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DESCRIPTION AND TEXTS FOR THE AUXILIARY PROGRAMS FOR PROCESSING VIDEO INFORMATION ON THE YeS COMPUTER. PART 3. TEST PROGRAM

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Translation of " Opisaniye i Teksty Vspomogatel'nykh Programm Obrabotki Videoinformatsii na YeS EVM. Chast' 3. Programma Testa", -- Polucheniye Statisticheskikh Kharakteristiki Mnogokanal'noy Videoinformatsii, Academy of Sciences USSR, Institute of Space Research, Moscow, Report Pr-426, 1978
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16. Abstract In the present monograph, we describe the functions and give the operating instructions, the block diagram and the proposed versions for modifying the program for obtaining the statistical characteristics of multi-channel video information. The program implements certain man-machine methods for investigating video information: it permits representation of the material and its statistical characteristics in a form which is convenient for the user.

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1. INTRODUCTION /3*

The problems involved in studying the earth's natural resources, just as any other problem, are connected with the processing of large files of information needed primarily in the visual representation of this information. The quasi-photography of video information obtained on the alphanumeric printer of a computer [1] gives the researcher a convenient opportunity not only to evaluate the content of the incoming information, but also to identify the data recorded on magnetic tape and the image of the earth's surface with a precision down to the element of resolution.

However, even at the very beginning stage of research, it is necessary to study the material numerically. Such a study is impossible without an extensive use of computer technology. The construction of graphs, histograms, digital print-outs, computation of elementary statistical characteristics, etc.--this is far from a complete enumeration of the problems which the researcher has to know how to solve when processing large data files.

The data recorded on magnetic tape from remote sensing of the terrestrial surface are color vectors assembled in a line [2]. The number of vectors in a line can vary--this depends on the properties of the recording apparatus. Each sequence of lines recorded on tape is an image.

Each color vector $a_{ij}=(a^1,\ldots,a^8)$ can have up to eight components which characterize the intensity of the electromagnetic radiation reflected from an element of resolution in one of the spectral ranges. During recording of the radiation, the signal /4 is modulated in such a way that each of these components a^i can have a maximum value of 255 nominal units, i.e., it can be placed in a single byte.

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*Numbers in margin indicate foreign pagination.

The position of an element of resolution from an image is determined by the number of the line and the number of the color vector in the line. Thus the entire image can be regarded as a matrix whose elements are the color vectors a_{ij} .

The proposed program makes it possible to obtain a chart of the change in the signal (along a line or a column of the image) in digital or graphic form; to calculate the vector magnitudes of the mathematical expectation and dispersion; to construct histograms of the distribution of the signal in each spectral range. The program consists of several blocks written in the languages ASSEMBLER and FORTRAN for the Disk Operating System of electronic computers of the Unified Series (ДОС/ЕС) [3]. The reading of magnetic tape (МЛТ) , storage, rearrangement of files and the development of charts is carried out by blocks written in the ASSEMBLER language. This makes possible more complete use of the machine's capacity. The storage files are transferred for subsequent processing by FORTRAN modules, which facilitates programing processing.

Preliminary processing in the ASSEMBLER language results from the fact that an element of information on МЛ occupies one byte, and a minimally addressable field from the problem-oriented language (ПОЯ) FORTRAN occupies two bytes. The program admits an increment of the functions being executed both at the stage of file formation, as well as after the storage procedure is completed.

The results of the operation of the program can be used to determine and compare the statistical characteristics of various fragments of an image, and also for qualitative and quantitative analysis of materials obtained from remote sensing of the earth's surface.

2. Description of the functions implemented in the program /5

We shall call a set of elements from several neighboring lines which includes elements with the same number of columns an oriented image fragment. The program makes it possible to process an arbitrarily chosen oriented fragment of any magnitude, up to the entire image.

In the version of the program to be described the following functions are implemented:

R - executes successively digital read-out of the values of the signal in all spectral ranges for all lines of the given fragment;

C - constructs a chart of the line-to-line change in the mathematical expectation of the color vectors for the elements which are between the extreme columns of the given fragment;

S - interprets graphically the change in the color vector of each element along the lines of the given oriented fragment, beginning with its first line.

M - computes the vector value of the mathematical expectation of the signal for the entire given fragment;

r - executes digital read-out of the files for the frequencies of the intensities of the fragment in all spectral ranges;

x - computes the components of the vectors for the mean value m^e and the dispersion D^e of the signal in the eth channel in the given range involved in the signal change;

F - graphs the frequencies K_i and the relative frequencies P_i involved in the intensities of the elements of a fragment in any given channel;

G - prepares a file with elements of the type INTEGER*2, representing a line of a fragment or its part; /6

B - computes the self-covariational and self-correlational functions of the line.

The program described consists of three sections of ASSEMBLER (TESTAM, ZNTGE, MACCMB) [file]) and several modules of the type SUBROUTINE, written in the ПОЯ FORTRAN (Fig. 1). In order for the program to begin operating, initiation on the part of the calling program is necessary in whose function there is also a storage reservation for the operating file IAR. The scale of the file is determined by the number of spectral ranges. It must be determined for the functions M,C,S,F by the formula 256*KCHAN, and for the function G--the formula is the length of the part of the line X KCHAN, where KCHAN is the number of channels of video information. The file IAR for the functions X,F must be described as INTEGER*4, and the file for G, as INTEGER*2. From the operator CALL TESTAM (IAR) control is transferred to the section TESTAM which reads the ИИ, searches for and isolates the given fragments, implements the functions R, C, S, M, r, and also prepares the files used by the algorithms of the functions F, B, X and G. The sequence of operations for the blocks and modules TESTAM (Fig. 2) is determined by the symbol for choosing a function which together with the coordinates of the fragment being processed must be printed on the control punched card. The coordinates of a fragment are the number of the initial and final lines СТРОК NBSTR and NBSTR and the columns NBSTO and NFSTO. The control parameters of this punched card also include the number of spectral ranges (channels) KCHAN.

Let us consider in more detail the possibilities represented by the program. To implement all the functions of the program after entering the control card, the next line is read and the given initial number is compared with the number which is in the first four bytes of the line on [illegible]. If the number read is less than the given number, then reading proceeds until the numbers coincide. If the initially read number is greater than the given number, then fictitious reading of a group of lines backward occurs (the number of lines is determined by the formula [illegible]), and the group is read once in the forward direction in the standard mode (checking the numbers).

When the symbols R,C,S are given, printing on the [illegible] begins immediately after the next line of the given oriented fragment is read.

In the case of the function G, the subprogram transforms the multi-spectral data of a single line into the form INTEGER·2 and returns control to the initiating program for further processing of the file [illegible]. In this case the length of the output file is determined by the formula [illegible] (here [illegible] characterizes the number of color vectors of the initial line). The file created is organized as follows: the first [illegible] elements correspond to the first spectral channel, the second, to the following channel, etc. To implement the remaining functions, files are accumulated for all the given fragments.

By means of the function R in one line on an [illegible] are printed the digital values of the elements of a line in the first spectral range (but not more than 30 items); in the following line, the values of the elements of the next spectral range, etc. If the number of elements in a line of the fragment under consideration exceed 30, then again the [illegible] of the lines is printed, etc., until all the elements of the line are printed out. The

