THE PERKIN-ELMER MODEL E-1 MONOCHROMATOR

The Perkin-Elmer Model E-1 Monochromator is a linear wavelength, Ebert-mounted, grating monochromator which offers high resolution, an extremely broad wavelength range of use, and an exceptionally low stray-light level. The monochromator serves as a nucleus for a new series of building block spectrometers which can cover the wavelength range from 2000 Å to 40 μ. A series of source and detector modules to cover this range may be mounted on an optical bench accessory which fastens to the front of the monochromator base, as shown in Figure 1.

OPTICAL SYSTEM

In designing the E-1 Monochromator, various grating mountings were considered. The Ebert mounting was selected because, for a given focal length and aperture, it gave less aberration than the other systems studied. The final design maximizes resolution and light-gathering power, and yet provides a monochromator sufficiently compact so that it fits readily on standard laboratory benches or tables.

OPTICAL PATH

The optical path of a conventional single pass Ebert monochromator is shown in Figure 2. Incoming radiation passes through the entrance slits (S_1), is collimated by the spherical mirror (M_1), and is returned to the diffraction grating (G) which is mounted along the optical center line of the system. Diffracted radiation returns to the spherical mirror (M_1), and is focused on the exit slits (S_2). Wavelength is scanned by rotating the diffraction grating about a vertical axis.

Dispersion may be doubled, and we may approach the performance of a monochromator with twice the focal length, if the radiation is sent through the system a second time. A double pass Ebert System is shown schematically in Figure 3.

It should be noted that a different portion of the slits is used for entrance and exit of system energy, as shown in Figure 4. An "under and over" path is used in double pass. Mirrors M_2 M_3 (see Figure 3) are kinematically mounted for ease in changing from single to double-pass operation.

GRATINGS

The E-1 Monochromator is designed to operate over the wavelength range between 2000 Å and 40 μ. To cover this region, seven plane, replicated diffraction gratings are used. These gratings are listed in Table 1, together with their individual ranges of use and first order peak efficiencies. The gratings are on 90 mm x 90 mm blanks having an 84 mm x 84 mm ruled area.

Each grating is used only in the first order. This not only simplifies the problem of filtering out unwanted grating orders, but also eliminates the possibility of double diffraction. Double diffraction is a phenomenon in which an unwanted wavelength, which has already been diffracted by the grating, strikes the collimating mirror, returns to the grating, and subsequently passes out the exit slits. Double diffraction cannot occur in an Ebert system when the gratings are used in the first order, but it will occur when the gratings are used in the second, third, and higher orders.

