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DATA PROCESSING SYSTEM FOR THE 'SNEG-2MP' EXPERIMENT

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16. Abstract
The "Sneg-2MP" experiment is conducted on the "Prognoz-6" satellite station. The data processing system for scientific experiments on stations of the "Prognoz" type provides for the processing sequence to be broken down into a number of consecutive stages: preliminary processing, primary processing, secondary processing. The tasks of each data processing stage are examined in detail.

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DATA PROCESSING SYSTEM FOR THE 'SNEG-2MP' EXPERIMENT

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The "Sneq-2MP" experiment is conducted on the "Prognoz-6" station. /3* Before discussing the experiment's processing system let us briefly describe its purpose, the operation logic of the instrument, and some specific features of the preliminary processing system.

The principal purpose of the "Sneq-2MP" experiment is to study gamma splashes of galactic origin and solar flares lasting from several minutes to seconds in the 20 to 1000 kev energy range. It is expected that the experiment will help obtain characteristics of the frequency of occurence of gamma splashes and their temporal and energy structure.

The scientific equipment includes:

- three sensors (upper S and two side, 1L and 2L);
- amplitude analysis circuits (10-band differential amplitude analyzers and a 32-position energy band selector);
- splash detection circuits for sensors S, 1L, 2L;
- time counters for recording the splash instant;
- memories M1, M2, M6, coupled with the upper sensor;
- memory M7, coupled with the upper sensor S and the RGS instrument;
- memory M8, coupled with sensor 1L;
- memories M9, M10, coupled with sensor 2L;
- four internal patchboards (one for each sensor and a time label patchboard); /4
- two integrated channels, one each for detector 1L and 2L (parameters LL1, LL2).

A diagram of the operation of the instrument is presented in Fig. 1.

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*Numbers in the margin indicate pagination in the foreign text.

The "Sneg-2MP" instrumentation operates in two modes of data acquisition and transmission, depending upon whether the data come from studies of discrete sources and background gamma-radiation or of splashes. Data acquisition in the background measurement mode is continuous, with a telemetric channel polling frequency of 10.24 or 16·10.24 s. These data are fed into the on-board memory either directly (parameters LL1, LL2) or through the sensors' 16-channel patchboards.

During a splash the polling frequency of telemetric channels does not ensure the required temporal resolution. Therefore, to obtain a maximum of information on every splash the telemetric data are stored at varying polling frequencies and in different energy bands in memories M1, M2, M6, M7, M8, M9, M10. Transmission of splash data stored in the memory is effected over the same telemetric channels as the transmission of background measurements simply by cutting out the background measurement mode.

The "Sneg-2MP" experiment is an integrated experiment, since similar sensors are mounted on several simultaneously operating stations. Furthermore, in the "Prognoz-6" satellite the "Sneg-2MP" instrumentation operates together with the RGS instrument. When a splash of gamma-radiation is recorded the internal memory of the "Sneg-2MP" (M7) begins to store data from the sensor S and the RGS instrument with high temporal resolution. When the M7 memory store is filled splash data is transmitted to the on-board store via the RGS telemetric channels. During rerecording RGS readings are not recorded on these channels /5

Signals about the operation modes of the "Sneg-2MP" system (generation of the "splash" signal, rerecording of data from the system's memory in the memory store of the telemetric system) is recorded in the temporal label patchboard.

Each sensor has a time counter which records the instant a splash is detected. Readings of the time counters of sensors S and 2L are rerecorded in specific words of memories M1 and M10, respectively. Readings of the time counters of sensor 1L and and the

RGS instrument and the polling time of the S, 1L and 2L patchboards is recorded in the time label patchboard.

Special mention should be made of the importance of pinpointing the time of arrival of the gamma splash (required accuracy ~ ms), which is essential for precisely computing the coordinates of the splash sources.

To ensure fixation of the data of physical experiments to Moscow time with the required accuracy the "Prognoz-6" has a board time sensor which provides a digital code of hours, minutes, seconds and milliseconds.

The "Prognoz-6" data processing system provides for separating the whole processing sequence into a number of consecutive stages:
- preliminary processing,
- primary processing,
- secondary processing.

The data processing operations diagram for the "Sneg-2MP" experiment on board the "Prognoz-6" station is presented in Fig. 2.

