A continuous interference-filter monochromator*

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An inexpensive continuous interference-filter monochromator is described.

Several modest but professional monochromators are now commercially produced, e.g., by Jarrell-Ash, Schoeffel Instrument, and Farrand Optical. These miniature type monochromators cost approximately \$600.00 each. For experimental designs that necessitate more than a single stimulus channel, the cost of producing monochromatic stimuli multiplies accordingly. To circumvent the high cost of quality commercial monochromators, Terrace (1966) suggested using a mounted interference filter (the bottom side of the filter's frame consisted of a row of teeth engaged by a motor-driven gear to produce a relatively inexpensive, automatically programmable monochromator). Terrace's design, however, limited the experimenter to a given set of stimuli, whose number is equal to the number of teeth (in Terrace's case, 15). The present paper proposes a simple improvement on that design to allow access to the full set of stimuli potentially available from such a filter.

We have inverted the general use of a rack and pinion unit (Edmund Scientific, 40,891 and 60,572; approximately \$25.00[1]) by mounting the slide tray in a permanent position and allowing the track to travel vertically. Vertical mounting allows for greater compactness of the unit. Figure 1 shows a Schott Optical Glass Veril S-200 continuous line interference filter (approximately \$185.00) in an aluminum frame securely mounted to the track. The wedge position is thus controlled by a precision rack and pinion drive designed expressly for fine linear movement. The 12 in. (30.5 cm) track permits a full scan of the 8-in. (20.3-cm) filter, i.e., the filter may positioned at any visible wavelength between 400 and 700 nm.

In order to gain further control over the stimulus, we drive the pinion with a heavy duty synchronous, instantly reversible Hurst PC-DA motor (approximately \$25.00). Motors in several speeds (1-120 rpm) are readily available directly from the manufacturer; motor speed determines scanning and hence access time to different wavelengths. The motor runs continuously with the clutch and brake controlled by a switching actuator only. This type of clutch-brake action in combination with the positive-lock tension plate feature of the rack and pinion unit allows precise determination of wavelength selection. The brake stops the output shaft within 1 deg up to 5 rpm, and the positive clutch will start/stop the output shaft within 20 msec. For our purposes, either the E or S may have toggle-switch control over the clutch-brake operation as well as over the travel direction through conventional electronic dc circuitry. The switching actuator of this Hurst motor can

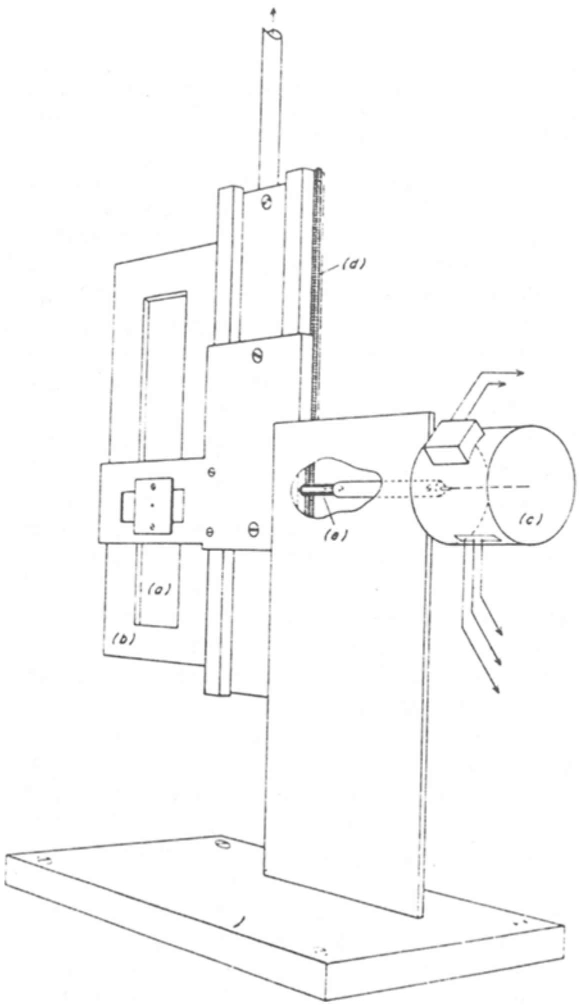

Fig. 1. A schematic of the continuous interference-filter monochromator. Inside the optical housing, the filter (a) frame (b) is mounted to a motor-driven (c) rack (d) and pinion (e) unit.

