



EUROPEAN SOUTHERN OBSERVATORY

# OPERATING MANUAL

No. 7 – March 1989



## THE ESO ECHELEC SPECTROGRAPH

# **The ESO ECHELEC Spectrograph**

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**ESO OPERATING MANUAL No. 7**

**Version No. 1**

**March 1989**

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# Chapter 1

## Introduction

This manual describes the operation of the ECHELEC spectrograph installed at the coudé focus of the 1.52m telescope. It is intended as a general guide to help observers prepare and perform their observations. Users are advised to read this manual carefully, and to familiarise themselves with the optical system, calibration exposures, and ECHELEC control program. It is recommended to do a dry run with the instrument in the afternoon preceding the first observing night.

A quick evaluation of the data is possible using the IHAP system both at the telescope and in the computer centers at Garching and La Silla. Complete processing of the data, however, requires more evolved programs such as those implemented in MIDAS.

This manual was written on the basis of experience gained during the first test period. Updated versions will be issued when required by changes in the instrument (modifications of the optics, detector, etc.) and as greater observing experience is gained. References [1], [2] and [3] provide further information for those interested in the instrument's design and installation at La Silla.

We strongly encourage users to make any comments and suggestions concerning this manual in order that we may refine future versions. Please do this by firstly writing on a copy of this manual which you will find in the control room of the telescope and secondly in your observing report to be completed at the end of your observing mission to La Silla.

## Chapter 2

# System Description

### 2.1 General Description

The ECHelle + ELECTronic camera (ECHELEC) spectrograph, installed at La Silla in 1973, was designed by A. Baranne to be used with a Lallemand - Duchesne type electronographic camera at the coudé focus of the 1.52 m telescope [1], [2]. It is a Littrow Echelle spectrograph mounted in a “white pupil” configuration with a grism as cross-disperser.

The present configuration uses a CCD as detector. The optical parts of the instrument are manually controlled. The blue limit of the useful wavelength range is situated around 3800 Å and a reasonable value for the red limit is 5500 Å. Growing vignetting of the beam at the Carpenter prism as well as increasing loss of efficiency in the prism itself rapidly decreases the total efficiency for wavelengths longer than 5500 Å. The exact amount of loss as a function of wavelength, however, remains to be measured. The telescope and the CCD are controlled from the control room. The CCD currently installed is a thinned, back-illuminated, high resolution RCA with  $640 \times 1024$  pixels (ESO # 13). The pixel size is  $15 \times 15 \mu m^2$ , which corresponds to  $0''.65$  arcsec on the sky. The telescope scale is  $228 \mu m$  arcsec<sup>-1</sup> at the slit.

### 2.2 Optical System

A layout of the spectrograph optics is presented in Fig. 2.1. The instrument consists of three different parts, each mounted on its own pillar. The light beam first encounters the slit unit, consisting of the slit, a decker, a field lens, and a 45° mirror. The field lens images the telescope pupil on the grating which is tilted to allow the diffracted light to reach the field mirror. This mirror restores in “white light” the grating image on the entrance pupil of the camera. Cross-dispersion is obtained by means of a Carpenter prism (grism) mounted in the parallel beam at the entrance of the camera. At 4300 Å, the beam is not deviated. The  $f/3$  camera, based on a Bowen camera, is formed by a reversed telescope

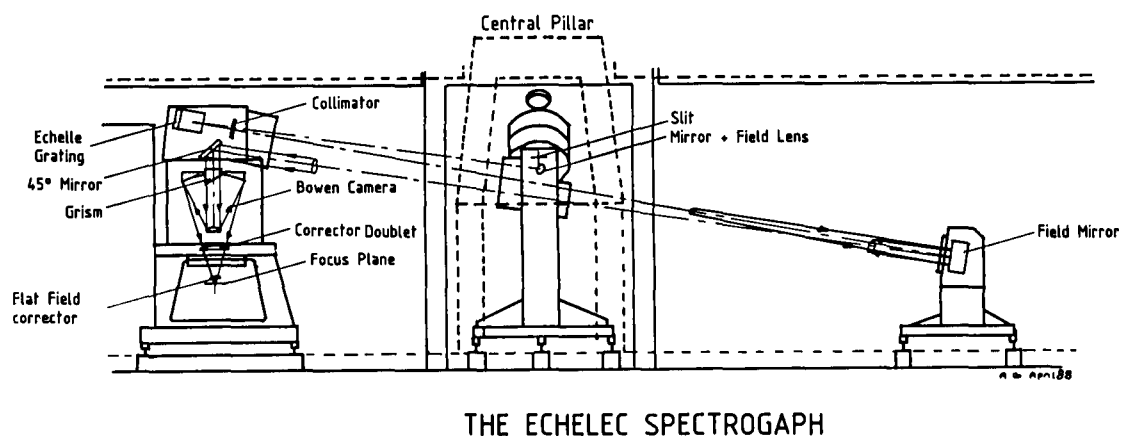


Figure 2.1: Optical layout of the ECHELEC spectrograph

which has been corrected for spherical aberration using a doublet lens. Finally, the echelle spectral beam is focused onto the CCD after passing through a flat-field corrector. The central order is selected by tilting the  $45^\circ$  mirror.

### 2.2.1 New Echelle Grating

The original echelle grating with  $79 \text{ lines mm}^{-1}$  has been replaced by one having  $31.6 \text{ lines mm}^{-1}$ , which gives a convenient format for the CCD detector. The grating is mounted at its blaze angle of  $63.5^\circ$  in a Littrow configuration. Fig. 2.2 shows the relative efficiency of the grating as a function of wavelength. The curve is the envelope of the peak efficiencies within each order.

### 2.2.2 Cross-Dispersion

The Carpenter prism is the one originally designed for the electronographic camera. It consists of a  $31^\circ$  prism with a transmission grating of  $632 \text{ lines mm}^{-1}$ . The non-deflected beam has a wavelength of  $4300 \text{ \AA}$  and the equivalent cross-dispersion is  $35 \text{ \AA mm}^{-1}$  in the detector plane. The dispersion range has been designed to approximately cover the interval from  $3800 \text{ \AA}$  to  $5500 \text{ \AA}$ . For longer wavelengths, due to the large incidence angle needed,



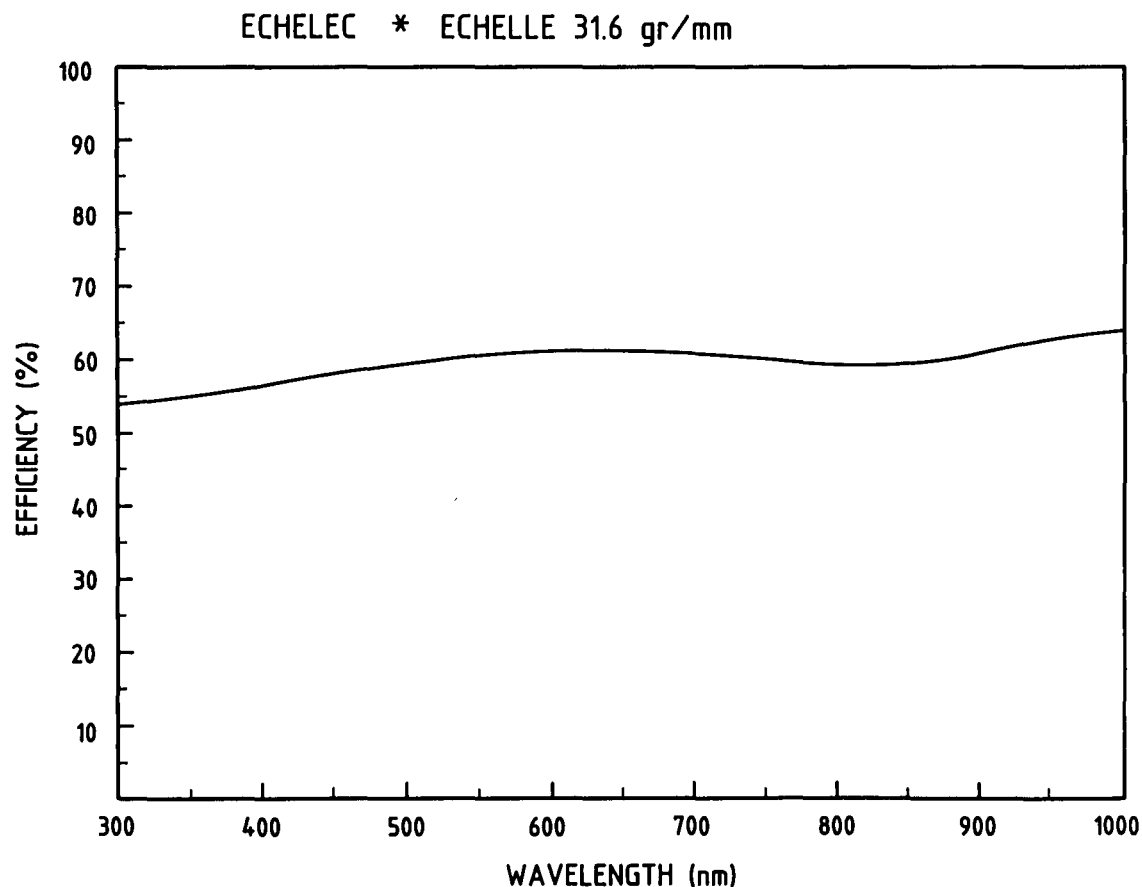


Figure 2.2: Relative efficiency of the ECHELEC echelle grating. The curve shows the envelope of the peak efficiencies within each order.

vignetting occurs at the entrance surface. Furthermore, in the red the grism efficiency is lower.

