

APPLICATION OF THE ELECTRONOGRAPHIC IMAGE CONVERTER FOR SPECTROSCOPY AT  
THE 2.6m REFLECTOR OF THE CRIMEAN ASTROPHYSICAL OBSERVATORY

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**ABSTRACT:** An Electronographic Image Converter (EIC) of the "Spectracon" type is being used for routine spectroscopic observations at the 2.6m reflector of the Crimean Astrophysical Observatory. Some details of the EIC and film-loop applicator are given and the spectrophotometric accuracy and detective quantum efficiency are discussed.

## 1. INTRODUCTION

The electronographic method has been in use for many years for recording direct images and spectra of astronomical objects. Well-known advantages of the method are as follows:

- a) high quantum efficiency,
- b) high spatial resolution (with fine grained nuclear emulsions),
- c) linear relationship between the intensity of incident light and density of an image,
- d) lack of reciprocity failure,
- e) high signal-to-noise ratio and informational capacity.

## II. EIC CHARACTERISTICS

The Electronographic Image Converter (EIC), similar in principle to the McGee spectracon, was developed at the all-Union Scientific Research Institute of Optical and Physical Measurements [1]. The EIC has the following features:

- a) multialkali photocathode mounted by the transfer method to eliminate multiple-electron events,
- b) Lenard window  $2.5 \times 45\text{mm}^2$ , mica thickness  $4 \mu\text{m}$ ,
- c) accelerating potential 40 kV, photocathode grounded,
- d) double loop electromagnetic focusing.

A general view of the encapsulated tube is shown in Fig. 1.

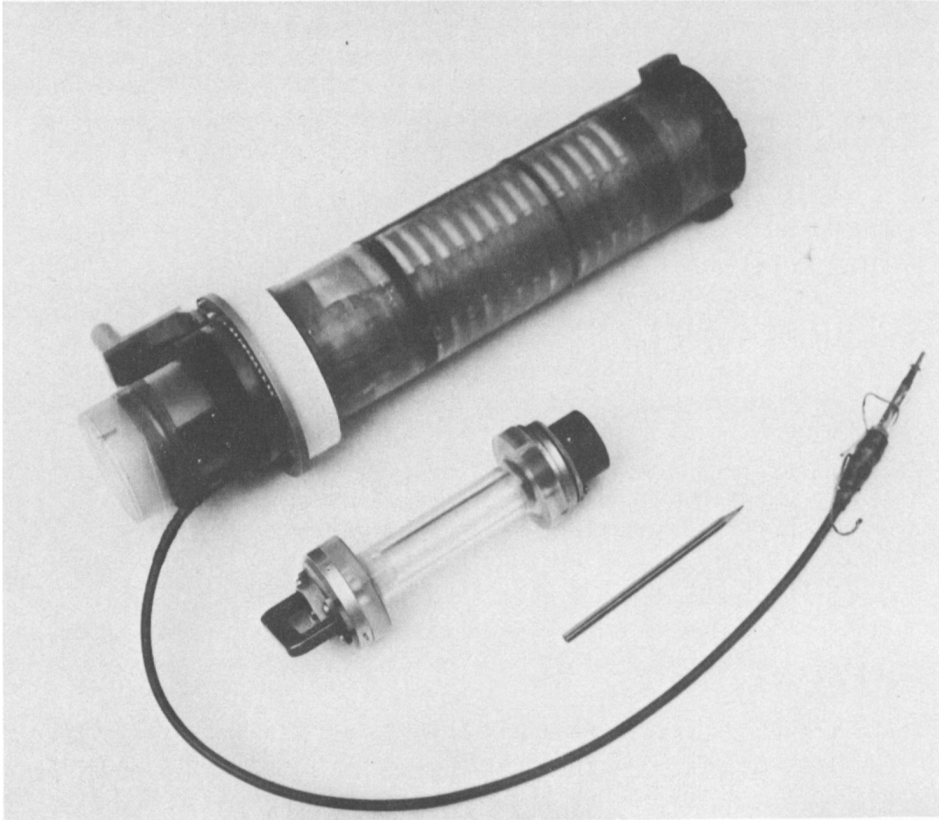


Fig. 1. Electronographic Image Converter (encapsulated tube and film-loop applicator).

