

A PROGRAM SYSTEM FOR DIAGNOSTICAL CLINICAL LABORATORY DATA PROCESSING AND SURVEY CONTROL

By

P. HANTOS, and M. VAJTA, JR.

Department of Automation, Technical University, Budapest

Received September 14, 1976

Presented by Prof. Dr. F. CSÁKI

Introduction

An important task of our Department is the development of application software for the Hungarian-made minicomputer R-10. In this context the research of the medical application of computer technics is of special importance. Our eager partner in this multiple and complex work is the collective of physicians of the Bajcsy-Zsilinszky Hospital, Budapest.

This paper deals with the computer processing of clinical laboratory test results.

The clinical laboratory is fitted in the first place into the diagnostical information system of the hospital. All the departments of the hospital and the out-patient treatment service — if it exists — may ask for laboratory tests. The therapeutical activities of the laboratory are — apart from the preparation of a few specific vaccines — negligible. The units of haematology, parasitology, immunology, bacteriology and virology show an increasingly independent development both methodologically and in their professional fields and become independent departments in higher developed institutions.

Nevertheless, there are certain common requirements in all these fields, such as:

- standardization of processes to be performed in various laboratories,
- reproducibility of test results obtained by identical processes,
- reduction of the cycle-periods of each test,
- reduction of the test sample quantities,
- classification and processing of the obtained data,
- introduction of new diagnostical methods in correspondence with the development of the professional field,
- economy.

The role of computer processing in the fields listed above is obvious. The program systems to be described are called to assist the diagnostic work of the physicians, and the activities of the clinical laboratory staff.

The second part of this paper presents the specific laboratory activities in the grouped testing network. The laboratory of the Bajcsy-Zsilinszky Hospital has been invited to take part as a "guest" in a similar network in the FRG.

Our task was to create a similar system also in Budapest, led by the laboratory of the Bajcsy-Zsilinszky Hospital. The purpose of the network is to control, qualify and assist clinical laboratories.

2. The laboratory subsystem of the Computerized Patient Record System

2.1. *The on-line Clinical Information System*

A clinical information system involves various documents of the physician-patient connections as information. The contents and forms of these documents are very different, yet certain identical characteristics permit to combine these documents into a group. Each observation related to a patient, the case-history sheet, the temperature chart, etc. are parts of a single case of illness, so they must form a single storage unit. The documents of the case have fundamentally two purposes. Primarily: Setting the care-therapeutical process, the information of the attending physician. In this case we wish to handle the data in the on-line mode.

Secondarily: Research. The case of illness is closed, the patient left the hospital and his case is stored in the archives. Here an off-line access is proposed, to permit more complex processing.

The research carried out at the Department involves development of an on-line system. The advantage of the computer is that it does not supply the case-sheet, but directly the required information in real-time, within a few seconds (Fig. 1). The program system intended to process the cases stored in the archives must be constructed on quite different principles, so only the junction points have been defined. The input of the archives processing program is the Archives File, obtained as output in the on-line system. The structure of the Archives Patient Record (APR) is shown in Fig. 2. The system is of a hierarchical structure with the smallest meaningful unit standing in the lowest point. These data elements are stored a single time, independent of how many times and for how many purposes they are going to be utilized.

The IPR library contains all the critical data of all the patients, who are at this time in the hospital, it is essentially the transient data base of the system. The transient data base is recorded on the fix-headed disc of 1.6 Mbyte capacity. The average access time to a sector is 10 ms, the IPR records may be accessed directly (Direct Access Method). The IPR records consist

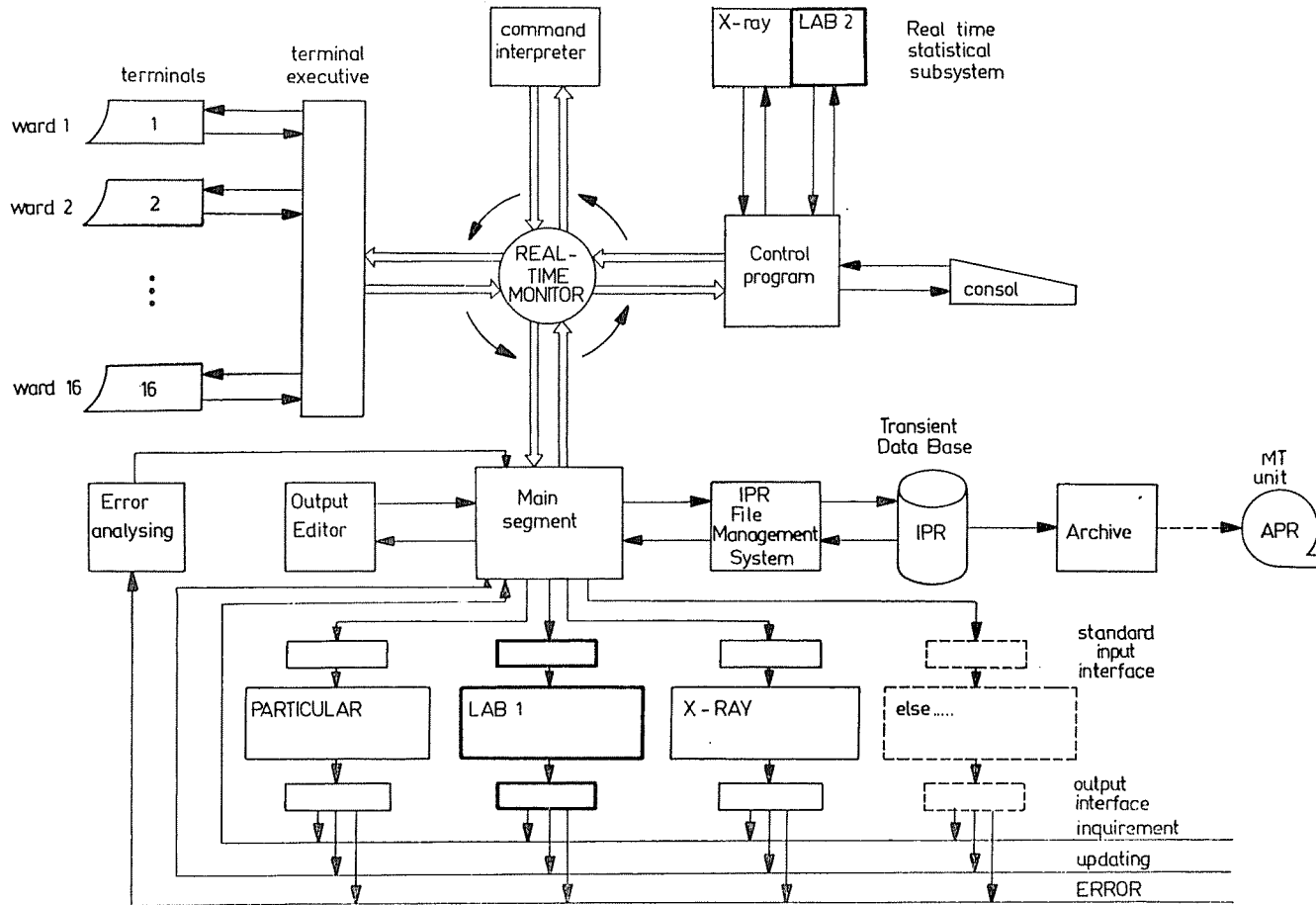


Fig. 1. On-line Interactive Patient Register System

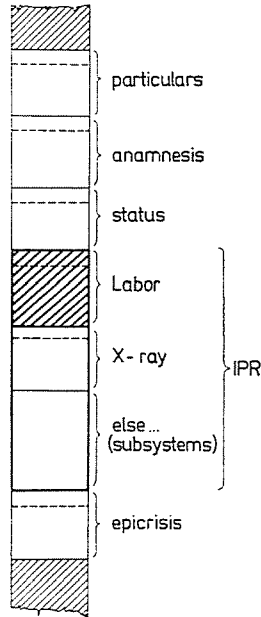


Fig. 2. Archive Patient Record (APR)

logically of three parts: personal data, X-ray data and laboratory test data. By adding further subsystems, the IPR is accordingly extended. The minimum length of the above blocks is 1/2 sector (128 byte), the maximum length is 4 sectors. The records of various lengths are handled by the IPR File Management System. For the sake of a fast access, we did not decompose essentially the sector organization of the disc, had been managed in spite of the fact that a one-byte access would have resulted in a significantly compacter structure.

2.2. The program LAB1

2.2.1. The program LAB1 has two functions:

- in the case of data input it codes the laboratory test result fed in the input interface and stores it in the laboratory segment of the IPR of the involved patient;
- in the case of retrieval it carries out the call command arriving in the input interface. At the level Laboratory Subsystem the call may be test-oriented, or time-oriented. The program compiles the called off data in decoded form in a disc output work-space. Controlling the printout is the task of the TERMINAL EXECUTIVE.