### 2.2.3 Bowen Camera

The design of the camera was made for the *full* optical spectral range. Hence, the need for blue ( $\leq 5500 \text{ \AA}$ ) and red ( $> 5500 \text{ \AA}$ ) correctors. To enable the use of a flat detector, two special field flatteners were fitted; one for each colour region. These correctors need to be mounted close to the camera's focal plane (the back focal length is  $\sim 50 \text{ mm}$ ). However, since a red cross-disperser is not yet available, the use of the instrument is presently limited to wavelengths shorter than  $\sim 5500 \text{ \AA}$ .

## 2.3 CCD

ESO CCD # 13 is a high-resolution RCA device, with  $1024 \times 640$  pixels of  $15 \times 15 \mu\text{m}^2$ . The read-out noise is  $\sim 57 e^-$  per pixel. The charge transfer efficiency is good. Only a few columns present offsets (in relative efficiency). One bad column (#517) is also present.

The pixel size corresponds to  $0''.65$  on the sky. Since the best image blur size of the 1.52-m telescope is  $\sim 1''.5$ , using a slit width of this size will come close to the ideal situation of two pixels per resolution element. Fringing due to internal interference in the CCD occurs, and is increasingly important towards the red part of the spectrum.

The quantum efficiency of CCD # 13, as measured in the ESO laboratory, is given in Fig 2.3. Note that the sensitivity drops by more than a factor of four from the peak efficiency for wavelengths shorter than  $4000 \text{ \AA}$ .

The CCD bias and saturation levels amount to  $\sim 200$  and  $32000$  ADUs respectively. The upper limit is set by the A/D-converter and corresponds to a value lower than the real saturation level of the CCD. (See CCD manual).

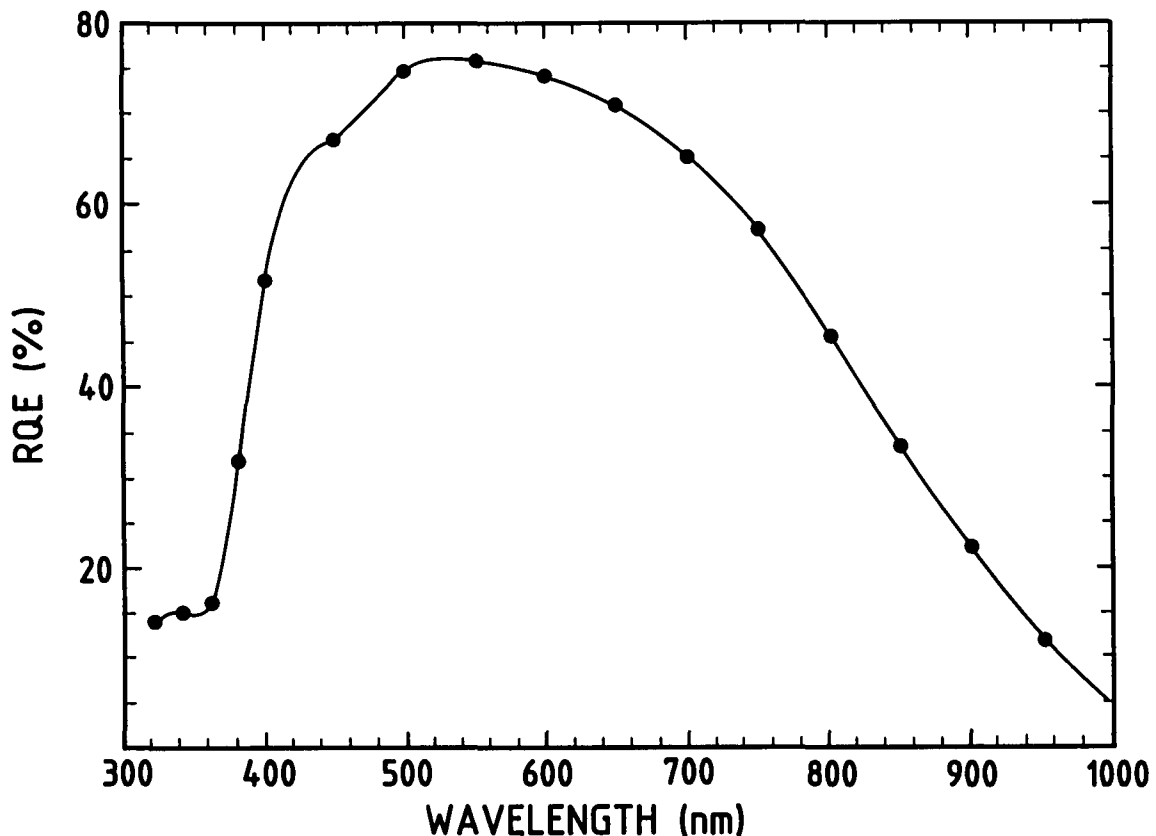


Figure 2.3: Quantum efficiency of ESO CCD #13 as function of wavelength

## 2.4 Calibration Lamps

Two calibration lamps are available in the spectrograph; a xenonphot lamp for flat-fielding, and a Thorium hollow cathode lamp for wavelength calibration. A set of neutral filters ranging in density from 0.3 to 3.0 is located in the calibration lamp assembly.

Switching between science and calibration exposures is done by moving a small mirror. Presently, calibration lamps, filters and mirror can only be operated manually (see Section 3.3).

# Chapter 3

## Observing

### 3.1 Spectral Coverage and Resolution

The linear dispersion varies from  $3.1 \text{ \AA mm}^{-1}$  at  $4000 \text{ \AA}$  to  $4.5 \text{ \AA mm}^{-1}$  at  $5500 \text{ \AA}$ . Given the size of the CCD this means that  $46 \text{ \AA}$  of an order are covered at  $4000 \text{ \AA}$  and  $67 \text{ \AA}$  at  $5500 \text{ \AA}$ . The distance between central wavelengths of neighbouring orders may be calculated from the formula  $m\lambda = 566400$ , where  $m$  is the echelle order. Thus, between orders 141 and 142 (at  $\sim 4000 \text{ \AA}$ ) the separation is  $28 \text{ \AA}$  resulting in an overlap of  $18 \text{ \AA}$  (39%) at both ends of the order. The corresponding values at  $5500 \text{ \AA}$  (between orders 102 and 103) are a separation of  $54 \text{ \AA}$  giving an overlap of  $13 \text{ \AA}$  (20%) at either end. In total a CCD frame covers approximately  $260 \text{ \AA}$  at  $4000 \text{ \AA}$  and  $270 \text{ \AA}$  at  $5500 \text{ \AA}$  (in 10 and 6 orders respectively).

The resolving power is 35.000 with an entrance slit width equivalent to two CCD pixels ( $\sim 1''.3$ ). The resolving power measured at  $5370 \text{ \AA}$  with a slit width of  $1''.4$  during the first tests of the instrument was 32.000, in good agreement with the theoretical value.

### 3.2 Manually Controlled Functions

#### 3.2.1 General Description

The following operations have to be done during an ECHELEC observing run:

<b>Instrument setting:</b>	Slit width
	Slit length
	Central wavelength setting
	CCD orientation
	Hartmann screens in/out
	CCD focus

**Calibrations:** Calibration lamp mirror in/out  
Lamp selection (white or thorium)  
Lamps on/off  
Slit-view shutter in/out

**Observations:** Check calibration lamp mirror out  
Check slit-view shutter out  
Telescope guiding (manually).

### 3.2.2 Slit Width/Length

The slit width is continuously adjustable from  $100\ \mu\text{m}$  to more than  $2\ \text{mm}$  by means of a rotating knob located at the top right of the instrument's central pillar. Each turn corresponds to  $500\ \mu\text{m}$  and each division to  $10\ \mu\text{m}$ .  $1\ \text{arcsec}$  corresponds to  $230\ \mu\text{m}$ .

The slit height is set by a wedge-shaped reflective decker located in front of the slit. This unit is moved by a sliding rod located at the top left of the central pillar. Since the decker is not equipped with a scale, its actual length must be determined by measurement of the spectrum width on a CCD flat-field exposure. Note that even the largest decker ( $\sim 17''$  on the sky) will still leave sufficient space between orders for a proper determination of the inter-order background level.

### 3.2.3 Central Wavelength Selection

Due to the rather difficult access to the mechanism, the setting of the central wavelength is done by the TRS operations group following the observer's instructions. The mechanism consists of a differential manual screw which tilts the  $45^\circ$  mirror in front of the grism. The curve in Fig. 3.1 shows the central wavelength as a function of screw position. It is described by the formula  $S = 0.008\lambda - 26.5$  where  $S$  is in mm and  $\lambda$  in  $\text{\AA}$ . Remember that the central wavelength *of each order* is, of course, determined by the fixed Echelle grating and remains unaffected by the setting of the  $45^\circ$  mirror. The formula simply states what wavelength you will find at the position of the central CCD column.

