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DATA ACQUISITION AND REDUCTION SYSTEM (DARS) AT BRATISLAVA - STATUS REPORT NO. 1

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Table of abbreviations

ACB	-	Auxiliary crate bus
ACC	-	Auxiliary crate controller
ADC	-	Analog-to-digital converter
BW	-	Black-white
DCC	-	Dedicated crate controller
DMA	-	Direct memory access
DMI	-	Direct memory increment
HISTM	-	Histogramming memory
ICC	-	Intelligent crate controller
LISTM	-	List mode memory
μP	-	Microprocessor
MUX	-	Multiplexer/Router
OUT	-	Output parallel register
RAM	-	Random access memory
RGB	-	Red-green-blue
PATT	-	Pattern module
TVD	-	TV driver
TRIGG	-	Fast logic trigger

I. General description

DARS is designed for the measurement of both single and coincidence spectra in nuclear spectroscopy. Single spectra are recorded in DMI mode while the coincidence ones in LIST mode. The measured data are stored on magnetic tape attached to the host computer. The present configuration allows to measure up to six single spectra and their mutual time relations (coincidences).

DARS is built in CAMAC and occupies two crates. In order to make DARS faster each crate performs its specific function autonomously as they are controlled by their own processors. These two crates are connected by one parallel channel to transfer data measured in LIST mode.

I.1 Hardware configuration

The block scheme of DARS is shown in Fig. I.1.-1. The following functions are performed by the two crates:

Crate 1:
- display of single and two parametric spectra including the display of slices of many parametric spectra
- preprocessing of LIST data to create required slices
- data manipulation
- data storage on mag. tape of the host computer
- data acquisition (DMI mode)

Crate 2:
- data acquisition (LIST mode) and their transfer to Crate 1

I.1.1 Operational description

Detectors' analog signals are processed by the corresponding ADC's. Their words are transferred (on line) via MUX to HISTM in DMI mode (single spectra). In the case of valid coincidence event PATT activates Crate 2 for data acquisition. PATT and ADC's data are transferred via DMA modules to the part of ICC operating memory serving as a LIST mode buffer (4 K). Once the buffer is full the data are transferred to LISTM in Crate 1 via OUT register. At the same time the transfer of LISTM data to the host computer (TPA-70) is activated and data are

stored on the magnetic tape. Then the LISTM data are processed by ACC to create coincidence spectra and their slices for display. These data are stored in the free portion of HISTM. Any part of HISTM can be transferred to the TPA-70.

I.1.2 Description of modules used

ACC - Auxiliary Crate Controller, model 2160, CES (Creative Electronics Systems), Switzerland

ACC is based on TEXAS TMS 99110 μP running at 6 MHz. It contains 16 K (16 bit) two-port memory (EPROM/RAM combinations possible), RS232C interface and programable timer. ACC decodes 23 NAF instructions.

HISTM - Histogramming memory, model 2161, CES

HISTM is specifically designed for ACC model 2160. Its capacity is 64 K (24 bit) and can be devided to 8 regions 8 K (24 bit) each. Three modes are avaliable: histogramming (DMI), multiscaling and list. In DARS part of the HISTM is used for storage of (required) coincidence spectra and slices.

MUX - Multiplexer/Router, model 1001, CES

MUX generates highest significant bits of adresses and routes data from a given ADC to a required region of HISTM.

ITV 574 - RGB TV Interface/Driver, Dubna, Soviet Union

TVD module consists of two parts. The first part contains all circuits needed for the work with RGB display. However its memory is sufficient for BW display only. The second part represent the memory extension needed for RGB display. The resolution is 256x256 pixels. TVD decodes 20 NAF instructions.

DDC - Dedicated Crate Controller, Institute of Physics, Bratislava, CSSR

DDC is a modified TPA-70 CAMAC Crate controller (model CAM 1.03, Hungarian Academy of Sciences, Hungary) fulfilling the function of the minimal crate controller according to the EUR 6500 standard. Thus DCC facilitates connections of crate 1 with TPA-70 while the control of Crate 1 is under ACC.

DMA - Direct Memory Access module, model CAM 1.15-31, Hungarian Academy of Sciences, Hungary

DMA module serves for fast data transfer from specified modules of the crate to the operating memory of ICC. It con-

tains 16 word of memory to store the data transfer program. The transfer is controlled by LAM signals. One DMA module can handle maximum 4 modules and cooperates exclusively with ICC, model CAM 1.15. The data transfer with DMA is 10 times faster compared with the use of NAF instructions.

ICC - Inteligent Crate Controller, model CAM 1.15, Hungarian Academy of Sciences, Hungary

ICC is based on Intel 8080 μP. It contains 60 Kb RAM/4 Kb PROM memory and is connected with double floppy disc driver. ICC can control either one crate or - using Branch Extender Driver - a CAMAC branch (EUR 4600).

ADC - In DARS one can use different types of convertors depending on details of the experiment. They have to have two additional features: Each ADC (i) must represent a CAMAC module and (ii) must be equiped with the output connector for MUX.

PATT - Pattern module, Institute of Physics, Bratislava CSSR

PATT is a multipurpose module which starts the data acquisition in Crate 2, generates the word containing information about which ADC is taking part in the valid coincidence event (from TRIGG) and contains timers facilitating proper function of DMA modules.

I.2 Software

Similarly as the DARS hardware also its software consists of three programming units. Each unit controls one of the three processors involved (TPA-70, ACC, ICC) in order to perform - with the attached hardware - the required functions of DARS. At the same time, however, each programming unit contains programs facilitating the necessary cooperations between processors once it is required.

In the following the corresponding programming units for ACC (display, manipulation and preprocessing of measured data), TPA-70 (data storage, two-way transfer of data and programs between TPA-70 and Crate 1) and ICC (data acquisition in LIST mode) will be described.

II. Data visualisation

Display, manipulation and preprocessing of measured data is performed by ACC which is controlled by DAVIS (DAta VISualisation program). Initially, DAVIS is stored on TPA-70 disk in the DAVIS.DAT file.

II. 1 Initialization of DAVIS

Here, the step by step procedure is given to transfer DAVIS from TPA-70 to ACC and its initialization:

1) Switch DCC (Crate 1) to "ON LINE"
2) On TPA-70 terminal:
   a) call Data Transfer Program DTP (see part III.) by
      .DTP CR (carriage return)
   b) identify the program to be transfered by
      DAVIS DAT CR
   c) identify the direction of the transfer by
      W CR (write to ACC)

After the transfer is completed DAVIS is autostarted and the basic configuration for oneparametric display is seen on the screen.

II.2 DAVIS' commands

DAVIS is an interactive program which - after initialization - is in COMMAND mode (it waits commands from the user).

From the point of view of the required functions the DAVIS' commands can be devided in two groups:

a) display commands
b) data manipulation commands

The user can enter the display commands (via ACC terminal) without the need to wait for DAVIS response. However this response can last up to several seconds for twoparametric spectra. On the other hand the data manipulation commands can be entered only individually i.e. DAVIS accepts the next command only after the preceeding one has been executed.

From the point of view of their structure the DAVIS' commands can be divided in other two groups:

i) parametric
ii) nonparametric

The format of the parametric commands is:

MC,PAR1,PAR2,...PARn CR

where MC is the mnemonic code (two alphabetic characters) for the required function and PARi are numerical parameters which characterize this specific function. Some commands of this type are fully characterized by the mnemonics and, therefore, no parameters are required after entering mnemonics. The required function is performed after pressing CR.

The format of the nonparametric commands is:

C ARROW1 ARROW2 .... ARROWn CR

where C (one alphabetic character) indentifies the required function and ARROWi its "direction". After pressing arrow (their number is not limitted) the required function is immediately executed. Function C is cancelled by pressing CR.

For editing commands (parameters) the user can use DEL key. Once an invalid command/parameter is enterd DAVIS responds by printing message COMMAND ERROR or PARAMETER ERROR.

II.3 Organization of the memory space in HISTM

In the present configuration of DARS the HISTM is divided to 8 region (each with 8 K/24 bit). One of these region is assigned to each ADC attached to the system. As the ADCs' conversion gain are usually less than 8 K it is advantageous to utilize the unused memory space for e.g. the storage of data created by data manipulation or preprocessing. Therefore DAVIS allows to divide each memory region to 1,2,4 or 8 groups. Then the specific segment of the HISTM is defined by the number of ADC' region and the number of group in that region. After initialization DAVIS assumes one group for each ADC region.

II.4 Oneparametric spectra

DAVIS consists of two independent parts:

i) display and manipulation with oneparametric spectra

ii) display, manipulation and construction (from LIST mode data) of twoparametric spectra

After initialization DAVIS is in (i) mode. The mode (ii) is called by DD command (sect.II.5.2.1) and (i) mode is called by DM,DO,DA commands (sect. II.4.2.2). The parameters of the current mode remain unchanged when switching to other mode.

II.4.1 Display configuration

The maximum display capabilities of DAVIS are shown in fig. II.4.-1. Referring to this figure DAVIS allows to display three spectra: Main spectrum - line 1, Overlap spectrum - line 2 and Above spectrum - line 3. Using the window (lines 6 to 9) the user can choose region of interest of displayed spectra (Main, Overlap or both). The expanded window can be displayed in the upper right part of the screen defined by lines 12 and 13 (the spectra 4 and 5 in the expanded view correspond to spectra 1 and 2 in the window). By moving the marker (line 10) one can read the number of counts in a channel and its energy. The marker moves along the spectrum which is identified by the pointer (the sign < at GRM,GRO,GRA parameters - see bellow). This spectrum is called the actual spectrum.

The parameters on the left part of the screen and those bellow and above the displayed spectra contain further informations about those spectra. They have the following meaning:

YSC: Y SCale-it can be either linear or square root.
Format: LINR or SQRT

GRM: GRoup of Main spectrum - the number of ADC region and the number of corresponding group which is displayed as the main spectrum

GRO: GRoup of Overlap spectrum - the number of ADC region and the number of corresponding group which is displayed as the overlap spectrum

GRA: GRoup of Above spectrum - the number of ADC region and the number of corresponding group which is displayed as the above spectrum

Rem: Format of the preceeding three parameters is: a - g;
$a,g \in \langle 1,8 \rangle$

DSC: Display Start Channel - the channel number displayed at $x_1(=88)$, fig. II.4.-1

DEC: Display End Channel - the channel number displayed at $x_7=255$, fig. II.4.-1

Rem: The parameters DSC and DEC are common for all- even not displayed - spectra

DSE: Display Start Energy - the energy corresponding to the channel DSC

DEE: Display End Energy - the energy corresponding to the channel DEC

RSC: Region Start Channel - the channel number corresponding to the left side of the window and displayed at x_4 (fig. II.4-1)

REC: Region End Channel the channel number corresponding to the right side of the window and displayed at x_5 (fig. II.4.-1)

RSE: Region Start Energy - the energy corresponding to the channel RSC

REE: Region End Energy - the energy corresponding to the channel REC

RTC: Region Total Counts - the sum of channel contents displayed within the window for the actual spectrum

$$RTC = \sum_{i=RSC}^{REC} Y(i);\ Y(i) = \text{channel content}$$

RNC: Region Net Count - RTC corrected for the "linear background"

$$RNC = RTC - (Y(RSC) - Y(REC)).(REC-RSC+1)/2$$

MCN: Marker ChaNnel - position of the marker displayed at x_2 (fig.II.4.-1)

MEN: Marker ENergy - the energy corresponding to the channel MCN

MCT: Marker CounTs - the content of MCN channel

HCN: Highest ChaNnel - the maximum channel content of the spectrum

HCE: Highest Channel Energy - the energy corresponding to HCN channel

HCT: Highest Channel counTs - the content of HCN channel

Rem: The parameters DSE,DEE,RSE,REE,RTC,RNC,MCN,MEN,MCT,HCN, HCE and HCT are valid for the actual spectrum marked by the pointer (<) - see fig.II.4.-1

Format of the parameters DSC,DEC,RSC,REC,MCN and HCN is I4

Format of the parameters DSE,DEE,RSE,REE,MEN and HCE is F6.0

Format of the parameters RTC,RNC,MCT and HCT is I8

Parameters displayed above/bellow spectra (fig.II.4.-1):

mcfs : Main spectrum Count Full Scale - the channel content of the main spectrum at full scale corresponding to the position at y_3 (fig.II.4.-1)

ocfs : Overlap spectrum Count Full Scale - the same as mcfs but for the overlap spectrum

acfs : Above spectrum Count Full Scale - the same as mcfs but for the above spectrum

mblc : Main spectrum Base Line Counts - the minimum channel content of the main spectrum displayed at y_1 (fig. II.4.-1)

oblc : Overlap spectrum Base Line Counts - the same as mblc but for the overlap spectrum

ablc : Above spectrum Base Line Counts - the minimum channel content of the above spectrum displayed at y_2 (fig. II.4.-1)

mrcfs: Main spectrum Region Count Full Scale - the channel content of the main spectrum at full scale in the window corresponding to the position at y_5 (fig.II.4.-1)

orcfs: Overlap spectrum Region Count Full Scale - the same as mrcfs but for the overlap spectrum

mrblc: Main spectrum Region Base Line Counts - the minimum channel content of the main spectrum in the window displayed at y_4 (fig.II.4.-1)

orblc: Overlap spectrum Region Base Line Counts - the same as mrblc but for the overlap spectrum

The relation between parameters of oneparametric spectra and the data stored in HISTM is shown in the upper part of fig.II.4.-2.

