AIR ION OBSERVATORY AT TAHKUSE: SOFTWARE
H. Tammet

Introduction

The control of measurement and recording of results at Tahkuse Air Ion Observatory is carried out by means of a computer [11] and the structure of observations and recordings is determined by a computer program. It is possible to consider the program as an addition to the instrumentation which can be either partially or totally changed according to current needs of the user. This approach cannot guarantee uniformity of observation methods and uniform structure of the data. Uniformity, however, contributes significantly to the value of data obtained in a permanently active observatory. For this reason the basic software used at Tahkuse is considered an integral part of the system which should be able to support longtime operation without major changes.

The basic software consists of an observation program and a service program. Regular observations are controlled by the observation program, whereas the service program carries out regular checkups on the state of air ion spectrometers, as well as the operations necessary for setting up and transforming the apparatus table. For the operation of the service program regular observations are interrupted. The observations are interrupted also for the operation of special programs which can be devised for temporary tasks.

The software is designed for the Elektronika D3-28 computer. The computer has a relatively poor general software. For high level languages only a Basic interpreter is accessible. The power of the computer and its inventory of operators are insufficient for the execution of the required algorithms with a Basic interpreter. Therefore the following approach to programming has been adopted:

- the Basic interpreter has been enlarged by an additional operator for data exchange with the controller which directly controls the measurement devices (an interpreter program for this operator was developed by A. Mirme),
- external machine-code subroutines have been written for three additional input/output operations,
- an initial variant of the program was written in Basic and debugged at a slow measurement rate.
- the speed was increased by the translation of some segments of the program into machine code.

Elektronika D3-28 computers have their own numerical displays and keyboards. During the execution of the measurement program the computer is used without the external CRT display. The service program has both, CRT display and no-display, options.

Below attention will be paid to basic structures and operations of the observation program and the checkup procedure. The discussion presupposes familiarity with the paper [1] where the equipment of the Tahkuse Observatory is described.

The structure of observations

The duration of one full period of measurement and data processing is one hour. During this period the data are accumulated in RAM. At the end of every period the data are statistically processed and the results are recorded on a tape. For recording ordinary audio compact cassettes are used, one C90 cassette accommodates the data of one month’s uninterrupted observations.

Every one-hour period consists of twelve 5-minute cycles. The internal structure of the cycles is identical for all the cycles but the first cycle has additional functions of statistical processing and recording of the data gathered in the preceding one-hour period.

Optionally, the data of every 5-minute cycle may be recorded in addition to the period data (this option can be selected by pressing a button on the control panel). This option is used only as an exception as it brings about a tenfold increase in tape consumption.

Each 5-minute cycle consists of five one-minute phases. The air ion spectrometer (see [1]) measurement modes are varied in different phases according to Table 1.

The structure of operations within a one-minute phase analogous to that described in [2] is presented in Table 2.
Table 1

Spectrometer modes in the order of phases

<table>
<thead>
<tr>
<th>Phase</th>
<th>6C spectrometer voltage</th>
<th>10C spectrometer voltage</th>
<th>charger mode and polarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>- 45.5 V</td>
<td>-</td>
<td>off</td>
</tr>
<tr>
<td>-</td>
<td>- 150.5 V</td>
<td>-</td>
<td>on -</td>
</tr>
<tr>
<td>z</td>
<td>0</td>
<td>0</td>
<td>off</td>
</tr>
<tr>
<td>+</td>
<td>+ 150.5 V</td>
<td>+</td>
<td>on +</td>
</tr>
<tr>
<td>+</td>
<td>+ 45.5 V</td>
<td>+</td>
<td>off</td>
</tr>
</tbody>
</table>