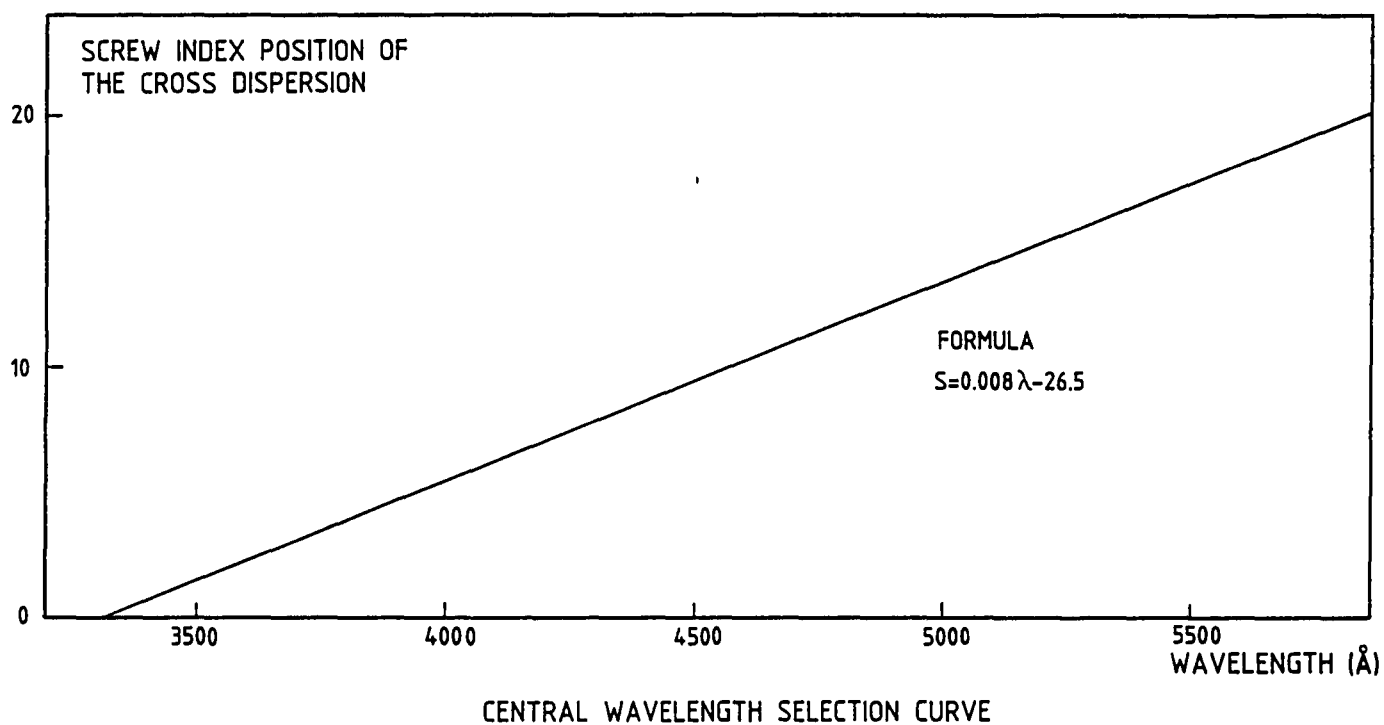


Figure 3.1: Central wavelength as a function of screw position.

### 3.2.4 Calibration Exposures

Before starting a calibration exposure, the following should be checked:

- The calibration lamp mirror has been moved into the light-path. This is done with two push buttons (in/out) located on a small electronic control box at the rear left of the central pillar. These buttons should be held down until the motion stops ( $\sim 15$  seconds). The lamp selection is done by shifting the sliding lamp support mounted on top of the central pillar to the required position.
- **The slit-view shutter must be closed to avoid saturation of and damage to the TV camera.** This is especially important with the white quartz flat-field lamp. The shutter is operated with a black knob located on the knee of the slit-view device.
- Neutral density filters are selected by pulling the sliding mount. A pilot light with five positions indicates the density value set. These lights are mounted on the same control box as the push buttons for the calibration lamp mirror. The density filters are only used with the white flat-field lamp.
- The thorium lamp should be switched on 2 minutes before the start of the calibration exposure for stability reasons. The switch and power supply are situated on the innermost wall behind the central pillar. *Lamps must be turned off after the end of an exposure.* The quartz flat-field lamp is switched on by starting the timer located on the coude lamp power supply. It is mounted on the wall to the right, behind the pillar. Any desired timing may be selected, but the lamp should not be left on for more than 5 minutes to avoid overheating its mount. *To avoid possible contamination from stray light, do not turn on calibration lamps during a science exposure.*

## 3.3 Before Starting Science Exposures

Initialise and point the telescope towards the object. Check that the slit-view shutter is open and the calibration lamp mirror is out. You should now see the object in the field of the slit-view TV monitor. The field has a size of  $1' \times 1'$  approximately. The spectral response of the TV camera (S25) peaks at  $\sim 4500 \text{ \AA}$  but is above 60% of the maximum sensitivity between  $3500 \text{ \AA}$  and  $5500 \text{ \AA}$  with a red tail extending to  $8000 \text{ \AA}$ . Colour filters are foreseen but not yet installed. This should be kept in mind when observing at large zenith distances where differential dispersion becomes important. No field rotator is available.

Normally, during ECHELEC observing runs no other instruments are mounted in the cassegrain focus. This allows a high degree of movability of the telescope. Should it become necessary, it is possible to reverse the telescope during the night.

### 3.3.1 Telescope Focusing and Guiding

The only focusing method is to obtain the smallest image size on the slit decker using the slit-view camera. Check that the TV camera has the slit well in focus. This can be done by using the dome illumination. Mark the midpoint of the slit. Guiding is made manually using a handset to move the telescope. All science targets should be kept as close to the marked position as possible to ensure that the same CCD pixels are used for all objects. This will facilitate later reductions. During guiding use moderate gain on the TV camera and check that you really have the maximum intensity peak of the image falling into the slit.

### 3.3.2 CCD Binning

The wide separation of the orders allows binning to be made in the cross-dispersion direction. This improves the S/N-ratio without any loss of resolution, and especially for faint stars where the readout noise is significant, binning should be considered. The CCD binning factor is set from the CCD softkey menu. However, binned-data require special care during subsequent order extraction. This is due to the tilt of the orders with respect to the CCD columns in combination with the small number of pixels defining the spectrum width. Even a fast on-line inspection of one order requires that the CCD frame is rotated 90° (a rather time-consuming operation) and then the IHAP ECHELLE command should be used with care for the extraction. Notice that excessive binning makes it much harder to identify and remove radiation events.

## 3.4 Control Software

The CCD is controlled by the GICCD program running in the HP computer. Full access to IHAP allows on-line work on the data during the night in the usual way.

Log on with the program name GICCD. At the appropriate moment type “:” followed by the “Return” key (or use softkey `f1`). The control program is loaded and the CCD is initialized. The `OBSERVATION` softkey menu will appear:

<code>OBSERVATION</code>	<code>TELESCOPE SETTING</code>	<code>BATCH DEFINITIONS</code>	<code>HELP</code>
	<code>Maintenance</code>		<code>TERMINATE</code>

The `TELESCOPE SETTING` is not yet implemented, `Maintenance` is used only by technical crew. Go back one level to the main menu with `TERMINATE`:



GIC CCD	CCD		
	LOG	IHAP	FINISH

**FINISH** twice will stop the GICCD program. Press **CCD** and another menu will appear:

Status	IHAP	CCD-frame/binning	HELP
Maintenance			TERMINATE

**Status** shows the set and actual temperature of the CCD. Hit **CCD-frame/ binning** and choose the CCD binning factors. Press the "ENTER" key and wait until the CCD has been reinitialized. If you want to escape a form without any changes being done use the **f1** softkey.

Return to the **OBSERVATION** menu by **TERMINATE** and **GICCD**. Press **OBSERVATION** and you will enter into the **Define exposure** menu:

Define exposure	Define sequence	Start focus exp.	HELP
IHAP	Start exposure(s)	Start sequence	Previous menu

The exposure definition is made in form # 2 which will appear when **Define exposure** is pressed:

\* GENERAL INSTRUMENT WITH CCD \* EXPOSURE DEFINITION \* FORM 02 \*

```

Exposure type  RE RE=Regular,FF=Flat F.,DK=Dark C.,NO=NO CCD,$$=NO F'S MOVE
Tape recording 1  0=Off,1=IHAP format,2=FITS format
Exposure time  0 10 00 Hours(0-8),Mins(0-59),Secs(0-59)
Identifier      Test
Batch progr.#   0 (0=None,1-9)
-----Counters-Autoincremented by computer-----
Rel.sequence # (in repeated and focus exposures)  1
Absolute sequence number                          8157

```

This form is largely self-explanatory. If exposure type is defined as DK the CCD shutter will not open. The default parameter for tape recording is 1 (IHAP format). Thorium exposures are defined as RE.

The batch program number identifies the particular batch which will automatically be executed at the end of an exposure. The batch program names are entered in a table in form # 5 which will be shown if **BATCH DEFINITIONS** is pressed:

\* GENERAL INSTRUMENT WITH CCD \* Batch filenames \* FORM 05 \*

Names of files containing IHAP batch programs, to be executed at  
(repeated) exposure end, as : BATCH, Name, CR, P0, P1, P2, P3

N.	Name	CR	P0	P1	P2	P3	Description
1	KDISPC	, 0,	,	,	,		Image display
2	KDISPB1	, 0,	,	,	,		Image+spect(CL)
3	PURGCC	, 1,	,	,	,		Purge data base
4	AV5	, 0,	,	,	,		AV5
5	CON#151	, 0,	,	,	,		CCD test
6	ECHCFF1	, 0,	,	,	,		Setup procedure
7	BCC1FF1	, 0,	,	,	,		for B&C and
8	ALIGN 1	, 0,	,	,	,		ECHELLEC
9	AVEX9 1	, 0,	,	,	,		Mean of 9 files

The text written in P0-P3 is transmitted to IHAP as it is,  
except the following variables, filled-in by GICCD at exec.time:

NE=Last exposure IHAP file No.

NT=Number of repeated exp. or steps(for a focus exp.)

Shown in form # 5 are some examples of batch programs. You may write and enter your own batches.