The organization of the screen for display of parameters, spectra and the expanded window is shown in the lower part of that figure.

In the expanded window only the relevant parts of the main and the overlap spectra are displayed. The parameters RSC and REC are, however, the same for all displayed spectra.

II.4.2 Graphics

DAVIS allows to display "live" spectra i.e. their channel content is continuously updated during the acquisition. Corresponding parameters (RTC,RNC,MCT,HCN and HCT) are also updated.

II.4.2.1 Command for HISTM division

Number of Groups per ADC area
Format: NG, adc#, #groups CR
Parameters: - adc# is the number of ADC region in HISTM (1 to 8)
- #groups is the number of groups per ADC region adc# (allowed values are 1,2,4,8)

II.4.2.2 Display commands

a) Display Main spectrum
Format: DM, adc#, gr# CR
Parameters: - adc# is the number of ADC region in HISTM
- gr# is the group number in adc#. (gr# $\leq$ #groups for a given ADC region)
Response: - display the specified memory space as the main spectrum
- update all relevant parameters and the expanded window

b) Display Overlap spectrum
Format : DO, adc#, gr# CR
Parameters: have the same meaning as in DM command
Response: - display the specified memory space in HISTM as the overlap spectrum
- update all relevant parameters and the expanded window

c) Display Above spectrum
Format: DA, adc#, gr# CR
Parameters: have the same meaning as in DM command
Response: - display the specified memory space in HISTM as the above spectrum
- update all relevant parameters
- generate lines no. 11 and 13 (fig.II.4.-1)

d) Display Window

Format: DW CR

Response: - generate lines no. 12 and 13 (fig.II.4.-1)
- display the expanded window

e) Erase Main spectrum

Format: EM CR

Response: - erase the main spectrum and its portion in the expanded window

f) Erase Overlap spectrum

Format: EO CR

Response: - erase the overlap spectrum and its portion in the expanded window

g) Erase Above spectrum

Format: EA CR

Response: - erase the above spectrum
- erase lines no. 11 and 13 if the expanded window is not displayed

h) Erase Window

Format: EW CR

Response: - erase the expanded window
- erase the line no. 13 if the above spectrum is not displayed

II.4.2.3 Dilatation of axes commands

This group of commands allows to change limits of displayed spectra both in the horizontal (number of channels) and the vertical (number of counts) directions and the linearity of the vertical (Y) axis. These limits are confined between 0 and 2^{24} in the vertical diroction and 0 and RL (Right limit= minimum dimension of displayed groups) in the horizontal direction.

Position of the marker (and the window) on the screen is not influenced by commands changing the horizontal limits. However the parameters RSC,REC and MCN do change and generate changes of other related parameters.

To simplify description of commands in this section the following convention is introduced:

The actual spectrum is characterized by the parameter "a" and

a = 3 represents the main spectrum

a = 2 represents the overlap spectrum

a = 1 represents the above spectrum

The following parameters are reassigned accordingly:

mcfs = cfs(3), mblc = blc(3), mrcfs = rcfs(3), mrblc = rblc(3)

ocfs = cfs(2), oblc = blc(2), orcfs = rcfs(2), orblc = rblc(2)

acfs = cfs(1), ablc = blc(1)

a) Shift DSC and DEC to the right

Format: S →

Response: - DSC = DSC + 1; DEC = DEC + 1
- update displayed spectra and relevant parameters

b) Shift DSS and DEC to the left

Format: S ←

Response: - DSC = DSC-1; DEC = DEC-1
- update displayed spectra and relevant parameters

c) Zoom right

Format: Z →

Response: - DEC = DSC + (DEC - DSC).2
- update displayed spectra and relevant parameters

d) Zoom left

Format: Z ←

Response: - DEC = DSC + (DEC - DSC)/2
- update displayed spectra and relevant parameters

e) Zoom up

Format: Z ↑

Response: - cfs(a) = (cfs(a)-blc(a)).2 + blc(a)
- update the actual spectrum and relevant parameters

f) Zoom down

Format: Z ↓

Response: - cfs(a) = (cfs(a) - blc(a))/2 + blc(a)
- update the actual spectrum and relevant parameters

g) Fine zoom right

Format: F →

Response: - DEC = DEC + 1
- update displayed spectra and relevant parameters

h) Fine zoom left

Format: F ←

Response: - DEC = DEC - 1
- update displayed spectra and relevant parameters

i) Fine zoom up

Format: F ↑

Response: - cfs(a) = cfs(a) + 1
- update the actual spectrum and relevant parameters

j) Fine zoom down

Format: F ↓

Response: - cfs(a) = cfs(a) - 1
- update the actual spectrum and relevant parameters

k) Tune at biggest

Format: T ↑

Respons: - $cfs(a) = \max \{Y(i)\}$, $i \in <DSC, DEC>$
- update the actual spectrum and relevant parameters

l) Tune at smallest

Format: T ↓

Response: - $blc(a) = \min \{Y(i)\}$; $i \in <DSC, DEC>$
- update the actual spectrum and relevant parameters

m) Cut at biggest

Format: C ↑

Response: - $cfs(a) = \max \{Y(i)\}$; $i \in <RSC, REC>$
- update the actual spectrum and relevant parameters

n) Cut at smallest

Format: C ↓

Response: - $blc(a) = \min \{Y(i)\}$; $i \in <RSC, REC>$
- update the actual spectrum and relevant parameters

o) Baseline shift up

Format: B↑

Response: - blc(a) = blc(a) + 1
- update the actual spectrum and relevant parameters

p) Baseline shift down

Format: B↓

Response: - blc(a) = blc(a) - 1
- update the actual spectrum and relevant parameters

q) Home right

Format: H→

Response: - DEC = RL
- update displayed spectra and relevant parameters

r) Home left

Format: H←

Response: - DSC = 0
- update displayed spectra and relevant parameters

s) Home up

Format: H↑

Response: - cfs(a) = 2^{24} - 1
- update the actual spectrum and relevant parameters

t) Home down

Format: H↓

Response: - blc(a) = 0
- update the actual spectrum and relevant parameters

u) Set linear Y scale

Format: Y↑

Response: - set Y scale to linear
- update displayed spectra and relevant parameters

v) Set square root Y scale

Format: Y↓

Response: - set Y scale to square root
- update displayed spectra and relevant parameters

II.4.2.4 Marker commands

a) Move marker to the right
   Format: M→
   Response: - MCN = MCN + 1
             - update relevant parameters

b) Move marker to the left
   Format: M←
   Response: - MCN = MCN - 1
             - update relevant parameters

II.4.2.5 Window commands

a) Upper line of window up
   Format: U↑
   Response: - rcfs(a) = rcfs(a) + 1
             - shift the line no. 8 up (fig.II.4.-1)
             - update the actual spectrum in the expanded window and relevant parameters

b) Upper line of window down
   Format: U↓
   Response: - rcfs(a) = rcfs(a) - 1
             - shift the line no. 8 down
             - update the actual spectrum in the expanded window and relevant parameters

c) Ground line of window up
   Format: G↑
   Response: - rblc(a) = rblc(a) + 1
             - shift the line no. 6 up
             - update the actual spectrum in the expanded window and relevant parameters

d) Ground line of window down
   Format: G↓
   Response: - rblc(a) = rblc(a) - 1
             - shift the line no. 6 down
             - update the actual spectrum in the expanded window and relevant parameters

e) Right line of window to the right
   Format: R→
   Response: - REC = REC + 1
             - shift the line no. 7 to the right

- update spectra in the expanded window and relevant parameters

f) Right line of window to the left

Format: R ←

Response: - REC = REC - 1
- shift the line no. 7 to the left
- update spectra in the expanded window and relevant parameters

g) Left line of window to the right

Format: L →

Response: - RSC = RSC + 1
- shift the line no. 9 to the right
- update spectra in the expanded window and relevant parameters

h) Left line of window to the left

Format: L ←

Response: - RSC - RSC - 1
- shift the line no. 9 to the left
- update spectra in the expanded window and relevant parameters

i) Window up

Format: W ↑

Response: - rcfs(a)=rcfs(a)+1; rblc(a)=rblc(a)+1
- shift lines no. 6 and 8 (fig.II.4.-1)up
- update spectra in the expanded window and relevant parameters

j) Window down

Format: W ↓

Response: - rcfs(a)=rcfs(a)-1; rblc(a)=rblc(a)-1
- shift lines no. 6 and 8 down
- update spectra in the expanded window and relevant parameters

k) Window to the right

Format: W →

Response: - RSC=RSC+1; REC=REC+1
- shift lines no. 7 and 9 to the right
- update spectra in the expanded window and relevant parameters

1) Window to the left

Format: W←

Response: - RSC=RSC-1; REC=REC-1
- shift lines no. 7 and 9 to the left
- update spectra in the expanded window and relevant parameters

II.4.2.6 Commands for change of actual spectrum

The actual spectrum is marked by the pointer (the symbol<) at the parameters GRM,GRO,GRA (fig.II.4.-1)

a) Shift pointer of actual spectrum up

Format: S↑

Response: - shift pointer to the line above
- put the marker on the new actual spectrum
- update relevant parameters

b) Shift pointer of actual spectrum down

Format: S↓

Response: - shift the pointer to the line below
- put the marker on the new actual spectrum
- update relevant parameters

II.4.3 Data manipulation commands

This group of commands allows to manipulate with all-not only displayed-data. The parameters DSC and DEC are the same for all groups defined in HISTM.

a) Move spectrum

Format: MO,adc#s,gr#s,adc#d,gr#d CR

Parameters: - adc#s, number of the ADC region in HISTM serving as the source of data to be manipulated with
- gr#s, number of the (source) group of the specified adc#s
- ads#d, number of the (destination) ADC region in HISTM to which the result of the manipulation will be transfered
- gr#d, number of the (destination) group of the specified adc#d

Rem.: The parameters gr#s, gr#d have to be less than #groups defined for corresponding ADC regions s and d resp.

Response: transfer spectrum from the group s to the group d within the limits from DSC to DEC

b) ADd two spectra

Format: AD,adc#s,gr#s,adc#d,gr#d CR

Parameters: have the same meaning as in MO command

Response: add two spectra in groups s and d and store the result in the group d:

$Y_d(i)=Y_s(i)+Y_d(i)$; $i \in <$ DSC,DEC $>$

c) SUbstract two spectra

Format: SU,adc#s,gr#s,adc#d,gr#d CR

Parameters: have the same meaning as in MO command

Response: substract the spectrum in the group s from that in the group d and store the result in the group d:

$Y_d(i)=Y_d(i)-Y_s(i)$; $i \in <$ DSC,DEC $>$

d) MUltiply two spectra

Format: MU,adc#s,gr#s,adc#d,gr#d CR

Parameters: have the same meaning as in MO command

Response: multiply the spectrum in the group d by the spectrum in the group s and store the result in the group d:

$Y_d(i)=Y_d(i).Y_s(i)$; $i \in <$ DSC,DEC $>$

e) DIvide two spectra

Format: DI,adc#s,gr#s,adc#d,gr#d CR

Parameters: have the same meaning as in MO command

Response: divide the spectrum in the group d by the spectrum in the group s and store the results in the group d:

$Y_d(i)=Y_d(i)/Y_s(i)$; $i \in <$ DSC,DEC $>$

if $Y_s(i) = 0$ than $Y_d(i) = 2^{24} - 1$

f) compute FRaction spectrum

Format: FR,fpn,adc#s,gr#s,adc#d,gr#d CR

Parameters:
- fpn, decimal number (>0 or <0) multiplying the data in the group s
- other parameters have the same meaning as in MO command

Response: substract the spectrum in the group s multiplied by fpn from the spectrum in the group d and store the result in the group d:
$Y_d(i)=Y_d(i)-fpn.Y_s(i)$; $i \in <DSC,DEC>$

Rem.: the spectrum in the group s remains unchanged

g) NOrmalize spectrum

Format: NO,fpnm,fpnk,adc#,gr# CR

Parameters: - fpnm,fpnk are decimal numbers (multiplier and constant, both <0 or >0)
- adc#, number of ADC region in HISTH
- gr#, number of the group of the specified ADC region

Response: normalize the specified spectrum as:
$Y(i)=fpnm.Y(i) + fpnk$; $i \in <DSC,DEC>$

h) SMooth spectrum

Format: SM,ints,adc#,gr# CR

Parameters: - ints defines the degree of smoothing; ints = 3 or 5
- other parameters have the same meaning as in NO command

