



FLYING-SPOT ANALYSIS OF SOLAR IMAGES

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1.- INTRODUCTION

This work has been performed to test the new and interesting results obtained previously with a photographic isodensitometric method about the photometric evolution of solar flares (Falciani et al., 1972; Falciani and Rigutti, 1972 a,b) and to study the degree of utility and reliability, and the general performances of high speed, computer controlled devices in the photometric analysis of extended sources. We studied some series of good H α solar filtergrams, obtained during 1969 (May 15-16-17-25 and Oct. 25-27), at the Athens National Observatory (we warmly thank Dr. C.J. Macris for having kindly put at our disposal such a material), with time resolution of about 30 sec, with uniform exposure and high photometric accuracy (\approx 5000 filtergrams).

2.- INSTRUMENTS DESCRIPTION

To study the huge amount of the above material we used the S.A.D.A.F. computer controlled flying-spot digitized machine of the Istituto di Elaborazione dell'Informazione (Pisa). This instrument has been extensively described elsewhere (Azzarelli and Panicucci, 1972; Carlesi and Montanari, 1973; Carlesi, 1975). It is a conventional type of flying-spot photometer (see the general plan in Fig. 1 and a general picture in Fig. 2), the main features of which are given below:

photograms dimensions	24 x 36 mm ²
Scanned area	24 x 24 mm ²
maximum length of automatically scanned roll film	45 m.

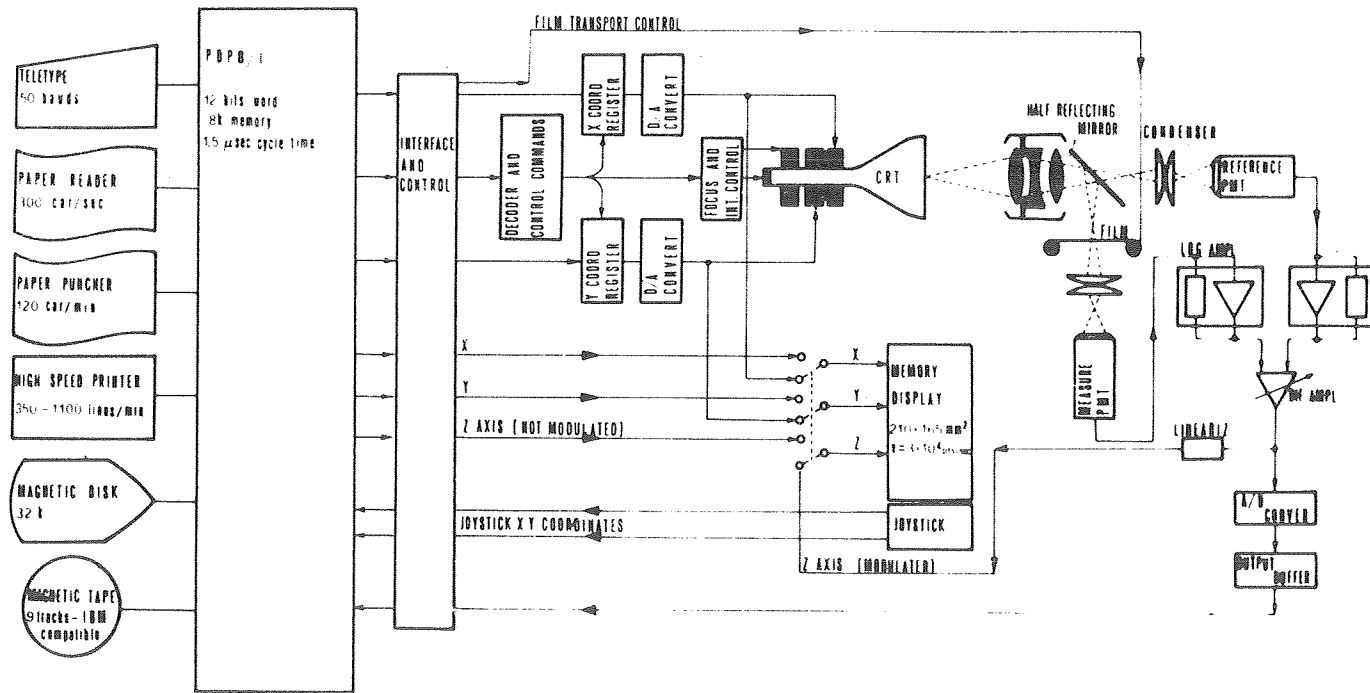


Fig. 1 Block diagram of S.A.D.A.F. flying-spot.