When you start an exposure by **Start exposure(s)** you will first be asked for the number of (identical) exposures you wish to have executed. Then form # 4 will be shown:

Telescope setting:

	hh mm ss.t		sdd mm ss.t
Right Ascension	17 43 28.0	Declination	5 24 36.0
	hh mm ss.t		
Sidereal time	16 41 41.*		

You have to fill this form manually if you wish to have correct coordinates and sidereal time in the header of the IHAP file containing your exposure. No link exists between the telescope computer and the HP computer controlling the CCD. After form #4 has been

filled and entered the exposure will start. During the integration you have access to the following menu:

Status	Comments	EXTM,n	HELP
IHAP			Abort exposure

The remaining exposure time is continuously displayed below this menu. The **Status** will show the requested and actual temperature of the CCD. **Comments** allows you to insert comments in the head of the current IHAP file. By **EXTM,n** you may change the exposure time by adding or subtracting a number of seconds. The **Abort exposure** pressed twice aborts the exposure without saving it. Three IHAP submenus are available providing you with the most commonly used commands.

The IHAP working disk space is limited, it will only hold between 10 to 15 full unbinned CCD frames. A warning will be given before the start of an exposure if the space is insufficient. You must then purge some files and pack the remaining ones.

With the **Define sequence** softkey you may create a sequence of (different) exposures (form # 3):

\* GENERAL INSTRUMENT WITH CCD \* SEQUENCE OF EXPOSURES\* FORM 03 \*

```
# RF TY M H.MM.SS      IDENTIFIER  B  SEQ#
*  3 DK 1 0. 0. 2 3 DARKS 2SEC      0 8183 # =REL.SEQUENCE # (0=SKIP,1-9)
2  2 DK 1 0.10. 0 2 DARKS 10MIN     0 8184 RF=REPETITION FACTOR FOR EXP.(0,20)
3  2 DK 1 1. 0. 0 2 DARKS 1HOUR     0 8185 TY=TYPE OF EXPOSURE (RE=REGULAR
0  0    0 0. 0. 0      0 8186   FF=FLAT F.,DK=DARK,NO=NO CCD)
0  0    0 0. 0. 0      0 8187 H.MM.SS=EXPOSURE TIME(HOURS=0-8)
0  0    0 0. 0. 0      0 8188 M =COPY TO TAPE(0=NO,1=IHAP,2=FITS)
0  0    0 0. 0. 0      0 8189 B =BATCH PROGR.AT END(0=NONE,1-9)
0  0    0 0. 0. 0      0 8190   (0=NONE,1=AVG.,2=FOCUS,3-9=OTHERS)
0  0    0 0. 0. 0      0 8191 SEQ#=ABS.SEQUENCE # (AUTOINCREM.)
```

The sequence is started by **Start sequence**.

### 3.5 Science Exposures: Efficiency and Limiting Magnitudes

The global efficiency of the system (telescope+ECHELEC+CCD) has been estimated by observations of the standard star HR9087 during the first tests of the instrument. With a  $1''.4$  slit, the measured count rate at  $5000\text{ \AA}$  corresponds to 0.6 electrons per second per wavelength bin ( $0.06\text{ \AA}$ ) for a star of visual magnitude  $m_v = 10$  [4]. Thus, taking into account the readout noise and the dark current of the present chip, a S/N ratio of 10 would be reached in 1 hour for a 10th mag star (a S/N of 100 for a magnitude of 7.3). With a binning of 4 pixels in the cross-dispersion direction, the limiting magnitudes in an 1 hour exposure would be 10.6 and 7.7, for an S/N of 10 and 100, respectively.

Fig. 3.2 gives the exposure time versus magnitude and S/N at a wavelength of  $5000\text{ \AA}$ . These measurements were obtained during relatively poor weather conditions with passing cirrus. They should however, give correct order of magnitude estimates. Fringing did not cause problems at this wavelength.

Bright flux standard stars can be found for example in references [5] and [6], fainter in reference [7].

## 3.6 Calibration Exposures

### 3.6.1 Dark Exposures

Several 1 second dark exposures can be averaged and subtracted from the science images to remove the electronic bias ( $\sim 200$  ADUs). Dark exposures of the same length as the object exposures should be used to subtract average dark current effects and to check for possible parasitic light in the spectrograph. The dark current of CCD #13 is  $\sim 60\text{ e}^-/\text{pix}/\text{hr}$ . Furthermore, light is to some degree diffused inside the spectrograph. This light is added to the spectrum as well as to the inter-order background. Thus, bias, dark current and inter-order background light must all be removed from the science exposures.

### 3.6.2 Wavelength Calibration Exposures

A thorium hollow cathode lamp is used for wavelength calibration. Remember to turn on this lamp 5 minutes before the exposure to allow it to heat up. A 3 min exposure is sufficient at  $4000\text{ \AA}$ , and 2 min is enough around  $5500\text{ \AA}$  with a slit width of  $1''.3$ . Since lamps and detector may change, these values should be checked at the beginning of a run and scaled up or down as needed. If the CCD is saturated with strong Th lines, a remnant charge may be present at the position of these lines. Wait a few minutes and then do a short dark. This will normally remove the remnants.

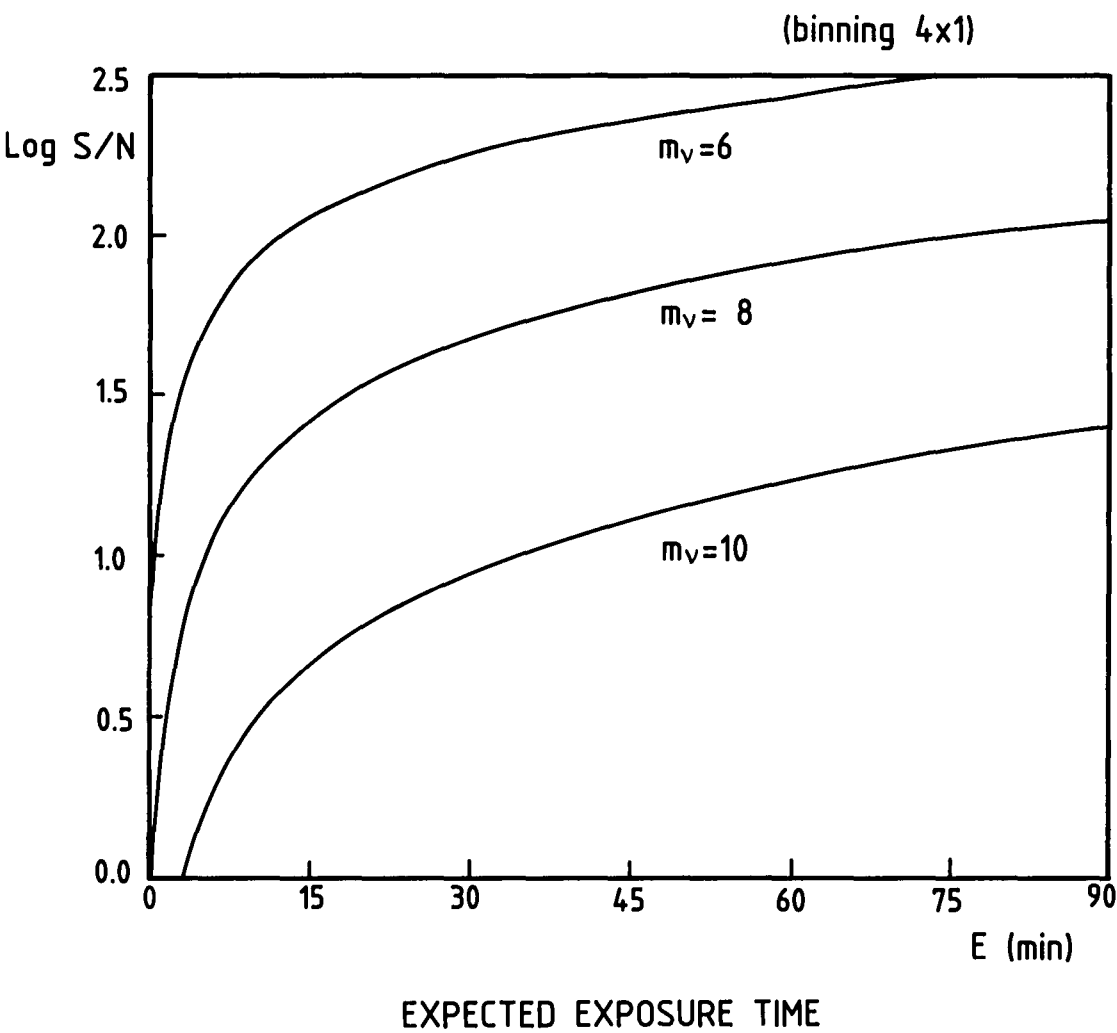


Figure 3.2: Exposure time versus magnitude and S/N ratio at 5000 Å

### 3.6.3 Flat-Field Exposures

A xenonphot halogen lamp is mounted on the ECHELEC for flat-field exposures. A neutral density filter is always needed with this lamp at all wavelengths. Except for faint stellar exposures, best flat-field corrections are achieved when science exposures have an exposure level similar to the flat-field. A series of flats should normally be taken to reduce the noise by averaging.

An exposure time of 20 seconds with a neutral density filter of 1.9 gives a flat-field level of  $\sim 4000$  ADUs at  $4000 \text{ \AA}$  with a background level of  $\sim 400$  ADUs (between orders). Similar levels are obtained after 3 seconds with a 1.9 filter at  $5500 \text{ \AA}$ .