Response: perform 3 or 5 point smoothing of the specified spectrum in the interval <DSC,DEC> and store the result in the original group

i) SQuare root of spectrum

Format: SQ,adc#,gr# CR

Parameters: have the same meaning as in NO command

Response: compute the square root of each channel of the specified group and store the result in that group:
$Y(i) = \sqrt{Y(i)}$; $i \in <DSC,DEC>$

j) CLear spectrum

Format: CL,adc#,gr# CR

Parameters: have the same meaning as in NO command

Response: $Y(i)=0$; $i \in <DSC,DEC>$

k) InteGrate spectrum

Format: IG,adc#,gr# CR

Parameters: have the same meaning as in NO command

Response: integrate the specified spectrum and store the result in the original group:

$$Y(i) = \sum_{k=DSC}^{i} Y(k);\ i \in \langle DSC, DEC \rangle$$

l) DiFforentiate spectrum

Format: DF,adc#,gr# CR

Parameters: have the same meaning as in NO command

Response: rewrite the specified group as

$$Y(i)=Y(i)-Y(i-1);\ i \in \langle DSC, DEC \rangle$$

m) Energy calibration

This command consists of two parts and refers to the actual spectrum:

1) number of points for Energy Calibration

Format: EC, #points CR

Parameters: # points (integer, ≥ 3) defines the number of points to be used for the energy calibration

Response: define the number of input points for the second part of the command

2) input of values Channel-Energy pairs

Format: CE, channel, energy CR

Parameters: channel, energy - integer, decimal numbers assigning the energy to the specific channel

Response: - input # points data pairs channel,energy
- fit the data by the second order polynomial
Energy=A.channel^2 +B.channel +C using the least square method
- update energy dependent parameters
- print the massage CALIBRATION READY on the ACC terminal

Rem.: DAVIS allows to calibrate all displayed spectra independently. Default values of calibration constants are A=0,B=1,C=0.

n) SearCh for peaks in spectra

Format: SC,m,r,b,adc#,gr# CR

Parameters: - m, integer $\in \langle 1,3 \rangle$, defines the weighting function w
- r, decimal number used in the function C defining the existence of a peak:

$$C(k)=\sum_{i=-l/2}^{l/2} w(i)\left[Y(k+i)-\{A(k)+r.\sqrt{A(k)}\}\right]$$

where l=3 m and A(k) is given as

$$A(k)=\frac{1}{l}\sum_{i=k-l/2}^{k+l/2} Y(i)$$

The criterion for the existence of a peak are at least three succeeding positive values of C(k). The position of a peak is calculated as

$$\sum_{i=p-l/2}^{p+l/2} i.Y(i) \;/\; \sum_{i=p-l/2}^{i=p+l/2} Y(i)$$

where p is an estimate of the peak position obtained from the behaviour of C(k)

- b, decimal number used to calculate the net peak area (see fig.II.4.-4)
- other parameters have the same meaning as in NO command

Response:
- search for peaks in a given spectrum between channel DSC and DEC
- calculate parameters of the identified peaks (position, energy, total and net area) and print the results on the ACC terminal

o) Hard Copy

Format: HC CR

Response: - copies the picture from TV screen to graphie line printer.

Rem.: Can be used also for twoparametric spectra.

II.5. Twoparametric spectra

II.5.1 Display configuration

DAVIS displays the specific memory region of HISTM defined by parameters shown in fig. II.5.-1 (they are described bellow). The basic display configuration of twoparametric spectra is shown in fig II.5.-2. The spectrum is displayed with the help of a grid which - approximately - follows its shape. Density of

the grid is specified by the parameter DTP (density of points) defining the number of nodes in the grid in both (X and Y) directions. DTP is the same for both directions. The larger is DTP the better is the spectrum shape reproduced.

Using the window the user can define region of interest. The movable marker provides further information about the spectrum in a similar way as in the case of oneparametric spectra. An example is shown in fig. II.5.-3. DAVIS allows to display various slices.

The user can look on the displayed spectrum at various angels α, β (see fig. II.5.-1). If $\alpha + \beta = 90^{\circ}$ the spectrum is displayed with the help of "equipotentials" (the look from above, in the direction - Z) - see fig. II.5.-4.

Along the Z direction the data are divided into count regions. Their number is defined by DTC parameter. Only those points of count regions are displayed which are inside the displayed counts in region defined by the parameter WCR - see fig. II.5.-4 for details.

Description of displayed parameters (fig. II.5.-2):

CFS - Count Full Scale
BLC - Base Line Counts
DSX - Display Start channel for X axis
DEX - Display End channel for X axis
DSY - Display Start channel for Y axis
DEY - Display End channel for Y axis
RSX - Region Start channel for X axis; the first channel in the window in X direction
REX - Region End channel for X axis; the last channel in the window in X direction
RSY - Region Start channel for Y axis
REY - Region End channel for Y axis
RTC - Region Total Counts. RTC is evaluated as follows: First, DAVIS sums up the contents of channels Z(X,Y) defined by X,Y coordinates

$$S = \sum Z(X,Y)$$

where

$$X = \frac{DEX-DSX}{DTP}\, i + DSX; \quad Y = \frac{DEY-DSY}{DTP}\, j + DSY$$

for $i,j \in \langle 0,DTP)$. In the same time $X \in \langle RSX,REX \rangle$ and $Y \in \langle RSY,REY \rangle$. Then RTC is evaluated as

$$RTC = a.b.S$$

where

$$a = \frac{DEX-DSX}{DTP} \; ; \quad b = \frac{DEY-DSY}{DTP}$$

The situation is depicted in fig. II.5.-5. RTC is evaluated excatly only if DTP=DEX-DSX=DEY-DSY.

RNC - Region Net Counts. The sum of channel contents of the region defined by the window corrected for the linear background:

$$RNC=RTC-(REX-RSX)(REY-RSY)\left\{Z(RSX,RSY)+Z(RSX,REY) + Z(REX,RSY) + Z(REX,REY)\right\}/4$$

MCX - Marker Channel X axis coordinate

MCY - Marker Channel Y axis coordinate

MCT - Marker CounTs. Content of the channel defined by MCX and MCY coordinates

Rem.: Marker is displayed only if the window is displayed.

HCX - Highest Channel X. X coordinate of a channel with the highest channel content

HCY - Highest Channel Y. Y coordinate of a channel with the highest channel content.

Rem.: Parameters HCX,HCY are searched for only at nodes of the grid, i.e. for

$$X = \frac{DEX-DSX}{DTP} i+DSX; \quad Y = \frac{DEY-DSY}{DTP} j + DSY$$

where $i,j \in \langle 0,DTP)$

HCT - Highest CounTs. Channel content Z(HCX,HCY)

Rem.: Parameters RTC,RNC,MCT,HCX,HCY,HCT are updated only if DW command was entered

DTP - DensiTy of Points. The number of nodes in the grid for display.

DTC - DensiTy of Count regions. The number of regions between BLC and CFS - fig. II.5.-4.

WCR - Width of displayed Counts in Region - see fig. II.5.-4.
Rem.: Parameters DTC,WCR are defined only for display with the help of equipotentials.

A - Angles. Current values of angles of rotation α, β, T.
$\alpha, \beta \in \langle 0^{\circ}, 90^{\circ} \rangle$, $T \in \langle 0^{\circ}, 350^{\circ} \rangle$; step 10° - fig. II.5.-1.
Format: A␣xx␣xx␣xxx.

II.5.2 Graphics

DAVIS allows to display twoparametric spectra which are either constructed during aquisition from the LIST - mode data or are transfered to HISTM from TPA-70.

In the following description of commands it is implicitely understood that after execution of a command the spectra and the relevant parameters are updated whenever necessary.

II.5.2.1 Display commands

a) Display Double parameter spectrum
Format: DD,adc#,gr#,dx,dy CR
Parameters: - adc#, the number of ADC region in HISTM
- gr#, the number of the group in the specified ADC region (gr#≤#groups for a given ADC region)
- dx, dimension (number of channels) of the displayed region along X axis
- dy, dimonsion of the displayed region along Y axis

Rem.: Parameters adc#,gr# define the starting memory location in HISTM (the first channel in the group gr#) at which the twoparametric spectrum starts. It is assumed that all higher location (up to 64 K) in HISTM are avaliable for the twoparametric spectrum. The product dx.dy must not exceed this avaliable area.

Response: initialize DAVIS' routine for a twoparametric display

b) Display Window
Format: DW CR
Response: - display window and marker (see figs. II.5.-3 and II.5.-6)

- update all relevant parameters (RTC,RNC, HCT,HCX,HCY,HCT)

c) Erase Window
Format: EW CR
Response: erase window and marker

d) Display slice for given X
Format: DX CR
Response: display slice X=MCX (see fig. II.5.-7 for DTP=1)

e) Display slice given Y
Format: DY CR
Response: display slice Y=MCY (see fig. II.5.-8 for DTP=8)
Rem.: To display only the required slice the user should define DTP=1 (see bellow). Moving the marker the slice is updated correspondingly.

f) Erase slice for given X
Format: EX CR
Response: erase the slice define by DX command

g) Erase slice for given Y
Format: EY CR
Response: erase the slice defined by DY command

h) SPan region
Format: SP CR
Response: display only the region defined by the window (see fig. II.5.-9)

II.5.2.2 Commands for dilatation of axes

The motions - to the right, to the left, up and down - - used in this section coincide with the movement of the figure on the screen only for $T=0^{o}$ (i.e. if no rotation around Z axis was introduced).

a) Shift spectrum to the right
Format: S→
Response: DSX=DSX+1; DEX=DEX+1

b) Shift spectrum to the left
Format: S←
Response: DSX=DSX-1, DEX=DEX-1

c) Shift spectrum up

Format: S↑

Response: DSY=DSY+1; DEY=DEY+1

d) Shift spectrum down

Format: S↓

Response: DSY=DSY-1; DEY=DEY-1

e) Zoom right

Format: Z→

Response: DEX=DSX + (DEX-DSX).2

f) Zoom left

Format: Z←

Response: DEX=DSX + (DEX-DSX)/2

g) Zoom up

Format: Z↑

Response: DEY=DSY + (DEY-DSY).2

h) Zoom down

Format: Z↓

Response: DEY=DSY + (DEY-DSY)/2

i) Fine zooming right

Format: F→

Response: DEX=DEX+1

j) Fine zooming left

Format: F←

Response: DEX=DEX+1

k) Fine zooming up

Format: F↑

Response: DEY=DEY+1

l) Fine zooming down

Format: F↓

Response: DEY-DEY-1

m) Tune up

Format: T↑

Response: $CFS=\max_{j\in\langle DSY,DEY\rangle}\{Z(i,j)\}$ for $i\in\langle DSX,DEX\rangle$,

n) Tune down

Format: T ↓

Response: BLC=min $\{Z(i,j)\}$ for $i \in \langle DSX, DEX \rangle$, $j \in \langle DSY, DEY \rangle$

o) Cut up

Format: C ↑

Response: CFS=max $\{Z(k,l)\}$ for $k \in \langle RSX, REX \rangle$, $l \in \langle RSY, REY \rangle$

p) Cut down

Format: C ↓

Response: BLC=min $\{Z(k,l)\}$ for $k \in \langle RSX, REX \rangle$, $l \in \langle RSY, REY \rangle$

q) Baseline up

Format: B ↑

Response: BLC=BLC+1

r) Baseline down

Format: B ↓

Response: BLC=BLC-1

s) eXpand count full scale up

Format: X ↑

Response: CFS=BLC+(CFS-BLC).2

t) eXpand count full scale down

Format: X ↓

Response: CFS=BLC+(CFS-BLC)/2

u) change count full scale by One up

Format: O ↑

Response: CFS=CFS+1

v) change count full scale by One down

Format: O ↓

Response: CFS=CFS-1

w) Home right

Format: H →

Response: DEX=dx

x) Home left

Format: H ←

Response: DSX=Ø

y) Home up

Format: H↑

Response: DEY=dy

z) Home down

Format: H↓

Response: DSY=Ø

II.5.2.3 Marker commands

Rem.: Marker commands are operational even if the window is not displayed and, therefore, the marker. All parameters connected with the marker are updated as usual.

a) Marker to the right

Format: M→

Response: MCX=MCX+1

b) Marker to the left

Format: M←

Response: MCX=MCX-1

c) Marker up

Format: M↑

Response: MCY=MCY+1

d) Marker down

Format: M↓

Response: MCY=MCY-1

II.5.2.4 Window commands

Rem.: Window commands are operational even if the window is not displayed. All parameters connected with the window are updated as usual.

a) Window to the right

Format: W→

Response: RSX=RSX+1; REX=REX+1

b) Window to the left

Format: W←

Response: RSX=RSX-1; REX=REX-1

c) Window up

Format: W↑

Response: RSY=RSY+1; REY=REY+1

d) Window down
Format: W↓
Response: RSY=RSY-1; REY=REY-1

e) Right line of window to the right
Format: R→
Response: REX=REX+1

f) Right line of window to the left
Format: R←
Response: REX=REX-1

g) Left line of window to the right
Format: L→
Response: RSX=RSX+1

h) Left line window to the left
Format: L←
Response: RSX=RSX-1

i) Upper line of window up
Format: U↑
Response: REY=REY+1

j) Upper line of window down
Format: U↓
Response: REY=REY-1

k) Ground line of window up
Format: G↑
Response: RSY=RSY+1

l) Ground line of window down
Format: G↓
Response: RSY=RSY-1

II.5.2.5 Commands for rotations

This groups of commands serve to change the user's angle of view (angles $\alpha, \beta \in \langle 0^o, 90^o \rangle$) at twoparametric spectrum and to rotate it around Z axis (angle $T \in \langle 0^o, 350^o \rangle$). All angles can be changed in 10 degrees steps.