The Subsystems join the MAIN SEGMENT through the unified input interface (Fig. 3.) The output interface may be of three types, depending on the function:

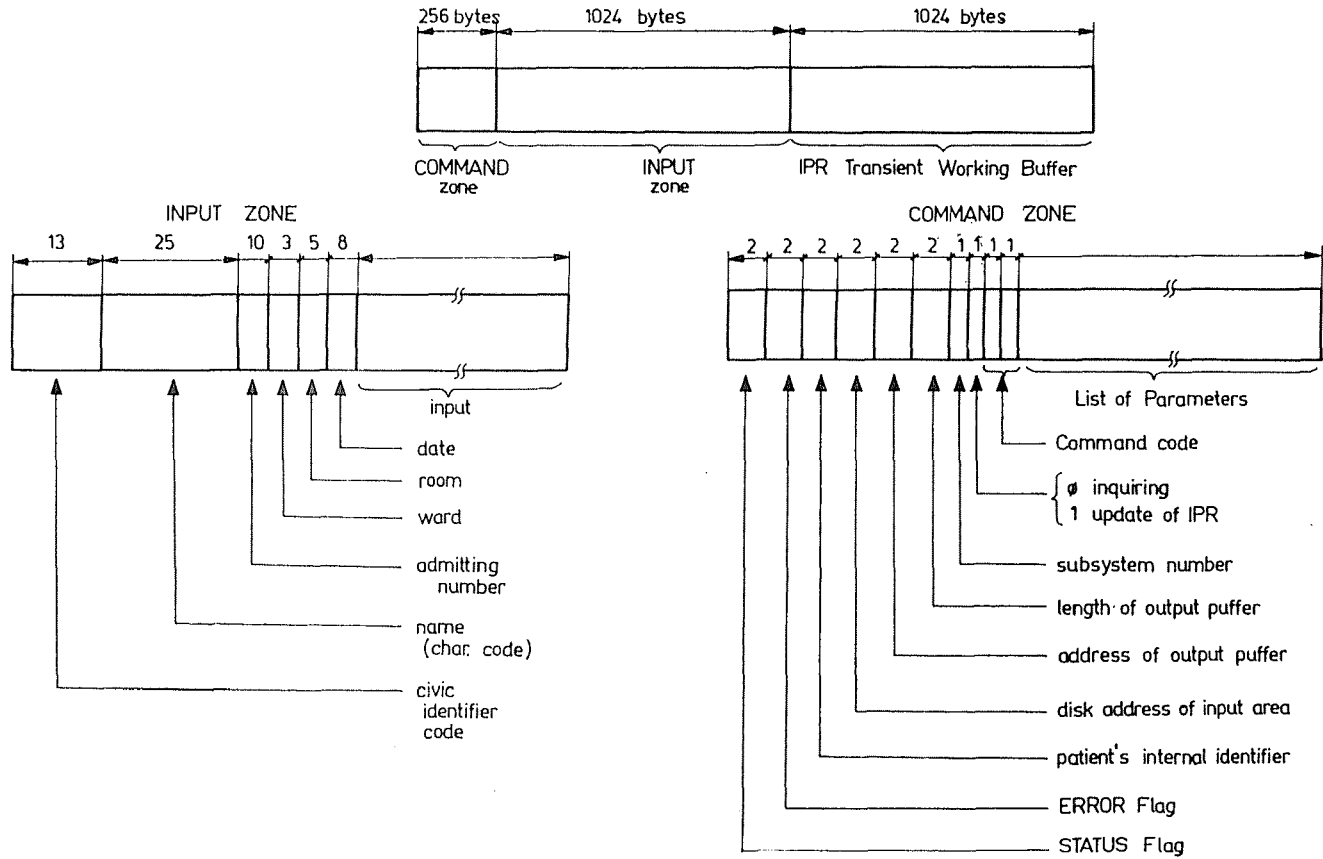


Fig. 3. Standard Input Interface

– in the case of calling-off the answer to be printed on the terminal is generated on the disc output work field with the help of the OUTPUT EDITOR;

– in the case of extension and data input, the extension is carried out in the transient work area of the IPR. So at the time of output, the updated IPR is in the interface field;

– in the case of error the operation of the subsystem is suspended and the error is indicated on the error-flag of the command field.

2.2.2. The logic data structure of the laboratory test data may be studied on Fig. 4. An element of the matrix contains the result of a certain test at a given date.

EXAMINATION DATE		Group 1			Group 2			...	Group 9		
		1.1	1.2	...	2.1	2.2	9.1	9.2	...
1	08.03.75		X							X	
2	09.03.75					X					
3	01.04.75										
4	03.04.75	X								X	
5	08.04.75										
6	09.04.75										
	⋮										

Fig. 4. Structure of Labor Data

The matrix elements may be of the following types:

- integer, e.g. SODIUM 15 mval/l;
- real, e.g. HAEMOGLOBIN 22.3 gr/100 ml;
- coded, e.g. VDRL REACTIO ++.

If a test has been omitted, its place is “empty” in the matrix. The central laboratory of a universal hospital is equipped as an average for carrying out 90 to 100 types of tests; during his stay in the hospital one patient is subject to 14 to 70 tests. The expected number of the tests is about 17, representing 14 routine tests + 3 specific tests. The data were established on the basis of trial processing performed in Medical Department No. 3 of the Bajesy-Zsilinszky Hospital.

2.2.3. Clinical laboratory data flow scheme:

- The attending physician encircles the serial number of the required tests on the Laboratory Data Sheet (Fig. 5);
- Sampling;

name of Hospital		LABOR DATA											
<table border="1"> <tr> <td>ID. NUMBER:</td> <td>12756473101</td> </tr> <tr> <td>NAME:</td> <td>JANOS KOVATS</td> </tr> <tr> <td>INT. NUMBER:</td> <td>6520 / 22</td> </tr> <tr> <td>WARD:</td> <td>01</td> </tr> <tr> <td>ROOM:</td> <td>02</td> </tr> </table>				ID. NUMBER:	12756473101	NAME:	JANOS KOVATS	INT. NUMBER:	6520 / 22	WARD:	01	ROOM:	02
ID. NUMBER:	12756473101												
NAME:	JANOS KOVATS												
INT. NUMBER:	6520 / 22												
WARD:	01												
ROOM:	02												
Date:	02. 03. 75	time:	<input type="text" value="8"/> h										
1. MAIN GROUP													
<input type="radio"/> 1.	Se - bilirubin	<input type="text" value="3"/> . <input type="text" value="2"/> mg/100ml	<input type="text"/>										
<input type="radio"/> 2.	Se - bilirubin qualitative r.	direct <input type="radio"/> D indirect <input checked="" type="radio"/> I	<input type="text"/>										
<input type="radio"/> 3.	Thymol r.	<input type="text" value="1"/> . <input type="text" value="12"/> E	<input type="text"/>										
<input type="radio"/> 4.													

Fig. 5. Structure of Labor Data Paper

— Preparation of the material and the pertinent information: the nurse takes the glue-backed labels from the name card holder of the examined patient. The label contains the internal identification data of the patient (the label is prepared by the "Personal" subsystem). The nurse glues one label each on the Data Sheet and on the sample material receiver. She applies the data on the labels by the data-printer;

— The material and the Data Sheet are transferred to the laboratory;
 — Next step: laboratory dispatcher activity and the execution of the tests;

— Documentation and on-line interactive data input to the transient data base are the last steps in the process.