In special cases, a stellar flat-field may be preferable. The star used for that purpose (fast rotating, type O - B) should be guided on the same position on the slit as the program objects, in order to illuminate the same pixels on the CCD. Even better is to slightly defocus the telescope and trail the star a short distance around the slit midpoint.

Due to the high stability of the ECHELEC mount, it is normally sufficient to do thorium and flats at the beginning and end of the night (if the same wavelength range is used throughout the night, of course).

### 3.6.4 Ghosts

Some ghosts have been identified on thorium lamp exposures. They probably originate between the Bowen Camera and the CCD dewar. They are best seen on over-exposed thorium spectra, which can be used to map the exact positions. The same ghosts are also present on the flat-fields and appear as superimposed orders with a different tilt. The science exposures will also be affected by the presence of these ghosts.

# ECHELEC Checklist

*At beginning of night:*

- Remove cover from slit unit.
- Check central wavelength setting, and the width and height of the slit.
- Open the ECHELEC manual shutter.
- Check that the wooden ECHELEC light baffles are all in place.
- Switch off coudé room lights.
- Check CCD temperature with the STATUS softkey in the CCD menu.
- Initialize telescope and check its pointing.
- Check slit-view camera.
- Focus telescope with a stellar image.

*Before starting a calibration exposure:*

- Close shutter in front of TV camera.
- Move in calibration lamp mirror.
- Select a calibration lamp.
- Select a neutral density filter (for flat-fields only).
- Switch on the selected lamp.

*Before starting a science exposure:*

- Check that calibration lamps are switched off.
- Move out calibration lamp mirror.
- Open slit-view shutter in front of TV camera.
- Check CCD and dome temperature from time to time (telescope focus variations).

*At end of night:*

- Check that all calibration lamps are off.
- Close the ECHELEC manual shutter.
- Mount slit unit cover.
- Move telescope to zenith.
- Follow instructions for telescope closedown.
- In case of problems during the night: Provide a detailed description in the Telescope Operations Report.



# Bibliography

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- [2] *The ECHELEC – A new spectrograph for ESO.* – J. Breysacher: ESO Messenger no. 5 – June 1976.
- [3] *Implementation of a CCD detector for spectroscopy at the ESO 1.5 m telescope with the B & C Cassegrain spectrograph and the Echelec.* – J. Breysacher, B. Delabre, S. D'Odorico, A. Gilliotte and P. Giordano – Note TP/OIG ESO – 86-1 / 3404.
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- [5] *The Monochromatic Flux of 14 Southern Standard Stars from 3200 Å to 8800 Å.* – H. Tüg – Astron. Astrophys. Suppl. Ser. **39**, 67, 1980.
- [6] *An Augmented System of Secondary Standards for Bright-Star Spectrophotometry* – B. J. Taylor – Astrophys. J. Suppl. **54**, 259, 1984.
- [7] *Spectrophotometric Standards* – P. Massey, K. Strobel – Astrophys. J. **328**, 315, 1988.

## Appendix A

# Thorium Atlas Frames

Figures 1 through 9 show CCD frames from the Echelec spectrograph covering the spectral region from about 3600 to 6000 Å. The order numbers are identified. Intensity tracings of the orders and line identifications can be found in the Atlas of Th-Ar Spectrum for the CASPEC Spectrograph (ESO Scientific Report No. 6, 1987).