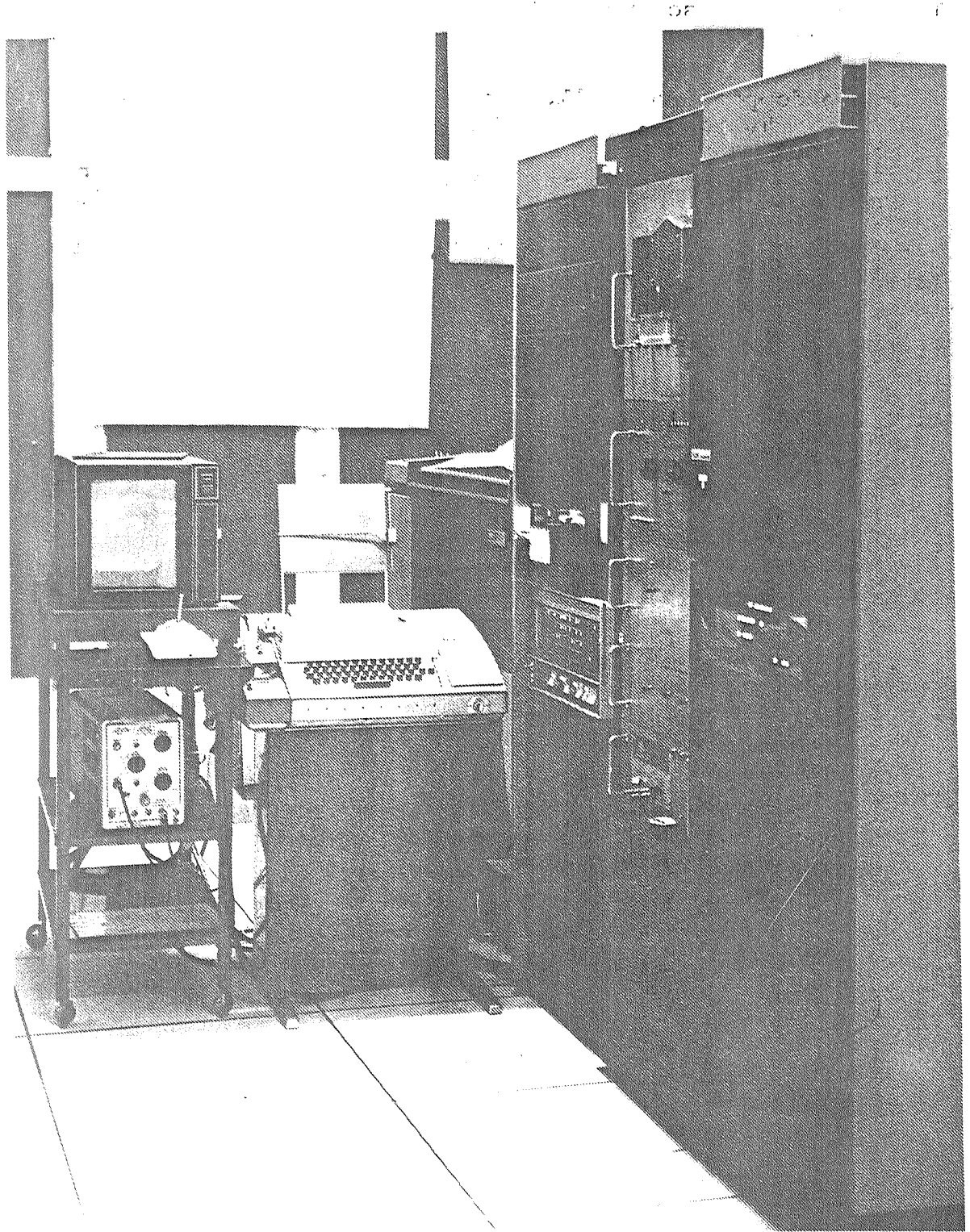
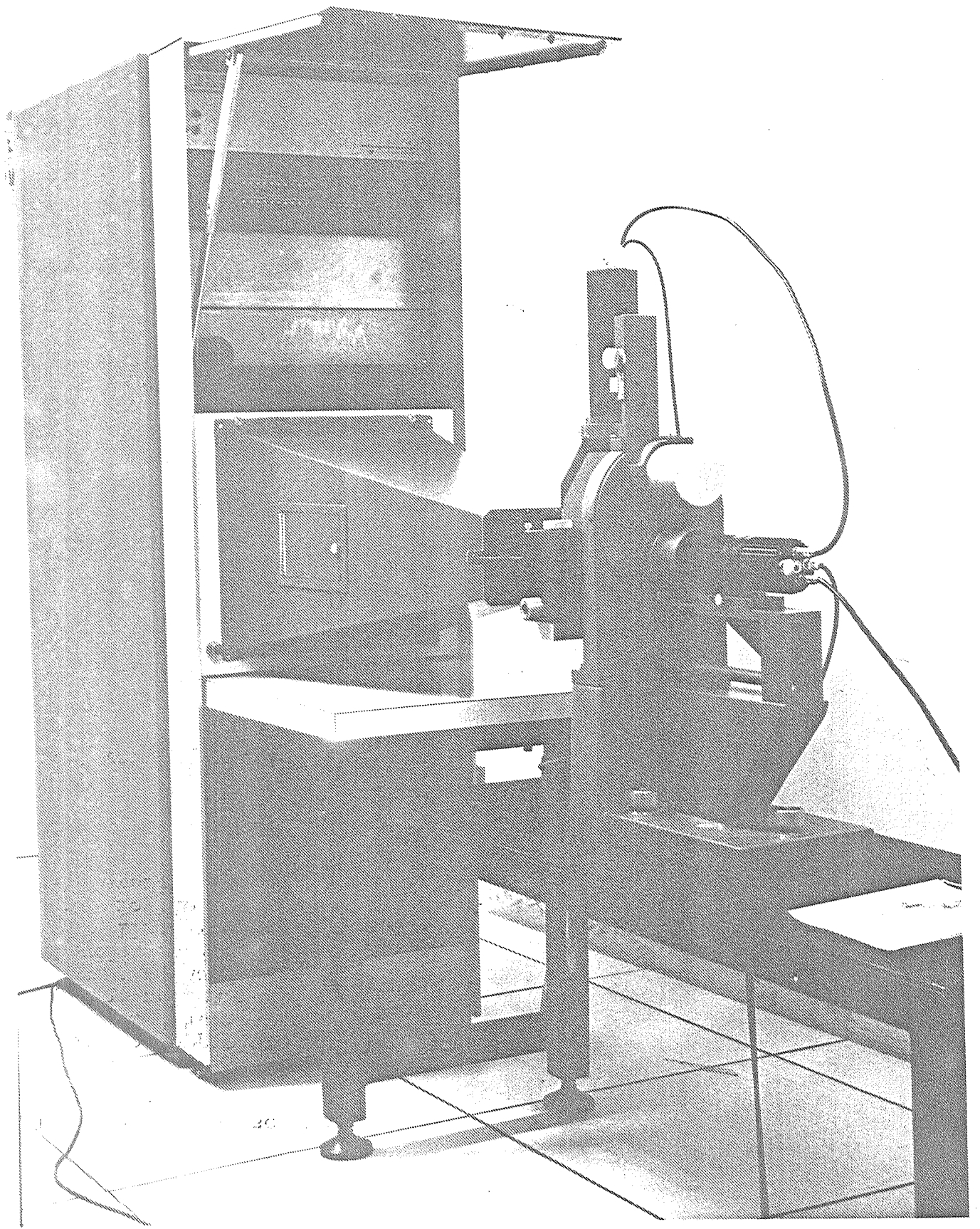