2.2.4. A critical problem is the design of the correct storage structure. The structure had to be designed from the aspect of fast calling off. The access to the IPR is direct access, while processing of the IPR is sequential. The IPR is processed in the storage, so the time problem is irrelevant. An advantage is the high grade exploitation of the storage. The rows of the matrix consisting of unified size data are compacted into vectors of various lengths and the vectors are continuously assembled. The data is identified by regarding

it the 63rd — otherwise non-existent — test of the 15th group. The length of the data elements stored in the IPR is 4 byte, their construction is the following:

Date:

No. of bit	Field length (bit)	Remark
∅	4	Date (compressed)
4	4	Contents: 15 ₁₀
8	3	Contents: ∅
11	5	Contents: 63 ₁₀
16	4	Year relative to '75
26	4	Month
24	8	Day

Test result:

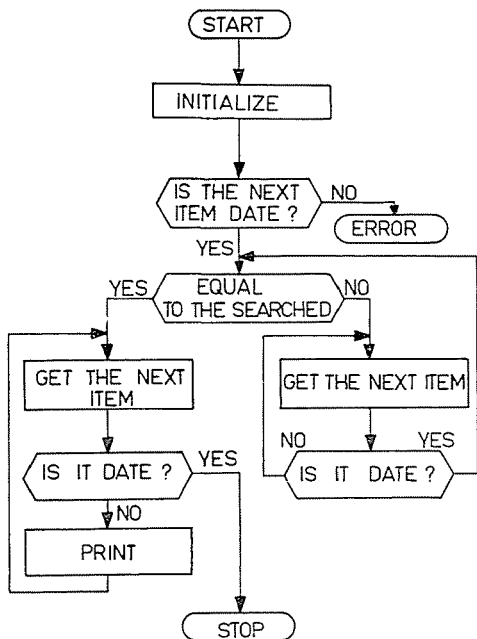
No. of bit	Field length (bit)	Remark
∅	1	Can the result be accommodated in a unit?
1	3	Type code
4	4	Group number
8	3	Code of "Result non evaluable"
11	5	Serial number within the group
16	16	Result zone

2.2.5. At the level of the subsystem two types of retrieval strategies may be conceived (Fig. 6):

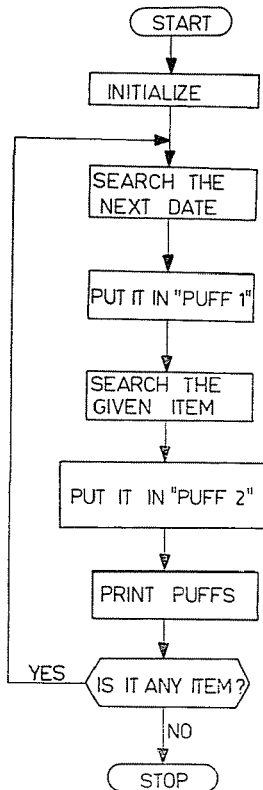
- at what date and with what result was a given test performed: this means a movement in the given column of the logic structure;
- at a given date which tests were performed and with what results: this means a movement in a given row.

2.3. The program LAB2

2.3.1. The program LAB2 continuously records the performance of, and load on, the Central Laboratory and performs the methodological control of the laboratory tests. The first function is of interest mainly for the Hospital Management and Health Statistics, the second service is claimed by the senior



"Per Line" Searching Method



"Columned" Searching Method

Fig. 6. Searching Methods

physician leading the laboratory. Every time, when the subsystem LAB1 introduces a new test result into the transient data base, the program LAB2 increases the content of the corresponding element of the counter field in the tabulated form. The counter fields record dynamically the state and the activities of the Central Laboratory. The statistics of the Central Laboratory work is prepared by calling off the contents of the above counter fields with the help of appropriate algorithms.

The program is constructed of independent segments, corresponding to the procedures required. The connection link is the commonly used table. A part of the procedures serves for updating the table, the rest for calling off. The table — due to its dimensions — is output on discs. On turning to the table, the sectors containing the required counter field is computed and fed alone into the storage this sector only.

Examina- tions	Wards			
	1	2	...	n
1.1				
1.2				
1.3		A_{ij} / B_{ij}		
⋮				
9.6				

Fig. 7. Structure of the Counter Zone

2.3.2. The logic construction of the main table is shown in Fig. 7.

A_{ij} : number of test i required by the j -th department during the given week;

B_{ij} : number of test i required by the j -th department during the month.

The construction of the disc file realizing the table is as follows:

Byte-address	Field length byte	Meaning
0	2	Number of points assigned to test 1.1
2	2	Number of tests on the given day
4	2	Average of tests on the given day
6	8	Reserve
14	2	A_{11}
16	2	B_{11}
18	2	A_{12}
20	2	B_{12}
.	.	.
.	.	.
.	.	.
68	2	Reserve for one new department
70	2	Number of points assigned to test 1.2
72	2	Number of tests on the given day
74	2	
.	.	
.	.	
.	.	

The occupied space is about 17 kbyte, one test takes a field of 70 bytes. In this random structure a total of max. 250 tests can be taken into account. The presented structure — irregarding completions — is obtained by the continuous row extension of the table in Fig. 7. The table records the data of 13 hospital departments and one extension possibility is built in.

2.3.3. In contrary to the preceding real-time nature access the calling-off is a batch process.

a) The performance of the Central Laboratory during the given week, or month by departments: The value of the corresponding counter field is weighted by the number of points assigned to the test, as the number of tests alone does not characterize the load.

b) List of all the tests required by the given department during the given week, or month;

c) The departments, which asked for a given test during the given week, or month;

(During calling off the data under b), c), the departments are controlled from the aspect of whether the text requirements were justified or not.)

d) The arithmetical mean of the results of the given test on the given day: naturally only for test giving a numerical results. The chief physician of the Laboratory performs the systematic control on the basis of the above data.

3. Survey Control

The sequential and permanent control is one of the most important conditions of the reliable functioning of the clinical laboratories. Usually the clinical laboratory analyses are routine examinations. In many cases the results of the clinical laboratory analysis give the basic information for the medical diagnostics. Because of this fact the day-to-day routine analyses have to be made at a high accuracy, and reliability; it is a very important task to control the work of a clinical diagnostical laboratory.

The surveys to be introduced in this item refer to the quality control of the clinical laboratories. The same serum has been distributed between many laboratories taking part in the scheme. The laboratories had to make the prescribed analyses of the serum and return the results — as soon as possible — to the organizing (or central) laboratory, where the statistical data processing would be done by digital computers. One of the main advantages of the digital data processing is to reduce the time interval between the distribution of the material and getting back the results. For a too long interval it is difficult to assess the effects of the results on the precision and accuracy of the work in the laboratories. It may be noted that the control of accuracy in the laboratories is not a static one.

In recent years some survey controls took place in the clinical laboratories in Budapest (Hungary). The scheme has been guided by the laboratory of the Bajcsy-Zsilinszky Hospital, headed by Dr. Imre Horváth. Generally the prescribed analyses were: potassium, sodium, calcium, chlorine, phosphorus, urea-nitrogen, rest-nitrogen, haemoglobin, uric acid, ferrum, glyucose. Let us note that this laboratory took part as an invited member in a similar scheme in the Federal Republic of Germany some years ago. To statistically evaluate the survey control results, a computer program package was elaborated by the authors.

A short introduction will be given to this program package presenting also some examples and results.

3.1. Statistical Data Processing

In most surveys the specimens consisted of more lyophilized animal serum. This serum distributed between the clinical laboratories, may be of two different origins:

- a) standard serum,
- b) serum made specifically by the central laboratory.

Exact value of the results are necessary to control the accuracy of the work in each laboratory. In the case a), the factory gives the exact value of the chemical component substances of the serum to be considered as reference values for quality control.

In the case b), the exact values of the components are unknown. Then the reference values will be obtained on a digital computer as the corrected statistical results of the laboratory.

The statistical data processing is made as follows:

- 1) The sample mean and standard deviation are computed:

$$m_s = E\{x_i\} = \frac{1}{N} \sum_{i=1}^N x_i \quad (1)$$

$$\sigma_s = \text{Var} \{x_i\} = \left(\frac{1}{N-1} \sum_{i=1}^N (x_i - m_s)^2 \right)^{1/2}$$

where m_s is the sample mean, σ_s is the standard deviation, N the number of laboratories participating in the same experiment, x_i is the result of the i -th measurement.

- 2) The coefficient of variation (CV) is computed

$$\text{CV}_1 = \frac{m_s}{\sigma_s} [\%] \quad (2)$$

and so is the variance index (VI):

$$\text{VI} = \frac{1}{N_i} \sum_{i=1}^N g(z_i) \quad (3)$$

where N_i is the number of experiments in the i -th laboratory, $g(z_i)$ is the step function with the argument:

$$z_i = \frac{x_i - m_s}{\sigma} \tag{4}$$

and

$$g(z) = \begin{cases} 0 & \text{if } |z| < 1 \\ 1 & \text{if } 1 \leq |z| < 2 \\ 2 & \text{if } 2 \leq |z| < 3 \\ 3 & \text{if } 3 \leq |z| < 4 \\ 4 & \text{otherwise} \end{cases} \tag{5}$$

The function $g(z_i)$ is seen to give the accuracy of the i -th measurement (Fig. 8) referred to the standard deviation.