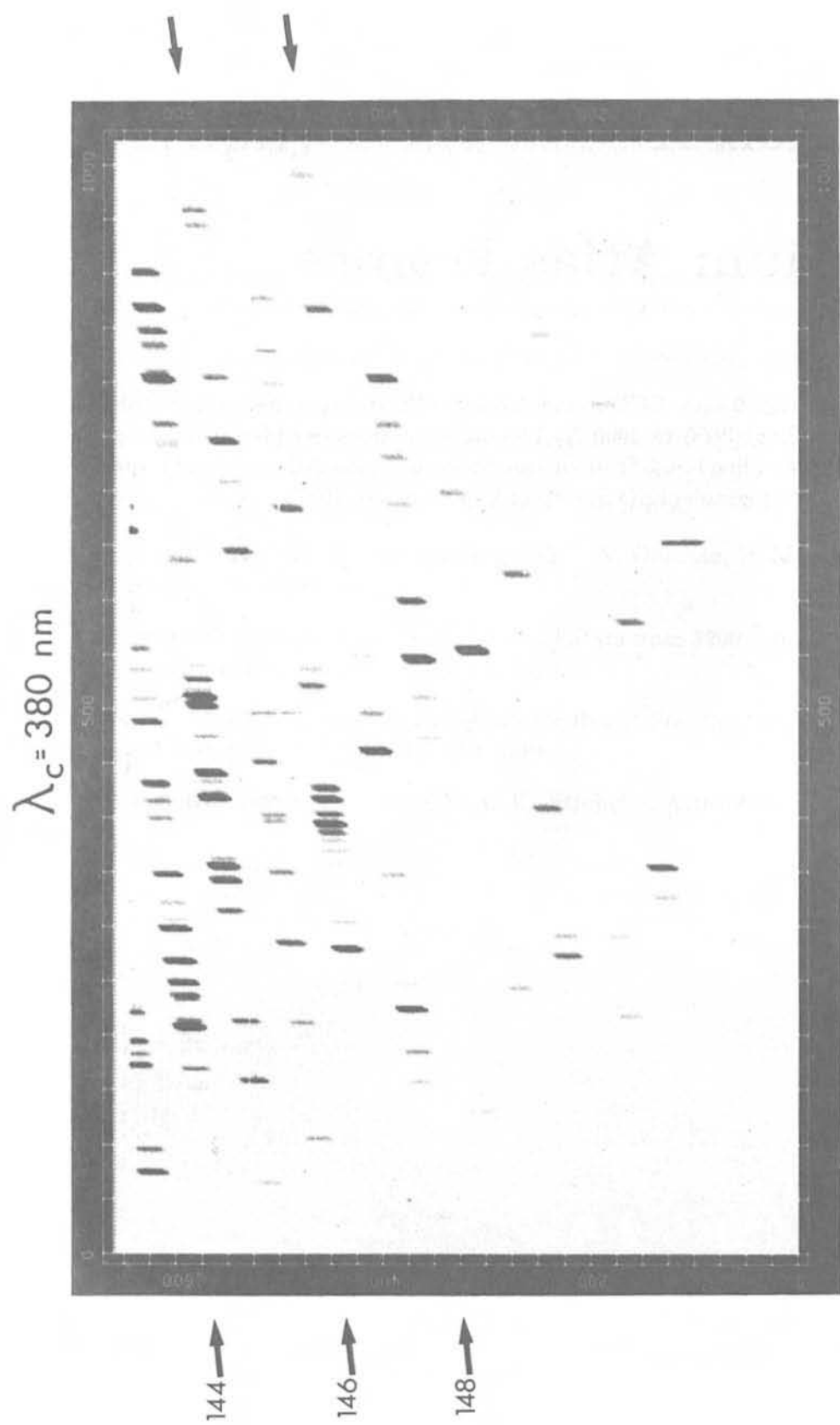


Fig.1

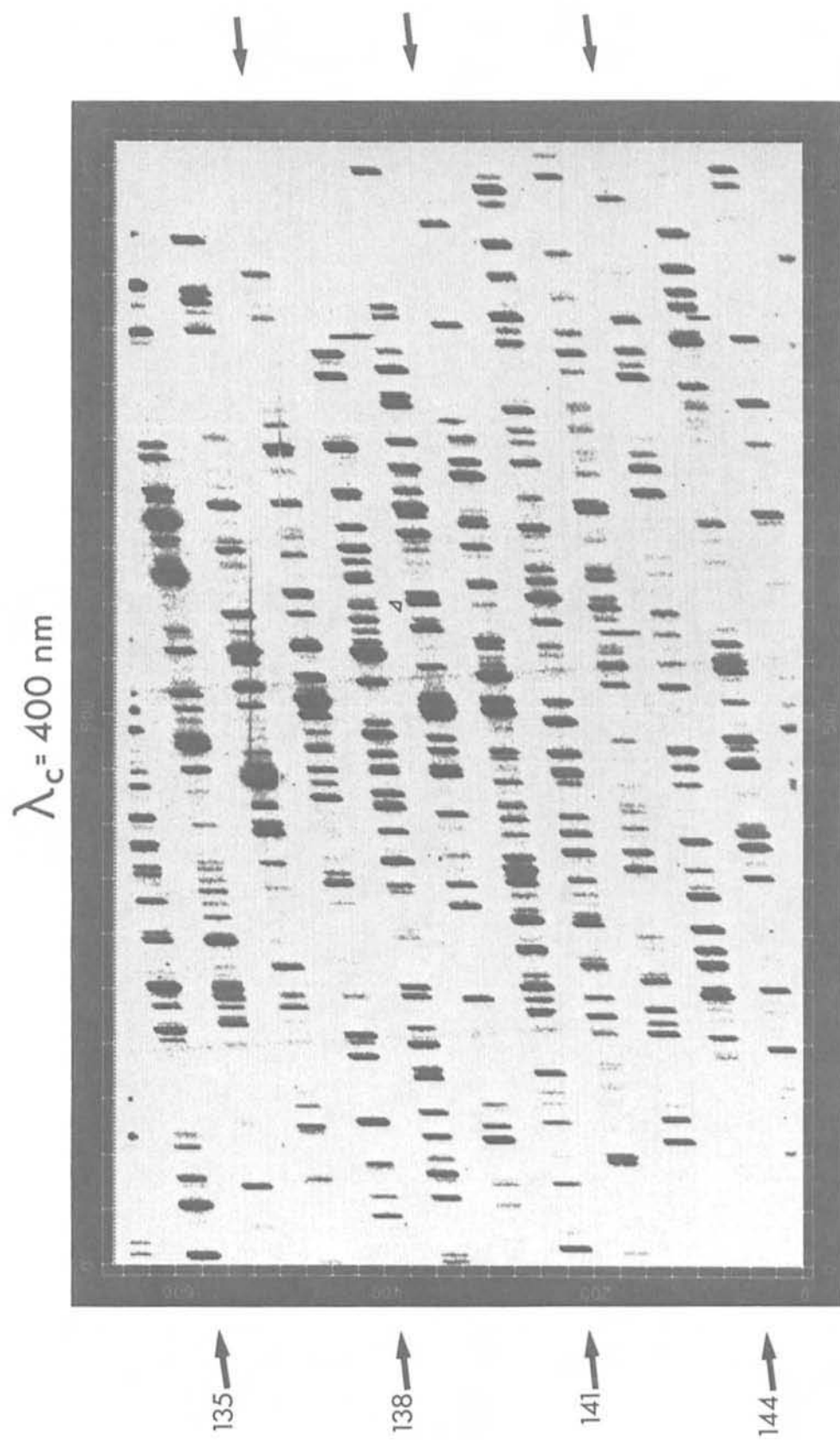


Fig. 2

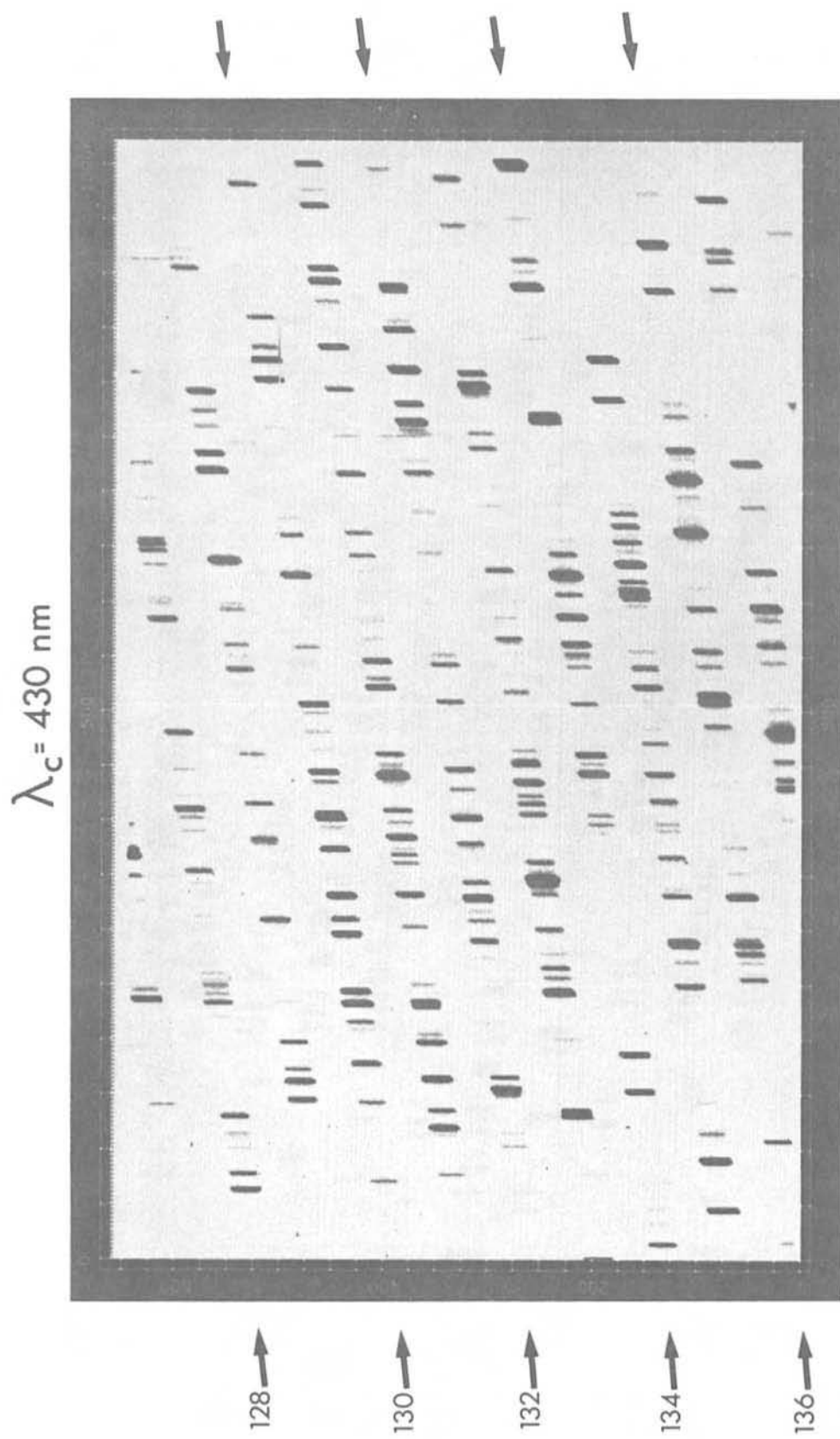


Fig. 3

$\lambda_c = 455 \text{ nm}$