Fig. 2 General view of the S.A.D.A.F. flying-spot

positioning precision of automatic film transport	± 0.2 mm
maximum number of random access points in the scanned area	(1024 x 1024)
densitometric resolution	64 gray - levels (6 bits digitized value) in the density range $0.05 \div 2.2$
time for the acquisition of the data from one point (random access)	$\simeq 40$ μ sec.
scanning velocity	30 photograms per hour at maximum resolution of 10^6 points with sequence scanning.

It is possible to monitor on-line on a CRT memory display all the scanned regions and through a joystick we can select some particularly interesting areas to further detailed reductions. In Fig. 3 a reproduction of an analyzed solar H_{α} filtergram is given, while in Fig. 4 it is shown the same active regions, present in Fig. 3, projected on the CRT memory display together with the limits, controlled through the joystick, of the areas to be extracted from the general digitization matrix to further elaborations. The little square below indicates the area over which we obtained the mean density of the undisturbed surrounding chromosphere. A flexible, interactive program enables to run and control all the working procedures of the equipment (interactive scanning parameters determinations, densitometric scale and digitization minors selections, output peripherals, magnetic tape memorization options, jump of not interesting photograms etc.). We also developed a program to reduce the obtained informations with an off-line computer. The raw data are converted, through the calibration curves of the instrument and the photographic emulsion, into intensity values, measured in unit of the mean undisturbed chromosphere, surrounding our events. The histogram of the counts per digitized gray level is shown in Fig. 5. From the mean dimension of the spot we get by interpolation the projected area of the phenomenon at a given intensity levels j and then deduce the energy E_j emitted from a selected intensity level upward. E_j 's are measured in terms of the energy emitted by a unit surface of the undisturbed chromosphere. We can select various output possibilities (print, write, plot, punch).



The picture of the preceding page shows the optical-electronical part of SADAF, comprising:

- the photo-camera, to be loaded with the film or photogram to analyze;
- the two photomultipliers, oriented along the x and z axes of the image, the first of which gives a reference-value for the automatic correction of the measurement;
- the main frame, with a C.R.T. and the circuitry for the beam deflections.