3) Related to the measurements, a confidence interval is determined (see Fig. 9). After removal of all points outside the confidence interval (in this case twice the standard deviations on either side of the sample mean):

$$m_s - 2\sigma_s \leq x_i \leq m_s + 2\sigma_s$$

the statistics are recomputed, to give the recomputed sample mean (m_{rs}) and the recomputed standard deviation (σ_{rs}), the recomputed coefficient of vari

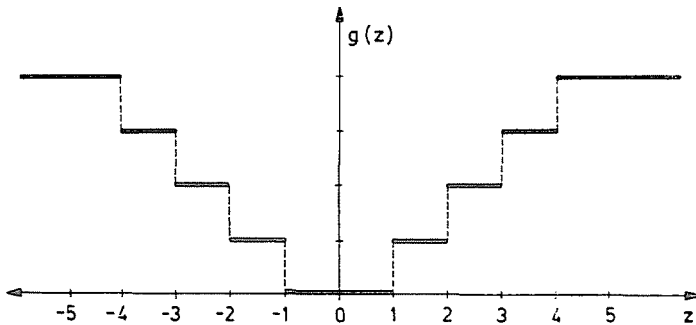


Fig. 8. Function $g(z)$

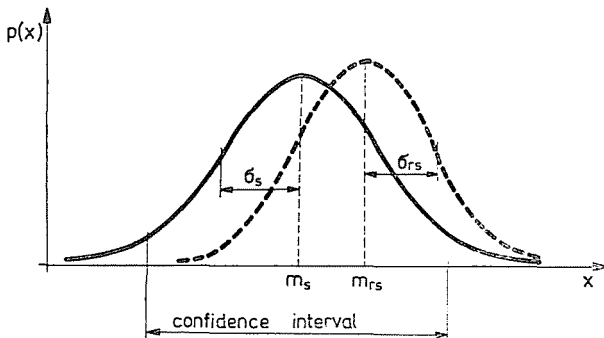


Fig. 9. Confidence interval; m_s - sample mean, σ_s - standard deviation, m_{rs} - recalculated sample mean, σ_{rs} - recalculated standard deviation

Fig. 10. Statistical results of the 6th survey control
from the week ending on 23. 10. 1975 number of lab. = 110

Measurements	Laboratory	Serum-A				
		<i>N</i>	<i>m</i>	σ	CV	VI
Potassium	all lab.	80	4.28	0.38	8.78	0.288
	selected lab.	76	4.28	0.27	6.20	0.375
	reference	0	4.20	0.27	6.20	0.375
Sodium	all lab.	81	141.40	4.60	3.25	0.309
	selected lab.	75	141.25	3.25	2.30	0.407
	reference	0	141.00	3.25	2.30	0.407
Calcium	all lab.	87	4.85	0.69	14.28	0.207
	selected lab.	83	4.81	0.38	7.98	0.322
	reference	0	4.60	0.38	7.98	0.322
Chlorine	all lab.	80	103.64	5.88	5.68	0.250
	selected lab.	77	103.92	4.10	3.94	0.250
	reference	0	103.00	4.10	3.94	0.250
Phosphorus	all lab.	80	3.43	0.70	20.44	0.325
	selected lab.	74	3.44	0.53	15.50	0.313
	reference	0	3.20	0.53	15.50	0.313
Urea-N.	all lab.	83	16.31	4.08	25.04	0.169
	selected lab.	80	15.98	2.33	14.60	0.325
	reference	0	15.00	2.33	14.60	0.325
Rest-N.	all lab.	13	32.77	7.51	22.91	0.385
	selected lab.	12	31.42	5.96	18.98	0.231
	reference	0	31.42	5.96	18.98	0.231
Creatinin	all lab.	74	1.01	0.30	29.64	0.392
	selected lab.	71	0.99	0.24	23.73	0.324
	reference	0	0.80	0.24	23.73	0.324
Carbamide	all lab.	63	4.26	0.73	17.22	0.333
	selected lab.	61	4.26	0.66	15.38	0.365
	reference	0	4.00	0.66	15.38	0.365
Ferrum	all lab.	63	99.97	30.35	30.36	0.175
	selected lab.	62	97.06	19.90	20.50	0.333
	reference	0	76.00	19.90	20.50	0.333
Glucose	all lab.	99	87.39	11.56	13.23	0.323
	selected lab.	96	86.16	9.18	10.66	0.313
	reference	0	86.00	9.18	10.66	0.313
Haemoglobin	all lab.	107	12.75	0.84	6.57	0.336
	selected lab.	102	12.68	0.66	5.24	0.364
	reference	0	12.68	0.66	5.24	0.364

(cont.)

Measurements	Laboratory	Serum-B				
		<i>N</i>	<i>m</i>	σ	CV	VI
Potassium	all lab.	85	6.73	0.51	7.64	0.318
	selected lab.	80	6.76	0.38	5.63	0.306
	reference	0	6.76	0.38	5.63	0.306
Sodium	all lab.	86	107.76	14.17	13.15	0.198
	selected lab.	83	108.16	8.31	7.69	0.291
	reference	0	108.16	8.31	7.69	0.291
Calcium	all lab.	100	4.28	1.13	26.29	0.290
	selected lab.	93	4.16	0.77	18.48	0.270
	reference	0	4.16	0.77	18.48	0.270
Chlorine	all lab.	91	80.73	5.73	7.10	0.253
	selected lab.	87	80.85	4.47	5.53	0.385
	reference	0	80.85	4.47	5.53	0.385
Phosphorus	all lab.	89	27.52	6.88	25.01	0.315
	selected lab.	83	28.48	5.00	17.54	0.281
	reference	0	28.48	5.00	17.54	0.281
Urea-N.	all lab.	91	66.31	18.55	27.97	0.209
	selected lab.	90	64.99	13.70	21.08	0.341
	reference	0	64.99	13.70	21.08	0.341
Rest-N.	all lab.	18	81.22	17.18	21.15	0.389
	selected lab.	18	81.22	17.18	21.15	0.389
	reference	0	81.22	17.18	21.15	0.389
Creatinin	all lab.	94	3.77	0.81	21.60	0.319
	selected lab.	91	3.71	0.65	17.41	0.372
	reference	0	3.71	0.65	17.41	0.372
Carbamide	all lab.	0	0.00	0.00	0.00	0.000
	selected lab.	0	0.00	0.00	0.00	0.000
	reference	0	0.00	0.00	0.00	0.000
Ferrum	all lab.	80	390.81	122.22	31.27	0.250
	selected lab.	74	394.86	70.37	17.82	0.363
	reference	0	394.86	70.37	17.82	0.363
Glycose	all lab.	109	306.63	31.55	10.29	0.349
	selected lab.	104	305.28	25.89	8.48	0.367
	reference	0	305.28	25.89	8.48	0.367
Haemoglobin	all lab.	109	8.92	0.73	8.20	0.303
	selected lab.	100	8.79	0.47	5.40	0.367
	reference	0	8.79	0.47	5.40	0.367

N = number of laboratories, *m* = sample mean, σ = deviation, CV. = coefficient of variance ($100 \times \sigma/m$), VI = variance index

Statistical results of the joint measurements in the 6th survey control

	Potassium	Sodium	Calcium	Chlorine	Phosphorus	Urea-N.
Number	72	74	80	72	68	79
Mean	4.18	141.14	4.82	104.01	3.46	15.97
	6.75	107.97	4.12	80.91	28.29	64.66
Deviation	0.26	3.09	0.38	4.08	0.51	2.33
	0.38	8.33	0.73	4.50	4.57	12.92
Covariance	0.05	-4.24	0.11	8.15	0.55	7.54
Correlation	0.477	-0.165	0.404	0.444	0.237	0.250
Lin. regr. X	0.678	-0.445	0.785	0.488	2.140	1.385
Lin. regr. Y	4.715	131.24	2.172	34.757	27.476	60.664

Fig. 11. Correlation coefficients of the 6th survey control

ance (RCV) and the recomputed variance index (RVI). Let us note that the recomputed sample mean is nearly equal to the sample mean ($m_{rs} \approx m_s$), but the recomputed standard deviation must be smaller than the standard deviation ($\sigma_{rs} < \sigma_s$) [3]. In the case b), if the exact values of the serum components are unknown, the recomputed sample mean (m_{rs}) is considered as reference value.