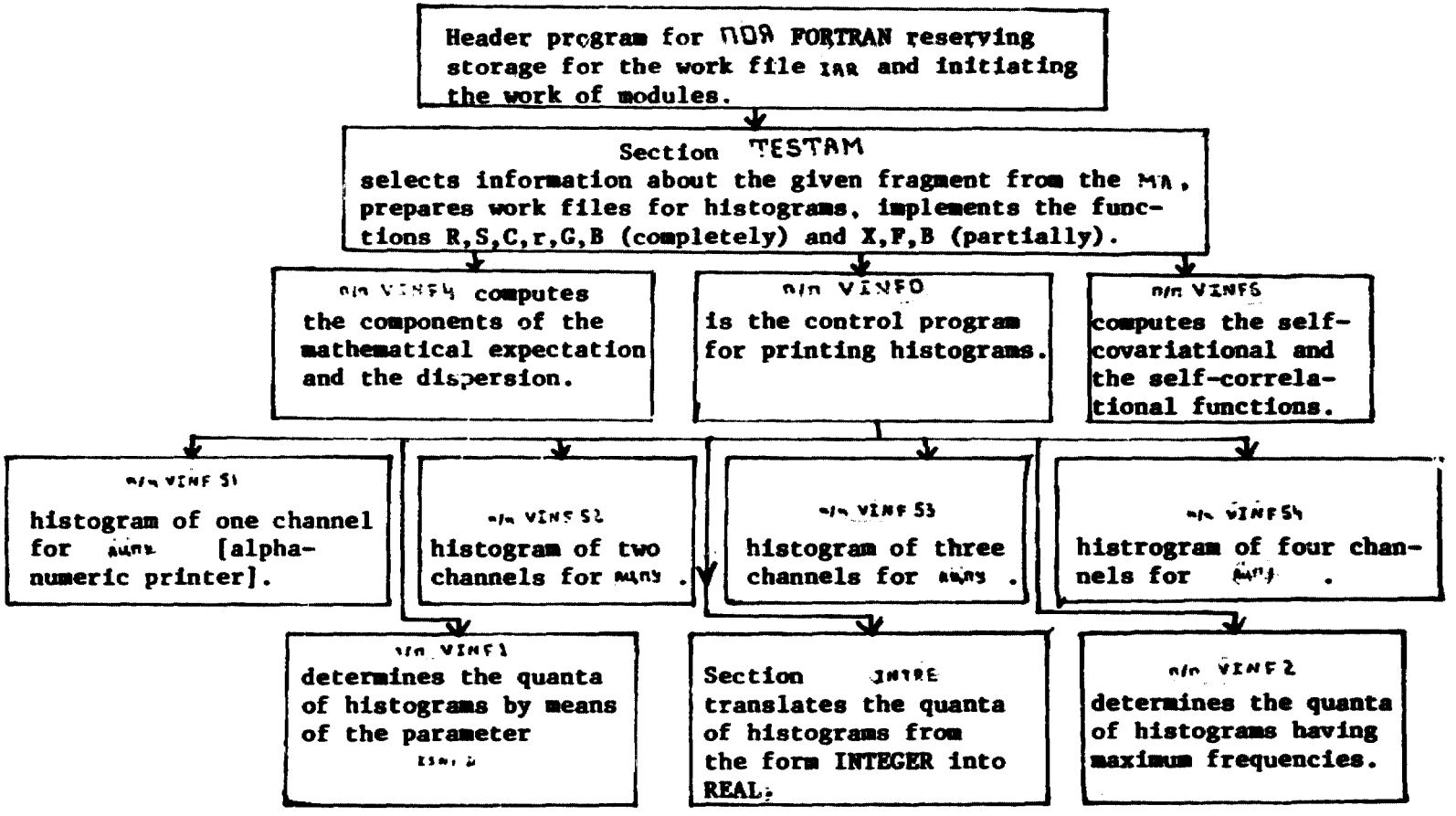
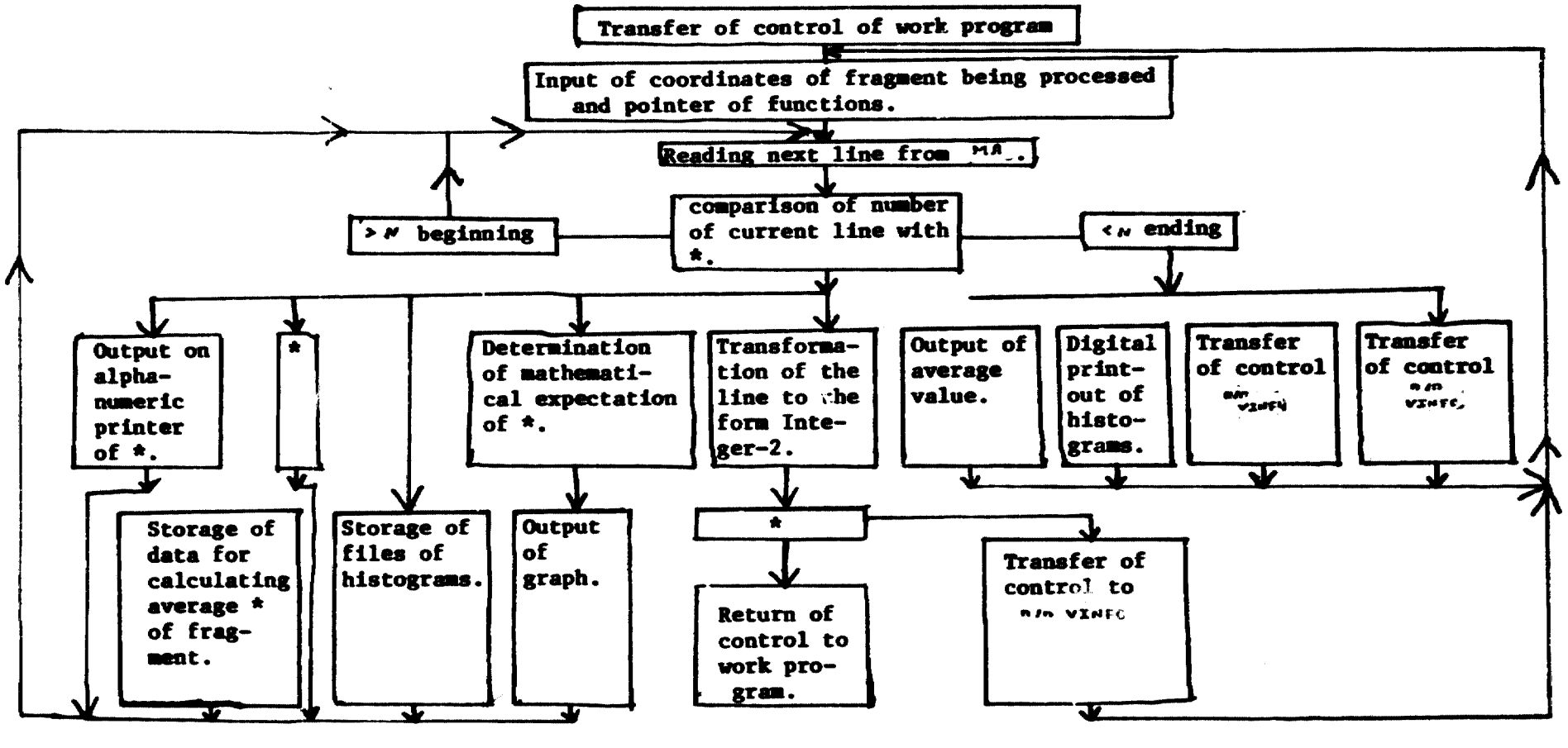


Fig. 1. Hierarchy of the blocks and modules of the program.



*Illegible in foreign text.

Fig. 2. Microenlarged block diagram of TESTAM.

number of the line and the number of the initial column are printed before the beginning of the line corresponding to the first spectral range. Then from the [illegible] the following line is printed, and the process is repeated until the last line of the given fragment has been read. After this, control is shifted to the input block of the next control card.

As a consequence of the function S each line of the [illegible] is a mapping of a color vector for the given fragment. Since the width of the [illegible] belt makes it possible to accommodate only 128 symbols (and the value of an element, as stated above, can amount at most to 255 conventional units), the values of all the components of a color vector are divisible by 2. Before the first multi-channel element of each line of a fragment is printed on the [illegible], the numbers of the mapped line and the initial column of the fragment are printed. In the positions determined by the values of the components of a color vector, from 1 to 8 symbols are printed. If the intensities of the signal in various channels coincide, then on the print the symbols are superimposed on each other. Thus all the elements of one line are printed, then all those of another, etc., until the last element of the last line in the given fragment is printed out. To facilitate inspection of the material, a coordinate network is printed over the graph (through 20 elements along the axis of abscissas and 40 conventional units along the axis of ordinates of the graph). In the nodes of this network, on the axes of coordinates along the perforations are printed the numbers designating the number of the color vector in a line, and in the perpendicular direction, its intensity. During a single access to the function S it is possible to map graphically an arbitrary number of lines of a fragment. /10

Implementation of the function C after reading through the next line in the module [illegible] the file:

$$\mathrm{COL}(e) = \sum_{j=NBSTO}^{NESTO} a_{ij}^{e} \tag{1}$$

is stored, and the value

$$c(e) = \frac{\mathrm{COL}(e) \times 0.5}{NBSTO - NESTO} \tag{2}$$

is printed out on the АЦПУ .

The range of change of each component c(e) also cannot exceed 128 conventional units (i.e., the entire width of the АЦПУ belt is used). Reading the next line of information calls /11
the АЦПУ to print one line, analogous to the function S. The number of a line is printed only on the axis of abscissas, and before the entire graph is printed, the number of the element is printed with which averaging begins. The number of elements of a line which can be averaged is arbitrary, and the number of lines is limited only by common sense in the consumption of paper.

As regards the function M the АЦПУ print out the text "the mathematical expectation of a color vector of the fragment", and in succession all the КЖАН of the components of the vector for the mathematical expectation ξ^{e} are printed. These components are found by means of the formula

$$\xi^{e} = \frac{1}{NESTO - NBSTO} \times \frac{1}{NESTR - NBSTR} \sum_{i=NBSTR}^{NESTR} \sum_{j=NBSTO}^{NESTO} a_{ij}^{e} \tag{3}$$

The results of executing the function r is the digital mapping of the file κ_i^{e} , prepared by the module ТЕКТАМ . This file contains the frequencies with which particular values of each component of all the color vectors involved in a given fragment appear. A single line of such a file contains 255 numbers, corresponding to the entire intensity range for each channel. But during printing on the АЦПУ the quantity of these

numbers may be reduced by preliminary averaging with any multiplicity KRAT . The value of the multiplicity is determined by the positions on the control card.

Each element r_i^k of the file being mapped is calculated by means of the formula

$$r_i^k = \frac{1}{KRAT} \sum_{s=KRAT(i-1)+1}^{i \cdot KRAT} K_s^k \qquad (4)$$

The prepared file is printed on the ALPH , channel by channel, and the spectral channels are separated from each other by a line consisting entirely of the letters X . For the kth channel, the values of the file r_i^k are printed successively in a line by the ALPH , and for each element *. If the number of file elements exceeds 30, then the remainder are transferred to the following line, etc., until all 256 KRAT values of the file r_i^k are withdrawn. To make it easier for the investigator to study the distribution of the intensities, the values of the intensities corresponding to the first element j of each line are printed in the first four positions of that line. They are separated from the digital values of the frequencies by the symbol % . /12

In order to implement the function X (calculation of the mathematical expectation and the dispersion) we begin by storing the file K_i^k which determines the frequency with which the intensities of the corresponding components for the color vectors a_{ik} appear. Then in the subprogram MATH we compute the components of the vectors of the first and second moments, using the formulas

$$M_i^k = \left[\frac{\sum_{s=0}^{255} s \cdot K_s^k}{\sum_{s=0}^{255} K_s^k} \right], \qquad (5)$$

*Illegible in foreign text.

and

$$D^{\ell} = \mathcal{E}\left[\frac{\sum_{s=0}^{\text{iff}} K_s^{\ell}}{\left(\sum_{s=0}^{\text{iff}} K_s^{\ell}\right)^2 - 1} \sum_{s=0}^{\text{iff}} K_s^{\ell} \cdot (s - M^{\ell})\right. \qquad (6)$$

Here $\mathcal{E}$ denotes the integral part of the given expression, and ℓ is the number of the channel.

When calculating the characteristics of the change in the signal in a selected part of the intensity range, rather than in the entire range, we take as the lower and upper limits of summation, the minimum and maximum values of the signals for the portion of the intensity under consideration. The subprogram VINF4 uses the following additional control parameters:

NCHAN - the number of the spectral range;

MINVAL, MAXVAL - the minimum and maximum values of the intensities of the chosen signal change range.