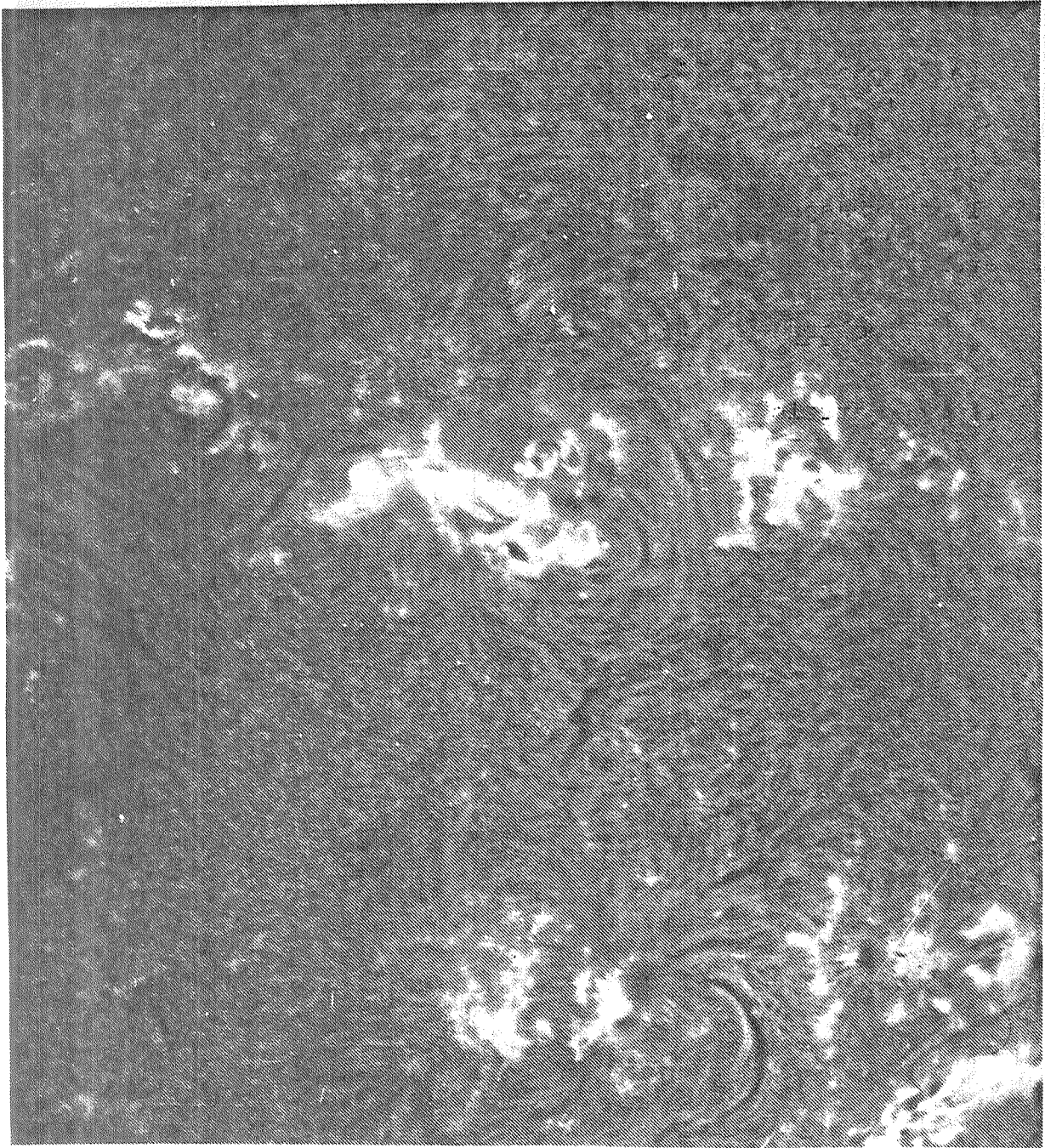


Fig. 3 Reproduction of an analyzed H_{α} filtergram.