Table 2

The structure of a one-minute phase

<table>
<thead>
<tr>
<th>Second</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Blocking of electrometers in spectrometers. Switch of per-minute control relay to position A. Switch of mode according to Table 1. Primary data processing of the preceding minute.</td>
</tr>
<tr>
<td>12</td>
<td>Deblocking of electrometers in spectrometers.</td>
</tr>
<tr>
<td>20</td>
<td>Measurement and storage of results into vector A. Switch of per-minute control relay to position B. If the first minute of a cycle, then intermediate data processing of the preceding cycle and if the 5-minute recording option, then recording on tape. If the first minute of a period and the preceding period has been complete, then statistical processing and recording on tape. Indication of current measurements on display.</td>
</tr>
<tr>
<td>60</td>
<td>Measurement and storage of results into vector B. Beginning of the next one-minute phase according to Table 1.</td>
</tr>
</tbody>
</table>
Primary data processing

One phase yields vectors $A$ and $B$ as measurement results, the vectors correspond to signals from all the channels. The channels are divided into four categories:
- channels of spectrometer,
- channels of sensors without zero control,
- channels of sensors with per-minute zero control,
- channels of sensors with per-hour zero control.

Per-minute zero control is carried out every minute by means of relay contacts the switching of which is described in Table 2. The formal operation is written as $X = A - B$ or $X = B - A$ depending on the relay position that switches the sensor to zero control. Per-hour zero control is carried out by the contacts of the other relay which operates with the period of one hour.

Spectrometer channel signals are reduced to steady-state values obtained by a method described in [3]. Formal calculation is done according to formula

$$X = a \cdot A + b \cdot B$$

(1)

where $a$ and $b$ are coefficients dependent on the time constant of the electrometer.

Formula 1 is universal in allowing non-spectrometric channels zero correction, for this purpose $a = 1, b = -1$ or $a = -1, b = 1$ are to be selected. For sensors without zero control $a = b = 0.5$ can be used. On the basis of the aforementioned considerations formula (1) has been adopted as a universal formula for primary processing of data from all channels.

Apparatus table

To contribute to the universality of the measurement program, information about the parameters of spectrometers and sensors has been brought together in an apparatus table. The apparatus table is written on the tape independently of the program and can be updated according to changes in the devices without making any changes in the program itself.

The equipment at the Tahkuse Observatory has 17 channels for spectrometer and of up to 19 channels for sensors. Thus,
the apparatus table comprises 94 numbers, the meanings of which are explained in Table 3.

Table 3

The structure of the apparatus table

<table>
<thead>
<tr>
<th>Number</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1...19</td>
<td>Physical numbers of sensor channels.</td>
</tr>
<tr>
<td>20...55</td>
<td>Constant a for primary processing.</td>
</tr>
<tr>
<td>56...91</td>
<td>Constant b for primary processing.</td>
</tr>
<tr>
<td>92</td>
<td>Actual number of sensors of range 10 V.</td>
</tr>
<tr>
<td>93</td>
<td>Actual number of sensors of range 10 mV.</td>
</tr>
<tr>
<td>94</td>
<td>Number of the apparatus table.</td>
</tr>
</tbody>
</table>

The numbers in the apparatus table appear in the order of logical numbers of the channels. Discrimination between physical and logical numbers makes possible arbitrary addition of sensors to the controller with subsequent respective corrections in the apparatus table. The physical numbers of sensor channels with per-hour zero control are labelled with a minus in front of the number of the channel.

Input of the apparatus table will take place immediately when the program is started.

Secondary data processing

After the accumulation of primary data of a 5-minute cycle the following operations are executed:
- six statistical sums for every spectrometric channel (the sums of signals of all phases and the sum of squares of Z phase signals) are accumulated,
- two statistical sums for every sensor channel (the sum of signals and the sum of squares of signals) are accumulated.

After the accumulation of statistical sums for the whole one-hour period:
- means and standard deviations are computed,
- data are formatted and written on tape,
- all statistical sums are set to zero.
Results of one-hour periods or 5-minute cycles are written as a separate block of data. Every block is written twice. Data are presented as two-byte decimal numbers. Each block contains (in the order of appearance): number of the day with the count starting on March 1, 1984, number of the minute with the count starting at the beginning of the day, number of apparatus table, code of the keys of the control panel. In the case of hourly recording these parameters are followed by:

- 17 standard deviations of zero for spectrometric channels,
- 4 x 17 hourly means of spectrometer signals for four modes - , -- , + , ++ ,
- N hourly means of sensor signals,
- N standard deviations of sensor signals.