The АЦПУ prints the line in which appear the number of the spectral range of the channel, the limiting values of the signal, the value of the mathematical expectation and the dispersion (together with the explanatory text).

The result of executing the function F is the files of histograms which make it possible to analyze the probability density distribution functions of the signal with respect to the intensities. /13

For the width of the АЦПУ belt, the program permits the output of one, two, three and four histograms. The printing error is determined by the width of the field removed for the histograms. Just as in the case of the function X, it is possible to

put out a selected part of the signal intensity range, rather than all of it, and to construct histograms with an average relative to a given parameter. Here as the quantum for a histogram we take the average value with respect to several quanta, the number of which is given by the averaging parameter ISRED . During operation of the algorithm for the function F, the module TESTAM , after forming the histogram files, transfers control to the subprogram VIHF which is the control program for printing histograms. This subprogram uses the following control parameters which assign the mode for constructing graphs:

NGIST - the number of histograms for the АЦПУ belt width;

NNNNC - the number of spectral ranges which must be mapped on the АЦПУ simultaneously according to NGIST;

$NBEG^c$, $NEND^e$ - the beginning and ending quanta of the mapping $(c = 1, \ldots, KCHAN)$.

ISRED - the averaging parameter;

VIDG - the type of histrograms (the frequency of impact (A) or the relative frequency (F)).

When constructing histograms reflecting the frequencies K_i^c , the i-ro quantum represents the number of elements of the given fragment with an intensity of i units. The quantum O_i^c in a histogram of relative frequencies is calculated by normalizing the quanta K_i^c so that

$$O_i^c = \frac{K_i^c}{\sum_{i=0}^{M} K_i^c} \quad [4]. \qquad (7)$$

The АЦПУ prints the number of the channel, the greatest frequency in the file and the number of this quantum, and also a digit on the axis of ordinates. The intensities are printed along the /14

axis of abscissas (the conventional unit of intensity is a quantum of a histogram). The digital network is laid off on the axis of ordinates. The frequency in the chosen quantum can be calc lated by multiplying an ordinate digit by the number of pad symbols, " Ж ". For example, in channel 1 (cf. Russian P. 23) on the histogram constructed by means of the parameter VIDG=F an intensity of 88 has the frequency 9 x 0.004313 = 0.03882.

As the result of executing the function B (which determines the self-covariant and the self-correlational functions of a line of a fragment or its part) the line with number i which has been read forms a file with elements [illegible] (Cf. function G) and control shifts to the module VINFG, written in FORTRAN. The following are computed: the average signal M^i for a given portion of the line (cf. formula 3) and the values of the self-covariant function, using the formula

$$C_s^i = \frac{1}{N}\sum_{j=1}^{N-K}(a_{ij}^i - M^i)\cdot(a_{i,s+j}^i - M^i).$$

The self-correlational function is calculated from the formula

$$r_s^i = \frac{C_s^i}{C_0^i},$$

where $s = 0, 1, \ldots, K$.

On the control card the user assigns the limiting value of the delay K and the portion of the line along which the characteristics are calculated. The [illegible] prints: the number of the line, the number of the column between which the portion of the line is located, and the values of the functions for all delays from the 0th to the Kth. Control is returned to the module [illegible] for input of the coordinates of the following fragment and the new function.

In an appendix we present examples illustrating the mapping of the results obtained by processing several fragments. In a separate appendix we give the complete text of the section in the ASSEMBLER language, together with the necessary commentaries and the texts of all subprograms, written in ПОЯ FORTRAN. /15

3. Instructions for working with the program

The program TECTA is controlled by means of symbols and numbers fed in on punched cards.

Each control card represents a sequence of whole numbers, arranged in succession, beginning with the leftmost position on the punched card.

To implement any of the functions, it is necessary to specify on a card the coordinates of a fragment, the number of spectral ranges and the symbol of the chosen function. The data are printed in the following sequence, each of the first five involving 4 positions per punched card:

NBSTR - the number of the beginning line of the fragment;

NBSTO - the number of the initial column of the fragment;

KCHAN - the number of spectral ranges;

NESTR - the number of the final line of the fragment;

NESTO - the number of the final column of the fragment;

* - the symbol indicating that in the next position a function will be given (1 position per card);

VIDFUN - for the choice of a function (one of R,c,S,M,G, X,r,F,B). /16

In the case of the functions X and F, additional parameters must be fed in.

The function X (for computing the mean value and estimating the dispersion of the signal in the given spectral range) uses the following parameters:

NCHAN - the number of the spectral range (1 position);
MINVAL - the minimum intensity in the chosen signal change range (3 positions);
MAXVAL - the maximum intensity (3 positions).

All these parameters are printed on one punched card. There can be any number of such punched cards (with additional parameters). In order to shift to feeding in the coordinates of a new fragment and/or specifying another function, it is necessary to insert a punched card with a zero in the first position. When executing the function X, if the next card in the first column is the digit 9, then the program concludes the operation.

The control punched cards determining the functions F and r (graphical or digital output of histograms) have a format different from that of other punched cards: in position 21 is printed the averaging parameter ISRED (for F or KPAT) (for r) (each occupying 4 columns), rather than the service symbol ",". Next comes the symbol *, characterizing the conclusion of the numbers; then the symbol of the chosen function (F or r), and, in the case of the function F, the additional symbol of VIDG, which determines the form of the histogram. This is the symbol (A), if the frequencies K_i' , and F -- in the case of the relative frequencies -- are calculated and mapped. Next comes the punched card which successively determines the initial N_{BEG}',

the final NEND^2 quanta of the mapping, beginning with the first channel. Each of the parameters NBEG^2 and NEND^2 occupy 4 positions. Then comes the punched card on which is given: the /17
number of histograms on the width of the АЦПУ belt NGIST, and the number of the channels relative to which histograms must be constructed. After the parameter NGIST comes a space; all the parameters of this punched card occupy 1 position.

The results of processing the fragments presented in the Appendix were obtained by means of the pack of control cards pictured in Fig. 3 (p. 18).

4. Suggested ways to modify the program

In the version described, the initiating program, written in ПОЯ FORTRAN, executes only a function reserving storage for preparing files accumulated during the operation of individual modules. From our standpoint it is advisable to extend its capabilities, committing to it the semi-automatic processing of results obtained during implementation of other functions. For example, it may be necessary for a user to compare the characteristics of individual fragments (coefficients of correlation, moments, etc.) in order to decipher thematically the information obtained. Therefore it is necessary to make provision for transmitting an initiating program for calculating the characteristics of fragments. They can be processed by means of algorithms written in ПОЯ FORTRAN in the form of subprograms called by an initiating program after the next fragment has been processed by the module TESTAM (or one of its auxiliary modules--the file, VINFØ ÷ VINFG).

An even higher degree of automated processing under the supervision of an initiating program can be achieved by means of the following modification of this program: the section TESTAM is altered so that the file of control parameters (coordinates

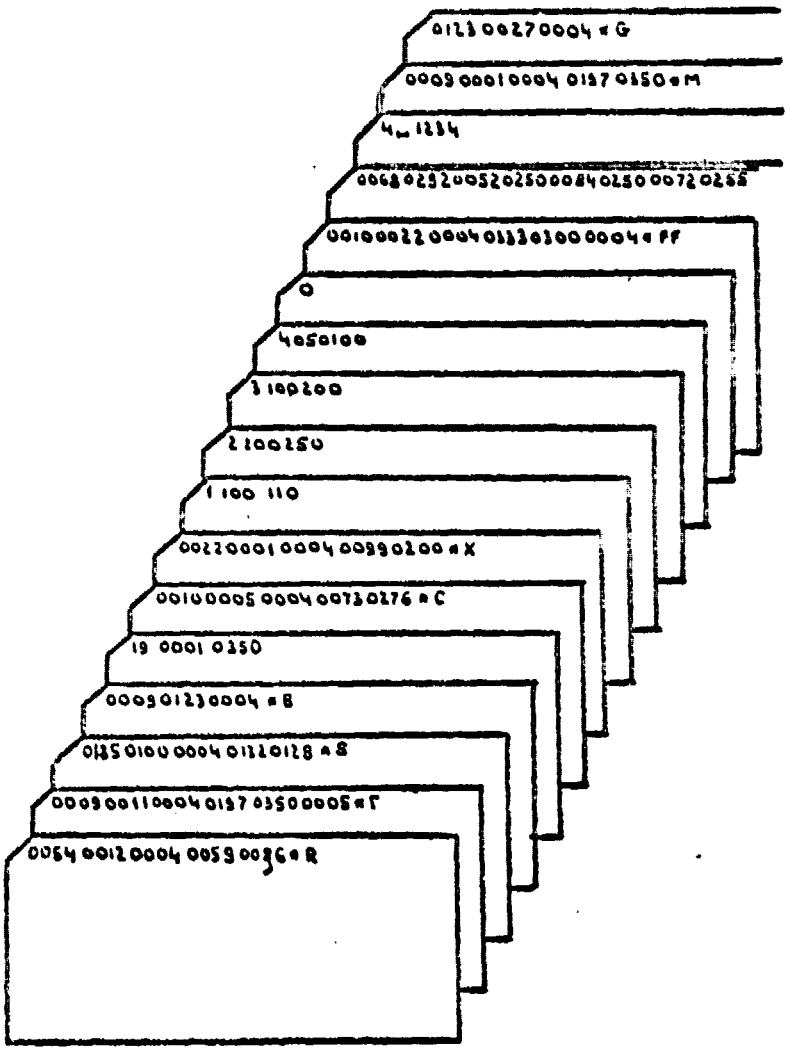


Fig. 3. An example of a pack of control punched cards.

of an oriented fragment and a type of processing function) are also transmitted by the initiating program. This makes it possible to form these parameters immediately in the initiating program (without feeding them in from punched cards). /19

One of the simplest methods for modifying an initiating program is to enlarge the function G. This can be achieved by adding an arbitrary processing program. (In the version described, a processing subprogram is nominally present). Such a subprogram obtains from the module TESTAM a file of lines of the type INTEGER*2 and then it may implement any processing algorithm which is conveniently programmable in FORTRAN.