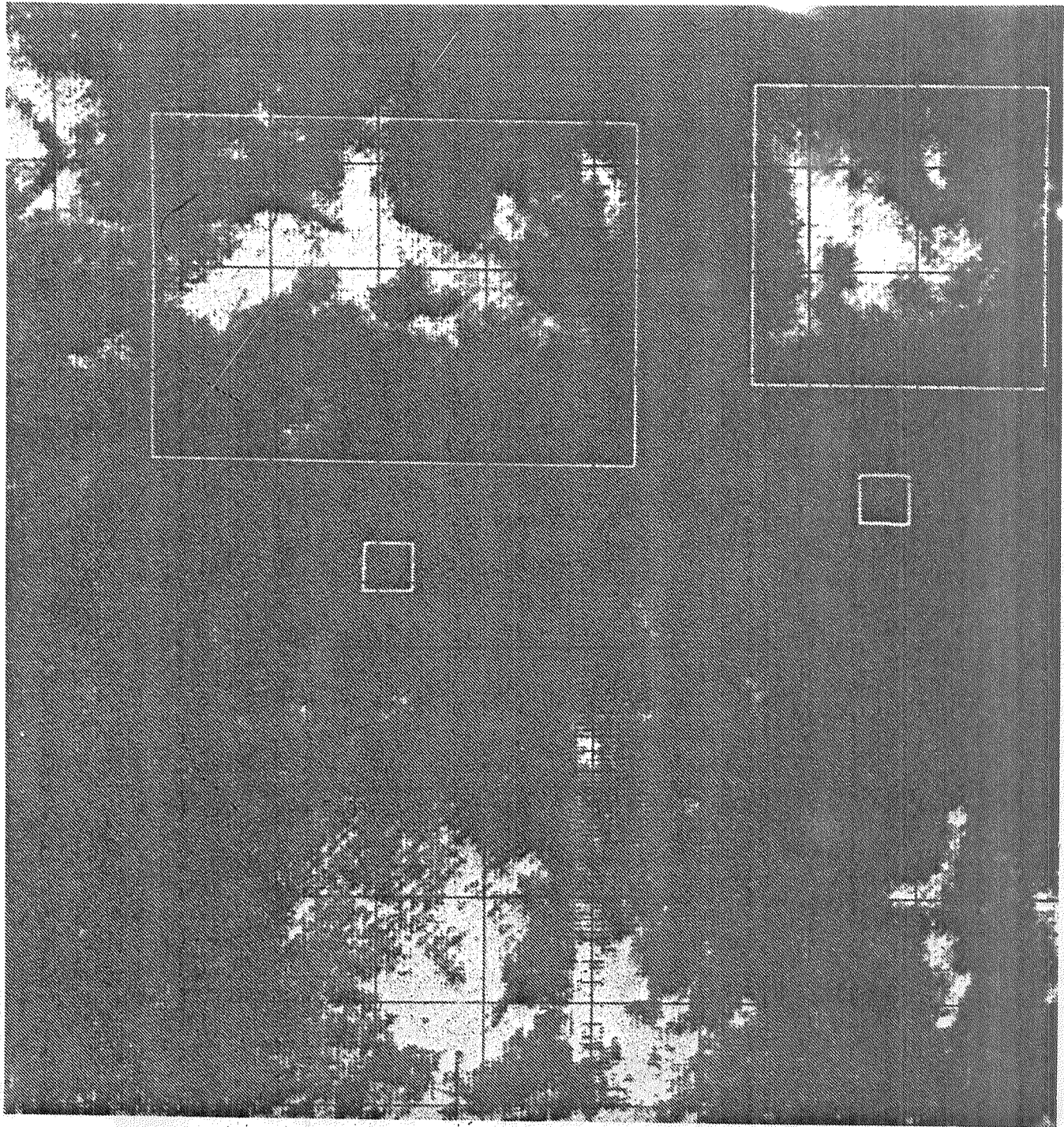


Fig. 4 Active regions (present in Fig.3) projected on the CRT memory display, with digitization minors limits.

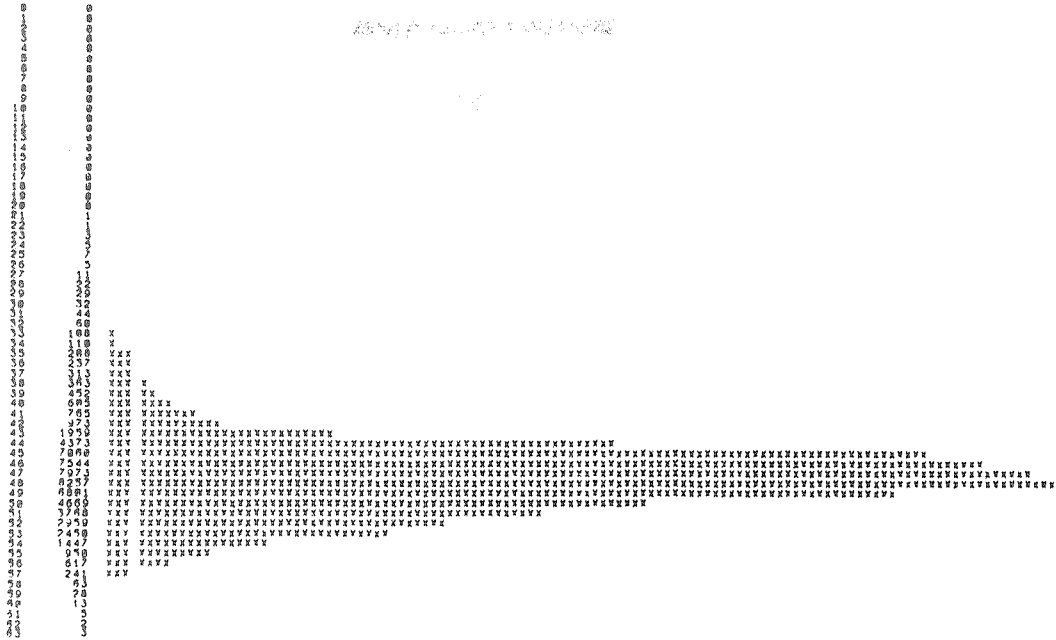


Fig. 5 Histogram of the counts vs. gray levels.

3.- EQUIPMENT PERFORMANCES AND TESTS

The step filter for the densitometric comparison and test of the machine has been calibrated in the same density scale D of the calibration curve of the analyzed photographic emulsion. Checks for the photometric stability of the flying-spot gave results of $\sim 2\%$ for $D < 0.6$, $\sim 8\%$ for $0.6 \leq D < 1.3$ and $\sim 1 \div 2\%$ for $D \geq 1.3$ (the latter is due only to the difficulties to disentangle and read exactly neighbouring histograms at high D values). We calibrated with extreme care the mean value of the scanning spot area and tested the reproducibility of all the photometric analysis (hard + soft) by scanning the same photogram many times and with various working conditions during several days. We obtained a rms error in the area determinations ranging from 2.3% to 7% for areas of 20 mm^2 and 0.3 mm^2 respectively.

To check the differences between this analysis method and the photographic isodensitometric one, we measured many filtergrams of our previous work (Falciani and Rigutti, 1972 a) and obtained a rms agreement of the order of $2 \div 10\%$ and a small systema-

tic deviation of $1 \div 2\%$ in the mean values for $1.1 < j < 1.6$. Finally we like to stress how powerful and flexible in comparison of similar ones is the present method of analysis, which supply all the wanted data (areas, isophotes, points determinations, etc.), keeps in a numerical matrix the information of the original photographs, viz. in a form particularly suitable to any further elaborations, and presents very simply any feed-back procedure between the first approximation results and the next steps of the work.

4.- SOME PRELIMINARY RESULTS

With the analysis of a series of solar H_{α} filtergrams we obtained the evolutive curves of E_j vs. time Fig. 6 show one example. From a very preliminary examination of the obtained evolutive curves we can confirm our previous results: before the flash phase of the flare a contraction of the whole active area, preceded by a sort of instability intensity fluctuations of the surrounding plage, takes place. After the flash phase (characterized by the birth of small bright points inside the active region), an exponential decay of the emitted intensity vs. time, with higher time constants for higher j values is observed. However we can emphasize that intensity fluctuations of $\approx 26\%$ are always present in the studied active regions, in "quiet" plages too. The autocorrelations of these fluctuating evolutive curves show clearly a periodicity of about 2 min ($1.5 \div 2.5$). It should be necessary more uniform material to establish with higher precision this feature.