4) Usually two specimens are distributed (below: "serum-A" and "serum-B"). The laboratory has to make the same analysis on both serums. In this case the correlation coefficient is given by:

$$r = \frac{\sum_{i=1}^{N_0} (x_i - m_A)(y_i - m_B)}{\left(\sum_{i=1}^{N_0} (x_i - m_A)^2 \right) \left(\sum_{i=1}^{N_0} (y_i - m_B)^2 \right)} \quad (6)$$

where N_0 is the number of laboratories having made both analyses on serums-A (x_i) and (y_i), m_A is the corrected sample mean of measurement X_i , m_B is the same for serum-B. Let us note that some laboratories do not make one of the measurements (that is $x_i - y_i$), so:

$$N_0 \neq N; \quad m_A \neq m_{rs}^A; \quad m_B \neq m_{rs}^B.$$

The statistical data processing is finished by computing the correlation coefficients. In Fig. 10 the statistical results of the 6th survey control made October 27th, 1975, are presented. Although both serums were standard ones, some of the components were unknown. The exact value of the components

		Rest-N.	Creatinin	Uric acid	Ferrum	Glycose	Haemogl.
	Number	12	69	0	55	94	93
Mean		31.42	1.00	0	97.31	86.01	12.65
		79.67	3.72	0	396.35	304.85	8.78
Deviation		5.71	0.23	0	19.55	9.03	0.60
		17.98	0.66	0	75.54	24.87	0.47
Covariance		79.89	0.08	0	195.77	53.93	0.19
Correlation		0.779	0.509	0	0.133	0.240	0.668
Lin. regr.	X	2.452	1.448	0	0.512	0.661	0.521
Lin. regr.	Y	55.207	3.217	0	383.45	284.21	0.332

were only known in advance for potassium, sodium, calcium, chlorine, phosphorus, urea-nitrogen, creatinin, uric acid, ferrum and for rest-nitrogen. Haemoglobin were unknown in serum-A. In the latter case the recomputed sample mean was considered as a reference value for each component in serum-B. This is clearly seen in Fig. 10.

Fig. 11 shows the correlation coefficient values computed.

3.2. Qualification of the laboratories

On the basis of the statistical results, the laboratories are easy to classify. The program computes the variance index for each laboratory. Depending on the function $g(z)$ (see (3) to (5)), each measurement is rated by an integer number between 0–4, expressing the measurement accuracy related to the recomputed standard deviation (Fig. 12). After the statistical data processing,

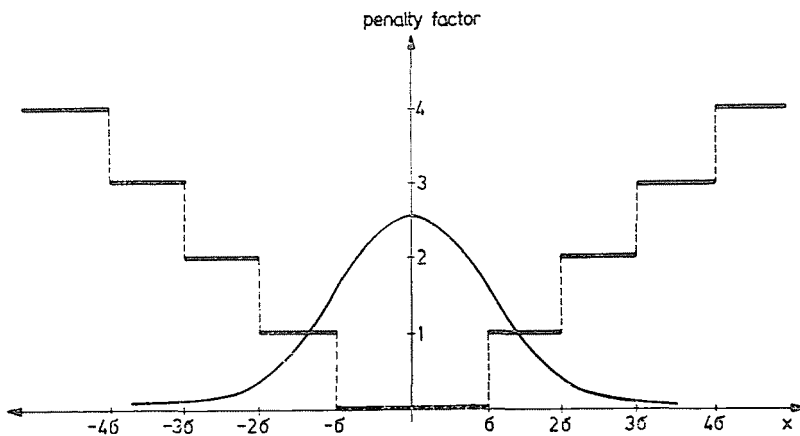


Fig. 12. The penalty factor depending on the distribution of data

each laboratory has two VI values, one for measurements on serum-A, the other for serum-B. Lower VI values mean higher classification. Generally, the VI values range from 0 to 1, 2.

If every VI of each laboratory is known, the VI histogram can be established. This histogram shows the average goodness of the survey control. In this case the mean of the VI values can also be recomputed and so can be the standard deviation. Figs 13 and 14 show the histograms of the variance index of the 6th survey control. The mean values and the standard deviations are:

	Serum-A	Serum-B
Mean	0.60812	0.70862
Deviation	0.40964	0.49741

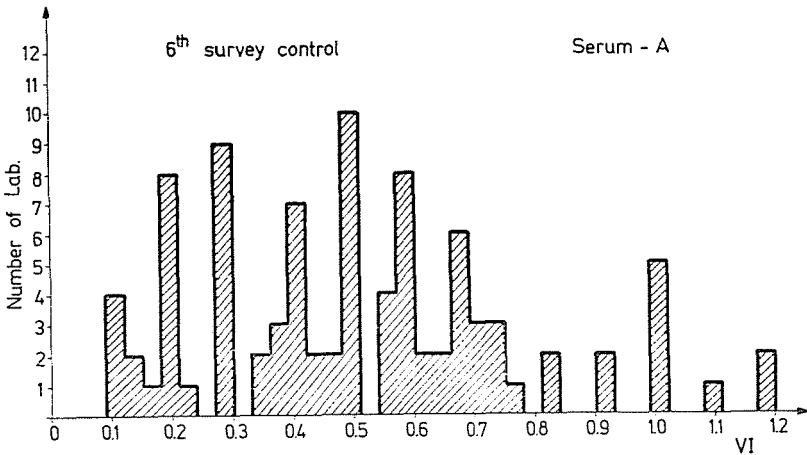


Fig. 13. Histogram of variance index (VI) of the 6th survey control for serum A.

Let us note that the qualification of the laboratories (or the variance index) is not static, but dynamic. So the variation with time of the VI-histogram gives the best information about the improvement or impairment of the results as an average.

The joint (x_i, y_i) results plotted in Figs 15 and 16 show results for potassium and sodium of the 6th survey control. The first step in classifying a laboratory is to determine the error $(x_i - m_{r_s})$ computed to a standard deviation (σ_{r_s}) ratio. Therefore, points inside the inner rectangle are within the confidence interval $\pm \sigma_{r_s}$ for both experiments, points between the two rectangles

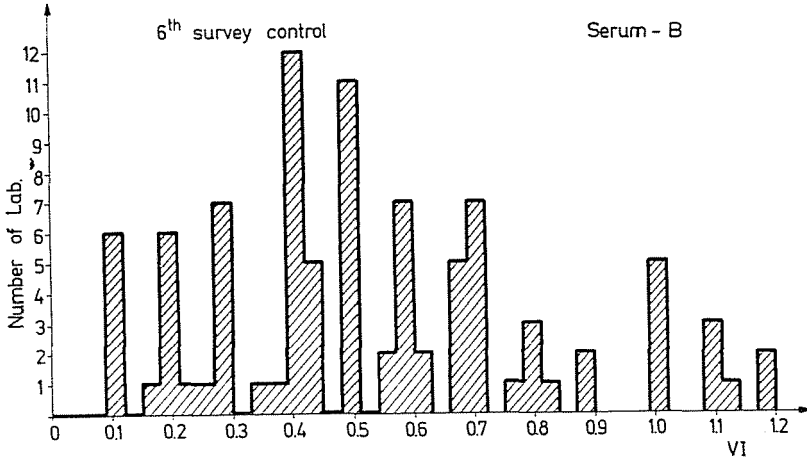


Fig. 14. Histogram of variance index (VI) of the 6th survey control for serum B

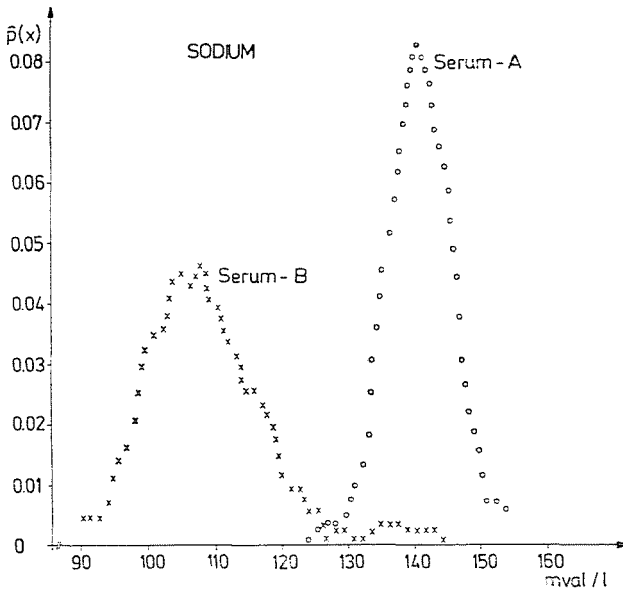


Fig. 15. Joint measurements for potassium

are within $\sigma_{rs} < \text{error} \leq 2\sigma_{rs}$ region. Most of the results are seen inside the inner rectangle and between the two rectangles, that is, inside the $\pm 2\sigma_{rs}$ confidence interval.

