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High-Speed Spectrograph for Shock Tube Studies

A high-speed spectrograph has been developed to provide information on the spatial distribution of the electron density of the gas flow in a high-performance shock tube. The instrument, with a measured resolution of 0.15 nm, uses a camera of $f/1.5$ aperture, and can record the spectral region of 390 to 670 nm in a single 200-nsec exposure. The exposure time is controlled either by a Kerr-cell in front of the slit or by a focal-plane shutter in the camera. The system permits measurement of the profiles of the hydrogen-alpha and -beta lines with enough spectral range to record spectral features from the near ultraviolet (390 nm) to the long-wavelength cutoff of the photographic film (670 nm).

The spectrograph is of modular construction; a variety of cameras, gratings, and readout systems permit modification of the instrument to suit the requirements of special experiments. By using cameras of different f number and focal length, both the optical speed and plate factor of the instrument may be varied; without changing the camera optics, the instrument plate factor and spectral range may also be varied by replacing the grating with one of either finer or coarser rulings.

The modular units are attached to a 1.25-cm thick aluminum base plate; the collimator module consists of a slit assembly, light baffles, focusing tube, and an $f/2.5$ lens in a support tower, and these components are rigidly attached to a Kovar temperature-compensating base plate. After the collimator is completely assembled and aligned, the unit is semirigidly attached to the aluminum base plate by nylon machine screws in oversize holes (to allow for differential thermal expansion of the Kovar base plate and the instrument base plate). A periscope built into the side of the collimator is used for angular alignment of the spectrograph with respect to the object to be examined; the periscope is required because the Kerr-cell shutter system completely obscures the slit aperture.

Fine-focusing of the image from the light collector lens on the slit of the spectrograph is accomplished by rotating a collar which holds the collector lens while the target is viewed through a split-image view-finder in the camera back.

The diffraction grating and its holder comprise a module that has three degrees of freedom: pitch, roll, and yaw. Since each motion is about the center of the front surface of the grating and about an orthogonal axis, adjustment about one axis does not introduce a change in the orientation of the other axes. Grating change is accomplished by removing three screws which hold the retaining ring and grating mask in place, and then slipping the grating out of its holder. After the new grating has been inserted and the screws are replaced, the holder need only be rotated about its horizontal (roll) axis until the rulings are parallel with the slit jaws.

For operation, the spectrograph slit is imaged parallel to the shock-tube flow. When the flow covers the length of the slit, the Kerr-cell shutter is triggered to provide a 200-nsec exposure. Such a short exposure effectively "stops" the motion of the test gas, that is, a 20-km/sec shock wave travels only 4 mm during that time. Since the slit image is stigmatic and because the direction of spectral dispersion is perpendicular to the slit, a spectrum will be recorded at each point along the flow direction.

(continued overleaf)

Reference:

Borucki, W. J.: Kerr-Cell Shuttered $f/1.5$ Stigmatic Spectrograph for Nanosecond Exposures. Applied Optics, vol. 9, p. 259, 1970.

Note:

No additional documentation is available. Specific questions, however, may be directed to:

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Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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