It should be noted that telemetric information is subject to noise and interence, which disrupts the standard telemetric structure (changes in frame length, appearance of frame markers) and distortion of on-board time and scientific data sensors. Therefore, in developing the processing system great attention is given at all its stages to analysis of information quality, localization of breakdowns in telemetric structure, and removing those breakdowns, taking into account a priori data on the telemetering system, the experiment, and the high stability and monotony of changes in readings of the board time sensor. /6

The preliminary processing stage involves the following operations:
- collection of telemtric data (magnetic tape, incidental information), assessment and preliminary analysis;
- determine of operation modes;
- data input to computer;

- analysis of data quality and board time codes;
- localization of breakdowns and restoration of telemetric structure;
- deciphering board time codes and tying in data to Moscow time;
- marking out slow patchboard lamels;
- arranging data according to increasing memorization time;
- setting up a software bank of preliminary processed data.

The most important and labor consuming stages in preliminary processing is restoration of standard telemetric structure and tying in on-board measurements to Moscow time.

Restoration of standard frame-by-frame structure of telemetric data is based on certain a priori data about the telemetric system: frame length, service information about frame marking, frequency of recording of measurement results on telemetric magnetic tape, information on the structure of the recording of board time sensor readings, stability of the sensor and the monotony of changes in its readings. The search for all frame markers and reliability checking of the frames is done at this stage. If the distance between found markers is not an integral of the whole number of frames the possible number of disrupted frames in this interval is determined and they are designated as unreliable. A magnetic tape file is formed with frames of standard length, each frame being provided with a heading to record data on the tying of measurements to Moscow time and indicators of data disruption. /7

During the stage of tying in telemetric measurement to Moscow time the following operations are performed: deciphering of board time codes, their analysis for monotony of change and stability of sequence, eliminating false codes, determining average frame length, determination of Moscow time for each frame.

After the preliminary processing stage a store of magnetic tape is established for use in subsequent processing stages.

The primary processing stage for the "Snog-2MP" experiment covers the following objectives:
- formation of output data formats on magnetic tape for primary processing;

- selection of data for orientation calculations;
- analysis of the level distribution stability of the channels of the "Sneg-2MP" instrument (32 or 64 levels);
- deciphering the inner logic of operation of the instrument (deciphering the time label patchboard, the S, 1L, 2L patchboards, the M1, M2, M6, M7, M8, M9, M10 memories);
- determination of Moscow time for the splash recording instants;
- formation of magnetic tape data output format of the "Sneg-2MP" experiment for transmission to France; /8
- creation of a software data bank on magnetic tape or disks following preliminary processing.

A block diagram of the primary data processing program for the "Sneg-2MP" experiment No. 1 is presented in Fig. 3.

The secondary processing stage covers the following tasks (see Fig. 4):

- Processing calibrations for each sensor:
  - plotting the dependence Nj = f(j), where j = 0÷31, and Nj is the value in the calibration channel,
  - averaging over K series of calibration measurements,
  - determination of 511 kev peak,
  - developing diagrams and tables for calibration measurements.
- Processing background measurement spectrum (for each sensor for constant orientation sections):
  - Plotting dependence $Ni = n_i r_i c_k$, where
    - n_i is the count intensity recorded by the instrument in different energy bands,
    - i is the number of energy bands,
    - r_i is the normalization coefficient,
    - c_k is a coefficient taking into account the change in the position of the 511 kev peak in the calibration characteristic,
  - determination of the mean and dispersion over all energy bands ($\overline{N}_i$ and σ_i),
  - processing of patchboard control parameters,
  - printout of $\overline{N}_i$ and σ_i for each patchboard,
  - listing of patchboard parameters after normalization for any given time interval.

- Processing of integrated channels LL1 and LL2:
  - determination of average count intensity (averaging step 512 measurements),
  - detection of splashes that did not trigger the "splash" signal, for which $Ni > \bar{N} + k\sigma$, where $\bar{N}$ is determined from 16 successive values (sliding mean), σ is the mean quadratic deviation from the sliding mean, k equals 3 or 6,
  - printout of mean counting rates $L\bar{L}1$ and $L\bar{L}2$,
  - printout of tables if splash is detected.
- Formation of "splash bank":
  - elimination of splashes appearing when the station crosses radiation belts,
  - classification of events caused by solar flares (by RF-2P instrument),
  - rerecording data according to splashes from memories M1, M2, M6, M7, M8, M9, M10 and patchboards S, 1L and 2L in the "splash bank". Data from patchboards S, 1L and 2L are taken over a time period relative to the splash time (40 cycles before and 32 cycles after the splash).
- Processing splashes:
  - plotting the dependence $Ni = f(t)$ for memories M1, M2, M10, and levelling over five points according to the formula