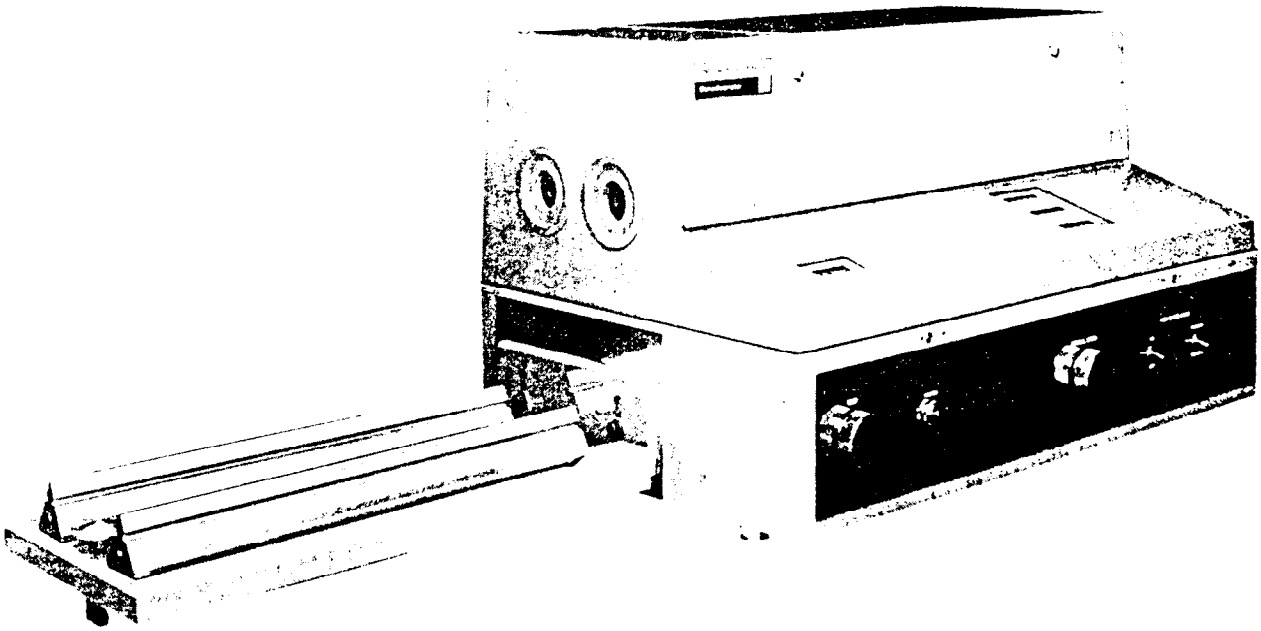


Figure 1. Perkin-Elmer Model E-1 Monochromator, with Optical Bench Accessory.

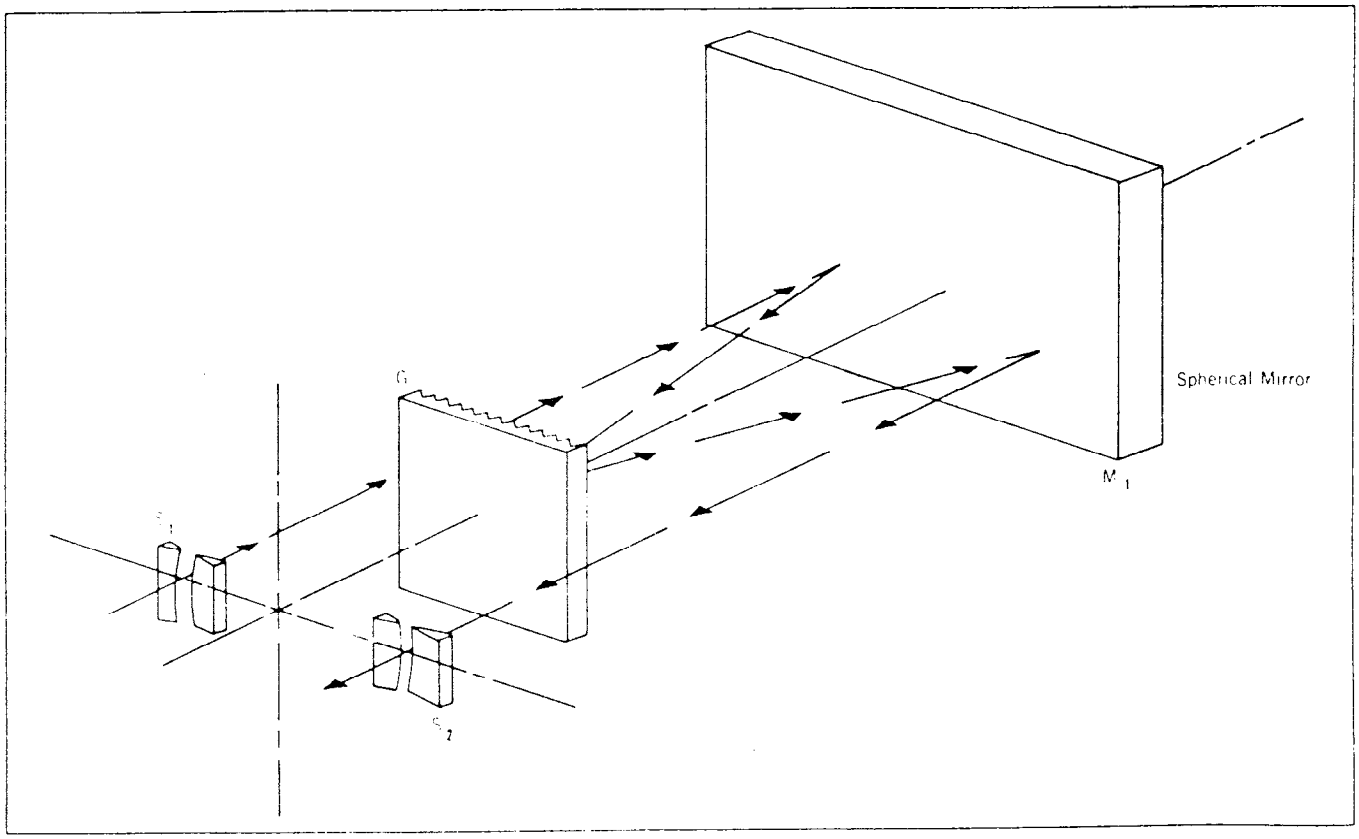


Figure 2. Optical Path of the E-1 Single Pass Ebert Monochromator.