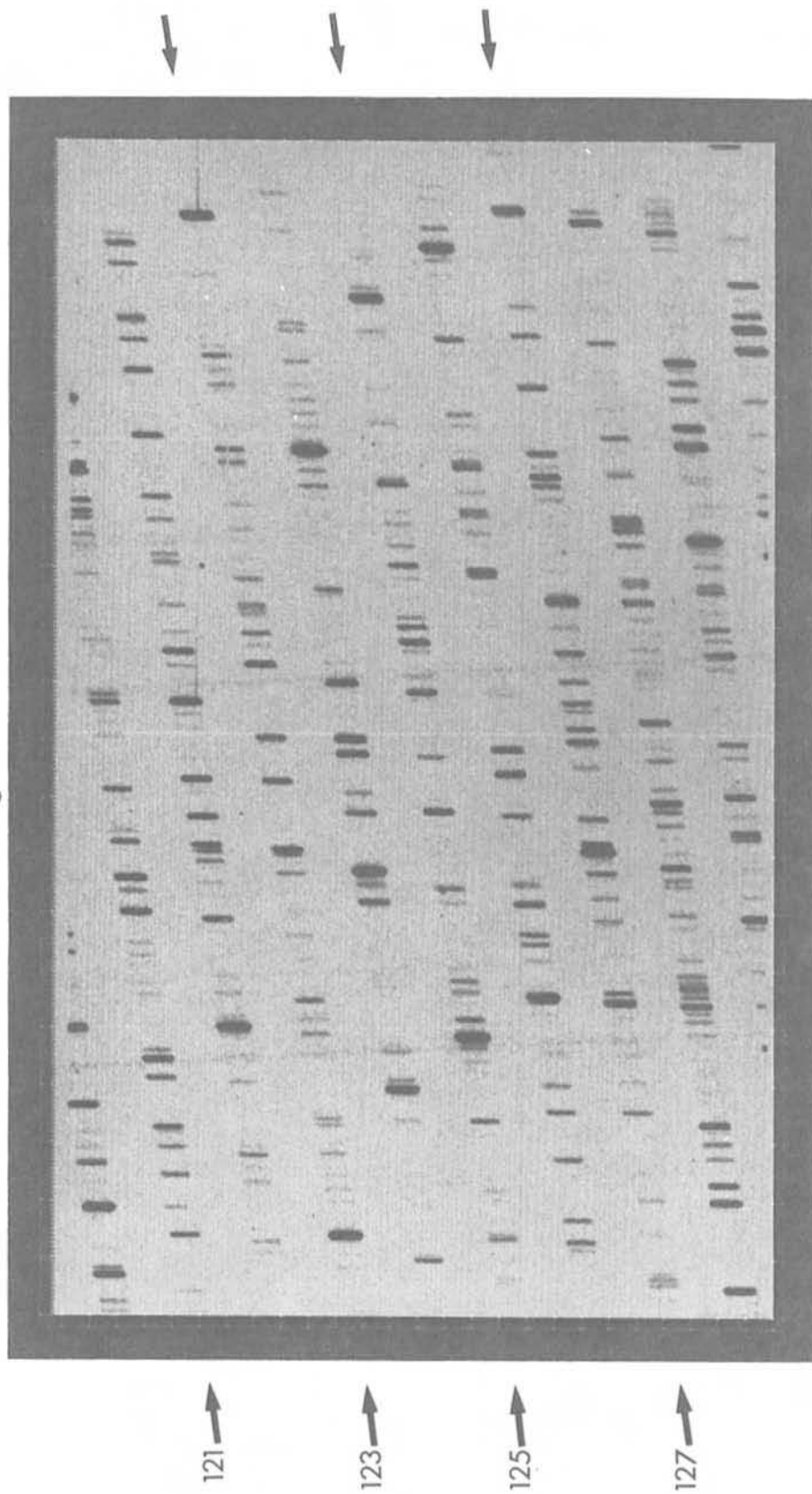


Fig. 4

$\lambda_c = 480 \text{ nm}$

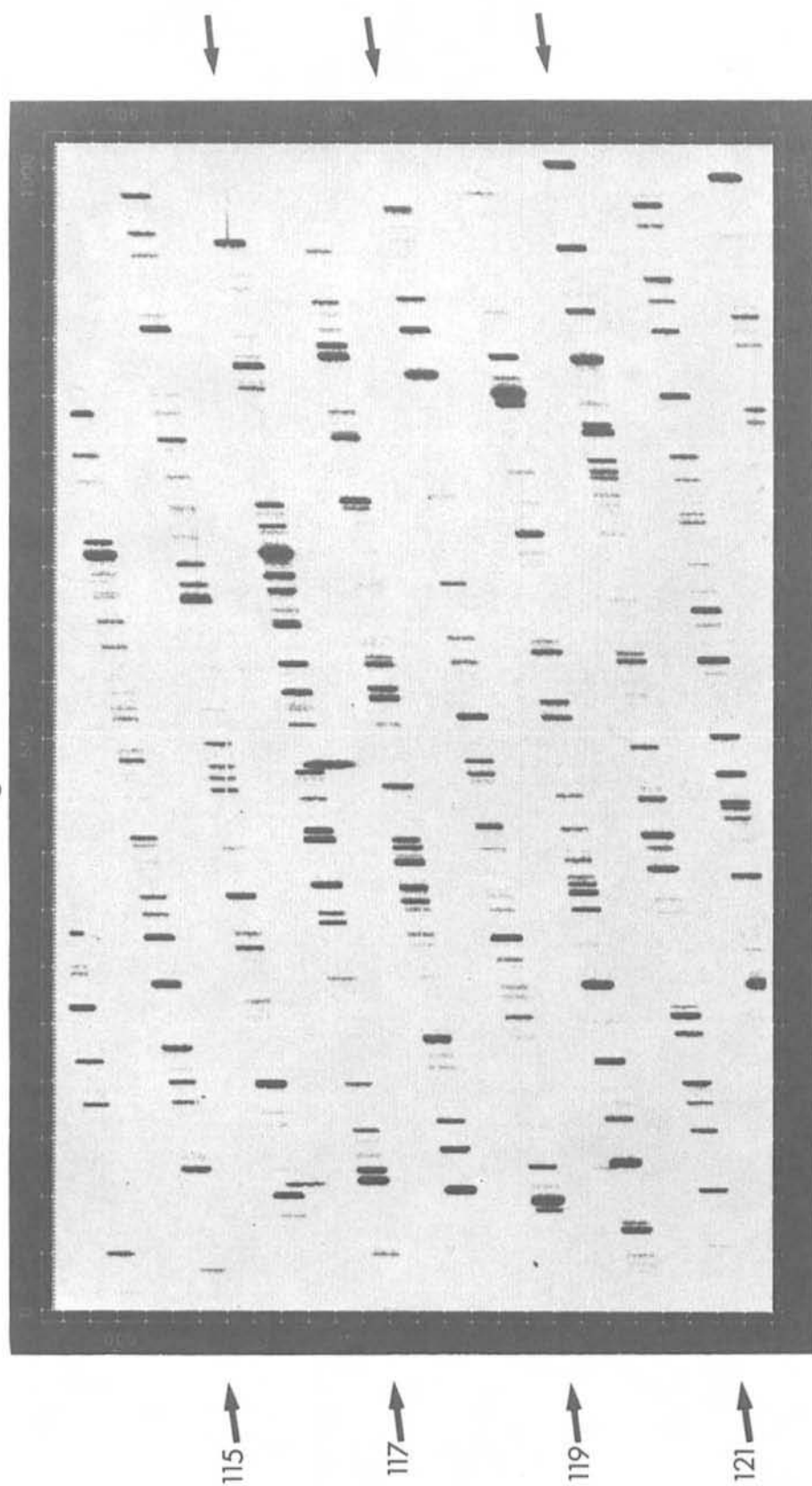


Fig. 5

$\lambda_c = 510 \text{ nm}$

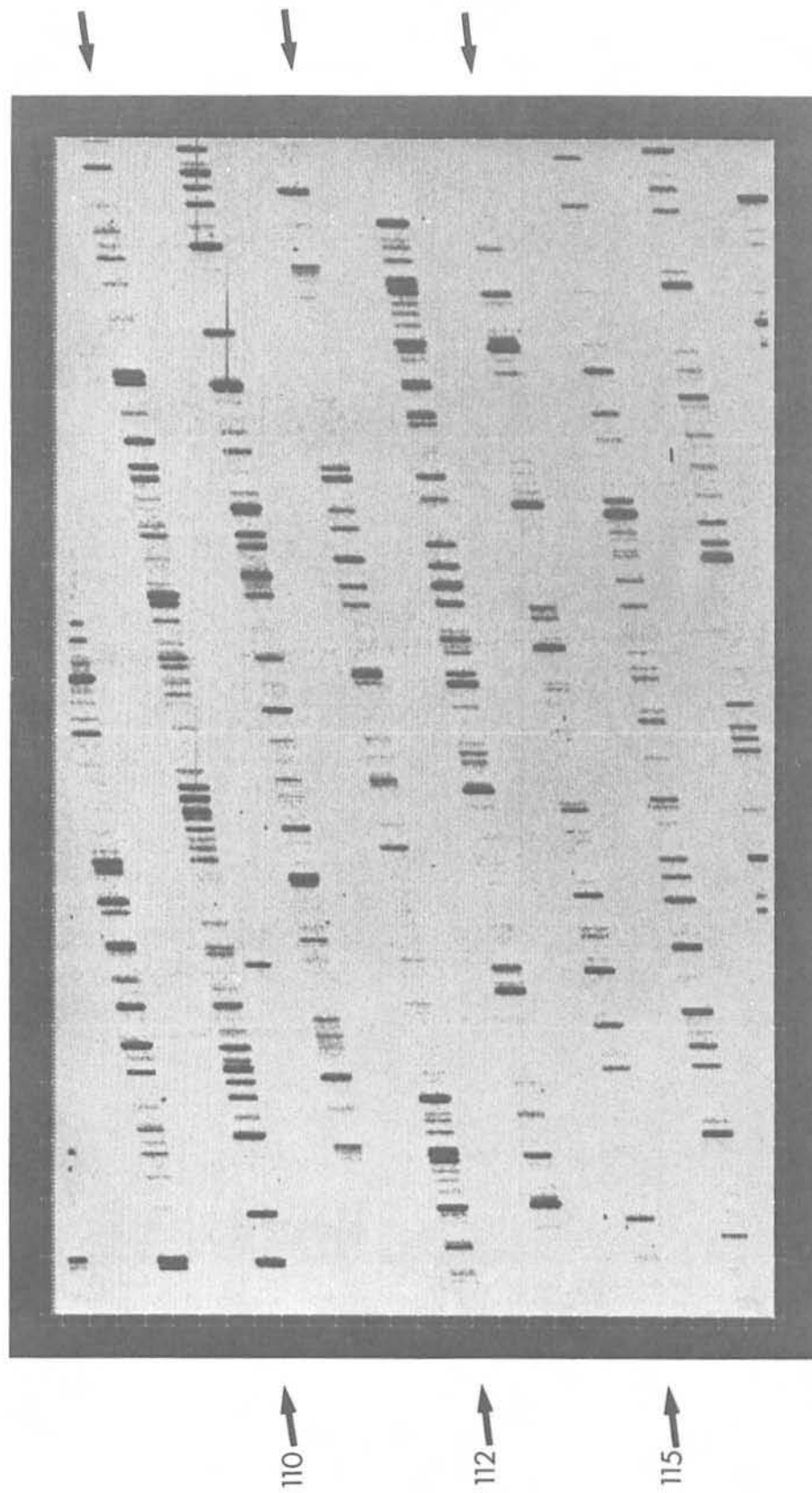


Fig. 6