Besides enlarging the function G, it is advisable to modify it so that a transmitted file of the type INTEGER*2 will contain information about the entire fragment, and not about an individual line of the fragment. This makes it possible to process immediately the entire fragment by means of a problem oriented language (for example, to apply a binary processing file for comparing the textural characteristics of various fragments).

The set of implemented functions must also be supplemented by a function for constructing two-dimensional histograms: the plane sections of multidimensional histograms will make it possible to analyze the correlational connections of various spectral channels.

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     00540012000400590086*R                                  0054  0012  0004  0059  0086
54
12   139 131 151 125 137 141 149 151 141 157 169 137 163 165 143 164 177 183 156 137
     146 145 167 155 151 141 125 133 133 128 125 139 133 132 127 125 113 128 125 125
     142 153 155 164 137 113 107 105 115 117 117 117 113 115 109 105  97 107 117 125
      26 116 123 109 121 117 109 108 102 111 109 113 120 102 117 111 109 105 109 121
54
42   139 149 141 149 137 162 177 193 181 185 173 124 135 107  87  93 111  88  98 109
     141 155 137 139 129 121 111 117 114 115 144 161 143 130 134 125 124 117 120 113
     133 130 124 117  97  89  81  87  81 103 141 153 135 117 116 115 109 105  97  99
     117 113 115 109  97  95  99 105 105 109 117 105 106 101 101  93  91  80  99  85
54
72   161 157 145 143 141 145 161 157 175 185 181 177 165 164 147 152
     117 121 135 131 130 134 110 115 114 105 113 109 109 113 111 119
     103 105 113 119 113 100  88  89  81  87  89  93  89  90  93 101
     113 101  97 109  93  95 100 105 113 105 109 101 111  97  93 101
55
12   141 133 141 137 133 144 149 157 153 145 141 149 145 146 141 149 169 173 173 177
     157 163 165 167 145 131 125 117 127 128 147 137 129 131 137 125 120 123 117 118
     157 166 169 164 134 105 107  99 111 121 139 125 113 117 117 109  97 100  97 112
     121 126 127 113 131 109 101 109 101 107 115 124 117 109 101 111 107 101 109 105
55
42   149 125 139 147 139 137 131 147 149 149 178 129 145 171 153 153 129 121 121  93
     141 125 131 128 133 129 141 133 129 125 125 141 120 117 121 131 137 149 141 137
     121 109 105 104 118 109 117 118 107  99 105 121  93  97  97 109 123 123 134 141
     115 105 115 113 109  97 101 116 105  93 100 104 104  95 103 101 111 104  93  97
55
72   133 121 141 139 134 153 151 149 181 177 201 177 177 189 161 153
     141 137 139 141 121 127 135 125 121 113 105 111 120 101 107 119
     133 124 120 112 105 111 105  93  85  87  89  93  89  89  95 105
     121 116 109 115 109 105 111 113 109 107 105 111 109  91  99 109
56
12   139 131 141 123 145 147 151 145 130 139 141 153 157 155 161 161 161 169 156 155
     153 165 169 177 144 125 135 125 129 137 161 137 125 131 125 123 124 125 109 118
     166 165 172 161 119 110 109 109 113 128 153 123 117 109 103 108 101  96  96 103
     123 119 124 141 105 [illegible] 109 101 108 113 109 109 111 113 112 109 107  97 107 111
56
42   145 144 125 149 142 165 153 137 153 145 139 135 125 153 145 141 142 141 141 129
     165 117 119 103 103 111 117 [illegible] 134 121 130 133 117 107 119 119 114 121 117 147
     143  93  87  85  81  85  89 101 113 120 121 123  97 104 101  97 101 102 109 149
     112 103  81  95  93  88  95  97  99 103 109 105  99 108 105  97 103 103  97 108
56
72    95 113 121 131 133 129 137 115 129 167 165 173 173 179 179 158
     137 127 141 141 135 133 141 147 125 121 122 117 117 113 105 120
     119 121 137 121 111 130 134 121 105 101  97  93  89  81  92 105
     105 105 109 105 103 113 107 101 108 103 115 105 105 109 112 113
57
12   137 131 135 131 153 145 157 149 153 129 147 165 145 160 161 173 173 189 173 157
     159 157 145 149 131 133 125 125 139 137 152 138 129 124 128 125 121 109 121 121
     153 144 143 141 113 115 109 105 115 135 157 121 117 105 107  97  95 104  93 102
     123 120 111 120 115 113 105 109  96 119 125 113 111 111 116 101 105 115 101  93
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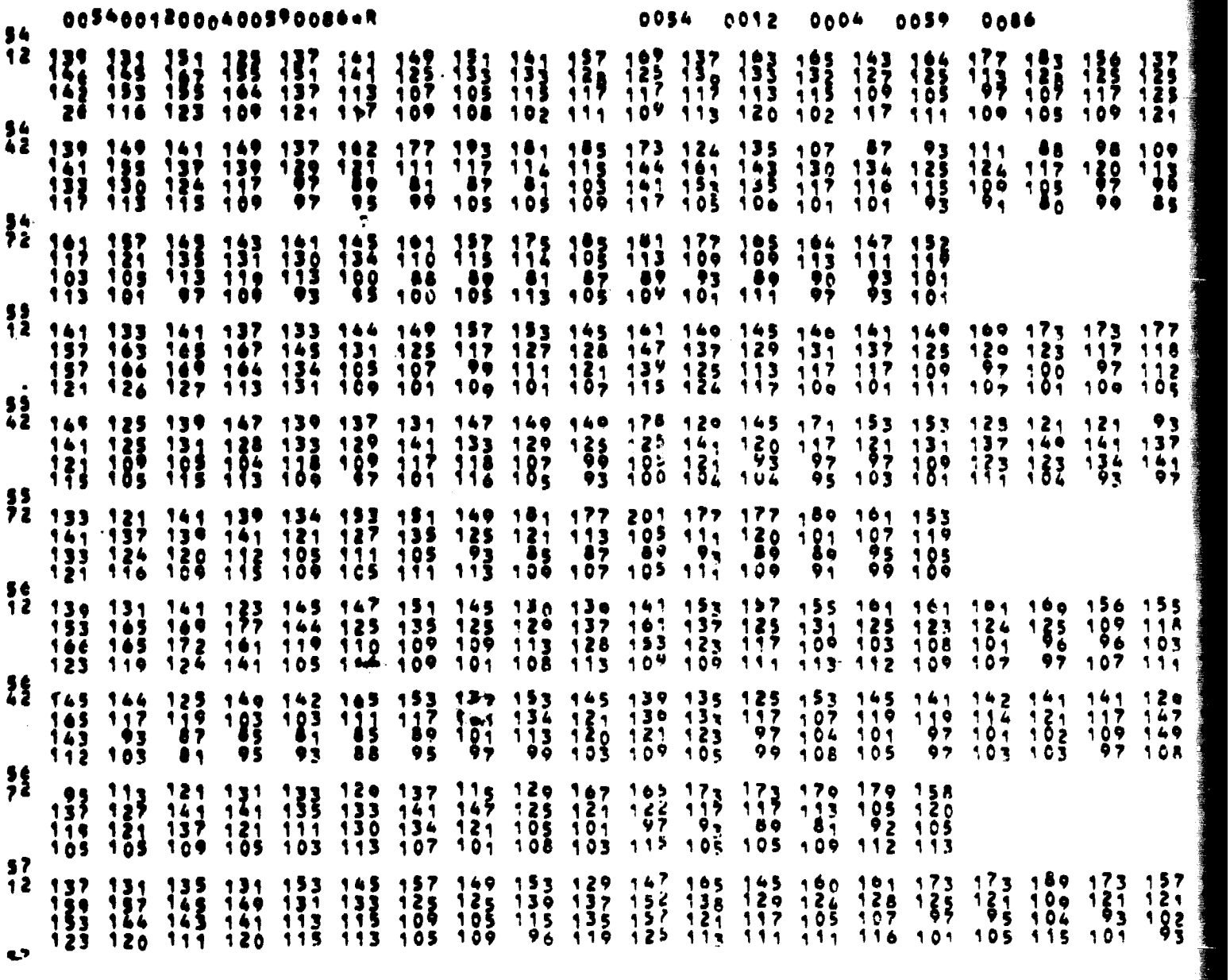
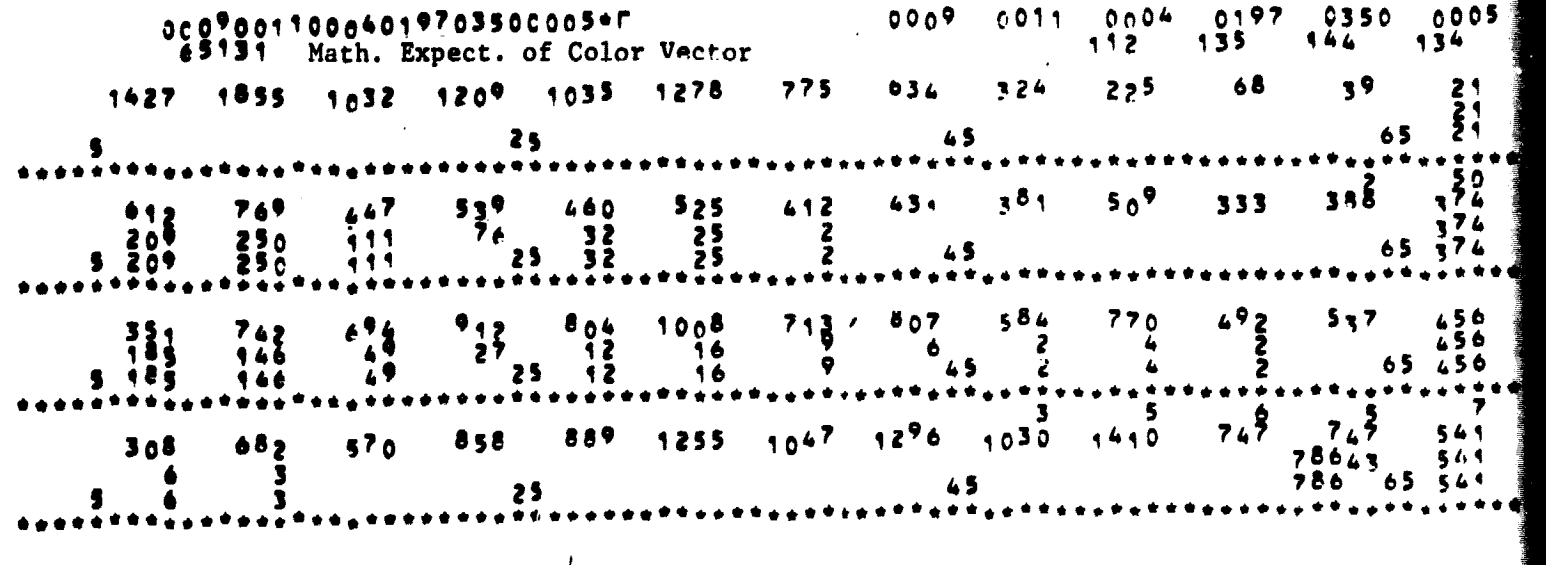




```
     0009001100040197035000 05*Г                          0009  0011  0004  0197  0350  0005
      65131  Math. Expect. of Color Vector                                  112   135   144   134

     1427  1855  1032  1209  1035  1278   775   634   324   225    68    39    21
                                                                                 21
   5                      25                        45                        65  21
*****************************************************************************************
                                                                                2    50
      612   769   447   539   460   525   412   431   381   509   333   388   374
      209   250   111    76    32    25     2                                      374
   5  209   250   111    25    32    25     2     45                        65  374
*****************************************************************************************

      351   742   694   912   804  1008   713   807   584   770   492   537   456
      185   146    49    27    12    16     9     6     2     4     2         456
   5  185   146    49    25    12    16     9    45     2     4     2     65  456
*****************************************************************************************
                                                          3     5     6     5     7
      308   682   570   858   889  1255  1047  1296  1030  1410   747   747   541
        6     3                                                      78643   541
   5    6     3          25                        45                  786  65  541
*****************************************************************************************
```