The isophotes maps (obtained through a computer code developed by Casalini and Cerri, 1975) confirm that the fluctuating points inside the active region are the same and there is a sort of diffusion of the perturbation from these fluctuating points to the outer parts of the plage. In Fig. 7 - 12 some examples of isophotes development, obtained at some particularly interesting points of the evolutive curve of the phenomenon, are given. These very rough results are in agreement with the conclusions obtained through direct scanning of the solar images by Argo et al. (1973).

Figures 7 ÷ 12 show the isophote curves corresponding to the points A, B, C, D, E and F indicated on the evolutive graph of Fig. 6.

These isophote maps were obtained by setting $j = 1.2, 1.4, 1.6, 1.8$ and 2.2 , respectively.

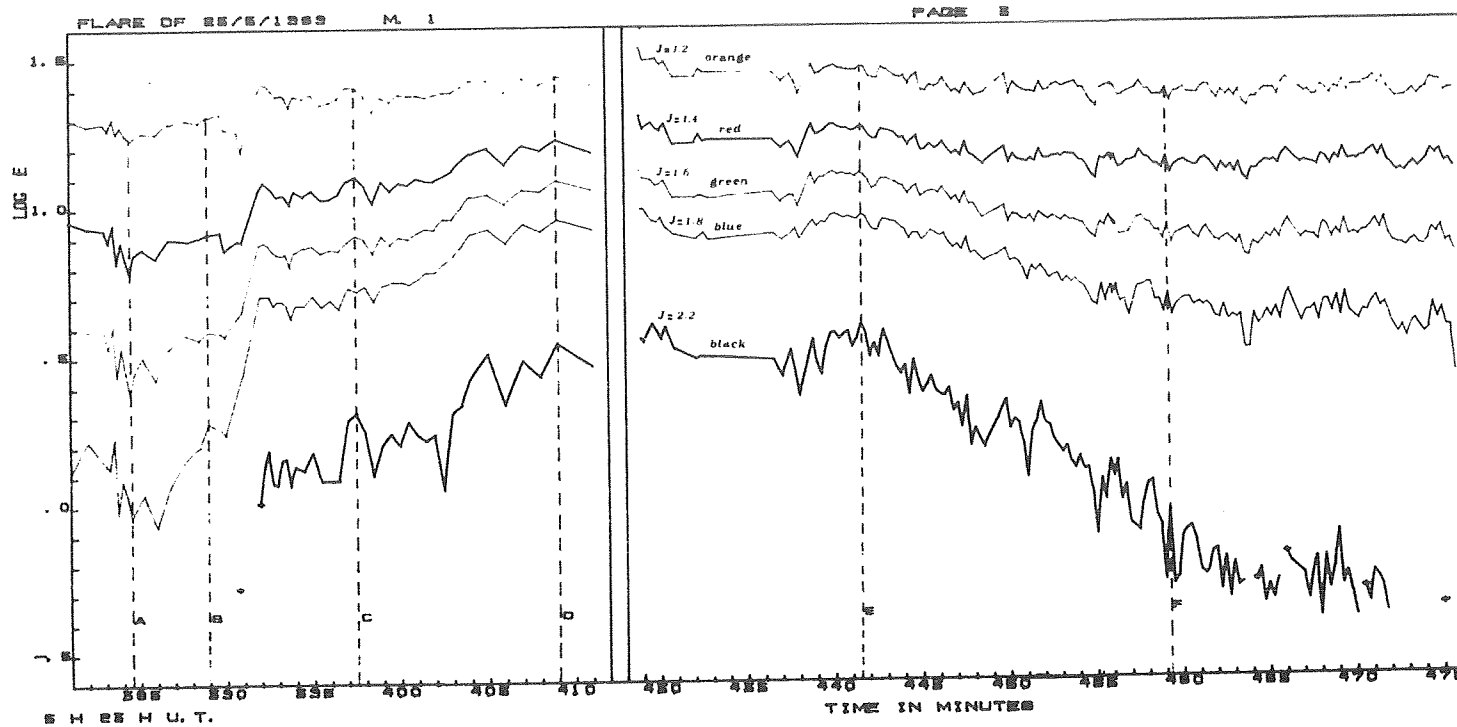


Fig. 6 Evolutive curves of May 26, 1969 solar flare.