To record the electronic image, we use a Soviet electronographic emulsion coated on 20  $\mu\text{m}$  thick lavalan film. The grain size of the R-type emulsion is about 0.3  $\mu\text{m}$ , i.e. analogous to Ilford G-5 emulsion.

At the Crimean Astrophysical Observatory we have developed the film-loop applicator. A strip of emulsion-coated lavalan film is cut to 22 x 32mm in size and held by the film jaws so that the strip takes a semi-cylindrical shape (Fig. 2). The film-holder is attached to the applicator mechanism which enables the film loop to be pressed against the mica window. A force of only 30 g is enough to make close contact between the emulsion and the mica surface, giving a spatial resolution of about 60 lp/mm on the film. So far, no mica window has yet been broken by this applicator.

In operation, the mica window of the tube is permanently dried by air, which makes it possible to operate at high humidity. Air cooling of the focusing coil is applied to eliminate the heat generated.

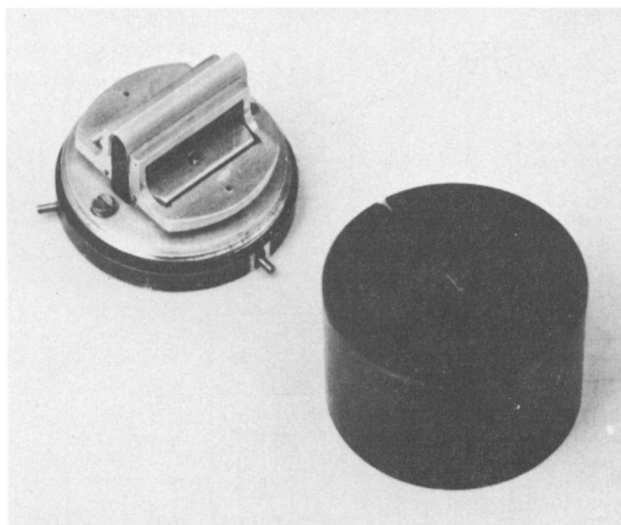


Fig. 2. Film-loop holder (cassette).

### III. EIC OBSERVATIONS

Since 1979 the EIC has been used for routine observations at the 2.6m telescope of the Crimean Astrophysical Observatory. The EIC is attached to a grating spectrograph at the Nasmyth focus. The optical system of telescope and spectrograph is shown schematically in Fig. 3. 350 spectra of stars have been obtained with the same tube during two years of observations. Taking into account the laboratory testing, this tube has undergone 800 applications of the film.

Usually we observe the spectra of  $10^m - 13^m$  stars with dispersion  $40 \text{ \AA/mm}$ . The typical exposure time for a G - K star of  $10^m$  in the  $H\beta$  region of the spectrum is about 10 min, for a photometric accuracy of 1% (S/N = 100). The image geometry is good enough to measure the radial velocity with the usual accuracy.

In order to determine the spectrophotometric accuracy available with the EIC, several spectra of the star GC 12200 (A0, V = 6.1) have been taken under the following conditions:

- dispersion  $40 \text{ \AA/mm}$
- exposure time 5 min
- widening 0.5mm
- spectrograph slit  $0''.5$
- seeing  $1''.5$ .