19

FOLDOUT FRAME

0054 0012 0004 0059 0086

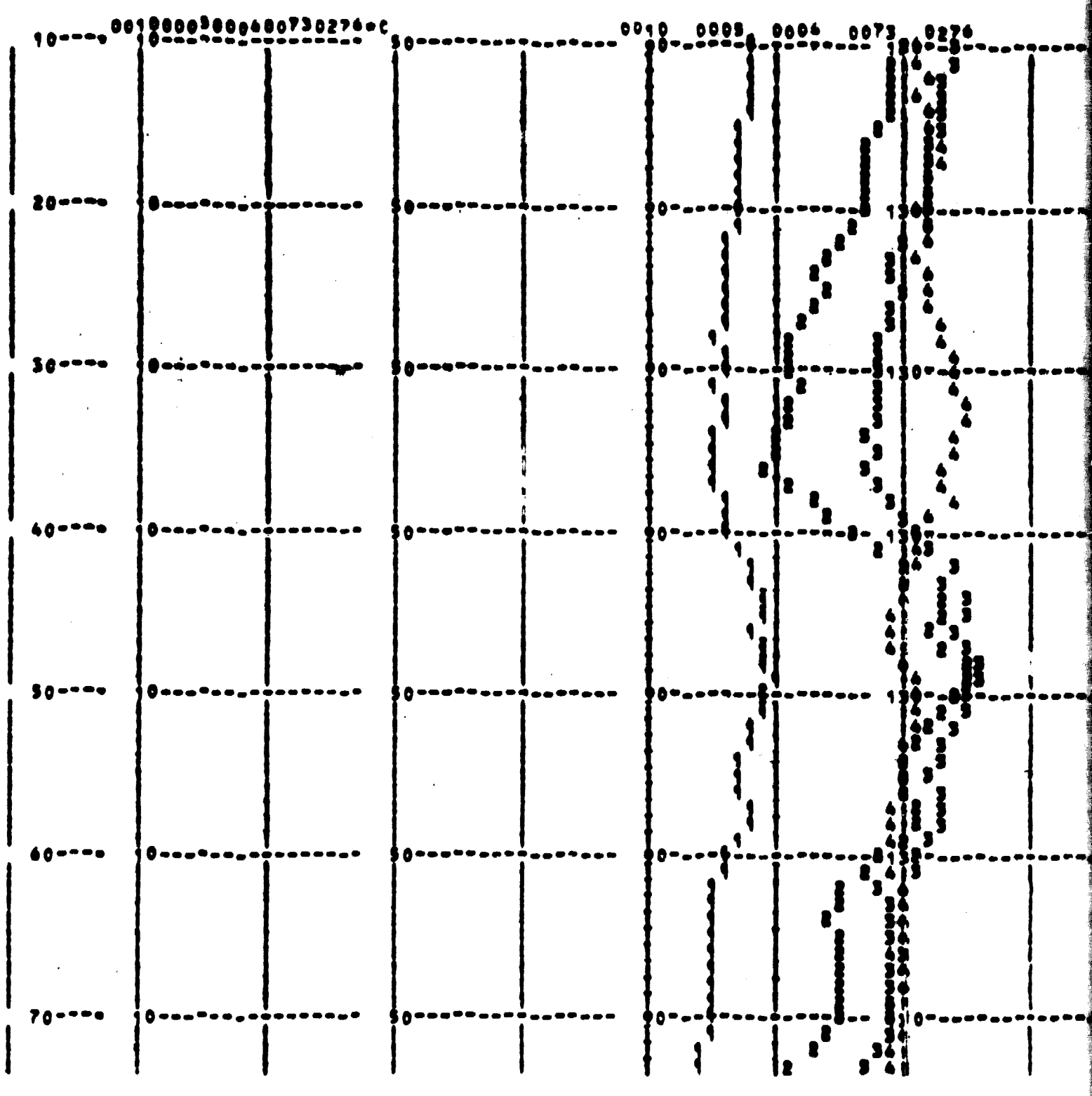
109	137	103	105	143	104	177	183	156	137	137	173	1	9	131	131	137	147	147	149	131
125	139	153	132	127	125	113	128	125	125	142	115	1	5	145	145	125	113	121	126	158
117	119	113	115	100	103	97	107	117	125	135	109	1	1	121	135	99	81	97	120	146
109	113	120	102	117	111	109	105	109	121	121	101		9	105	107	107	95	106	109	99
173	124	135	107	87	93	111	88	98	109	101	124	1	3	119	124	142	147	149	151	157
144	161	143	130	134	125	124	117	120	113	121	148	1	0	126	136	140	145	129	125	135
141	153	135	117	116	115	109	105	97	96	113	130	1	9	135	135	131	117	104	103	97
117	105	106	101	101	93	91	80	99	85	97	105	1	9	116	117	113	101	106	89	107
181	177	105	164	147	152															
113	109	100	113	111	118															
89	93	89	90	93	101															
109	101	111	99	93	101															
141	140	145	146	141	140	109	173	173	177	145	157	1	7	121	121	147	135	133	143	161
147	137	129	131	137	125	120	123	117	118	146	129	1	2	127	131	117	105	120	121	141
139	125	113	117	117	109	97	100	97	112	129	107	1	3	125	133	105	81	93	111	125
115	124	117	109	101	111	109	101	100	105	115	119	1	9	105	116	111	89	93	99	117
178	120	145	171	153	153	129	121	121	93	105	89		1	100	88	103	103	105	119	124
123	141	120	117	121	131	137	140	141	137	128	148	1	5	142	129	133	136	153	141	147
105	121	93	97	97	109	123	123	134	141	121	125	1	5	115	116	128	137	141	145	141
100	104	104	95	103	101	111	104	93	97	90	105		7	101	100	106	105	115	109	113
201	177	177	189	161	153															
105	111	120	101	107	119															
89	93	89	89	95	105															
105	111	109	91	99	109															
141	153	157	155	161	161	161	169	156	155	167	165	1	3	128	113	147	139	151	159	145
161	137	125	131	125	123	124	125	109	118	135	113	1	9	137	124	143	107	113	113	139
153	123	117	109	103	108	101	96	96	103	113	107	1	3	121	122	120	81	89	93	130
109	109	111	113	112	109	107	97	107	111	109	91	1	1	101	107	115	105	101	99	109
139	135	125	153	145	141	142	141	141	128	105	101	1	5	129	105	104	101	87	99	95
130	131	117	107	119	119	114	121	117	147	147	137	1	3	155	165	161	157	153	133	146
121	123	97	104	101	97	101	102	109	149	137	133	1	1	157	165	157	145	131	131	121
109	105	99	108	105	97	103	103	97	108	112	105	1	1	109	119	105	111	103	105	101
165	173	173	179	179	158															
122	119	117	113	105	120															
97	93	80	81	92	105															
115	105	105	109	112	113															
147	105	145	160	101	173	173	189	173	157	163	173	1	7	113	120	151	141	153	143	131
152	138	129	124	128	125	121	109	121	121	127	111	1	9	135	130	119	101	109	109	125
157	121	117	105	107	97	95	104	93	102	108	89	1	6	125	133	101	77	80	85	113
125	113	111	111	116	101	105	115	101	95	119	109	1	5	113	113	101	95	93	97	101