$$Ni = \frac{1}{9}(a_{i-2} + 2a_{i-1} + 3a_i + 2a_{i+1} + a_{i+2}),$$

    where a_i is the measurements in the memories,
  - representing the data of memories M1, M2, M10 in a graph,
  - summing the data of memory M2 over 8 values and printout,
  - determination of the mean background level according to patchboard readings before and after the splash,
  - determination of the intensity of the splash, less the background,
  - printout of splash data (background level, splash intensity) for M1, M2, M10, /10
  - processing the energy spectra of memories M6, M7, M8, M9 according to the formula

$$Nki = k_i p_i N_i - r_i N_{\phi i}, \text{ where}$$

$i = 1 \div 6$ for M6, M8, and M9,

$i = 1 \div 3$ for M7,

N_i is the count recorded in the band,

k_i are the coefficients of logarithmic compression for memories M6 and M7,

p_i is a normalization coefficient,

r_i is a normalization coefficient,

$N_{\phi i}$ is the background level in the band;

- printout of energy spectra of memories M6, M7, M8 and M9.

The described data processing system for the "Sneg-2MP" experiment is based on the use of computers of a single series (ES-1020, ES-1140).

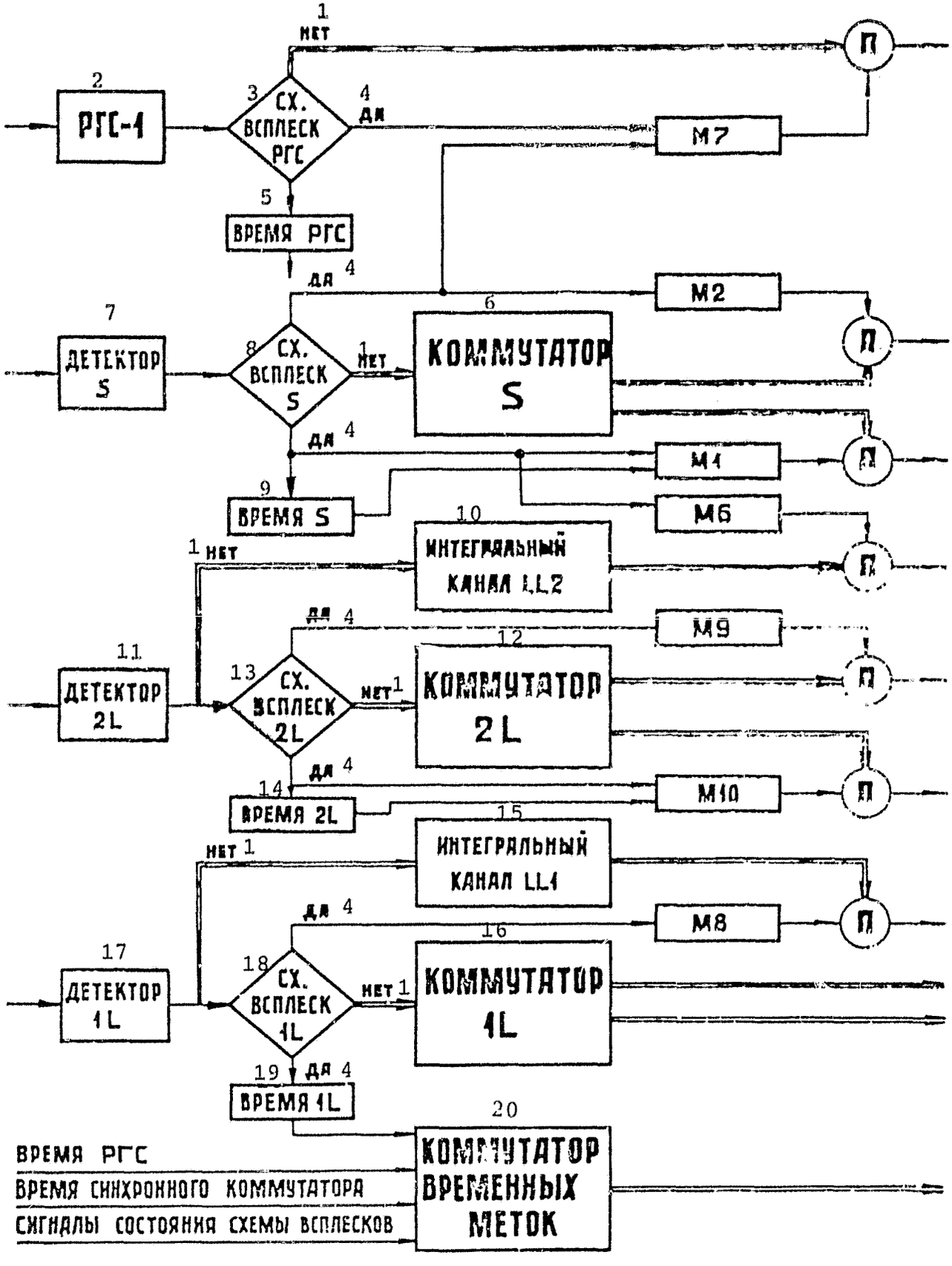


Fig. 1. Diagram of operation of "Sneg-2MP" instrument

Key: see p. 9

Key (Fig. 1. Diagram of Operation of "Sneg-2MP" instrument):

1. No
2. RGS-1
3. RGS splash circuit
4. Yes
5. RGS time
6. S patchboard
7. S detector
8. S splash circuit
9. S time
10. Integrated channel LL2
11. 2L detector
12. 2L patchboard
13. 2L splash circuit
14. 2L time
15. Integrated channel LL1
16. 1L patchboard
17. 1L detector
18. 1L splash circuit
19. 1L time
20. Time label patchboard
21. RGS time
22. Synchronous patchboard time
23. ignals of splash circuit condition