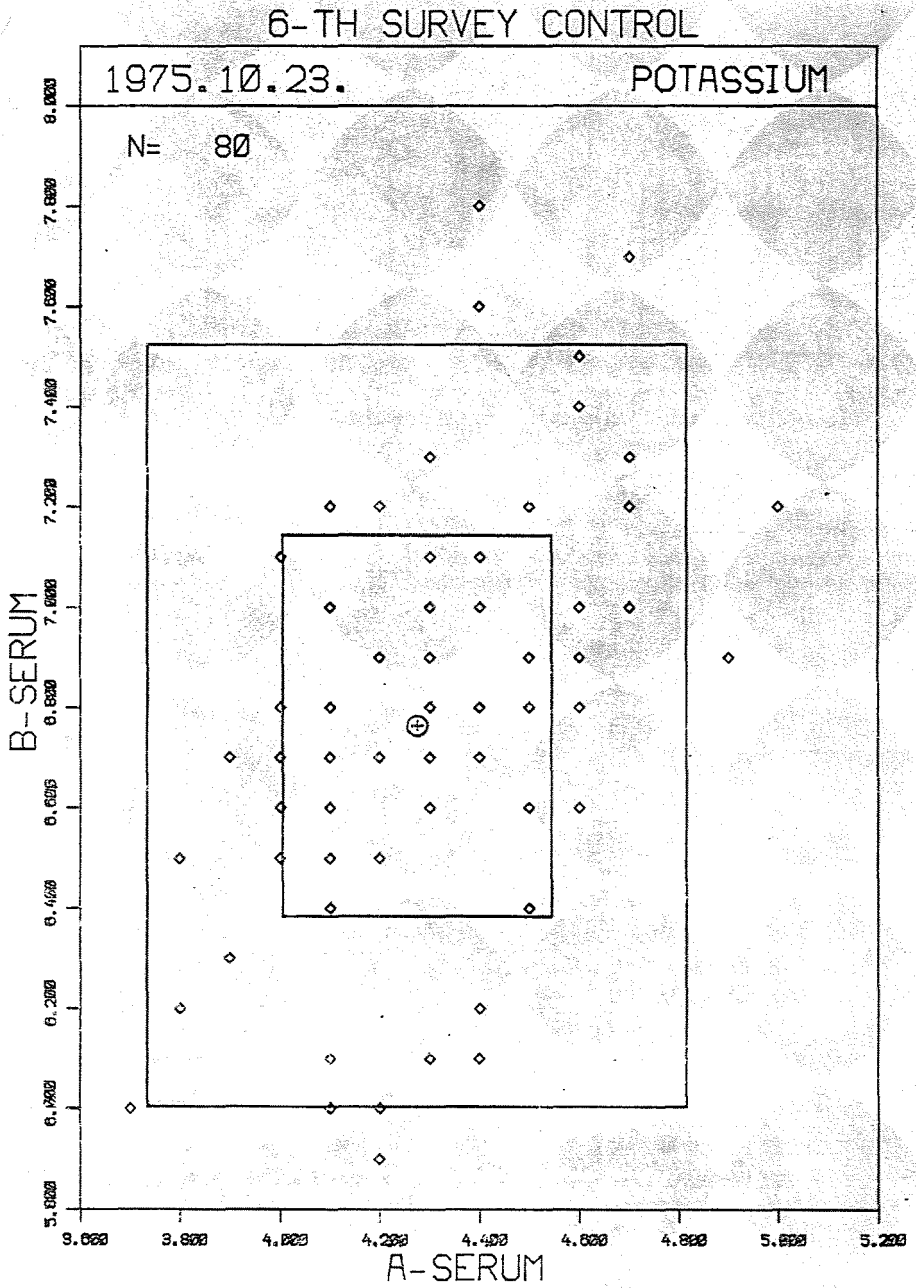


Fig. 16. Joint measurements for potassium

Since the results of the analyses are random variables, they have distribution functions. The distribution function is a two-dimensional Gaussian one – in most of the experiments. The well-known density function of a multi-dimensional Gaussian distribution with mean vector \mathbf{M} and covariance matrix \mathbf{K} [3] is:

$$p(\mathbf{x}) = (2\pi)^{-1} |\mathbf{K}|^{-1/2} e^{-(1/2)(\mathbf{x}-\mathbf{M})^T \mathbf{K}^{-1}(\mathbf{x}-\mathbf{M})} \quad (7)$$

In this case

$$\mathbf{X} = \begin{bmatrix} x_i \\ y_i \end{bmatrix}; \quad \mathbf{M} = \begin{bmatrix} m_A \\ m_B \end{bmatrix}; \quad \mathbf{K} = \begin{bmatrix} \sigma_A & \sigma_{AB} \\ \sigma_{BA} & \sigma_B \end{bmatrix} \quad (8)$$

\mathbf{X} , \mathbf{M} and \mathbf{K} are estimated from the results.

As an example, these variables for potassium are (see Fig. 15):

$$\mathbf{M} = \begin{bmatrix} 4.28 \\ 6.75 \end{bmatrix}; \quad \mathbf{K} = \begin{bmatrix} 0.26 & 0.05 \\ 0.05 & 0.38 \end{bmatrix} \quad (9)$$

$$r = 0.477; \quad N_0 = 75.$$

The program computes the coefficients of the linear regression equation [3]:

$$y = ax + b = r \frac{\sigma_B}{\sigma_A} (x - m_A) + m_B \quad (10)$$

In this case, for potassium:

$$y = 0.678x + 4.715 \quad (11)$$

Let us note that the value of the normal density function is constant, satisfying the equation:

$$\frac{1}{2} (\mathbf{X} - \mathbf{M})^T \mathbf{K}^{-1} (\mathbf{X} - \mathbf{M}) = \lambda^2 \quad (12)$$

where λ is a real constant.

$\lambda = 1$ yields the equation of the variance-ellipse.

The estimated density function delivers the probability of a point to be inside the ellipse with parameter λ [3]:

$$P(\lambda) = 1 - e^{-\frac{\lambda^2}{2(1-r^2)}} \quad (13)$$

If this probability is higher, then the results of the same laboratory are more accurate, that is, more points get inside the variance-ellipse. As an example, $P(\lambda)$ for potassium:

$$P(\lambda = 1) = 0.48$$

and

$$P(\lambda = 2) = 0.926 \quad . \quad (14)$$

3.3. Density function estimation

In simple cases, experiment histograms give enough information about the distribution of the measurement values. The probability density function of data $\{x_i\}_{i=1}^N$ can be estimated by the well-known histogram method:

$$\hat{p}_N(x) = \frac{v_i}{N \cdot h} \quad (15)$$

where v_i is the number of data inside the interval h , N is the total number of data.

The computer program computes the histograms and plots them on a line-printer. Fig. 17 is the histogram of potassium for both serums. Let us note that in some cases the density function is not a Gaussian one. As an example, Fig. 18 is the histogram of phosphorus.

A density function that is accurate enough yields sufficient information about the relative accuracy of results for serum A and B. Therefore, another density estimation technique was applied, known from the statistical pattern recognition theory as the Parzen density estimation [2]. In this case the estimated probability density $p(x)$ is formed from the superposition of known kernel functions $K(x, y)$ to samples of $p(x)$:

$$\hat{p}_N(x) = \frac{1}{N h(N)} \sum_{i=1}^N K\left(\frac{x - y_i}{h(N)}\right) \quad (16)$$

where $h(\cdot)$ is function of the sample size (N).

Parzen proved this method to give more accurate results than does the histogram method.

Sharpness of the density function by this method gives an information about the goodness of the survey control.

Figs 19 and 20 show density functions for each of both serums.