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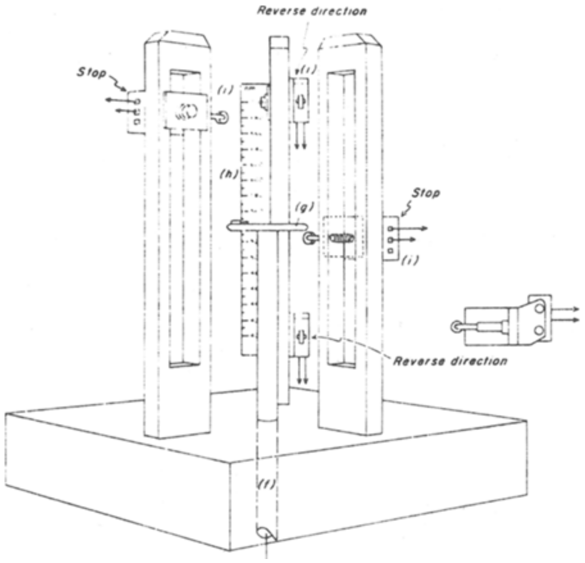

Fig. 2. A schematic of the calibration and semiautomatic control system. Outside the optical housing, the steel rod (f) is correlated with filter position, and the "hat" (g) indicates wavelength (h) which may be semiautomatically (i) programmed.

be modified to operate on any voltage, ac or dc, and the motor can be modified to operate on any ac voltage.

In order to determine filter position, a stainless steel rod was attached to the top of the track and brought outside the optical housing. Figure 2 shows a Bakelite "hat" worn by the rod. Its position is directly correlated with the position of the filter. The rod rides in the middle of three aluminum stock turrets that have unimax 1LR1-1C overtravel roller-type subminiature switches (approximately $7.75) facing the hat. These switches can be easily positioned over the length of each pylon. Two switches (*Stop*) program instantaneous clutch-brake action. In this way, variable wavelength selection has also been semiautomatically programmed. A third and fourth safety switch (*Reverse Direction*) program motor reversal and return. We have likewise mounted a Kodak 96 neutral density wedge (approximately $100.00) for brightness control in independent superposition.

In the past few years, several methods for presentation of monochromatic stimuli have been designed and proposed by researchers in the behavioral sciences. Johnson (1966) and Daley, Alvord, and Lehner (1968) have proposed apparatuses for discrete spectra produced by single interference filters. Although an improvement over the simple isolation of narrow source bands, these solutions are often complex in construction, require close maintenance, and tend to be bulky in direct relation to the number of stimuli. More important, each experimental wavelength necessitates the expense of another filter (approximately $75.00).

Semicontinuous techniques for producing monochromatic light, proposed by Terrace (1966) and Wright (1972), although certainly ingenious, have drawbacks. Test wavelengths are fixed with respect to both selection and number in the former. In the latter, stimulus size may be a function of degree of filter rotation, and wavelength availability is limited to the center of the visible region.

Researchers with the need of one or more stimulus channels each with access to indeterminate spectra will find the solution proposed here amenable from budgetary as well as experimental vantages. This unit is comparatively inexpensive: The total cost, including filter, motor, aluminum, and four switches is approximately $250.00. In addition to its relative compactness, the unit is quiet, has been efficient over several months of experimental service, and is not complex in construction. Yet there is excellent wavelength specificity, as well as maximal wavelength availability.[2] Schott Optical Glass specifies the wavelength of the light transmitted to be a linear function of the distance along the filter. (Jenaer Glaswerk provides individual calibrations for each wedge.) Reliable confirmation of this relation has been made by independent calibration. With three filters, manufacturer's specifications did not differ by more than 3 nm. As Terrace (1966) noted, the resolution of the Veril S-200 filter is quite good. The half-bandwidth of this line filter is as good as most single-value interference filters and is essentially constant across the visible spectrum, 10 nm at 450 nm to 12 nm at 650 nm. The transmittance characteristic of the filter also varies minimally with wavelength, approximately 36% at 450 nm to approximately 40% at 650 nm. Finally, this continuous line filter may be outfitted with blocking glasses that suppress unwanted short wavelength (ultraviolet) and long wavelength (infrared) components.

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NOTES

1. These are 1972 prices.

2. One disadvantage of the system is that the filter must be mounted normal to the observer or the diffusing screen.

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