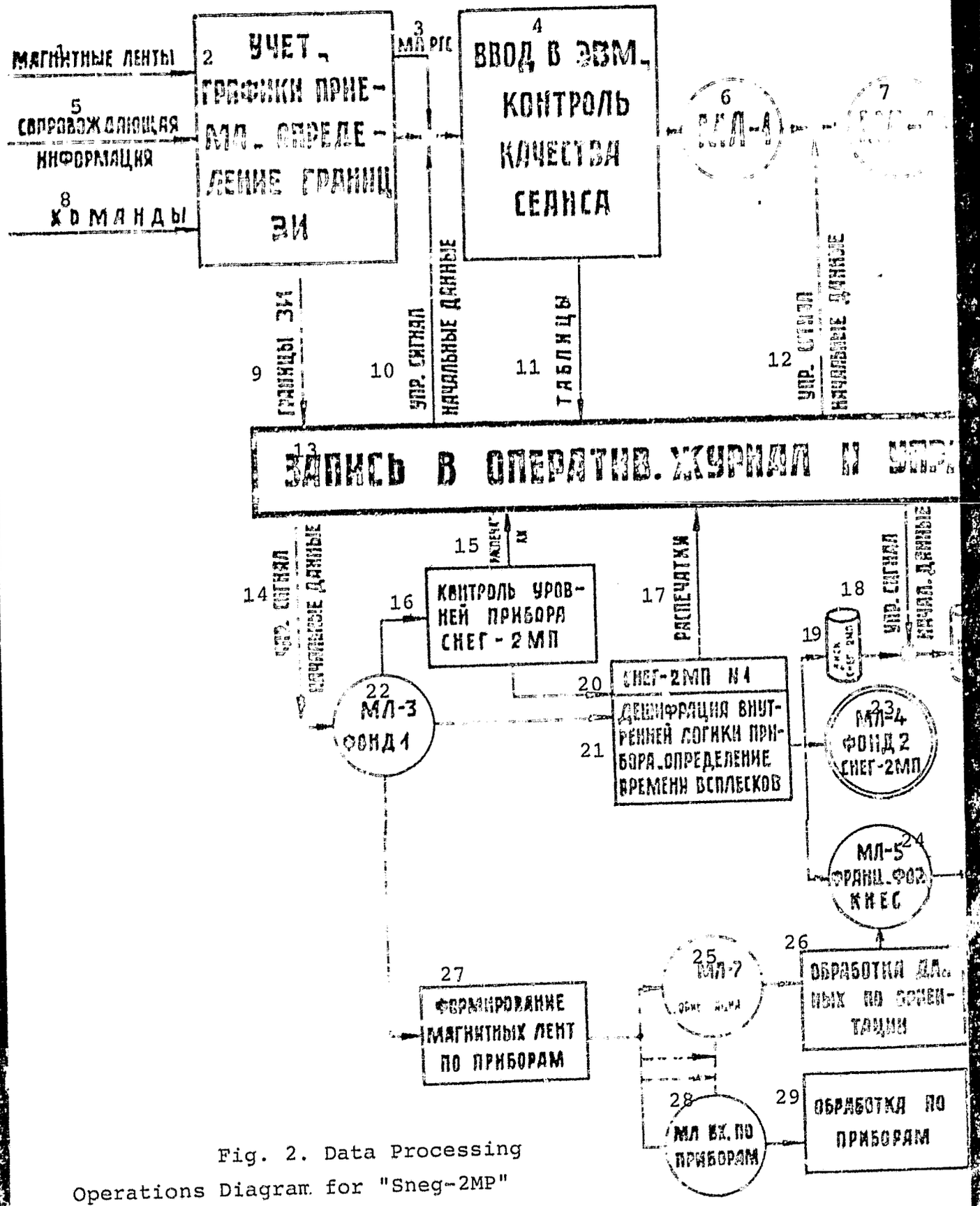
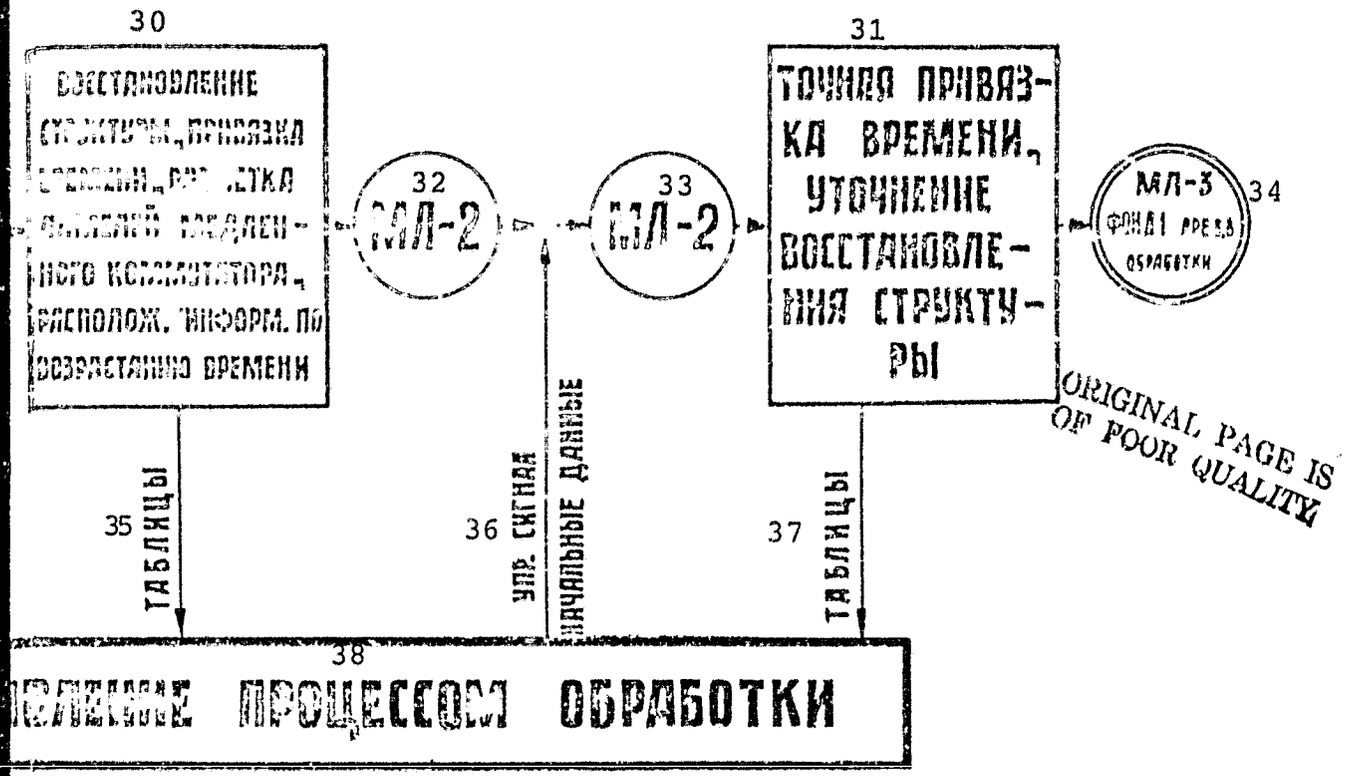


Fig. 2. Data Processing Operations Diagram for "Sneg-2MP" Experiment.