The sense of arrows which are used in these commands is derived from the apparent movement of the point A (fig. II.5-1):

→(←): the picture on the screen rotates as if the point A would move to the right (to the left)

↑(↓): the picture rotates as if the point A would move up (down)

a) increase α, decrease β Angles
Format: A→
Response: - if $\beta = 0^\circ$ the command is ineffective
- $\alpha = \alpha + 10^\circ$; $\beta = \beta - 10^\circ$
(compare figs. II.5.-2 and II.5.-10)

b) decrease α, increase β Angles
Format: A←
Response: - if $\alpha = 0^\circ$ the command is ineffective
- $\alpha = \alpha - 10^\circ$; $\beta = \beta + 10^\circ$

c) decrease α, decrease β Angles
Format: A↑
Response: $\alpha = \max\{\alpha - 10^\circ, 0^\circ\}$; $\beta = \max\{\beta - 10^\circ, 0^\circ\}$
(compare figs. II.5.-2 and II.5.-11)

d) increase α, increase β Angles
Format: A↓
Response: - if $\alpha + \beta = 90^\circ$ the command is ineffective
- if $\alpha + \beta = 80^\circ$ then $\alpha = \alpha + 10^\circ$; $\beta = \beta$
- $\alpha = \alpha + 10^\circ$; $\beta = \beta + 10^\circ$

e) turn View counter-clockwise
Format: V→
Response: - $T = T + 10^\circ$
- the picture rotates around Z axis passing through the point (DEX-DSX)/2, (DEY-DSY)/2 counter-clock-wise (fig. II.5.-12)

f) turn View clockwise
Format: V←
Response: - $T = T - 10^\circ$
- the picture rotates around Z axis passing through the point (DEX-DSX)/2, (DEY-DSY)/2 clockwise

II.5.2.6 Commands for density of display

a) multiply number of Nodes in grid by 2
Format: N↑
Response: DTP=DTP.2

b) divide number of Nodes in grid by 2

Format: N↓

Response: DTP= [DTP/2] ; [...] represents the integer part

c) increment number of Nodes in grid

Format: N→

Response: DTP=DTP+1

d) decrement number of Nodes in grid

Format: N←

Response: DTP=DTP-1

Rem.: Using N commands the parameter DTP vary between 1 and min {dx,dy} . Examples for DTP=1 and DTP=64 are given in figs. II.5.-7 and II.5.-13 resp.

e) multiply density of count regions (DTC) by 2

Format: P↑

Response: DTC=DTC.2

f) divide DTC by 2

Format: P↓

Response: DTC= [DTC/2] ; [...] represents the integer part

g) multiply width of displayed counts region (WCR) by 2

Format: P→

Response: WCR=WCR.2

h) divide WCR by 2

Format: P←

Response: WCR= [WCR/2] ; [...] represents the integer part

i) increment DTC

Format: Q↑

Response: DTC=DTC+1

j) decrement DTC

Format: Q↓

Response: DTC=DTC-1

k) increment WCR

Format: Q→

Response: WCR=WCR+1

1) decrement WCR

   Format: Q ←

   Response: WCR=WCR-1

Rem.: The effect of commands P and Q is visible only if $\alpha + \beta = 90^0$ i.e. for display with the help of "equipotentials".

Equipotential display of pyramide for different values of DTP and WCR are shown in figs. II.5.-14 and II.5.-15

III. TPA-70/Crate 1 communication

The following two programs (DTP and HMRW) were designed for two-way transfer of data between TPA-70 and ACC 2160 (DTP) and HISTM (HMRW). These programs are not a part of DARS data acquisition software and in this sense the user can use them only "off-line".

III.1. Data Transfer Program DTP

DTP serves for communication between ACC 2160 and TPA-70. The purpose is the two-way transfer of data/programs stored in ACC memory or on a disk file in TPA-70.

In the following the step by step procedure for initialization and use of DTP is described:

1) Switch DCC to "on line"
2) Using TPA-70 terminal call DTP typing
   .DTP CR
3) Specify file name (FILNAME) and extension (EXT) from (to) which data/program will be transfered typing
   FILNAMEXT CR

   Rem.: It is implicitly assumed that the specified file is on TPA-70 DK1 disk (exchangable) and in USRLIB
4) Specify the direction of transfer typing
   R CR (read data/program from ACC to TPA-70) or
   W CR (write data/program from TPA-70 to ACC)
5) Once the transfer is completed switch DCC to "of line" or call DTP again

III.2 Histogramming Memory Read/Write program HMRW

HMRW serves for communication between TPA-70 and HISTM. The purpose is the two-way transfer of the block of data stored

in HISTM or on a disk file in TPA-70. The length of a block equals to the number of channels of a group in a specific ADC region in HISTM as defined by the appropriate command of DAVIS.

In the following the step by step procedure for use of HMRW is described :

1) Using TPA-70 terminal call HMRW typing
   .HMRW CR
2) After loading HMRW prints the message:
   IS DCC ON LINE (Y)?
   The user should switch DCC of Crate 1 to "on line" and type
   Y CR
3) Then HMRW asks for the specific ADC region in HISTM (adc#) and prints:
   ADC(1,2,3,4,...,8)?
   The user should define this region typing
   adc# CR (adc# $\in$ < 1,8 >)
4) Then HMRW wants to specify the number of the group (gr#) of that region and prints
   GROUP (1-8)?
   The user should specify that group typing
   gr# CR
   (gr# $\leq$ # groups per given adc#)
5) HMRW then prints the message
   READ FROM HM OR WRITE TO HM (R,W)?
   The user should specify direction of the transfer typing
   R (or W) CR
6) HMRW then prints
   FILE NAME (DK1:FILNAM.EXT)?
   The user should specify the file name (FILNAM), its extension (EXT) and the library name (LIBNAM) on DK1 disk of TPA-70 (exchangable disk) from (to) which the data will be transferred typing
   DK1: FILNAM.EXT [LIBNAM] CR
7) After completing the required transfer HMRW prints the message
   CONTINUE WITH ANOTHER TRANSFER OR END (C,E)?
   The user might continue the transfer typing
   C CR

and HMRW starts communication from point 3) or

E CR

Now HMRW reacts by printing

IS DCC OFF LINE (Y)?

The user should switch DCC to "of line" and type

Y CR

and the transfer is finished

Warning: Should DCC be "on line" when the user types

Y CR (in the step 8)

the ACC memory and HISTM will be cleared!

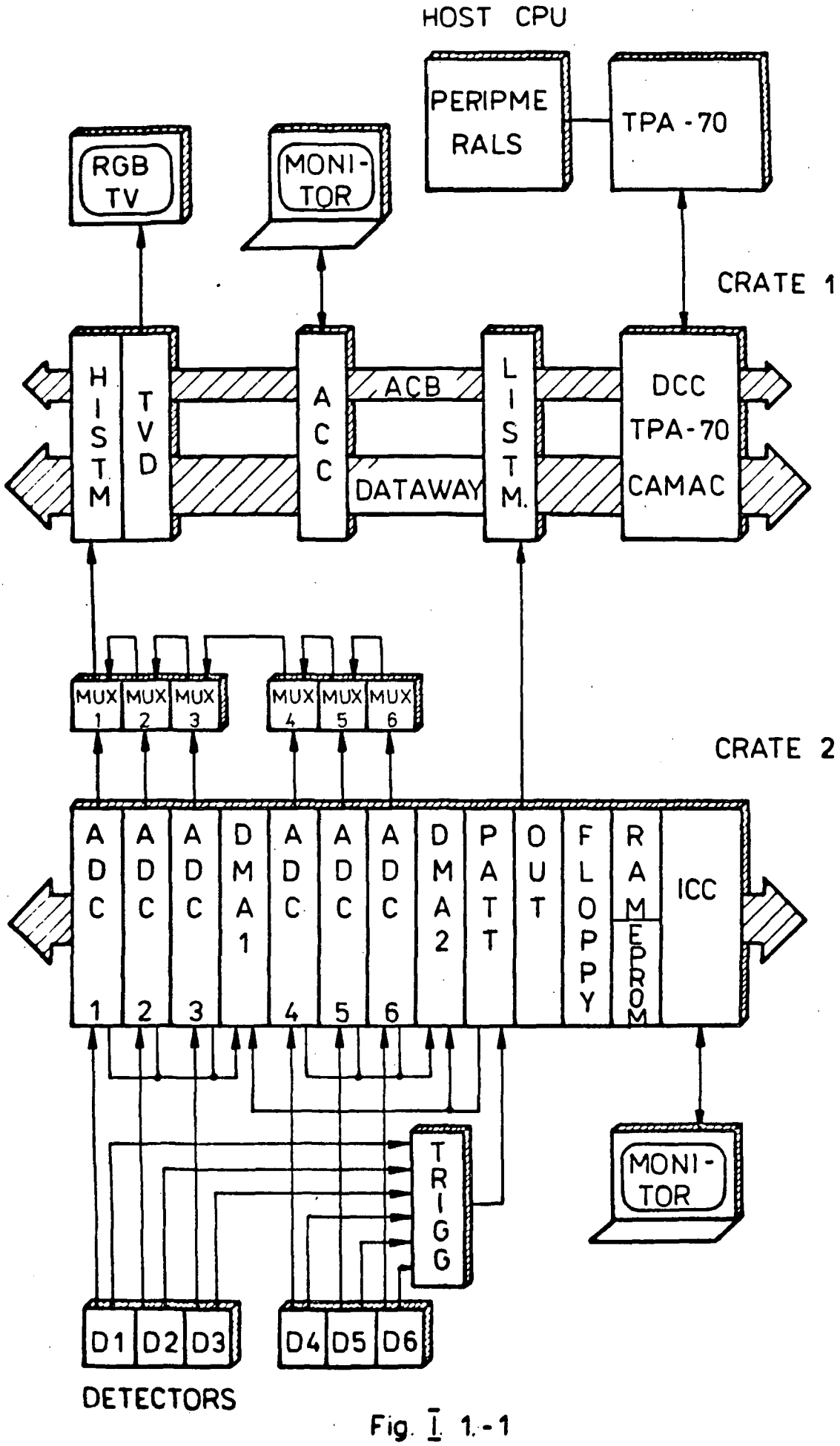
HOST CPU
PERIPME RALS
TPA - 70
RGB TV
MONI- TOR
CRATE 1
HISTM
TVD
ACC
ACB
DATAWAY
LISTM.
DCC TPA-70 CAMAC
MUX 1
MUX 2
MUX 3
MUX 4
MUX 5
MUX 6
CRATE 2
ADC 1
ADC 2
ADC 3
DMA 1
ADC 4
ADC 5
ADC 6
DMA 2
PATT
OUT
FLOPPY
RAM
EPROM
ICC
TRIGG
MONI- TOR
D1
D2
D3
D4
D5
D6
DETECTORS