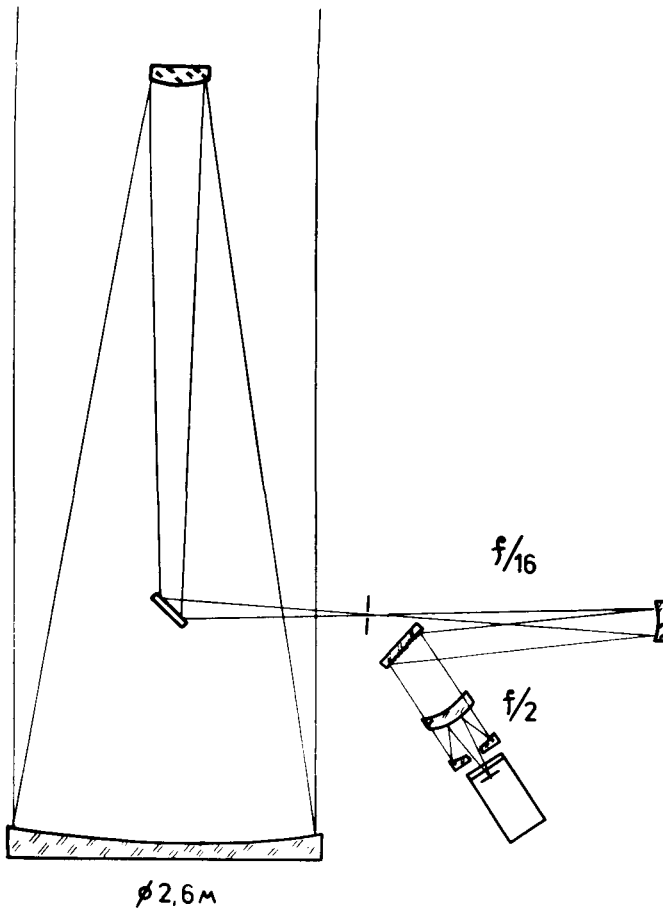


Fig 3. The telescope and spectrograph optical system.

At density  $D = 1$  the r.m.s. error is 0.5% (signal-to-noise ratio = 200). The equivalent widths of the weakest absorption lines which can be measured reliably are about  $0.04 \text{ \AA}$  (Figure 4).

The detective quantum efficiency of the system "EIC + emulsion + densitometer", defined by the ratio

$$\text{DQE} = \frac{(S/N)_{\text{out}}^2}{(S/N)_{\text{in}}^2}$$

was derived from the spectra of RW Aur obtained on Dec. 16, 1980, when the seeing was  $1''.5$  and the light losses on the spectrograph slit ( $1''.2$  wide) were negligible. During our spectroscopic observations the star

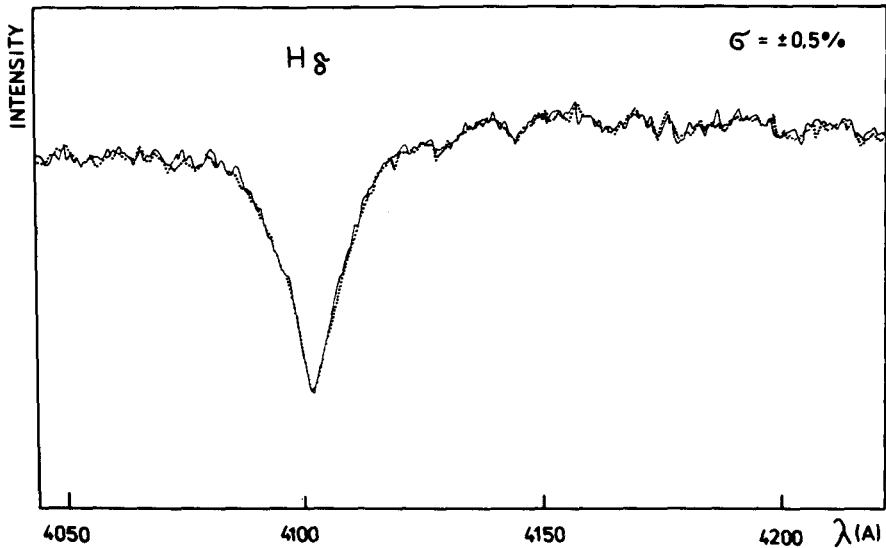


Fig. 4. Tracings of two spectra of GC 12200 (AO). Signal-to-noise ratio is about 200.

was monitored photometrically, which gave the energy flux from the star at  $\lambda$  4150 Å as  $2.8 \times 10^{-13} \text{ erg cm}^{-2} \text{ s}^{-1} \text{ Å}^{-1}$  above the Earth's atmosphere.