N signifies the number of sensors. In the case of 5-minute storage the above parameters are modified to:

- 4 x 17 values of spectrometer signals for four modes - , -- , + , ++ ,
- N values of sensor signals.

The encoding of numbers in a record block is oriented to processing by a two-computer system described in [4].

In every storage cycle data are set to zero by the Z phase signal. Empirical results have given indications of small shifts not eliminated by the zero correction. Therefore the observation technique requires special observations with the air flow through the measurement capacitors cut off; such special observations should be conducted at three-month intervals. The results should be taken into account during the processing and analysis of the data carried out outside the framework of the present observation and storage system.

Diagnostics of spectrometers

For diagnostic measurements observations are interrupted, the fan is switched off, and inner covers of the measuring capacitors are connected to a computer-controllable voltage source.

To determine the state of the spectrometers the voltage on the inner covers will be modified from one stable level to
another, after that the transition processes in the electrometers of all the channels are investigated. If the electrometers have no faults, then the actual transition process is in good correlation with the theoretical exponential model. The jump of the electrometer signal and the time constant of the transition process make it possible to calculate the measuring capacitance and resistance of the electrometer. The calculation is based on the effective capacitance of the measuring capacitor. The effective capacitance can be measured with high accuracy during the calibration of spectrometers, as it does not undergo subsequent changes.

The diagnostics takes about one hour. In this time the transition processes are investigated in 10 runs for each electrometer. In addition, several other experiments are carried out. Having completed the necessary computations the computer will issue a table with the results of diagnostics. In the table the following data are indicated for every spectrometer channel:

- measuring resistance of the electrometer,
- measuring capacitance of the electrometer,
- zero point of the deblocked electrometer,
- zero shift at deblocking,
- ionization chamber current in the measuring capacitor of the spectrometer.

All the above parameters are provided with standard deviations computed according to the differences in the results of the series of runs.

The values of measuring resistance and capacitance can be used for the calculation of coefficients of formula (1). Information about the zero point and the zero shift is necessary to estimate current technical conditions of the electrometers and the insulators of the measuring capacitors. The current of the ionization chamber gives information about radioactive contamination of the measuring capacitor.

Acknowledgement

The author is indebted to A. Mirme who wrote the computer programs for data exchange with the controller. Appreciation goes to U. Hõrrak for his help in debugging and running the programs.
References


ОБСЕРВАТОРИЯ АТМОСФЕРНЫХ ИОНОВ ТАХКУЗЕ: ПРОГРАММНОЕ ОБЕСПЕЧЕНИЕ

X. Таммет

Реэюме

Структура наблюдений и некоторые элементы методики наблюдений с помощью аппаратуры [1] определяются через программу управляющей ЭВМ. Для обеспечения единообразия рядов наблюдений программа рассматривается как фиксированная составляющая системы наблюдений. Описывается программа наблюдений и самостоятельная процедура диагностики состояния аппаратуры. Программы реализованы для ЭВМ "Электроника Д3-28".

Период операции в программе наблюдений – один час. Статистические сводки результатов наблюдений за каждый час записываются на магнитофонную кассету. Одна кассета достаточна для размещения записей за один месяц. Одночасовой период измерения распределяется на 12 пятиминутных циклов и один цикл на 5 одноминутных фаз, описанных в табл. 1. Структура действий внутри фазы описана в табл. 2. Перечисленная обработка данных в каждой фазе по формуле (1) позволяет редуцировать сигналы электрометров на установившиеся значения [3] и скорректировать на нулевой отчет сигналы датчиков, имеющих режим проверки нуля. Параметры аппаратуры фиксируются раздельно от программы аппаратуарной таблицей, структура которой описана в табл. 3.