Fig. I 1.-1

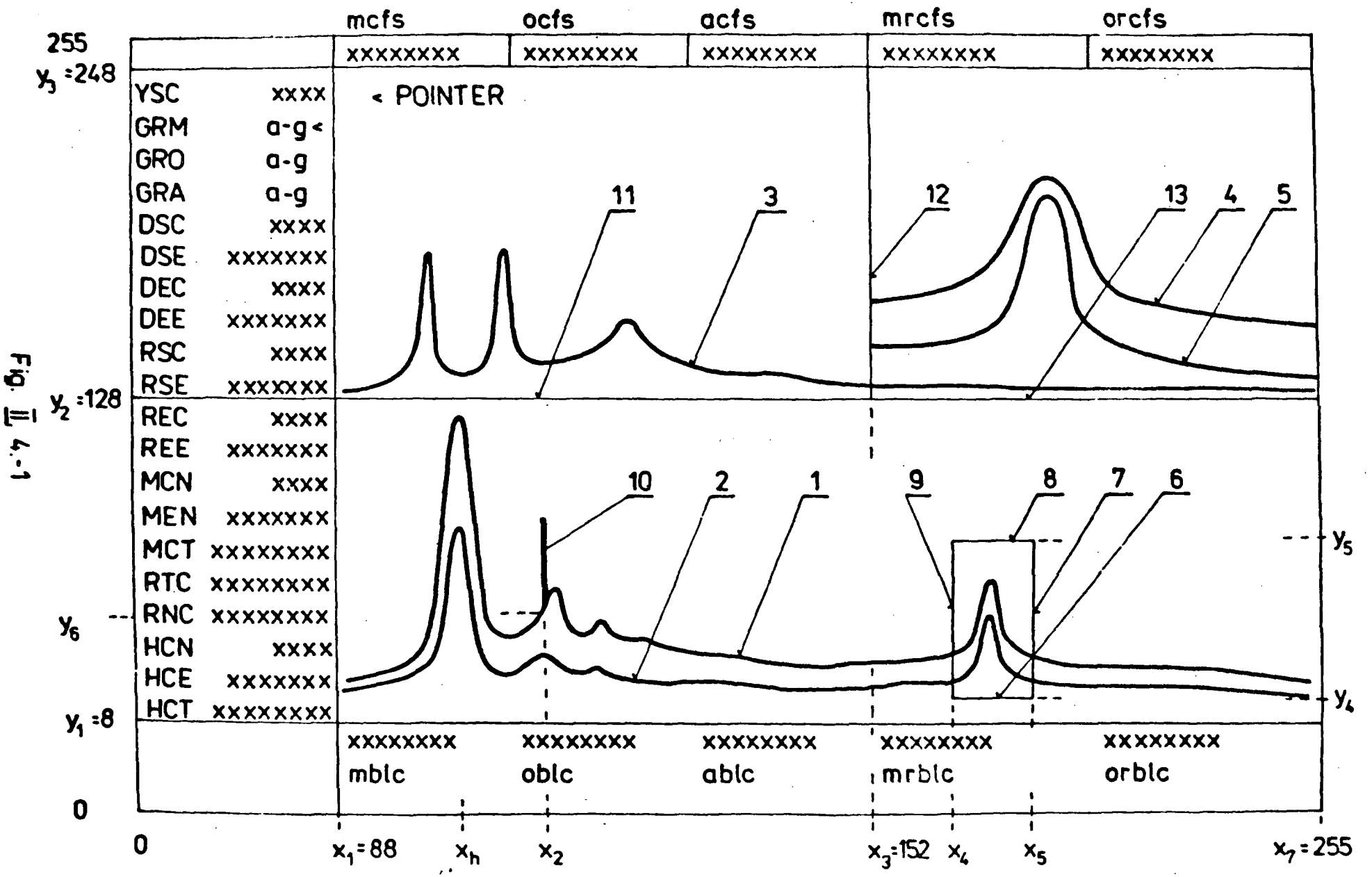
mcfs
ocfs
acfs
mrcfs
orcfs
255
y_3 =248
xxxxxxxx
YSC xxxx
< POINTER
GRM a-g<
GRO a-g
GRA a-g
DSC xxxx
DSE xxxxxxx
DEC xxxx
DEE xxxxxxx
RSC xxxx
RSE xxxxxxx
y_2 =128
REC xxxx
REE xxxxxxx
MCN xxxx
MEN xxxxxxx
MCT xxxxxxxx
RTC xxxxxxxx
RNC xxxxxxxx
HCN xxxx
HCE xxxxxxx
HCT xxxxxxxx
y_6
y_1 =8
0
11
3
12
13
4
5
10
2
1
9
8
7
6
y_5
y_4
mblc
oblc
ablc
mrblc
orblc
0
x_1=88
x_h
x_2
x_3=152
x_4
x_5
x_7=255

Fig. III 4.-1

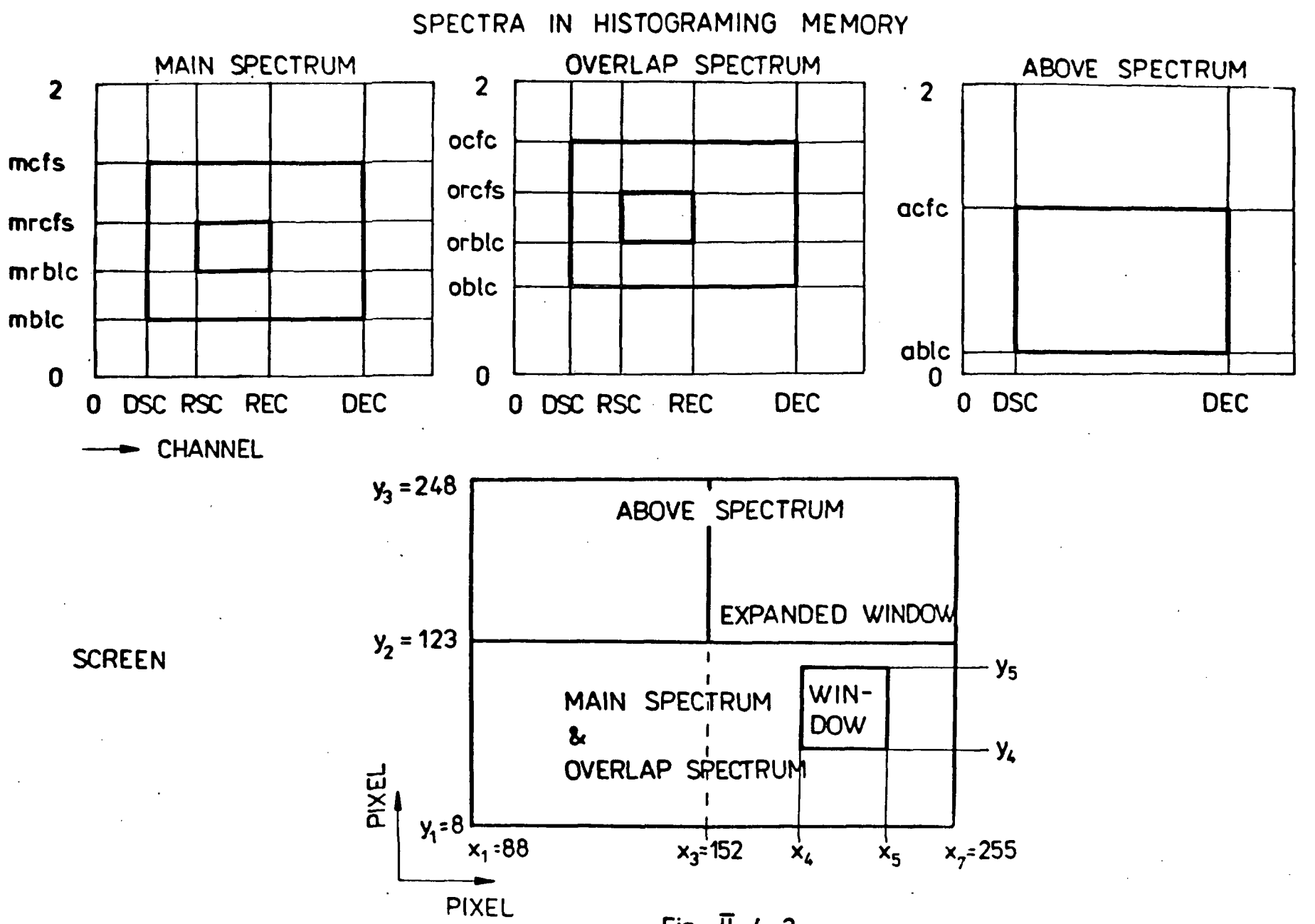
SPECTRA IN HISTOGRAMING MEMORY
MAIN SPECTRUM
OVERLAP SPECTRUM
ABOVE SPECTRUM
2
mcfs
mrcfs
mrblc
mblc
0
ocfc
orcfs
orblc
oblc
acfc
ablc
DSC
RSC
REC
DEC
CHANNEL
SCREEN
y_3 = 248
y_2 = 123
y_1 = 8
y_5
y_4
EXPANDED WINDOW
MAIN SPECTRUM
&
OVERLAP SPECTRUM
WIN-
DOW
PIXEL
x_1 = 88
x_3 = 152
x_4
x_5
x_7 = 255