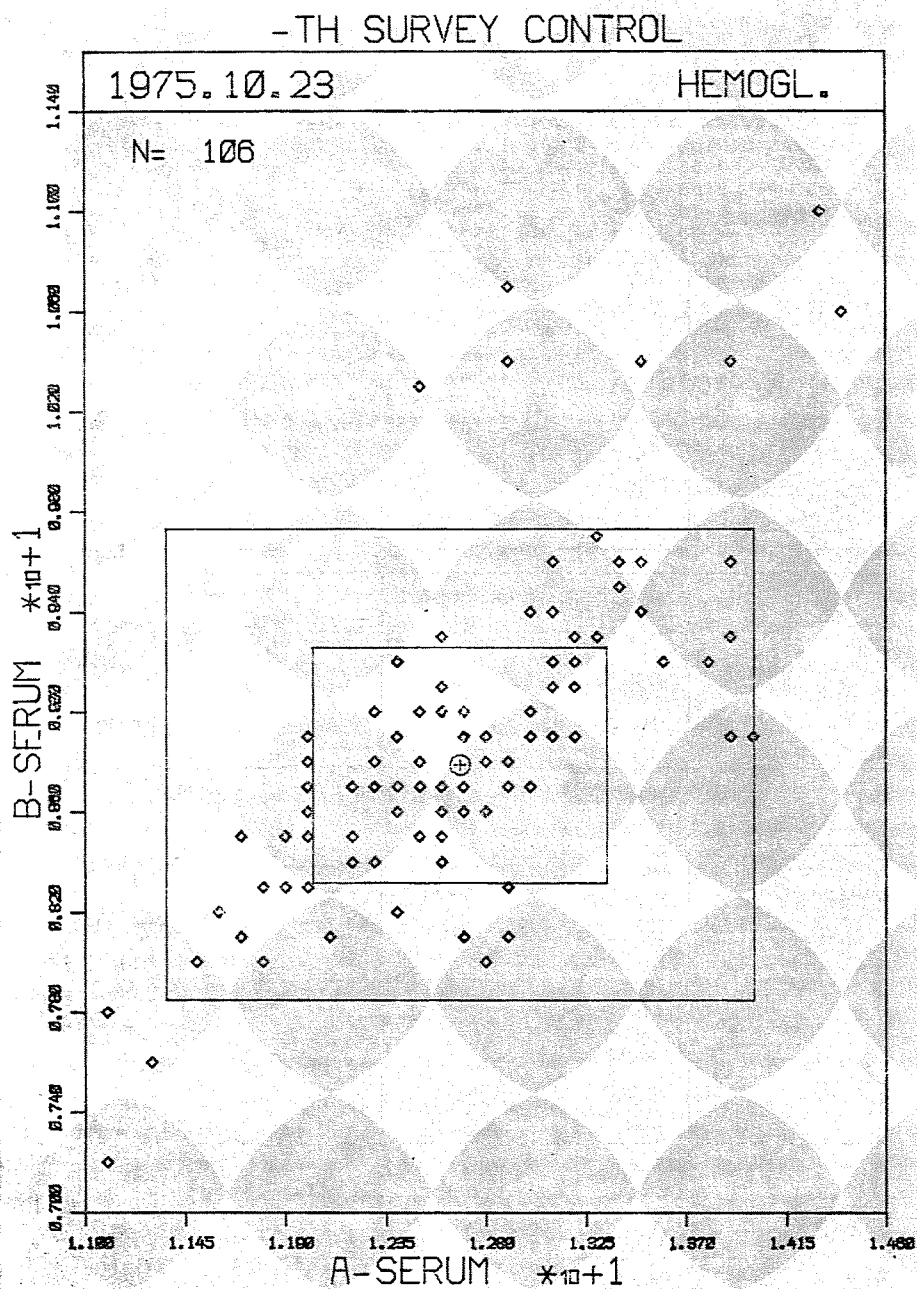


Fig. 17. Histogram of the results for haemoglobin

HISTOGRAM OF POTASSIUM FOR BOTH SERUMS:

LESS THAN MINIMUM	2	I....
3.45 - 3.55	0	I
3.55 - 3.65	0	I
3.65 - 3.75	1	I**
3.75 - 3.85	2	I****
3.85 - 3.95	3	I*****
3.95 - 4.05	8	I*****
4.05 - 4.15	16	I*****
4.15 - 4.25	6	I*****
4.25 - 4.35	12	I*****
4.35 - 4.45	8	I*****
4.45 - 4.55	7	I*****
4.55 - 4.65	6	I*****
4.65 - 4.75	5	I*****
4.75 - 4.85	0	I
4.85 - 4.95	1	I**
4.95 - 5.05	1	I**
5.05 - 5.15	0	I
5.15 - 5.25	0	I
GREAT. THAN MAXIMUM	2	I....

NO. OF RESULTS WITHIN HISTOGRAM LIMITS = 76

LESS THAN MINIMUM	2	I....
5.55 - 5.65	0	I
5.65 - 5.75	0	I
5.75 - 5.85	0	I
5.85 - 5.95	1	I**
5.95 - 6.05	3	I*****
6.05 - 6.15	3	I*****
6.15 - 6.25	2	I****
6.25 - 6.35	1	I**
6.35 - 6.45	6	I*****
6.45 - 6.55	3	I*****
6.55 - 6.65	8	I*****
6.65 - 6.75	11	I*****
6.75 - 6.85	10	I*****
6.85 - 6.95	5	I*****
6.95 - 7.05	8	I*****
7.05 - 7.15	3	I*****
7.15 - 7.25	6	I*****
7.25 - 7.35	2	I****
7.35 - 7.45	1	I**
7.45 - 7.55	1	I**
GREAT. THAN MAXIMUM	4	I.....

NO. OF RESULTS WITHIN HISTOGRAM LIMITS = 74

Fig. 18. Histogram of the results for potassium

HISTOGRAM OF PHOSPHORUS FOR BOTH SERUMS:

```

-----
LESS THAN MINIMUM      4      I.....
2.21 - 2.26            0      I
2.26 - 2.51            1      I**
2.51 - 2.66            0      I
2.66 - 2.81            3      I*****
2.81 - 2.96            1      I**
2.96 - 3.11            20     I*****
3.11 - 3.26            6      I*****
3.26 - 3.41            12     I*****
3.41 - 3.56            6      I*****
3.56 - 3.71            5      I*****
3.71 - 3.86            3      I*****
3.86 - 4.01            4      I*****
4.01 - 4.16            2      I***
4.16 - 4.31            4      I*****
4.31 - 4.46            1      I**
4.46 - 4.61            4      I*****
4.61 - 4.76            1      I**
GREAT THAN MAXIMUM    3      I.....
-----
    
```

NO. OF RESULTS WITHIN HISTOGRAM LIMITS = 75

```

-----
LESS THAN MINIMUM      4      I.....
15.05 - 16.55          0      I
16.55 - 18.05          1      I**
18.05 - 19.55          1      I**
19.55 - 21.05          3      I*****
21.05 - 22.55          2      I***
22.55 - 24.05          5      I*****
24.05 - 25.55          5      I*****
25.55 - 27.05          9      I*****
27.05 - 28.55          10     I*****
28.55 - 30.05          7      I*****
30.05 - 31.55          14     I*****
31.55 - 33.05          9      I*****
33.05 - 34.55          1      I**
34.55 - 36.05          3      I*****
36.05 - 37.55          4      I*****
37.55 - 39.05          2      I***
39.05 - 40.55          0      I
40.55 - 42.05          0      I
42.05 - 43.55          0      I
43.55 - 45.05          0      I
GREAT THAN MAXIMUM    0      I
-----
    
```

NO. OF RESULTS WITHIN HISTOGRAM LIMITS = 76

Fig. 19. Estimated density functions for phosphorus

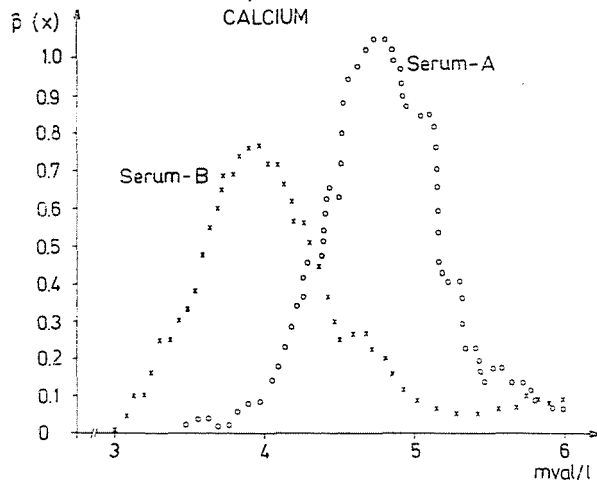


Fig. 20. Estimated density functions for calcium

Summary

Computer processing of clinical laboratory test results has been presented. A laboratory subsystem of an on-line Clinical Information System (CIS) has been elaborated by the authors. This program consists of three main parts; the first one is for coding, storing and handling the data, the second one is to record and to analyse statistically the work of the Central Clinical Laboratory, finally the third program makes the statistical data processing of the survey control and qualify the work in clinical laboratories.

E I T Ű L T É S I U T M U T A T Ó

a

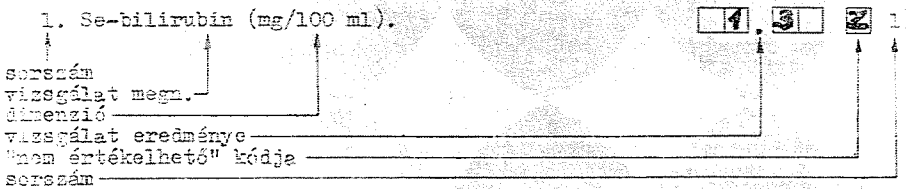
"Laboratóriumi vizsgálatok" c. adatlaphoz

Az adatlap a laboratóriumi vizsgálatok-számítógépes feldolgozását segíti elő. A kockákba - a beteg nevét kivéve - mérési értékek vagy kódok kerülnek.