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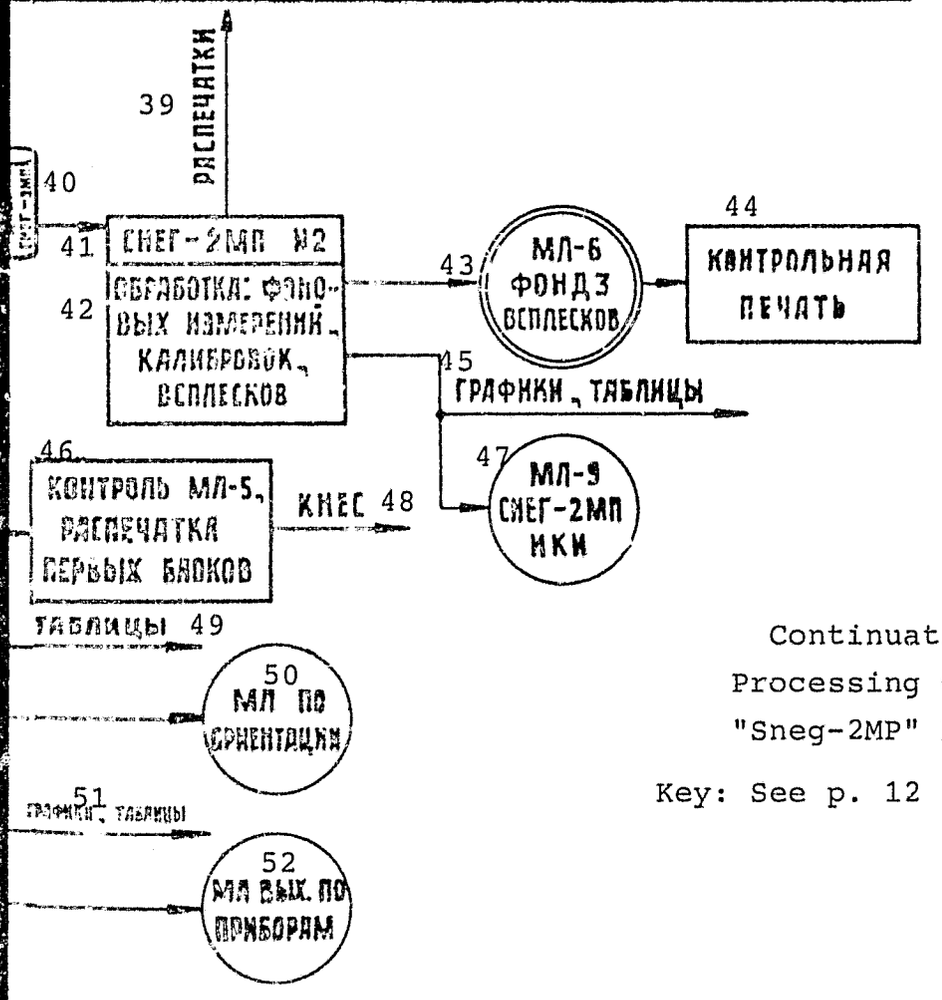


Continuation of Fig. 2. Data Processing Operations Diagram for "Sneg-2MP" Experiment.

