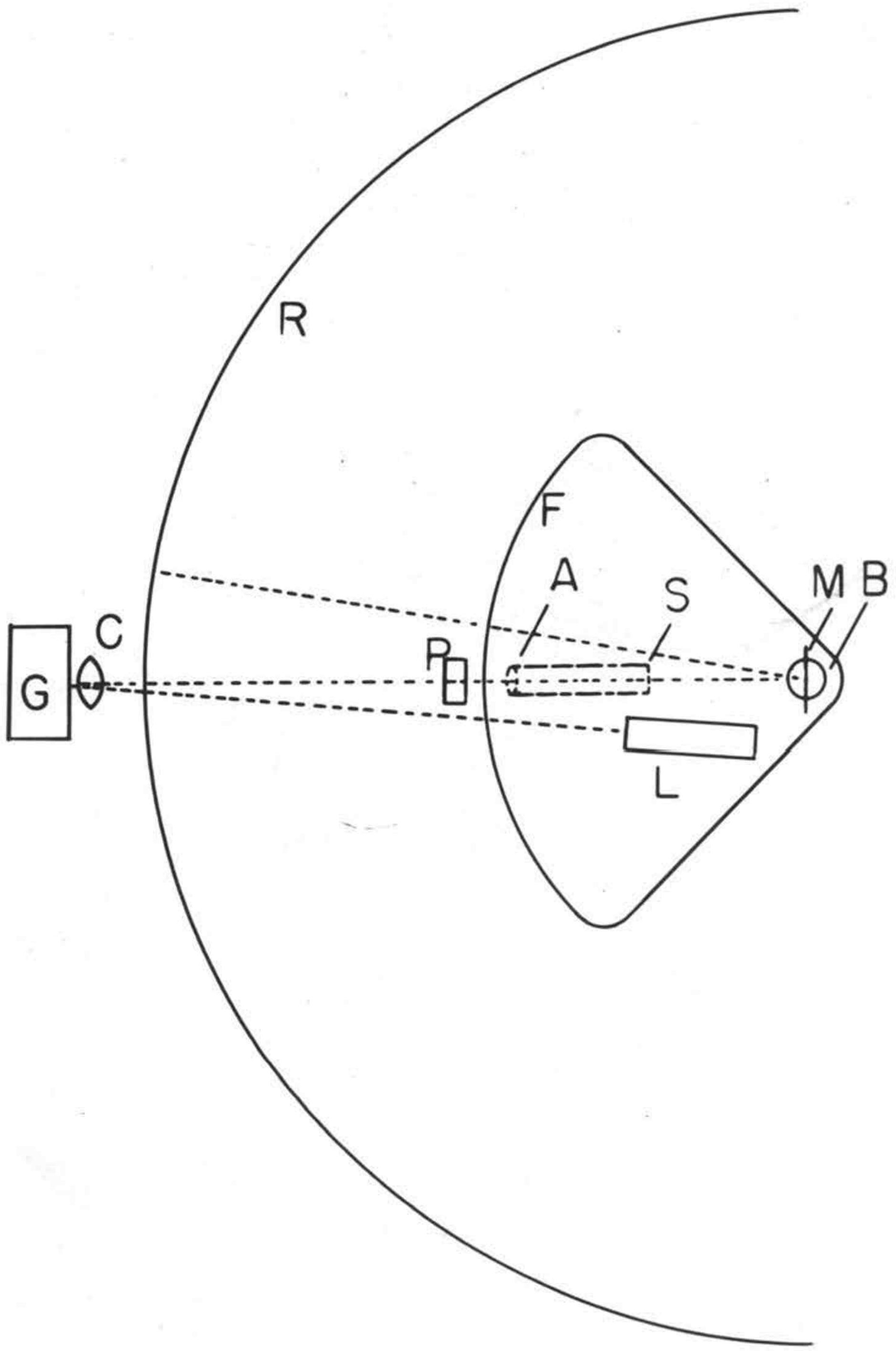

Fig. 3

cell P which in turn sends its current to the galvanometer G. The deflections of the galvanometer are recorded by a beam of light from the source L reflected in succession by the galvanometer mirror and the rotating mirror M and focused by the lens C on the photographic paper fastened to the concave side of the arc R. The rotation of mirror M causes the spot to travel the length of the arc R, the galvanometer deflections being crosswise to this arc.

Summary

A simple, accurate, low cost recording microphotometer having a magnification of 4:1 has been designed, constructed, and tested. A simple method of doubling the magnification is described. The apparatus has been used for instruction in laboratory sections.

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