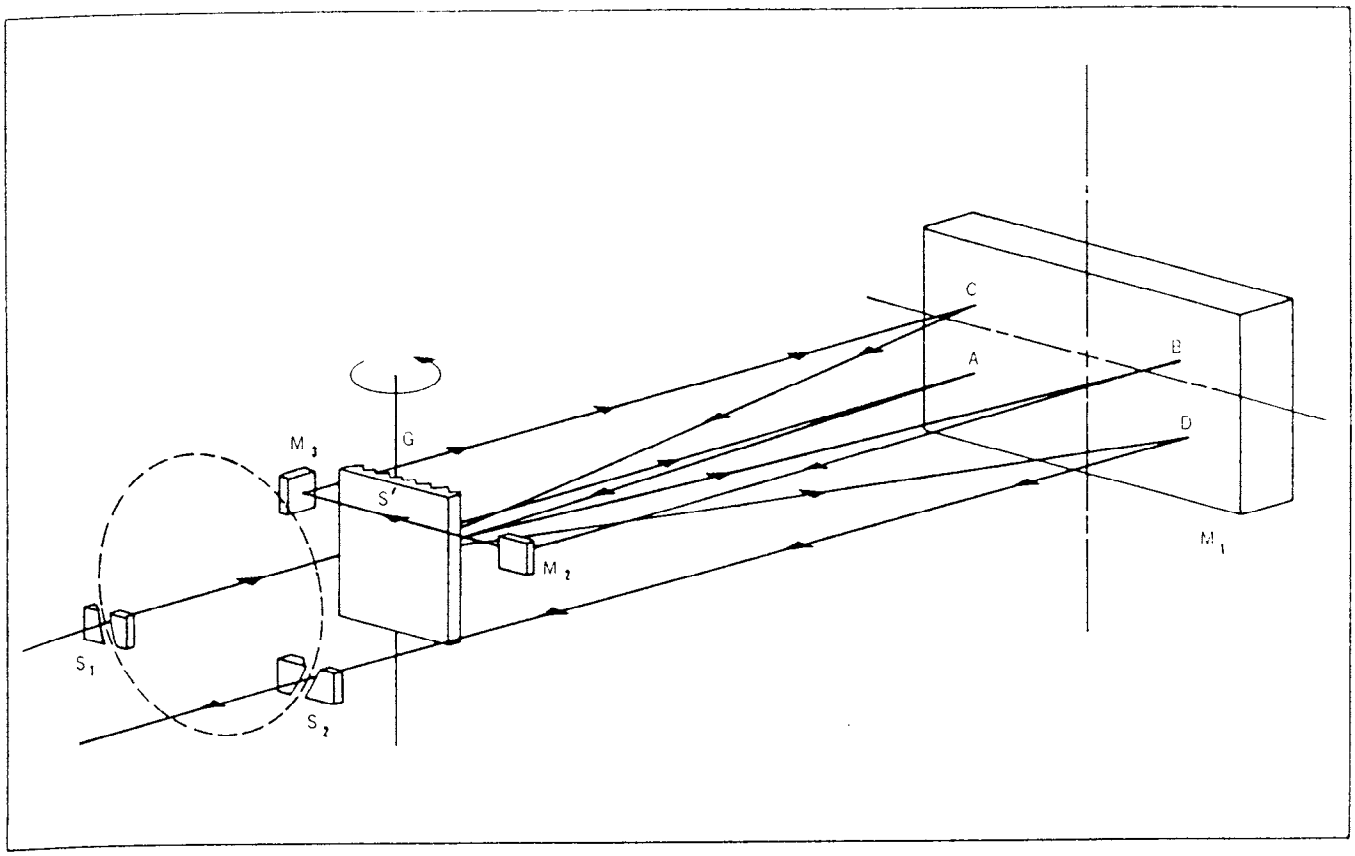