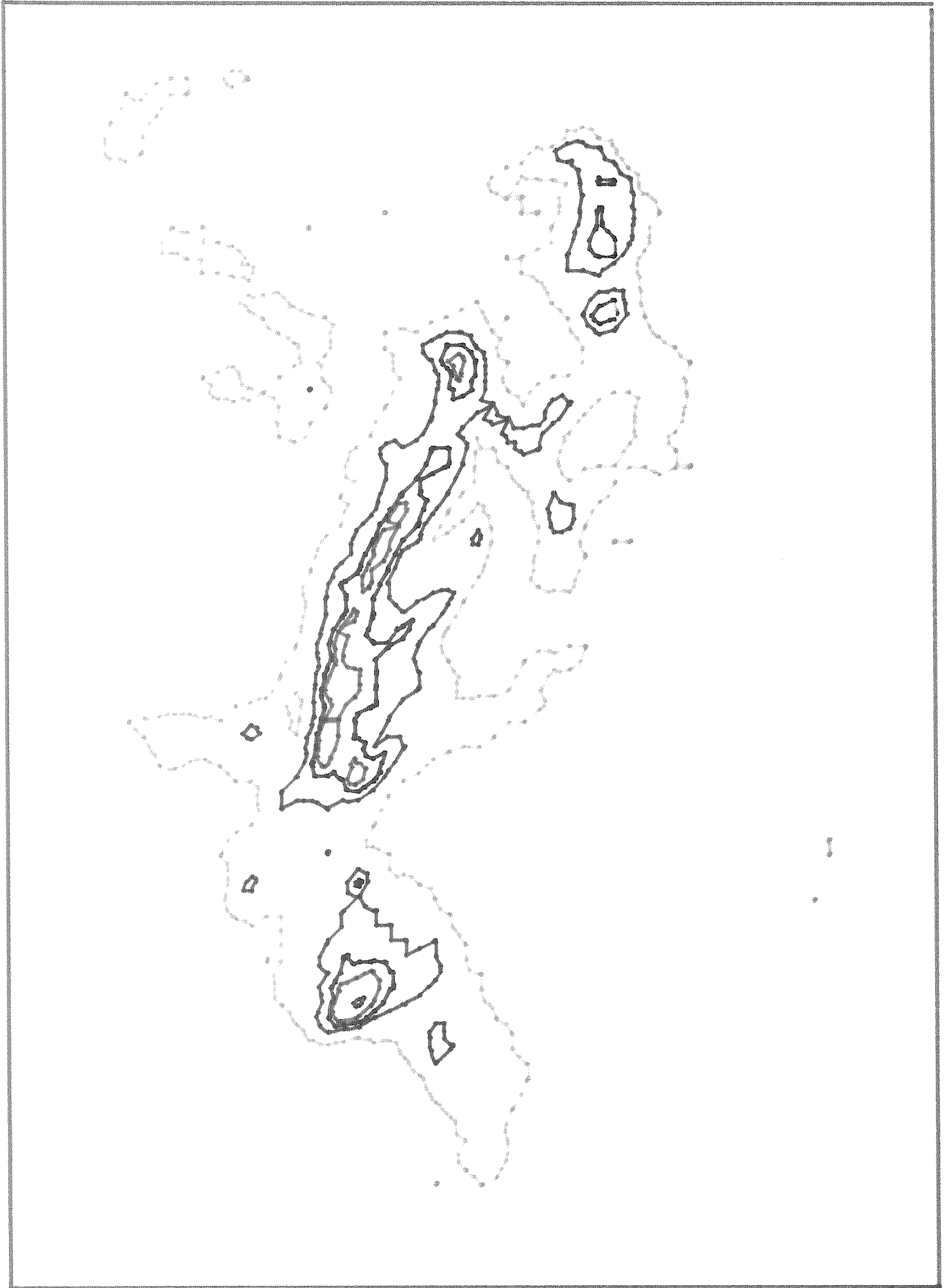


fig.7



fig. 8

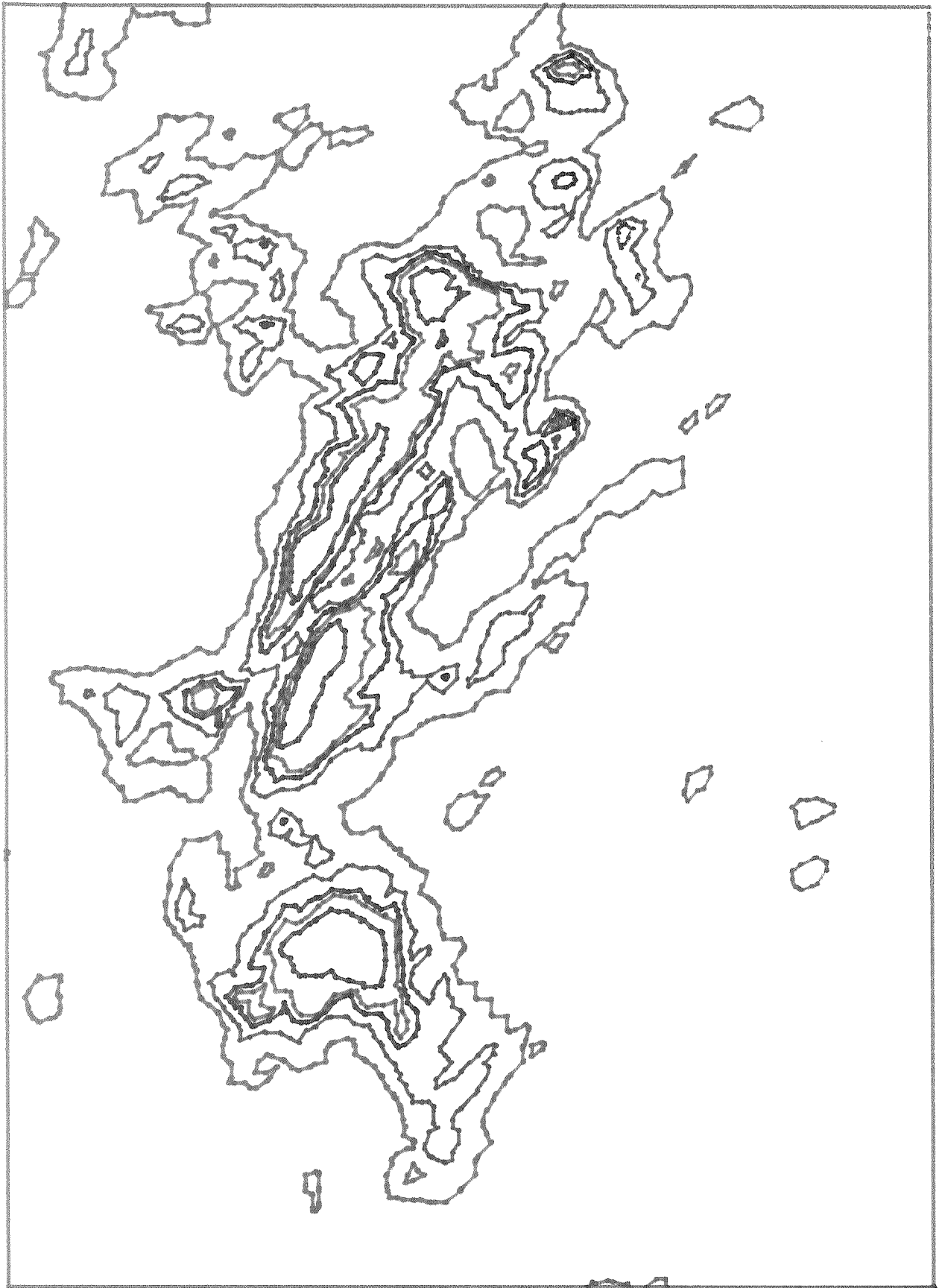


fig. 9