Fig. II. 4.-2

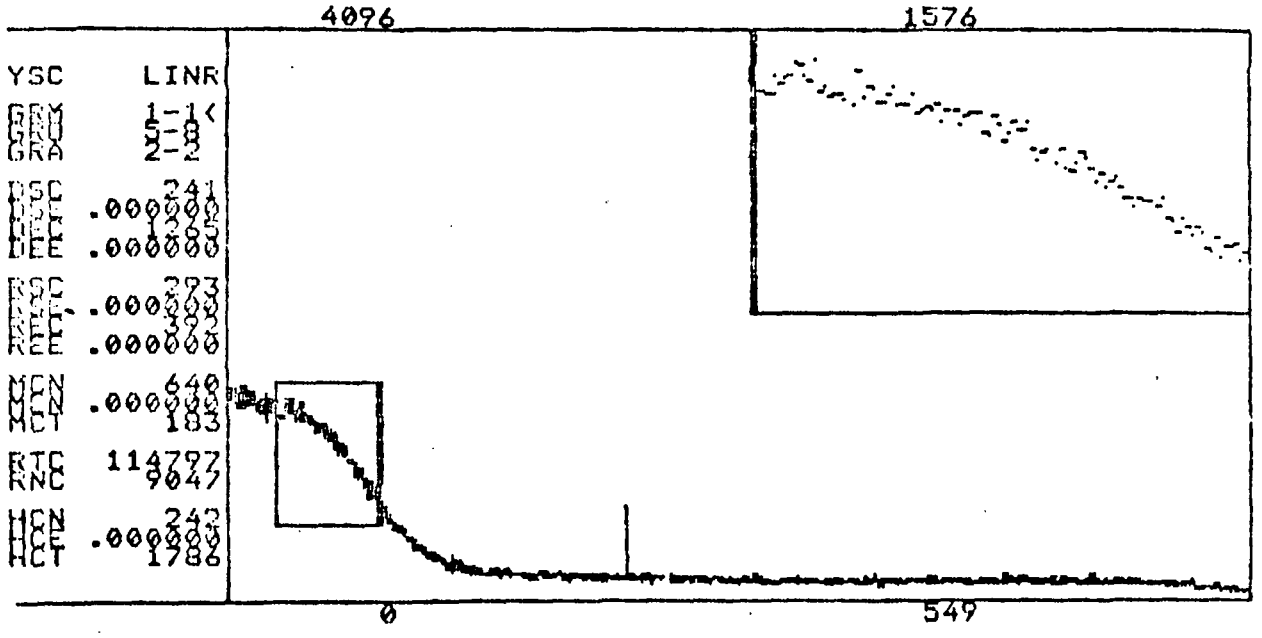

Fig. II.4.-3

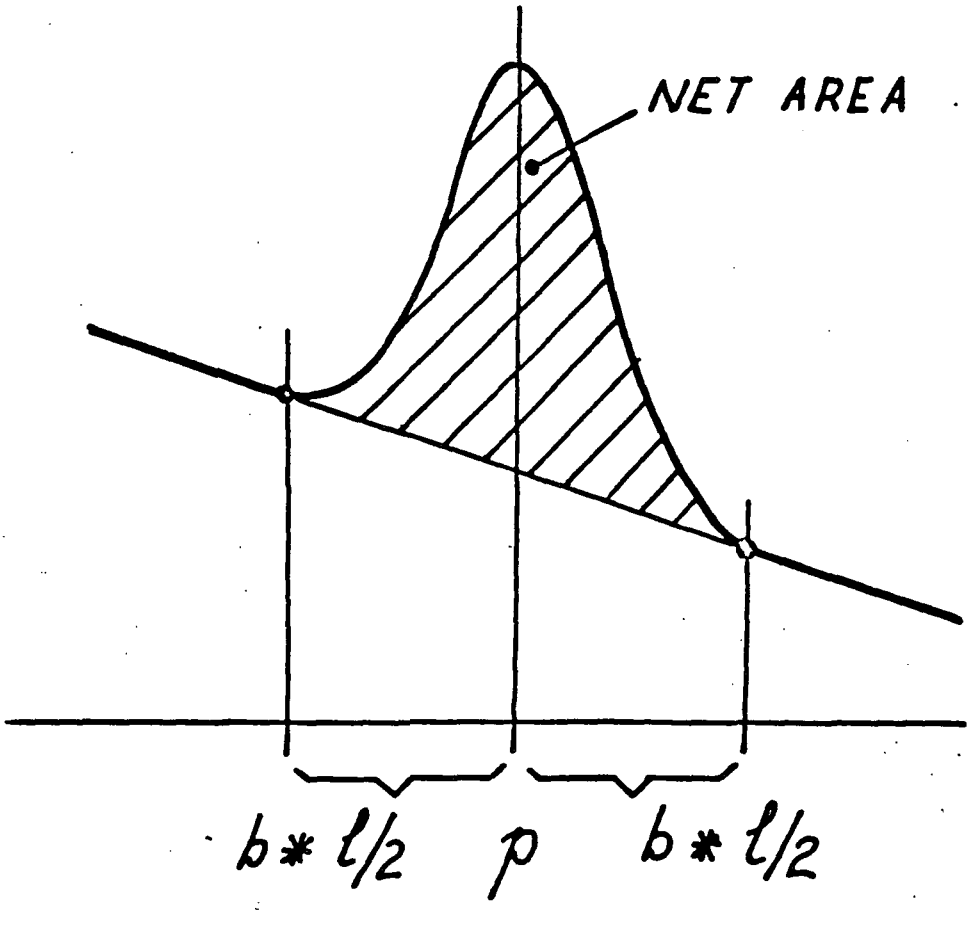

Fig. II.4.-4

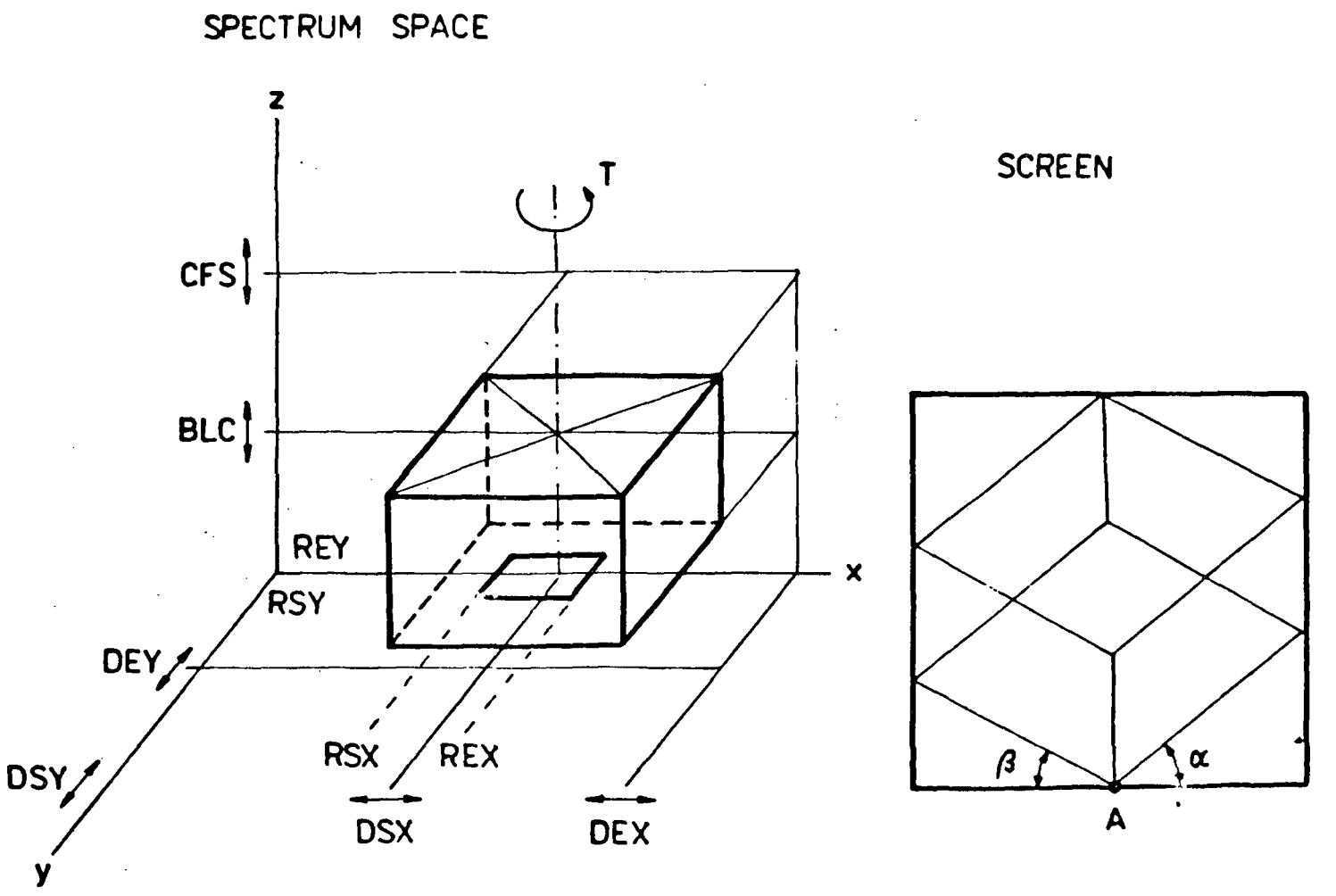
SPECTRUM SPACE
z
T
CFS
BLC
REY
RSY
x
DEY
DSY
y
RSX
REX
DSX
DEX
SCREEN
β
α
A