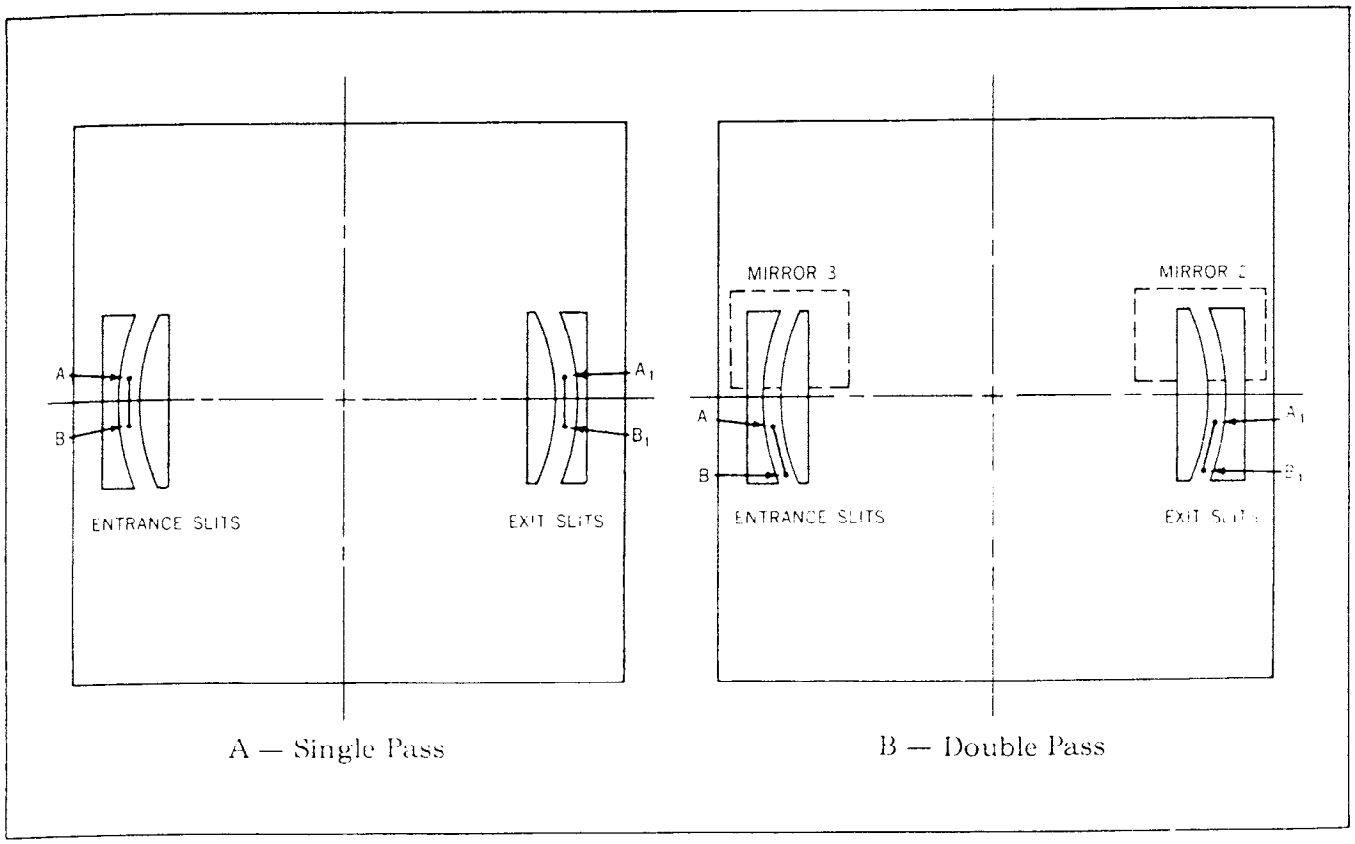