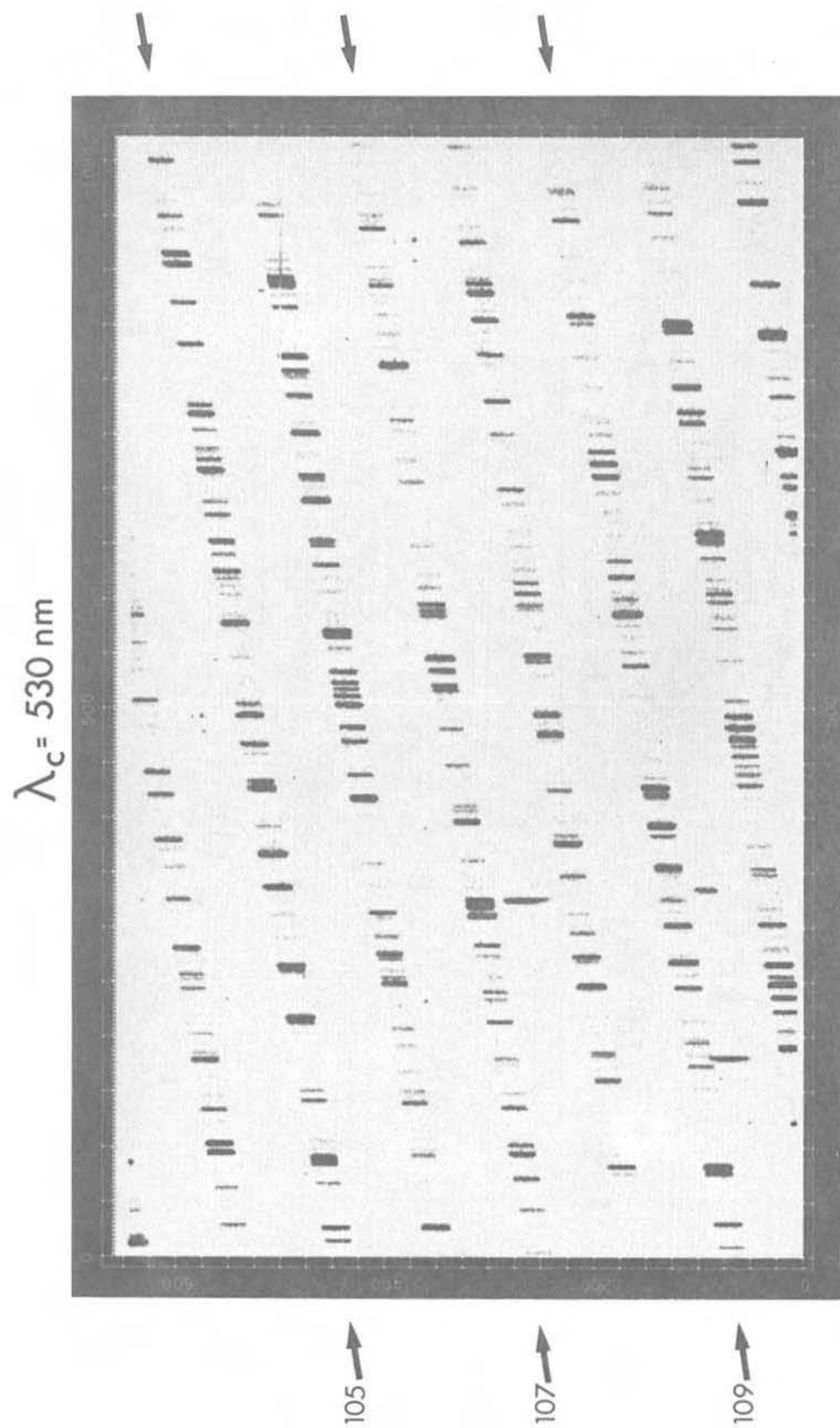


Fig. 7

$\lambda_c = 560 \text{ nm}$

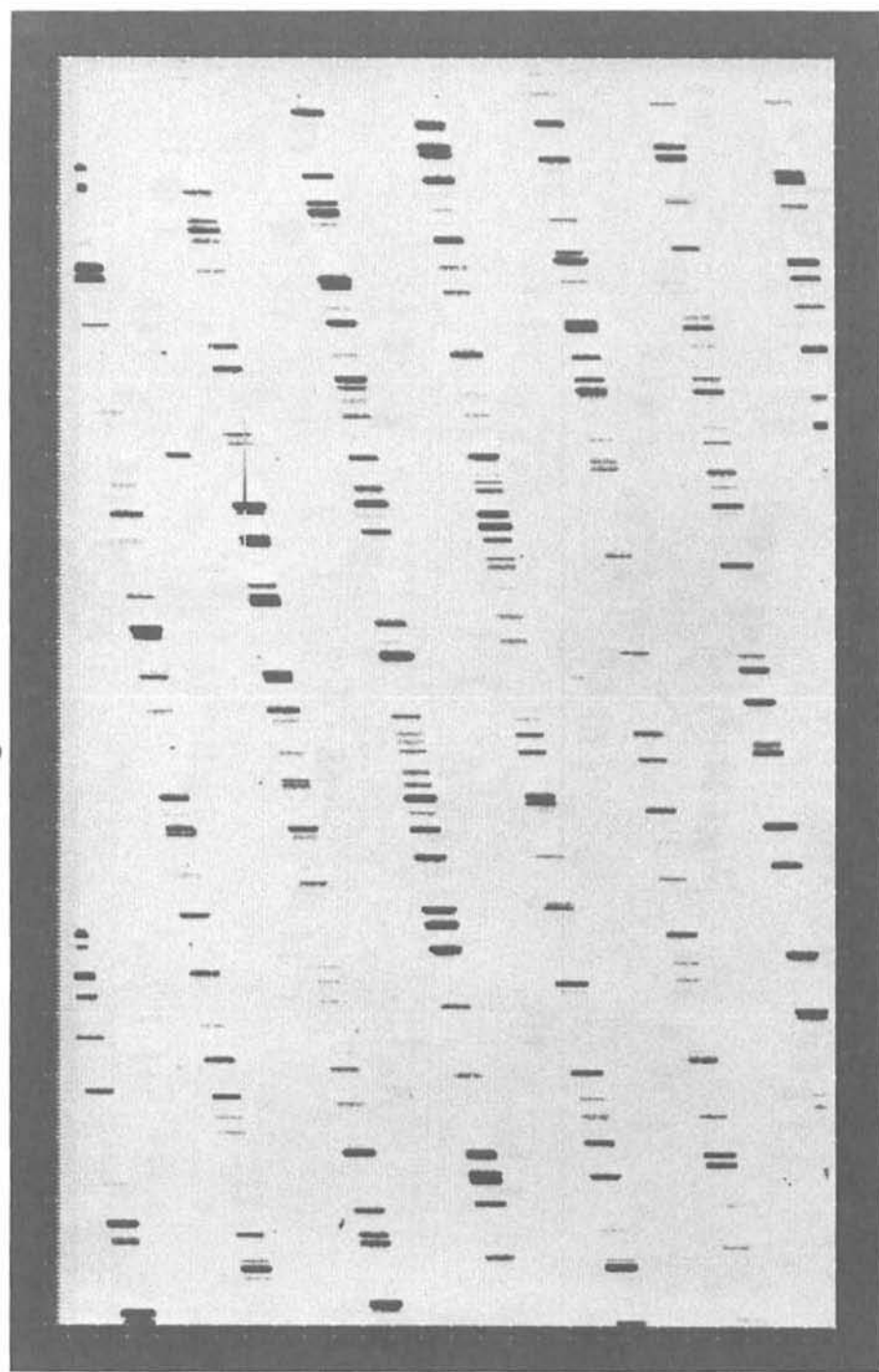


Fig. 8

$\lambda_c = 580 \text{ \AA}$

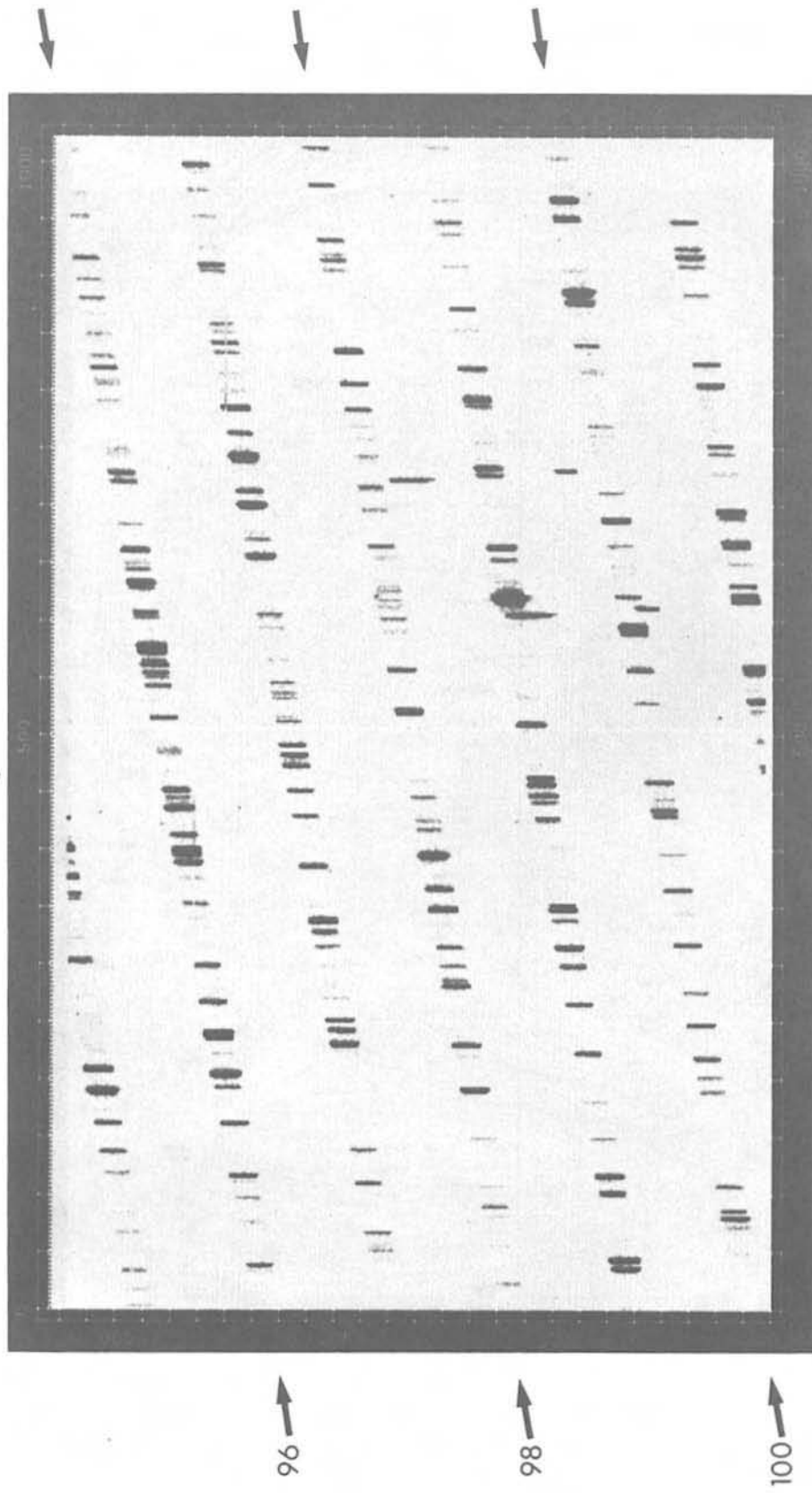


Fig. 9