A kitöltés szempontjából három fő típus különböztethető meg:

1. Rörtjellegű mérési eredmény

Példa:



2. Egész jellegű mérési eredmény

Példa:

11. Lymphocyt (%) 11 11.

3. Kódolt mérési eredmény

Példa:

4. Latex pr. +, ++, +++ + 4.

"egy kereszt" kódja +

Az alkalmazott kódok táblázata

direct (D)	+	(+)	AB	(AB)
indirect (I)	++	(++)	Ø (vércsoport)	(O)
negatív (N)	+++	(+++)	savas	(S)
pozitív (P)	A	(A)	lúgos	(L)
kóros (K)	B	(B)	neutrális	(-)
normál (NR)		fokozott (F)		

A "nem értékelhető" kódok táblázata

hit vétel (U)	nem érkezett ag.	(X)
eltől az üveg (Y)	Ismétlést kérünk	(Y)
hemolizált (W)	bizonytalan	(Z)

Bajcsy Zsilinszky Kórház

Laboratóriumi vizsgálatok

AP. AZONOSÍTÓ : 12345673101
 NEVE : KOVÁTS JÁNOS
 FELV. SZÁM : 6520/22
 OSZTÁLY : 01
 KÓRFEJEZ : 02

1. M Á J F U N K C I Ó

1. Sz-bilirubin (mg/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.
2. Sz-bilirubin qualitativ r. direct (D), indirect (I)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.
3. Thimol r. (E)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3.
4. Aranyosol r. (E); negativ (N), kóros (K)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.
5. Takata r. negativ (N), kóros (K), +, ++, +++	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.
6. Bronsulphalein próba 5 perces érték (mg/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6.
45 perces érték (mg/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
retentio (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

2. I O N O K

1. Kálium (mval/l)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.
2. Nátrium (mval/l)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.
3. Chlor (mval/l)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3.
4. Intracell. K (mval/l)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.
5. Intracell. Na (mval/l)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.
6. Calcium serumban (mval/l)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6.
7. Calcium vizeletben (ug/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	7.
8. Fe (ug/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	8.
9. Serum vaskötő képesség (ug/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	9.
10. Serum jód (ug/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10.

 APPENDIX
 Labor Data Paper*

* Original Hungarian version

3. VEGYES CSOPORT

1. Vérsejtsüllyedés (mm/óra)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.
2. Acidotest negatív (N), pozitív (P)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.
3. Keringő vérmennyiség (ml/tests.kg)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3.
4. Körtén/euglobulin negatív (N), pozitív (P)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.
5. Rezerv alkali (SCO_2)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.

4. HAEMATOLÓGIA

1. Vörösvérsejt (millió/ μ l)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.
2. Fehérvérsejt (ezer/ μ l)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.
3. Haemoglobin (gr/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3.
4. Haematokrit (vol.%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.
5. MCHG (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.
6. Monoccyta (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6.
7. Eosinophil (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	7.
8. Fialtal (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	8.
9. Pálca (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	9.
10. Karélyos (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10.
11. Lymphoccyta (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	11.
12. Lymphoid s. (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	12.
13. Basophil (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	13.
14. Reticuloccyta (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	14.
15. Abs. eo. sejtszám (1/ μ l)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	15.
16. LE sejt negatív (N), pozitív (P)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	16.
17. Vvs. resist. (% NaCl)	alsó határ	<input type="checkbox"/>	<input type="checkbox"/>	
	felső határ	<input type="checkbox"/>	<input type="checkbox"/>	17.
18. Thromboccyta szám (ezer/ μ l)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	18.
19. Alvadási idő (perc)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	19.
20. Fibrinogén (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	20.
21. Prothrombin (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	21.
22. RH faktor negatív (N), pozitív (P)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	22.
23. Vércsoport A, B, AB, O,	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	23.

5. VIZELET

1. Vegyhatás savas (S), lúgos (L), neutrális (-)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.
2. Fajsúly (gr/l)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.
3. Fehérje (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3.
4. Dohány +, ++, +++,	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.
5. Cukor negatív (N), pozitív (P),	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.
6. Uti. negatív (N), normal (NR), fokozott (F)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6.
7. Vizelet cukor (gr/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	7.
8. Aceton +, ++, +++, negatív (N)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	8.
9. 5-hidroxil-ind.acets. negatív (N), pozitív (P)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	9.
10. Bence-Jones fehérje negatív (N), pozitív (P)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10.

6. KÉMIAI VIZSGÁLATOK

1. Koleszterin (mg/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.
2. Clearance (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.
3. 4 óráé vizelet menny. (ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3.
4. Furoziduresis (ml/perc)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.
5. Serum creatinin (mg/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.
6. Vizelet creatinin (mg/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6.
7. Cukor/vér, serum/ (mg/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	7.
8. Vércsefehérje (gr/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	8.
9. Elektrophoresis: Albumin (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	9.
Globulin-alfa ₁ (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Globulin-alfa ₂ (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Globulin-beta (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	
Globulin-gamma (%)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	9.
10. Albumin/globulin quotiens	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	10.
11. Serum kalcium (mg/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	11.
12. 17-Ketosteroid (3 nap átlaga/24 óra)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	12.
13. Serum lipoc.-lipid/Kunkel sz./ (mg/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	13.
14. Urea-N/24 (mg/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	14.
15. Coombs-protein negatív (N)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	15.

7. BEMÉRÉSEK

1. Alfa amylase serum (IE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.
2. Alfa amylase vizelet (IE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.
3. Cholinesterase (perc)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3.
4. SGOT (IE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.
5. SGPT (IE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.
6. Phosphatase alkalikus (IE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6.
7. Phosphatase acidikus összes (IE) tartarát resistens (IE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	7.

8. SEROLÓGIA

1. ASO antistreptolysin (IE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.
2. ASK antistreptokinase (IE)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.
3. Paul-Bunnell r.	1:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3.
4. Latex pr. +, ++, +++	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.
5. VDRL r. negatív (N), +, ++, +++	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.
6. Reiters r. -negatív (N), pozitív (P)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6.
7. Kolmer r. negatív (N), +, ++, +++	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	7.

9. LIQUOR CEREBROSPIN

1. Pandy r. negatív (N), +, ++, +++	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.
2. Ússzefehérzés (mg/100 ml)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.
3. Sejtszám	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	3.
4. Cukor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	4.
5. Kolmer r. negatív (N), pozitív (P)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	5.
6. Aranyosz r.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	6.

[Handwritten Signature]
 kitöltötte

[Handwritten Signature]
 ellenőrizte

References

1. BRECHER, G. M. D.—LOKEN, H. F. M. D.: The Laboratory Computer — Is It Worth Its Price? Amer. J. Clin. Path. Vol. 55 (1971), pp. 527—540.
2. FUKUNAGA, K.: Introduction to the Statistical Pattern Recognition, Academic Press, New York (1972).
3. GNEDENKO, B.: The Theory of Probability, Mir Publishers, Moscow (1973).
4. HANTOS, P.—HORVÁTH, I.—VAJTA, M. JR.: Clinical Laboratory Data Processing, Proc. of 2nd European Congress on Clinical Chemistry, Prague, Oct. 3—8. (1976).
5. HORVÁTH, I.—MOLNÁR, M.—VAJTA, M. JR.: Statistical Data Evaluation of Survey Controls, Proc. of 2nd European Congress on Clinical Chemistry, Prague, Oct. 3—8. (1976).
6. HORVÁTH, I.—MOLNÁR, M.—PAKSI, A.: Csoportos vizsgálatok biometriai értékelése és tanulságai (Biometrical Evaluation and Conclusion of Survey Controls*). Laboratóriumi Diagnosztika, Vol. 1 (1974), No. 1—2, pp. 3—24.
7. KATONA, P. G.—PAPPALARDO, A. N.—MARBLE, C. W.—BARNETT, G. O.—PAHBY, M. M.: Automated Chemistry Laboratory: Application of a Novel Time-Shared Computer System. Proc. of IEEE., Vol. 57, No. 11 (1969), pp. 2000—2006.
8. NORDSCHOW, C. D.—SHIPTON, H. W.: Data Management in the Diagnostic Laboratory. A Data-Centered Approach Using High-Density Mark Sense Documents for Computer Entry. Computers and Biomedical Research, Vol. 3. (1970), pp. 218—228.
9. Referencia kézikönyv (Reference Handbook*). VIDEOTON Számítástechnikai Gyár, Budapest (1974).
10. WHITEHEAD, T. P.—BROWING, D. M.—GREGORY, A.: A Comparative Survey of the Results of Analyses of Blood Serum in Clinical Chemistry Laboratories in the United Kingdom. Journal of Clinical Pathology, Vol. 26. (1973), pp. 435—445.

* In Hungarian

Péter HANTOS	}	H-1521 Budapest
Dr. Miklós VAJTA JR.		