Figure 3. Optical Path of the E-1 Double Pass Monochromator.



A — Single Pass

B — Double Pass

Figure 4. Image Position on Slit Jaws.

TABLE 1

MOUNTED DIFFRACTION GRATINGS FOR USE IN E-1 MONOCHROMATOR

Part No. of Mounted Grating	Lines/mm	Region of Use	First order Peak Efficiency
231-0054	2880	2000 Å — 4000 Å	3000 Å
231-0056	1440	4000 Å — 1 μ	5500 Å
231-0058	576	1 μ — 2.5 μ	1.25 μ
231-0060	288	2 μ — 4 μ	2.27 μ
231-0062	144	4 μ — 10 μ	4.35 μ
231-0064	57.6	10 μ — 25 μ	11.1 μ
231-0066	28.8	20 μ — 40 μ	25 μ

The gratings are mounted individually on kinematic mounts and are changed manually. The precision of the mount is such that no indexing or alignment is required upon interchange. Figure 5 shows a grating being inserted in the monochromator.

Stray light in the E-1 Monochromator was evaluated in the region between 4000 Å and 5000 Å, using a tungsten lamp source and a photomultiplier with an S 20 response as the detector. The normal 1440 line/mm grating was used in the first order, and the monochromator was operated double pass with 13 cps chopping, done internally between the first and the second passes. A long pass filter with a cut-on wavelength of approximately 3800 Å was used to reject higher grating orders.

By using neutral density filters to optically expand the ordinate scale by a factor of 10^4, and observing the spectrum of a long pass filter with a cut-on of approximately 5100 Å, the stray is stated conservatively as being less than one part in 10^4.

MECHANICAL DESIGN

WAVELENGTH ADVANCE

In an Ebert monochromator, wavelength scanned by rotating the diffraction grating. the E-1 Monochromator, the grating is mount on a heavy table which, in turn, is rotated means of a reinforced arm, 15.75 inches lo riding against a barrel cam. This cam is cut a tape-controlled Moore jig borer to a si function, so that scanning is linear in wa

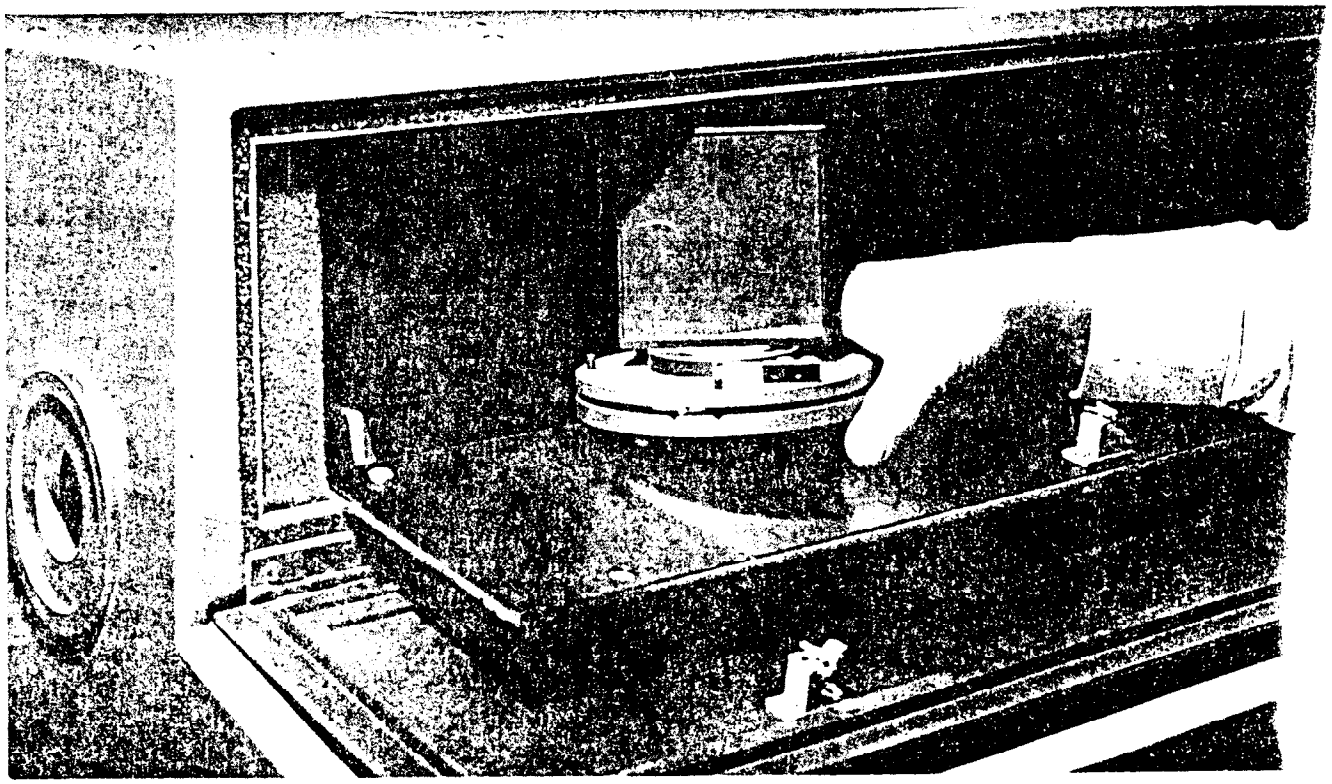


Figure 5. Inserting a Grating in the Monochromator.

length. The mechanism may be seen in Figure 6, a view of the monchromator with covers removed to show details of the construction.