0009 0011 0004 0197 0350 0005

112 135 144 134

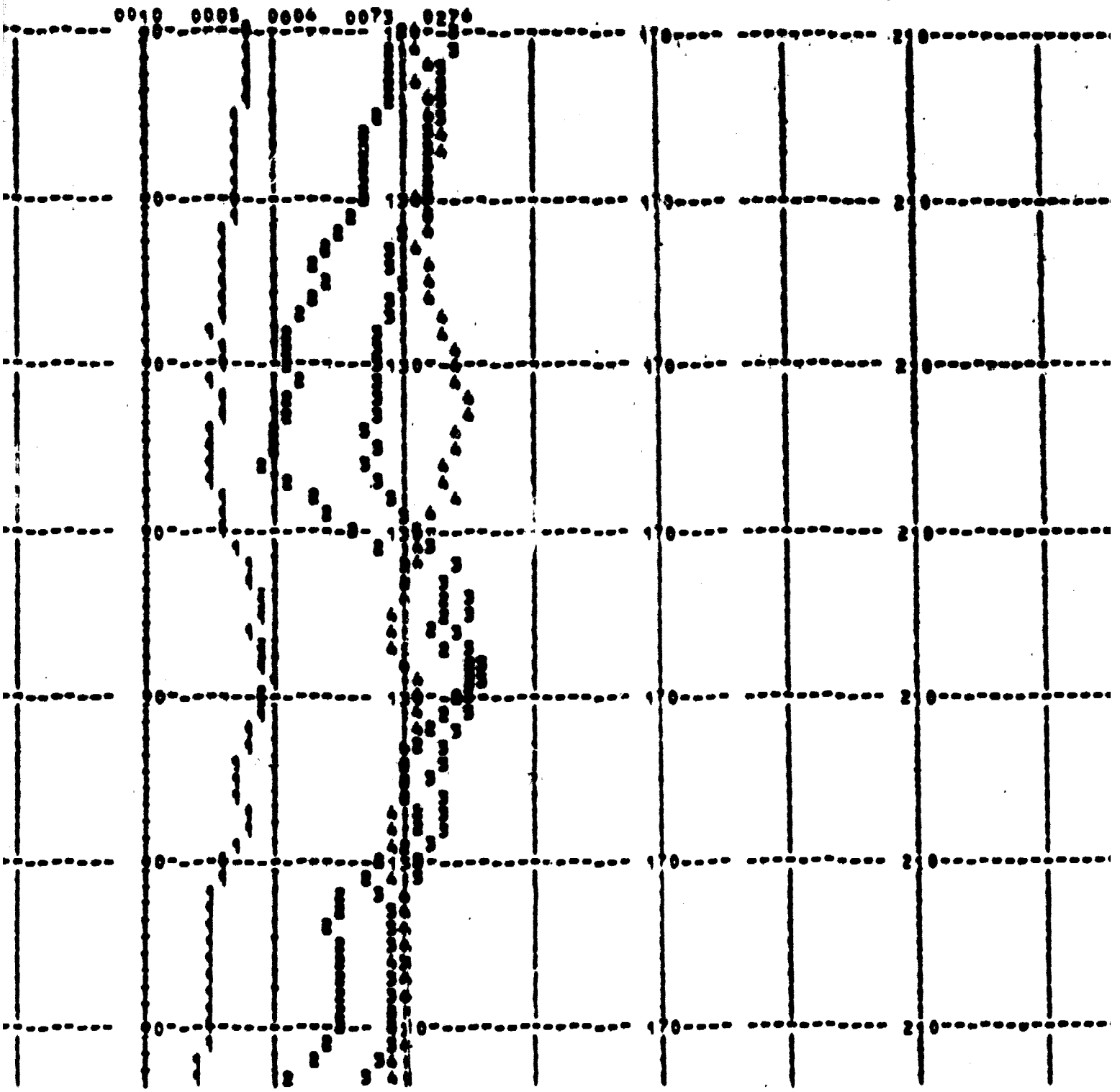
									1		7		47		130		613		828	1443
775	634		324		225		68		39		21		15		4		3		1	
											21		15		4		3		1	
		45								65	21		15		4			85	1	
									2		50		226		205		0		371	
612		434		381		509		333		388		174		553		365		35		445
2												374		553		365		35		445
2			45							65		374		553		365			85	445
713		807		584		770		492		537		456		680		420		81		403
9			6		2		4		2			456		680		420		81		403
9			45		2		4		2		65	456		680		420			85	403
047		1296		1030		1410		747		747		541		512		206		55		80
									78643			541		512		206		55		80
			45						786		65	541		512		206			85	80

FOLDOUT FRAME 2 20



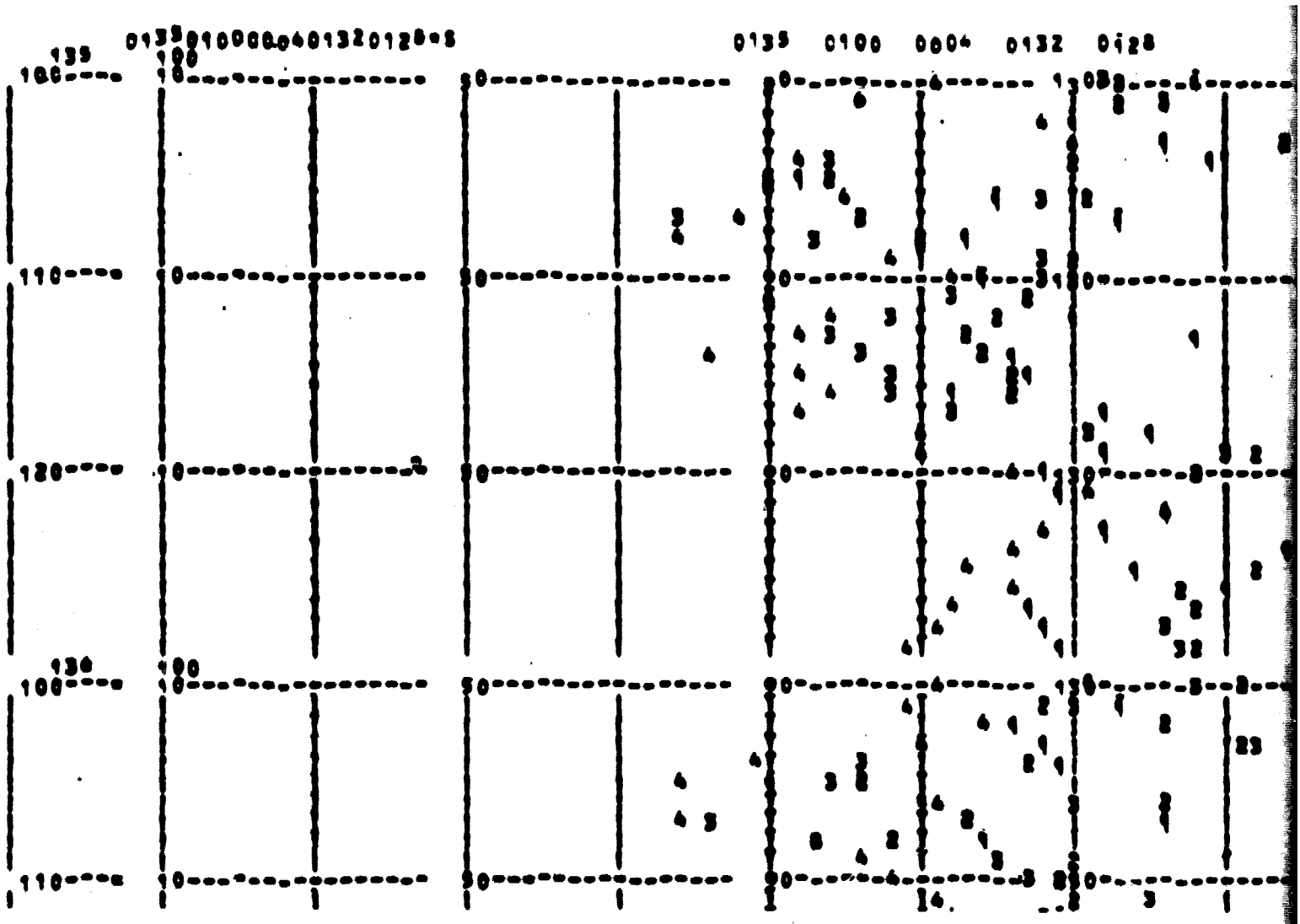
0022 0001 0004 0099 0200

Channel$_1$.	Range of intensities	(100,110)	Math expectation	=104;	Dispersion=
Channel$_2$.	Range of intensities	(200,250)	Math expectation	=206;	Dispersion=
Channel$_3$.	Range of intensities	(100,200)	Math expectation	=133;	Dispersion=
Channel$_4$.	Range of intensities	(50,100)	Math expectation	= 91;	Dispersion=



022 0001 0004 0099 0200

)	Math expectation	=104;	Dispersion=	10
)	Math expectation	=206;	Dispersion=	28
)	Math expectation	=133;	Dispersion=	7
)	Math expectation	= 91;	Dispersion=	12