Fig. II. 5.-1

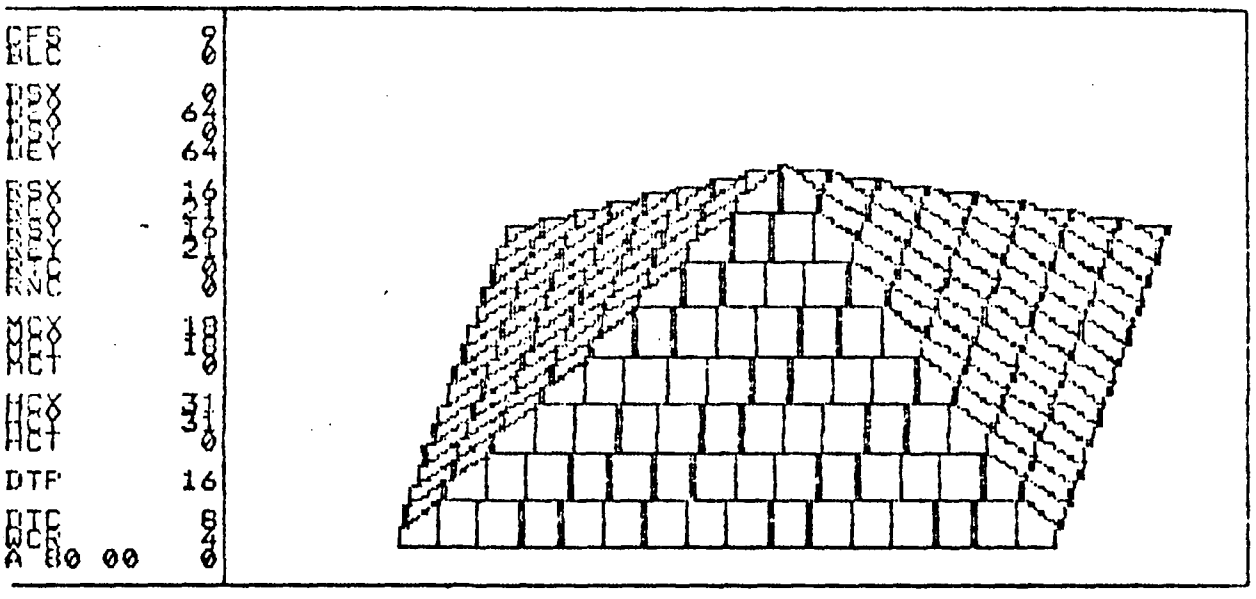

Fig. II.5.-2

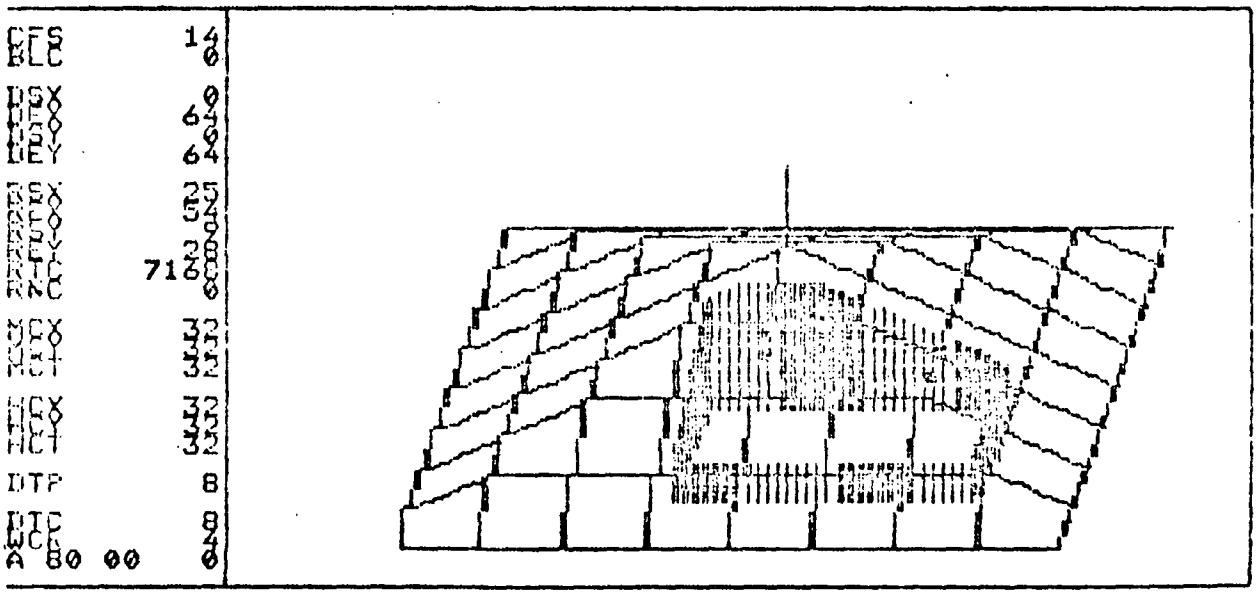

Fig. II.5.-3

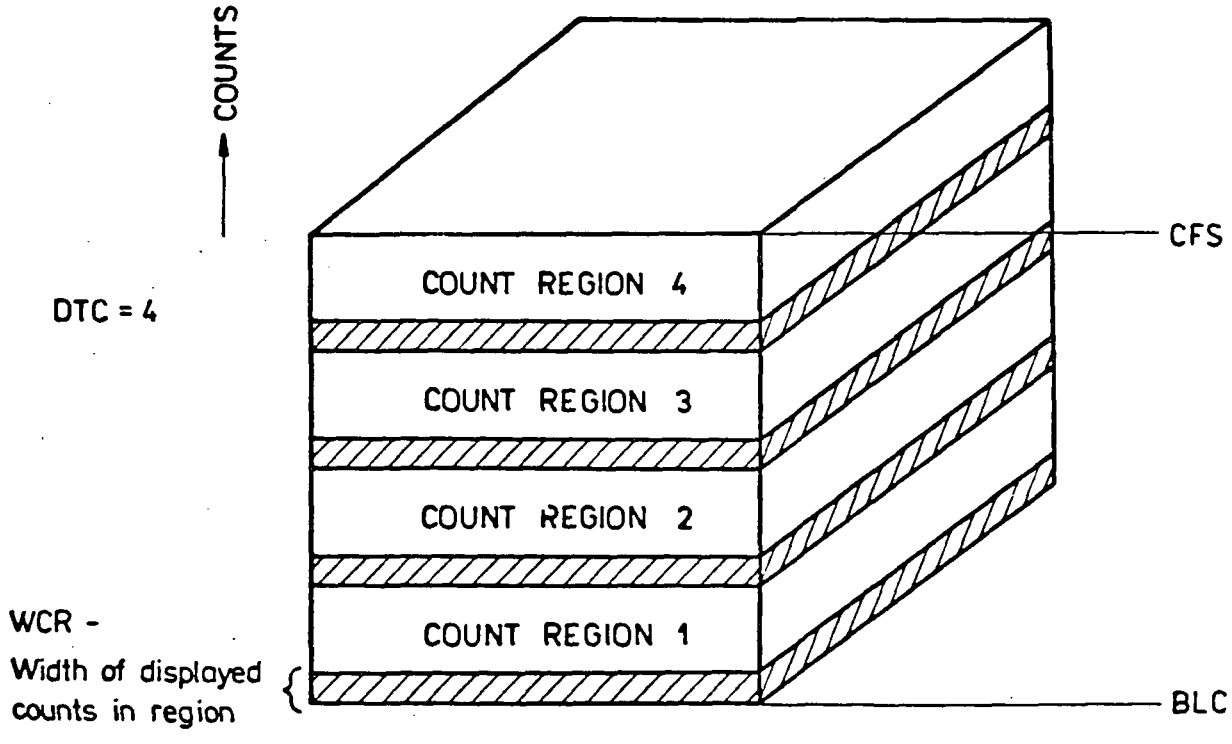

Fig. II. 5.-4

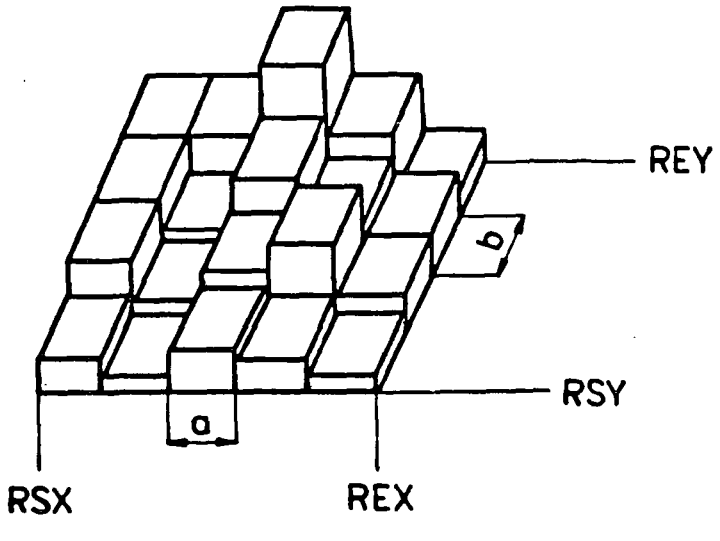

Fig. II. 5.-5

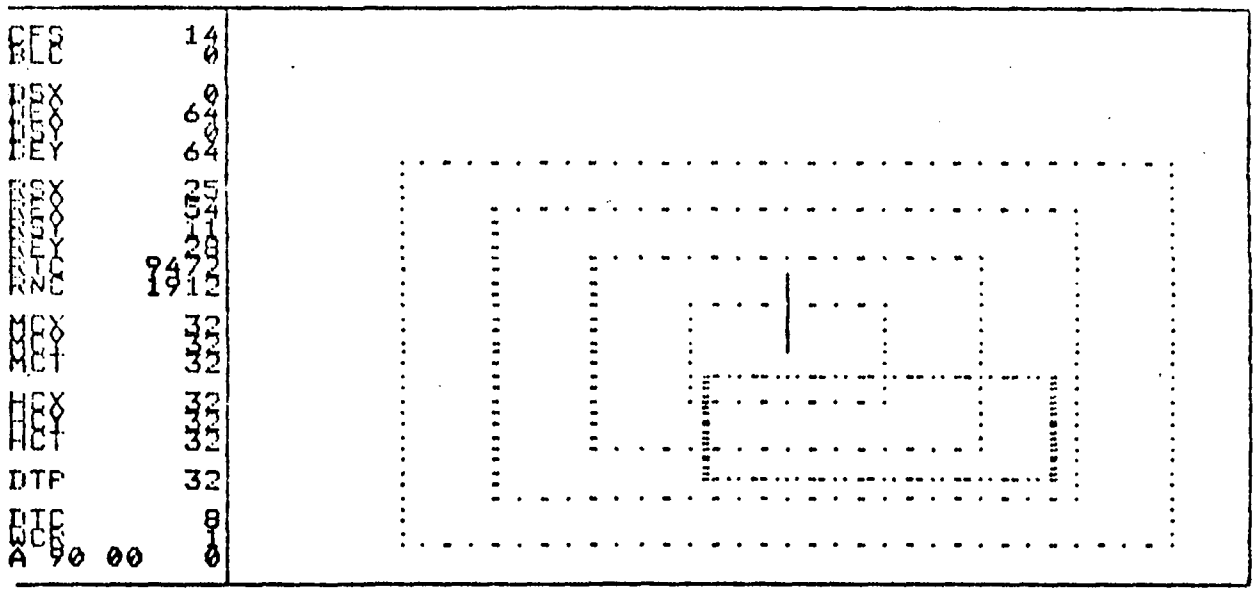

Fig. II.5.-6

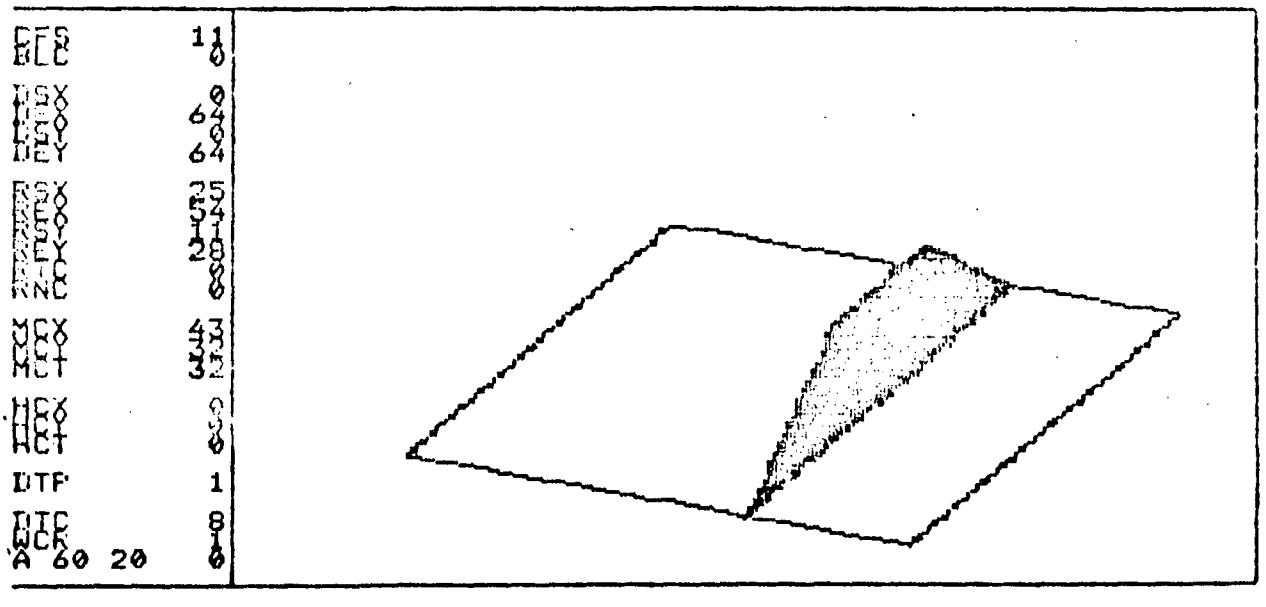

Fig. II.5.-7

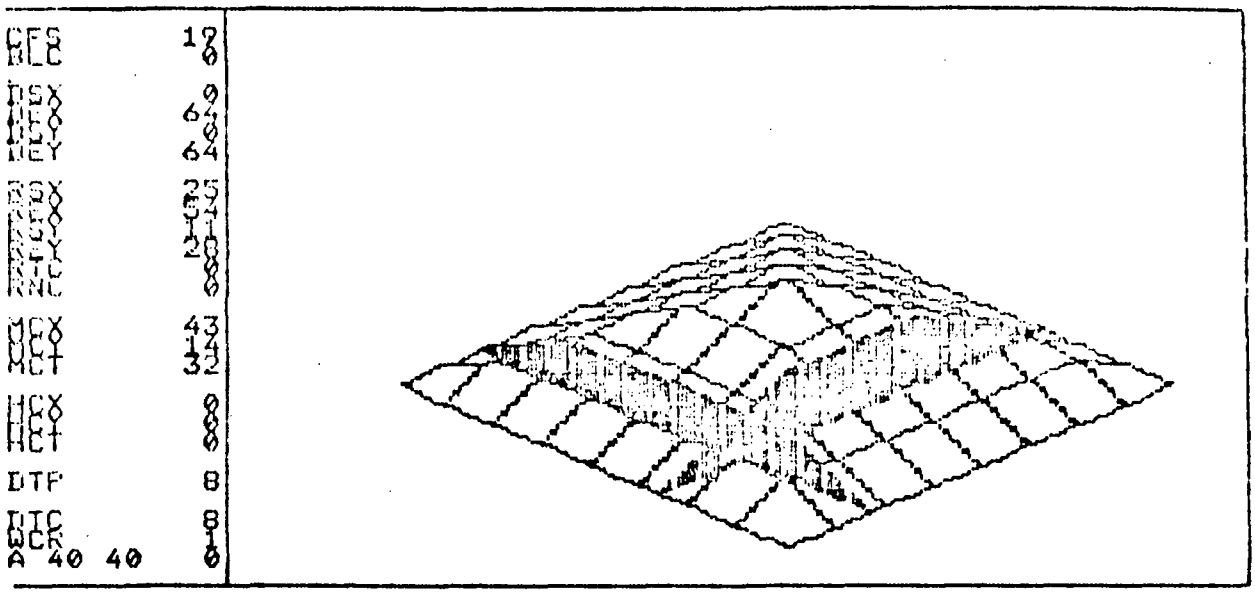

Fig. II.5.-8