This design was chosen to maximize accuracy and repeatability. The length of the lever arm does not change with respect to grating angle while the monochromator is being scanned, as it does in some computer-type wavelength mechanisms. Therefore, accuracy is relatively independent of wavelength. The barrel cam has a minimum of moving parts, thus reducing the number of mechanical tolerances which must be maintained. Also, this type of cam permits a long cam surface (approximately 120 inches) which can be finished to micro-inch tolerances.

The basic monochromator is supplied with a fast scanning motor (about two minutes forward and reverse to scan the wavelength range of each grating) for rough indexing purposes. A manual scan knob is provided for precise wavelength setting.

Wavelength may be read to five significant figures by viewing a counter on the monochromator's front sloping panel. Three wavelength counters are used to cover the entire range of the monochromator, due to the different ruling ratios of the seven gratings. One counter is supplied with the basic monochromator.

To maintain high-wavelength performance, the Model E-1's optical table is mechanically isolated from the outside cover and the accessory bench. Loading of the accessory bench, or leaning on the monochromator, will not change wavelength setting. Also, the monochromator is thermostatted to $\pm 1/2°F$ to eliminate effects of ambient temperature changes.

Wavelength accuracy is stated as one part in 10,000 absolute, and repeatability at all wavelengths as 1 part in 50,000. Regardless of direction of scan, the cam follower rides reproducibly against the same surface of the cam. Consequently, the system is free of backlash.

SLITS

The slits are bilateral, curved and continuously variable from 10 μ to 10mm, with a setting repeatability of $\pm 2\ \mu$. Actual slit jaws are 43mm in height, but normally they are masked to 12mm. All standard accessory modules are designed for a 12mm slit height. Special techniques are required for manufacturing slits of this type and precision. The slit jaws are photo-etched, gold on copper, to eliminate rough edges and the manufacturing process enables maintaining a coplanarity of .0001 inches.

The Model E-1 may be obtained as a simple, manually operated monochromator, or as part of a high-performance spectrometer. The following systems (or portions thereof) are available, complete with all sources, detectors, sample areas, wavelength drive, amplifier, associated power supplies, recorder, and gratings necessary to cover the specified wavelength range. Figure 7 shows some typical system configurations.

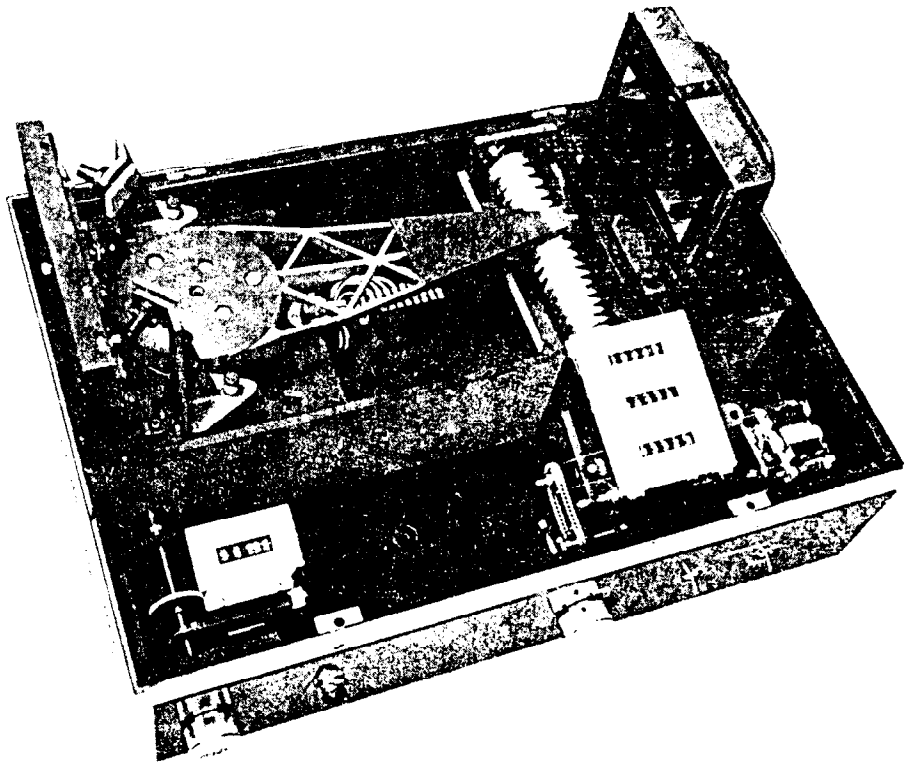


Figure 6. Model E-1 Monochromator with Looks Cover and Inner Cover Removed.