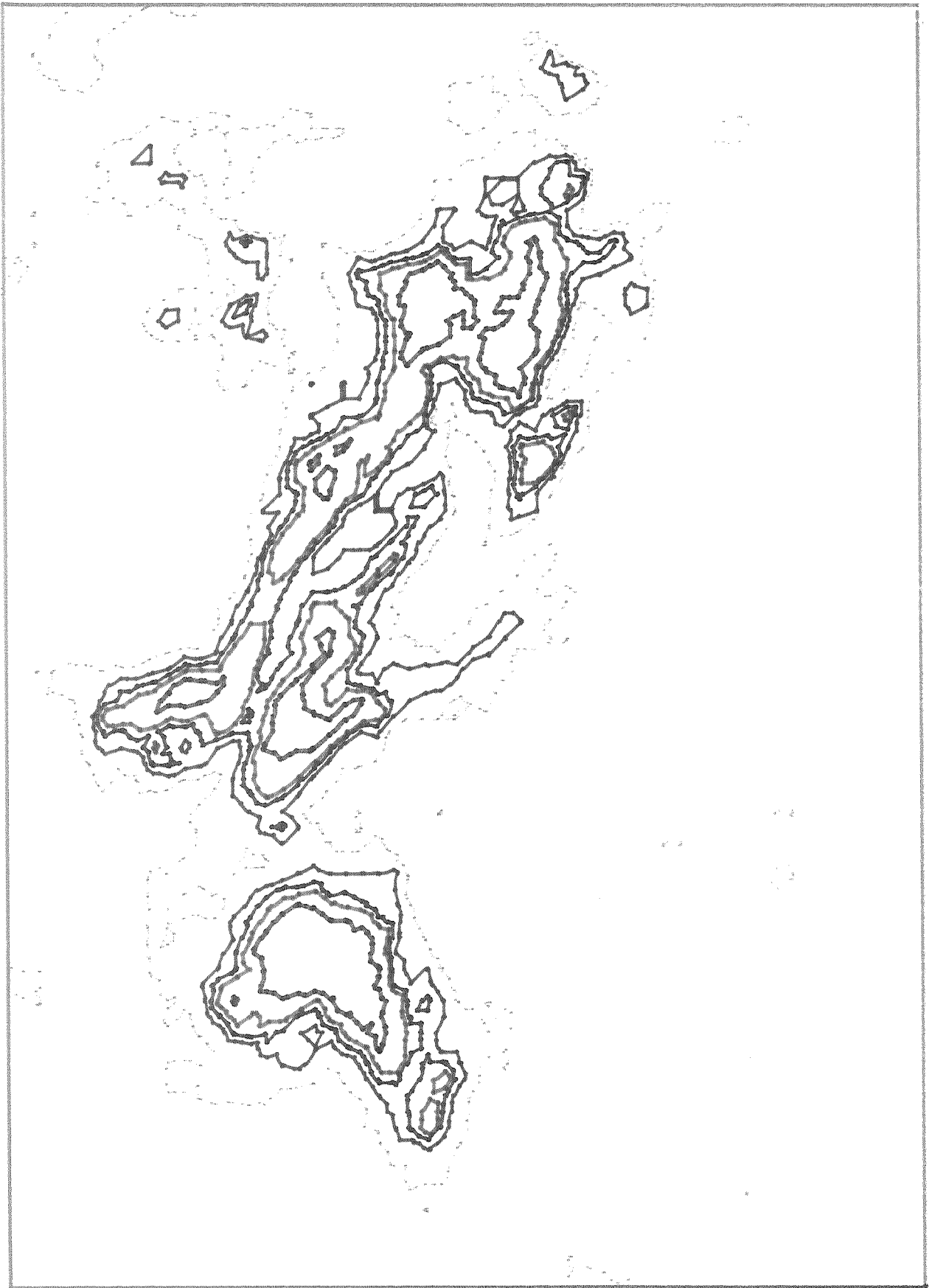


fig.10



fig.11



fig.12

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