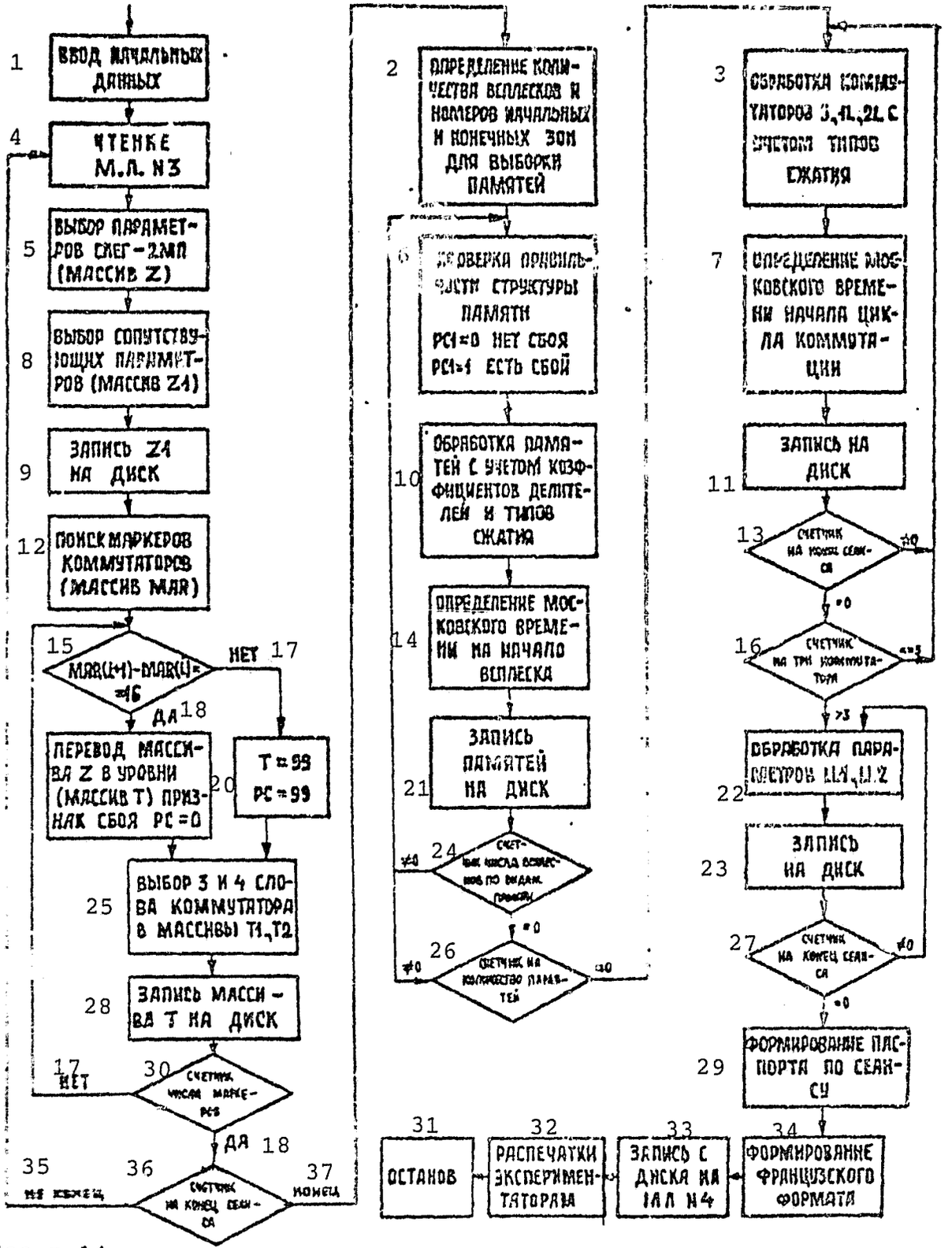
Key: See p. 12

Key (Fig. 2. Data Processing Operations Diagram for "Sneg-2MP" Experiment):

1. Magnetic tape
2. Record, reception graphs, determination of ZI boundaries
3. RGS M(agnetic) T(ape)
4. Computer input, quality control
5. Incident data
6. MT-1
7. MT-1
8. Commands
9. ZI boundaries
10. Control signal, initial data
11. Tables
12. Control signal, initial data
13, 38. Record in log and processing control
14. Control signal, initial data
15. Listing
16. Level control of Sneg-2MP instrument
17. Listing
18. Control signal, initial data
19. Sneg-2MP disk
20. Sneg-2MP No. 1
21. Deciphering of internal logic of instrument, determination of splash time
22. MT-3, store 1
23. MT-4, store 2, Sneg-2MP
24. MT-5, French
25. MT-7, "orientation"
26. Orientation data processing
27. Forming instrument magnetic tapes
28. Instrument MT input
29. Processing from instruments
30. Structure restoration, time tie-in, marking out slow patchboard lamels
31. Exact time tie-in, clarification of structure restoration
32. MT-2
33. MT-2
34. MT-3, preliminary processing store 1
35. Tables