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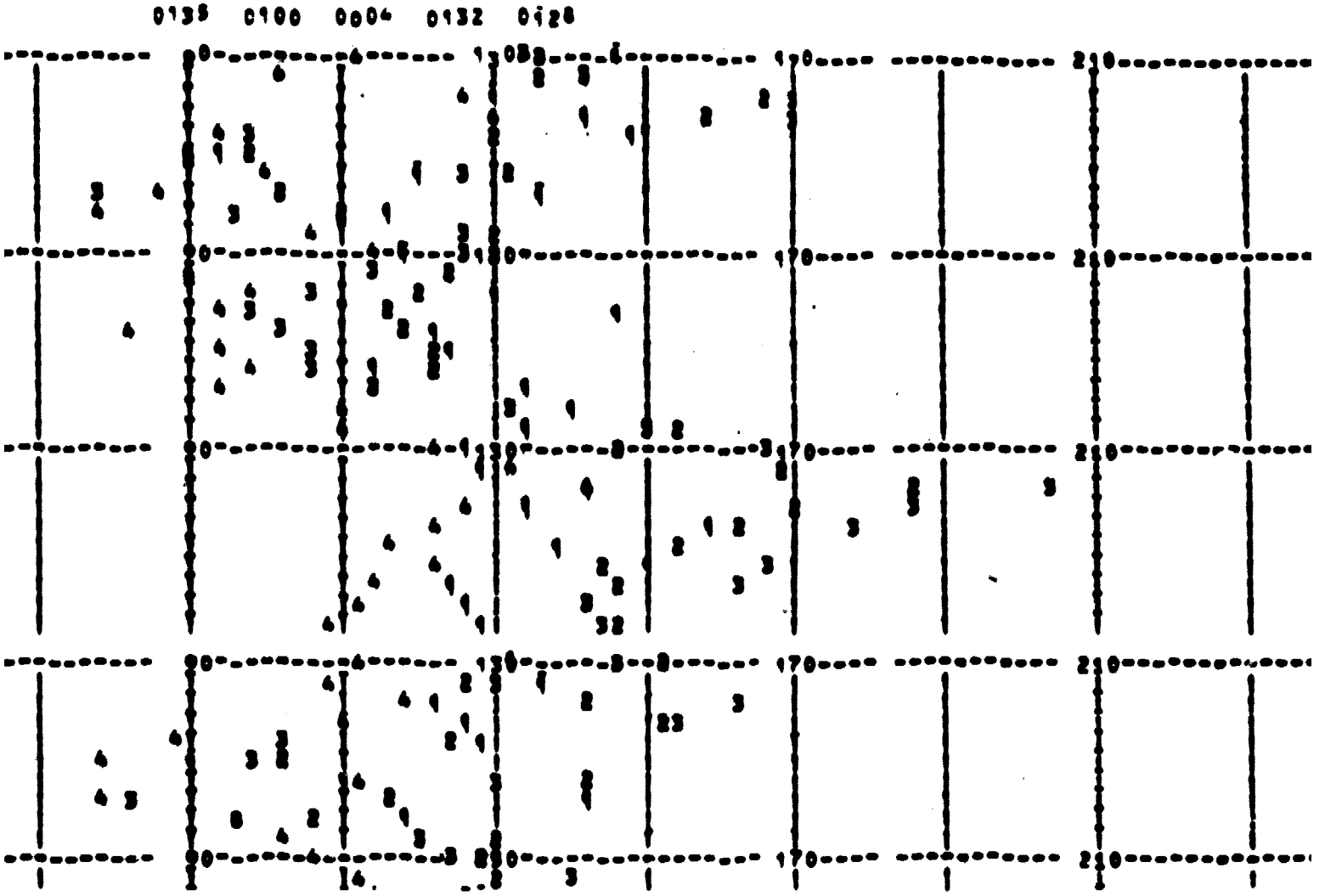
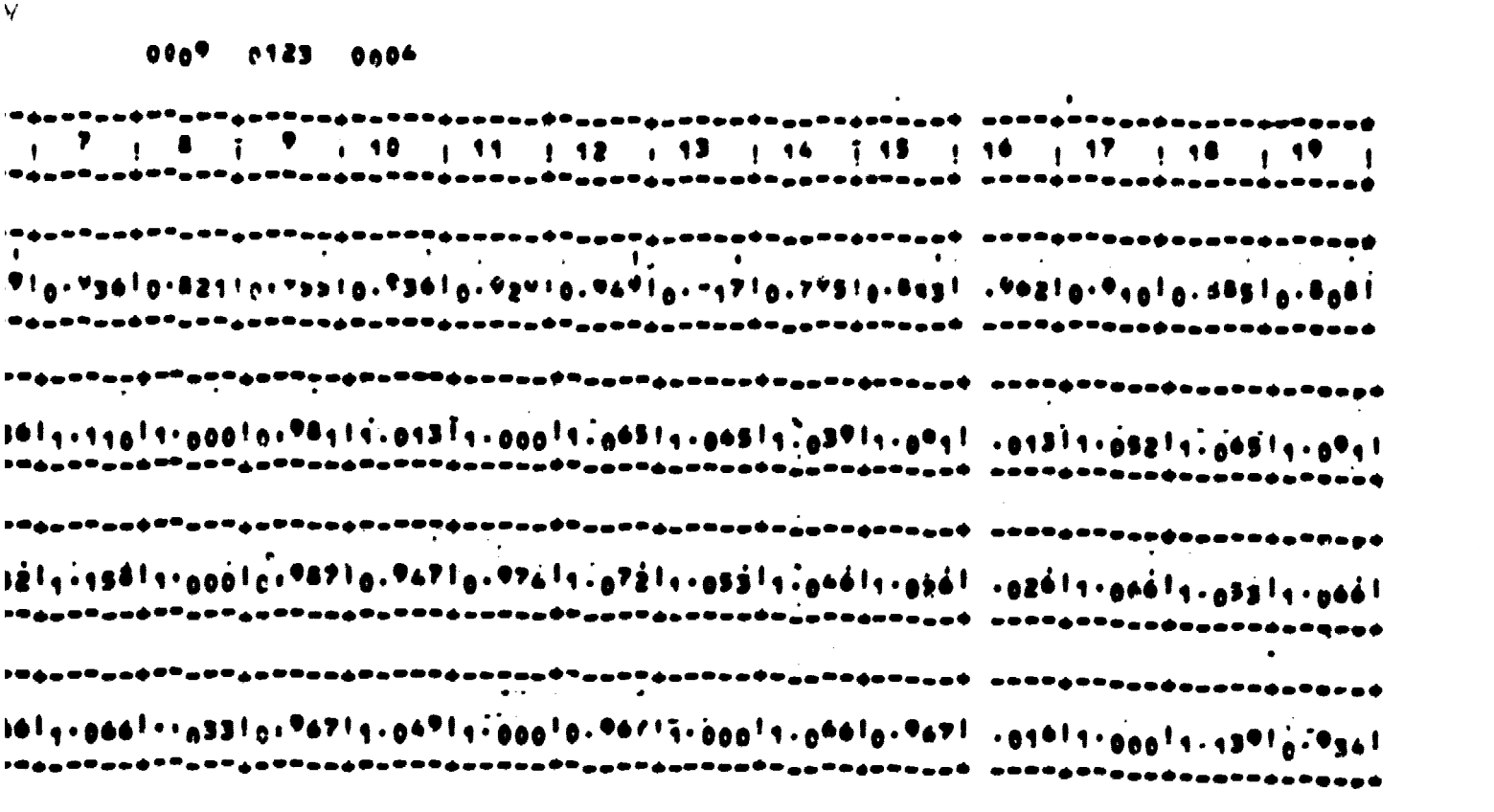
Se	1	2	3	4	5	6	7	8	9	10	11	12	13
Chan .# 1													
KAN.# 2													
KAN.# 3													
KAN.# 4													