Fig. 5 shows the tracings of two RW Aur spectra. They were scanned with the Joyce-Loebl densitometer using a 0.8 Å slit (as projected on the film), which corresponded to the spectral resolution. The signal-to-noise ratio  $(S/N)_{\text{out}} \approx 110$ , is derived from the comparison of two tracings. Assuming that the atmospheric transparency above the Crimean Observatory is 0.54 at  $\lambda$  4150 Å [2], the transmittance of the integrated optical system is 0.15 and the light losses on the spectrograph slit are about 20%, we obtain  $\sim 3.2 \times 10^5$  for the number of photons on the photocathode of the tube in an exposure time of 35 min. Since the input noise is caused by quantum statistics, we have

$$(S/N)_{\text{in}}^2 \approx 3.2 \times 10^5 \text{ and D.Q.E.} \approx 3.7\%.$$

This figure is an order of magnitude higher than that of photoemulsions in real observational conditions, but close to the efficiency of television systems.

It should be noted that the recording of the image on the fine-grained electronographic emulsion, which contributes very little to the noise, is a good method of information storage. Subsequent digital reductions of the image do not affect the signal-to-noise ratio.

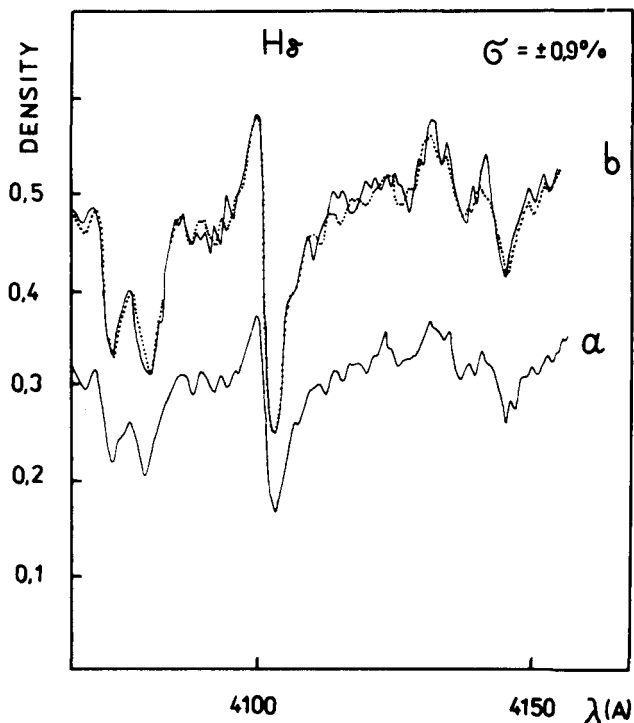


Fig. 5. Tracings of two spectra of RW Aur.

Spectrum (a) - exposure time 20 min, widening 0.15mm.

Spectrum (b) solid line - exposure time 50 min, widening 0.20mm;  
dotted line - spectrum (a) reduced to mean density of  
spectrum (b)

A disadvantage of the EIC is its relatively small window area; thus the detector would normally be used for obtaining high quality spectra with moderate and low dispersion.

#### REFERENCES

1. Khokhlova, V.L. and Lipatov, S.V. 1976, Proceedings of IAU Colloq. 40, ed. Duchesne, M. and Lelièvre, G., Paris-Meudon Obs., p. 7-1
2. Burnashev, V.I. 1977, *Izvestiya Krymskoi astrofiz. obs.* 57, p. 57