(continuation of Fig. 2 Key)

36. Control signal; initial data
37. Tables
38. (See 13)
39. Listing
40. Sneg-2MP disk
41. Sneg-2MP No. 2
42. Processing: background measurements, calibrations, splashes
43. MT-6, splash store 3
44. Control printout
45. Graphs, tables
46. Control MT-5, listing of first blacks
48. KNES
49. Tables
50. Orientation MT
51. Graphs, tables
52. Instrument output MT



Key: See p 14

Fig. 3. Block Diagram of "Sneg-2MP" Program. No. 1

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Key (Fig. 3. Block Diagram of "Sneg-2MP" Program. No. 1):

1. Initial data input
2. Determination of number of splashes and numbers of initial and end zones for memory printout
3. Procession of S, 1L, 2L patchboards taking into account types of compression
4. M(agnetic) T(ape) No.3 reading
5. Sneg-2MP parameter selection (array Z)
6. Checking of memory structure (RS1=0, no malfunction; RS1=1, malfunction)
7. Determination of Moscow time of start of cycle switching
8. Selection of incident parameters (array Z4)
9. Record Z1 on disk
10. Process memories, taking into account divider coefficients and types of compression
11. Record on disk
12. Search for patchboard markers (Array MAR)
13. End of session counter
14. Determine Moscow time of splash start
15. MAR(1+1)-MAR(i)=16
16. Counter for three patchboards
17. No
18. Yes
19. Transfer of Array Z to levels (Array T), malfunction indicator RS=0
20. T + 99, RS = 99
21. Record memories on disk
22. Process parameters LL1, LL2
23. Record on disk
24. Counter of number of splashes according to type of ....
25. Select 3 and 4 patchboard words in Arrays T1, T2
26. Counter for number of lamels
27. End of session counter
28. Record Array T on disk
29. Form session specification
30. Marker counter
31. Stop
32. Experimenter listings
33. Record from disk on MT No.4
34. Form French format
35. Not end
36. End of session counter
37. End

CALIBRATION PROCESSING FOR DETECTORS S, 1L, 2L:

- Plot $N_j = f(j)$, where $j = 0 \div 31$, and N_j is the value in the calibration channel;
- Average calibration characteristics;
- Determine 511 kev peak;
- Consruct graphs and tables.

PROCESSING BACKGROUND SPECTRUM OF MEASUREMENTS:

- Plot $N_j = n_i r_i c_k$, where n_i is the count rate in the i band, r_i is the normalization coef., c_k is a coef. taking into account calibration characteristics;
- Determine $\bar{N}_i$ and σ_i for all energy bands;
- Process patchboard control parameters;
- Printout $\bar{N}_i$, σ_i, patchboard parameters after normalization for any time interval.

PROCESS INTEGRATED CHANNELS LL1, LL2:

- Determine $\overline{LL1}$, $\overline{LL2}$ (averaging step - 512)
- Find "splashes" that did not originate "splash" signal, $N_i \geq \bar{N} + k\sigma$, where $\bar{N}$ is the sliding mean, k is equal to 3 or 6, σ is the dispersion, averaging mean - 16 measurements.

FORMATION OF "SPLASH" STORE:

- Select events taking into account radiation belts;
- Form manqetic tape file with data of memories M1, M2, M6, M7, M8, M9, M10, and patchboards S, 1L, 2L.

PROCESS "SPLASHES":

- Level over 5 points for M1, M2, M10;
- Plot M1, M2, M10 memory data;
- Tie in memory M2 to Moscow time;
- Determine background level before and after splash for all detectors;
- Determine splash intensity, less background;
- Process energy spectra of memories M6, M7, M8, M9 according to formula: $Nk_i = k_i \sum N_i - r_i N_{\phi i}$, where $i = 1 \div 6$ for M6, M8, M9, $r = 1 \div 3$ for M7, N_i is the count in the i band, k_i is the coef. of logarithmic compres-

sion, p_i, r_i are normalization coefficients, $N_{\phi i}$ is the background level in the i band;

-Printout energy spectra of memories M6, M7, M8, M9.

Fig. 4. Secondary Processing Tasks in the Sneg-2MP" Experiment.