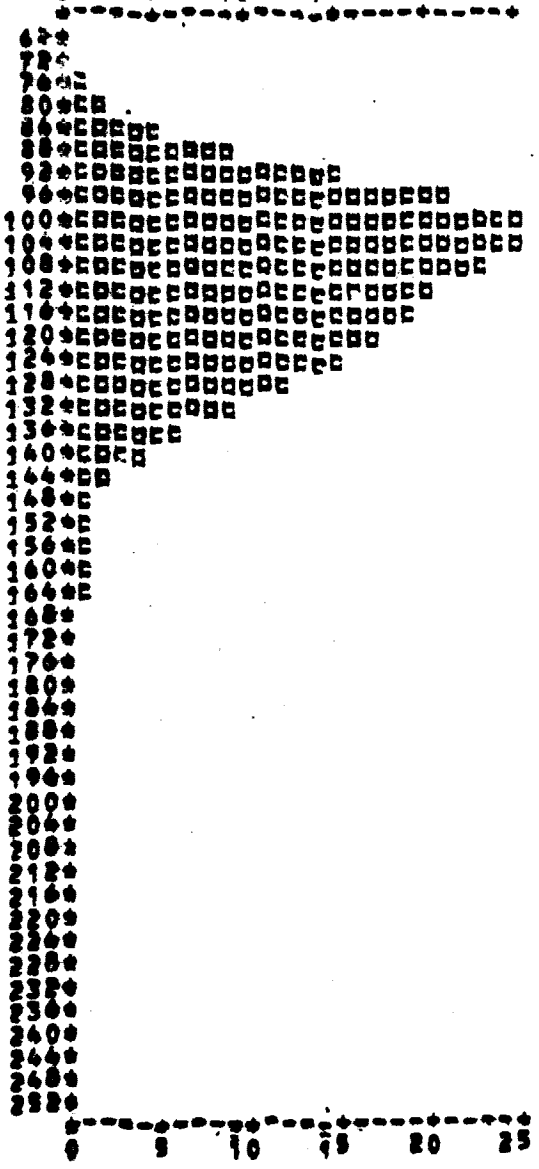




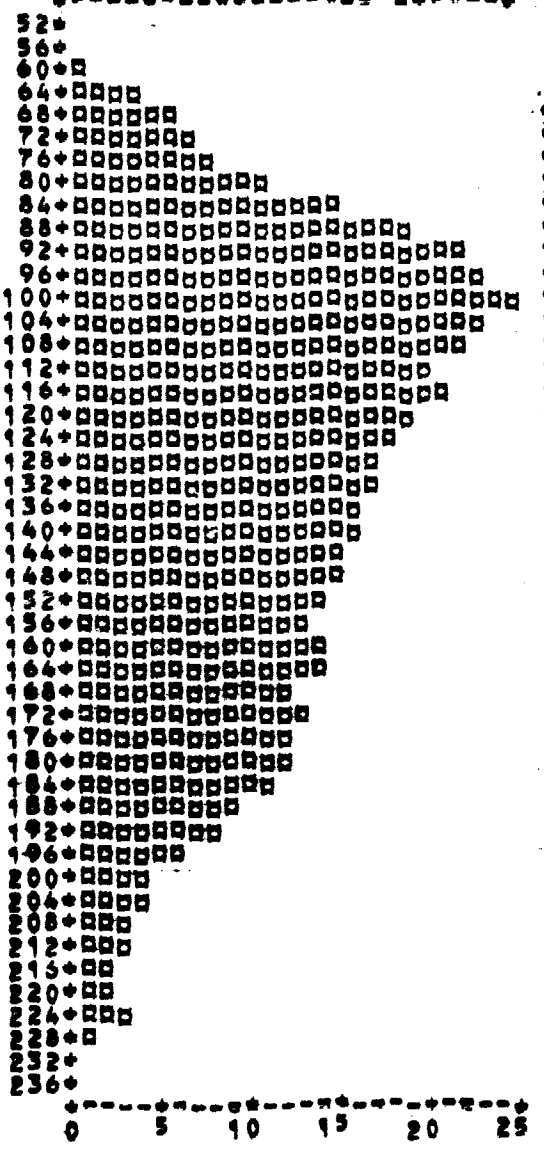
READOUT FRAME 2

0010002200060333030000004*FF 0010 0022 0004 0333 0300 0006

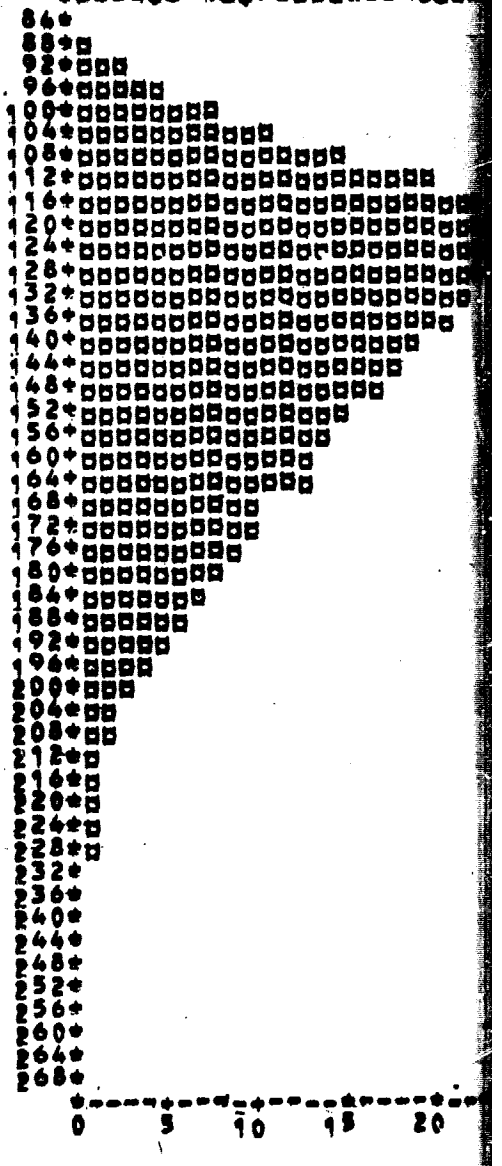
Channel 1
Quantum 100
Has the maximum frequency
0.107817
Value of the quantum of the ordinate
0.004313



Channel 2
Quantum 100
Has the maximum frequency
0.047774
Value of the quantum of the ordinate
0.001911



Channel 3
Quantum 120
Has the maximum frequency
0.066895
Value of the quantum ordinate
0.002596



000*0001000401970350*M. 0009 0001 0004 0197 0350

66339 Math. Expect. of Color Vector 111 133 143 134

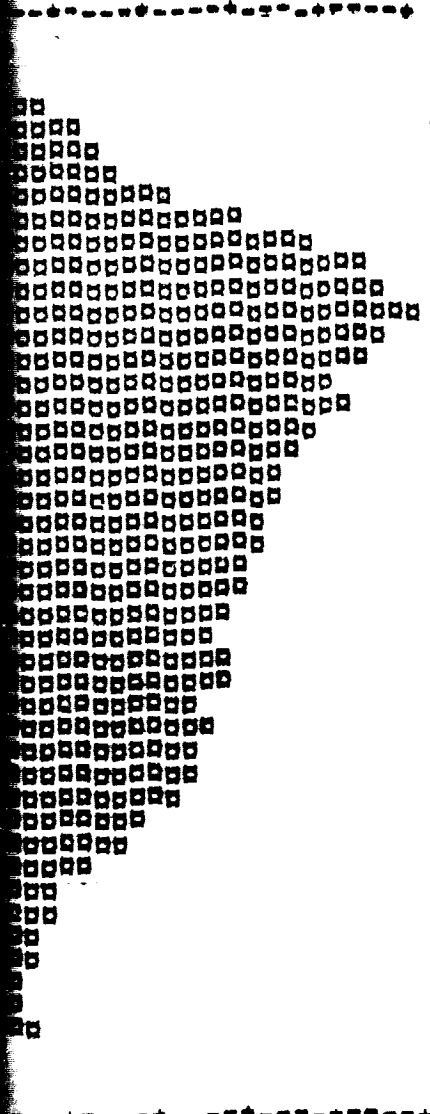
.123002700064*G 0123 0027 0004

# DATA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
KAN, # 1	145	173	137	121	119	122	117	125	111	109	97	111	124	120	119	120	126	119	135	12
KAN, # 2	0	121	125	133	154	154	153	167	140	120	127	133	121	115	118	119	113	115	134	11
KAN, # 3	0	114	0	153	167	161	183	169	123	107	115	120	99	99	97	107	105	111	109	11
KAN, # 4	0	152	6	36	113	127	130	123	109	89	103	97	93	100	91	109	97	113	97	10

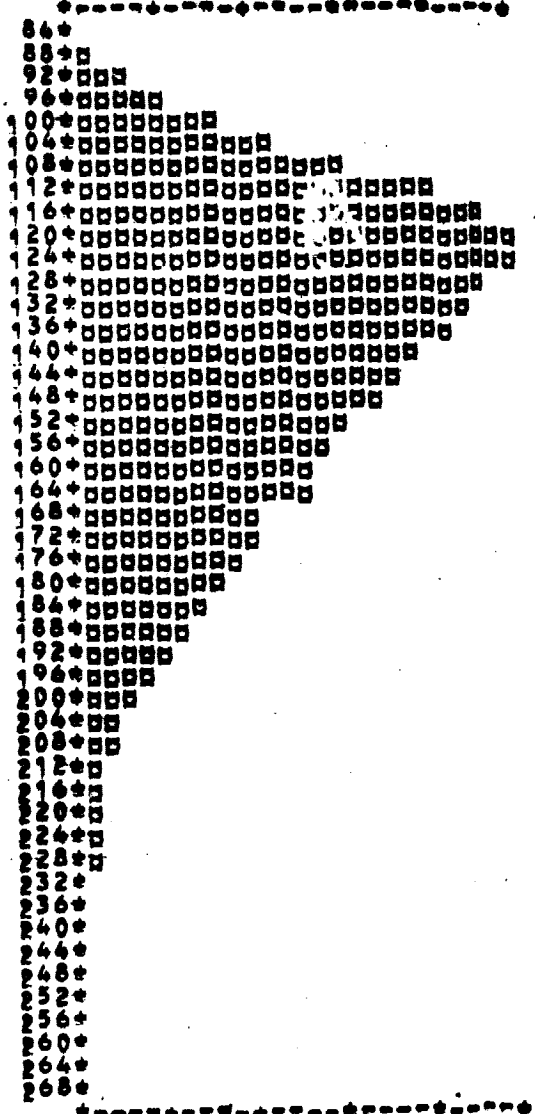
FOLDOUT FRAME

0018 0022 0004 0333 0300 0004

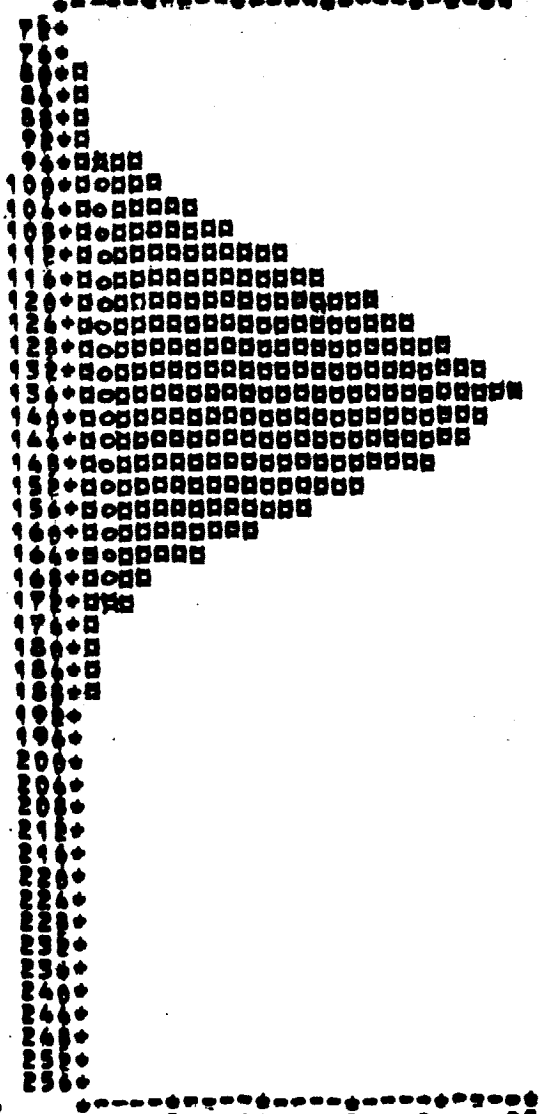
Channel 2
um 100
he maximum frequency
0.047774
f the quantum of the ordinate
0.001911



Channel 3
Quantum 120
Has the maximum frequency
0.066895
Value of the quantum ordinate
0.002596



Channel 4
Quantum 130
Has the maximum frequency
0.207420
Value of the quantum ordinate
0.008049



0009 0004 0004 0197 0350

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111 133 145 134

0123 0027 0004

8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
125	111	109	97	111	124	120	119	128	126	119	135	125	125	153	133	105	119	113	121
167	140	120	127	133	121	113	118	117	115	115	134	113	124	127	99	113	131	133	120
169	123	109	115	120	99	99	97	107	105	111	109	116	115	108	89	101	105	109	111
125	105	89	103	107	93	100	91	109	97	113	97	107	113	108	87	94	100	99	101

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