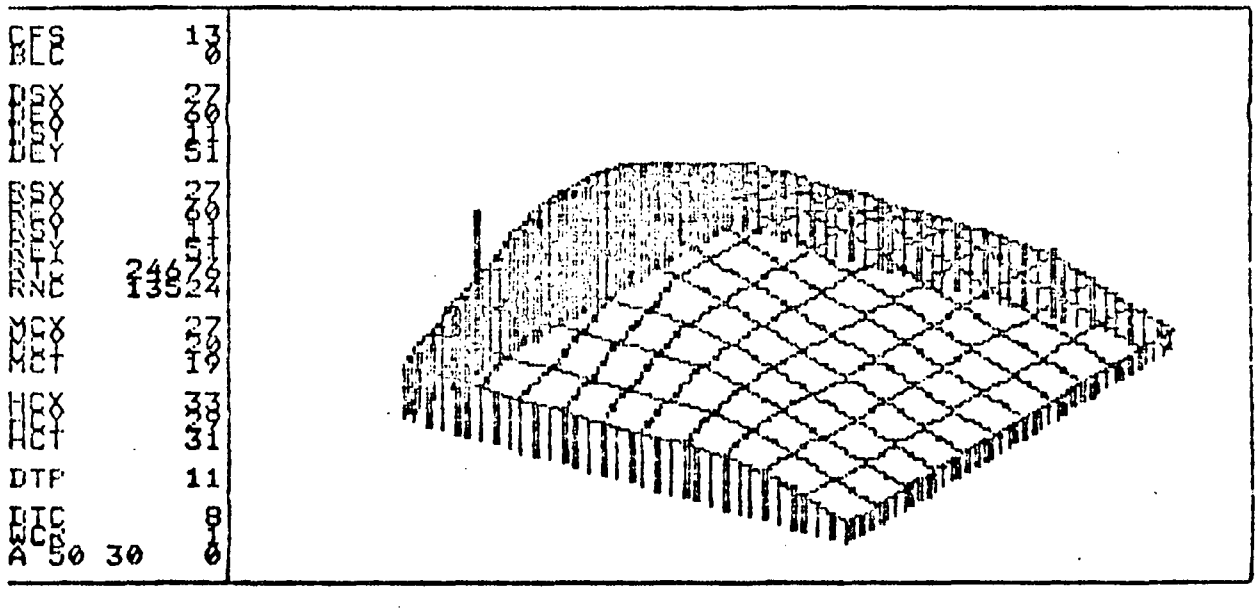

Fig. II.5.-9

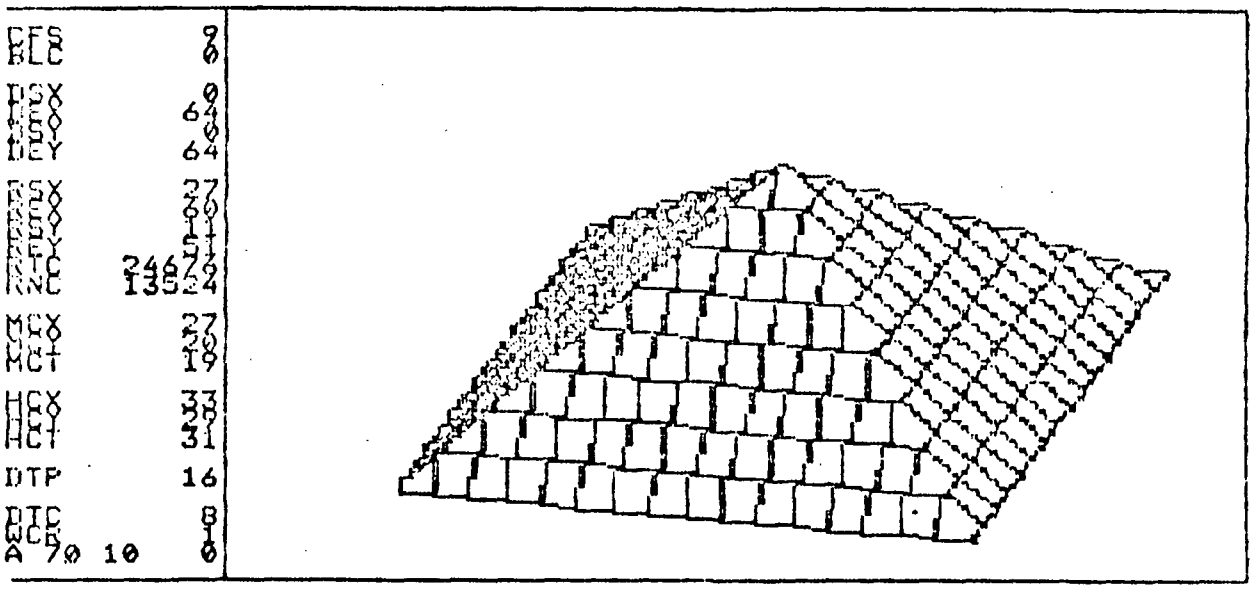

Fig. II.5,-10

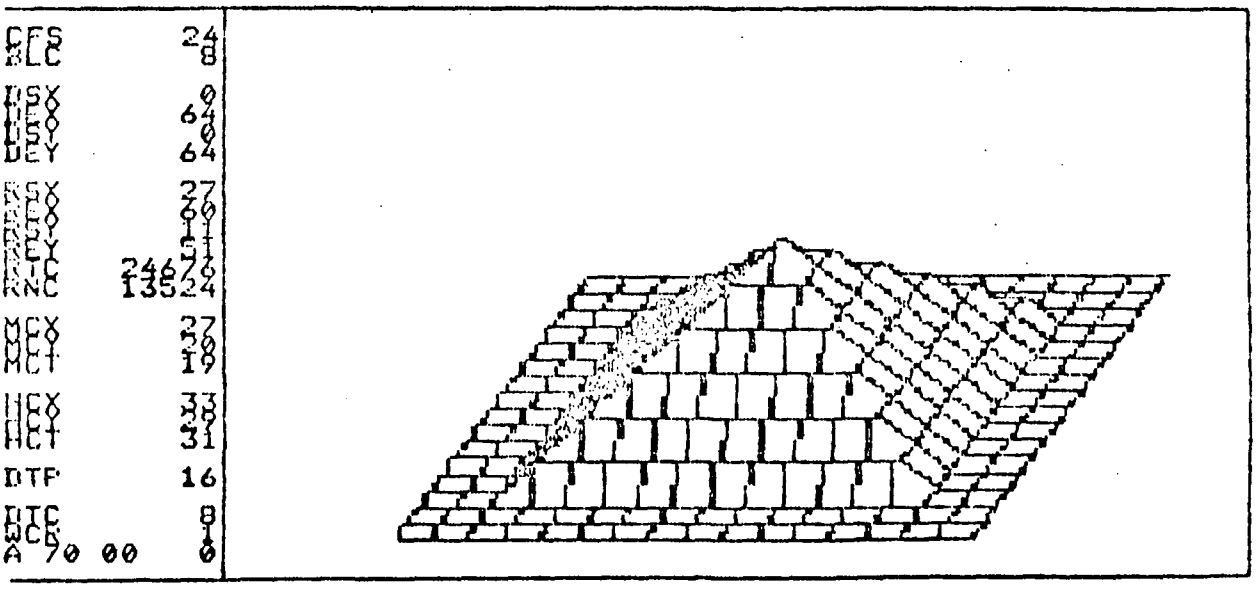

Fig. II.5.-11

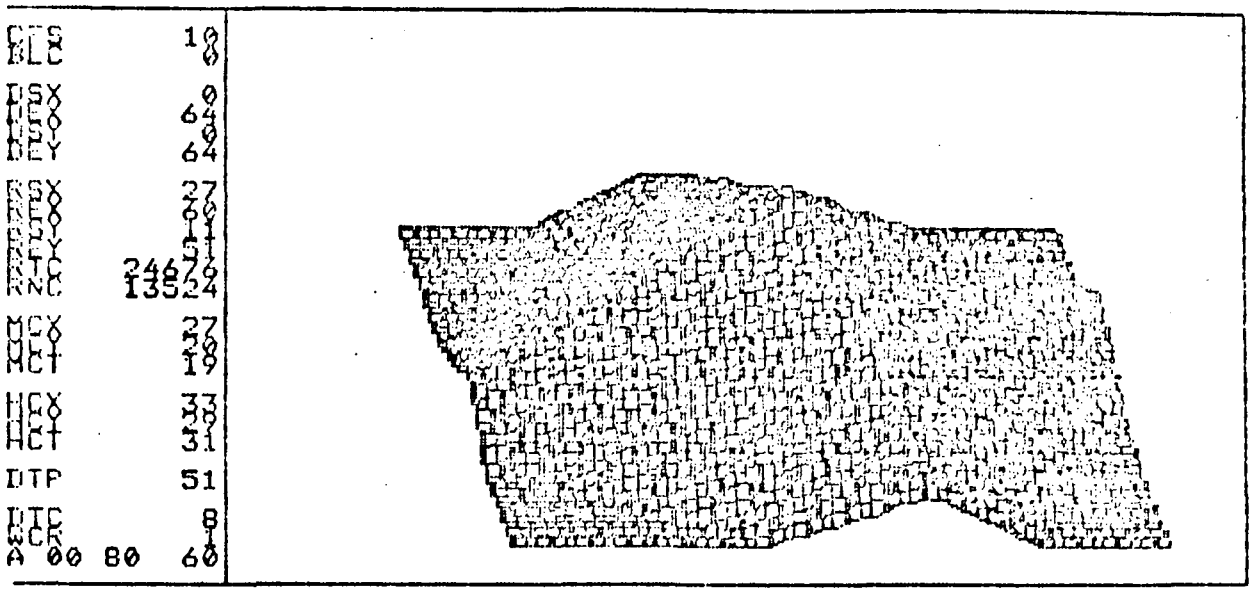

Fig. II.5.-12

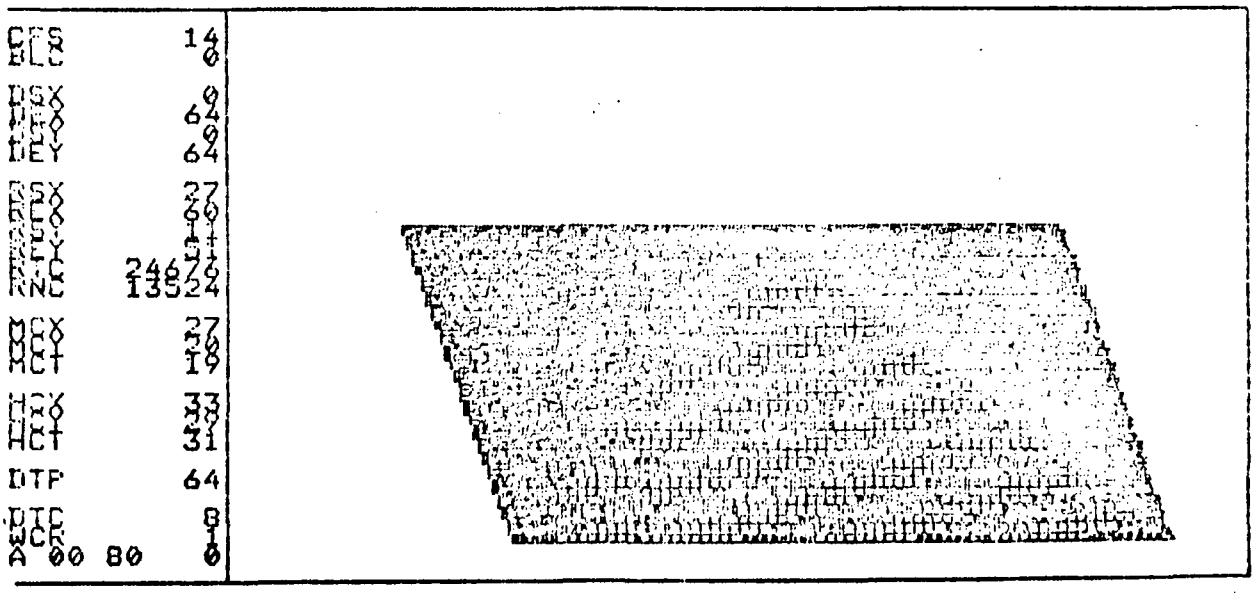

Fig. II.5.-13

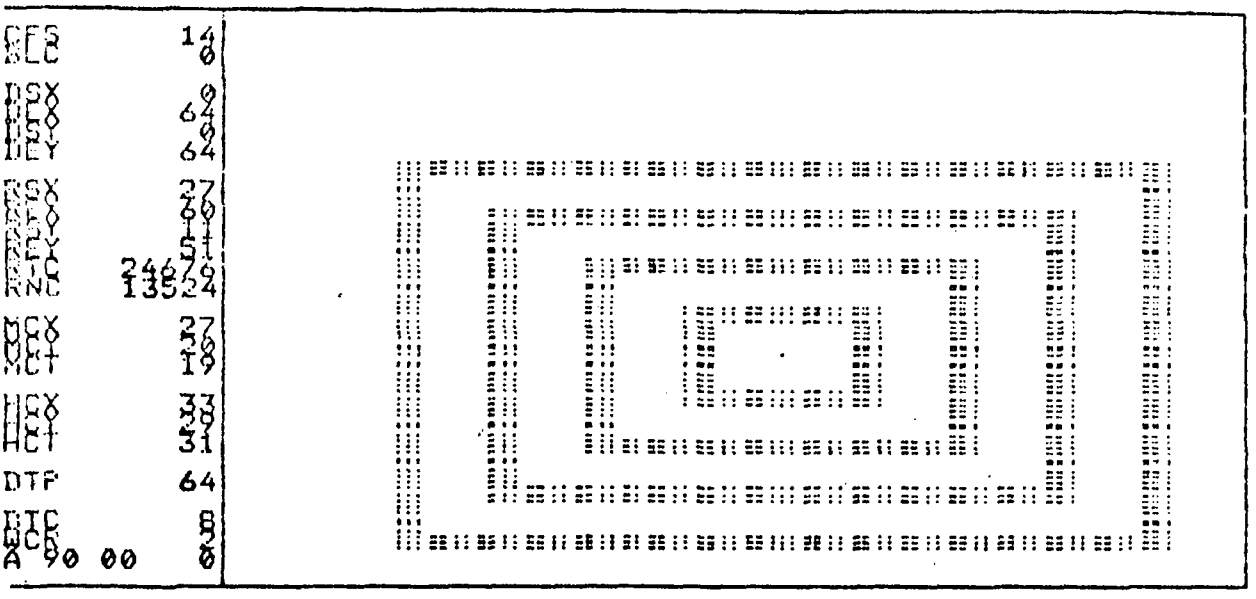

Fig. II.5.-14

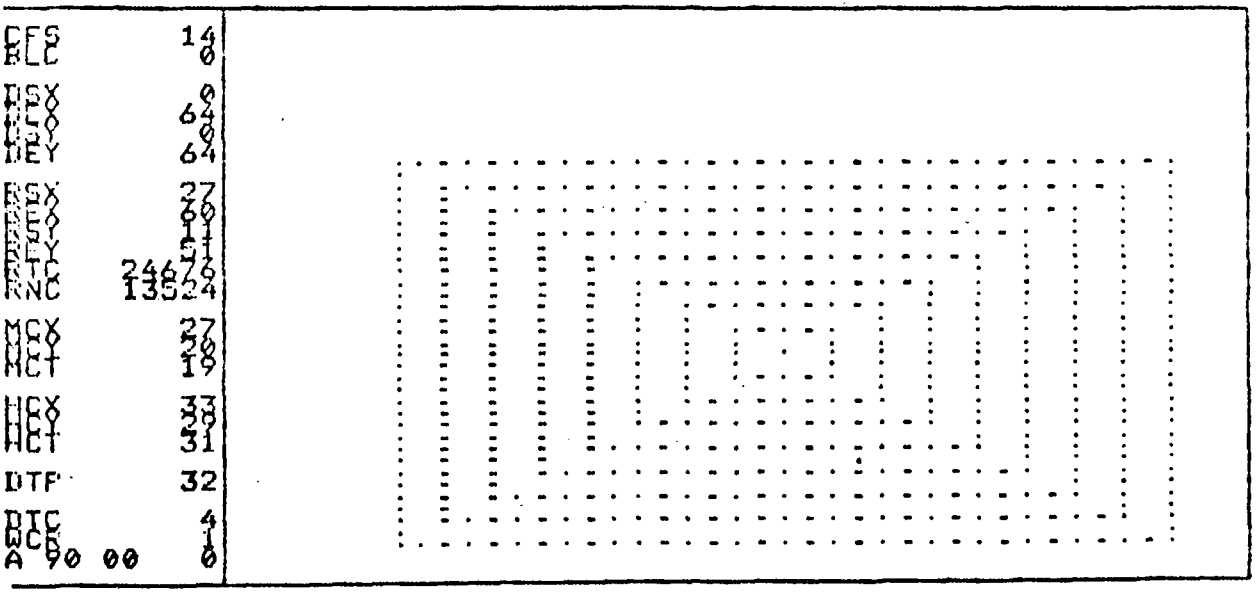

Fig. II.5.-15