

THE USSR STATE TIME AND FREQUENCY STANDARD

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ABSTRACT

The paper deals with detailed information about the State time and frequency standard of the Soviet Union, its structure, service conditions and operation of the basic systems. The metrological and technical characteristics of a group of standards producing the nominal frequency value as well as the characteristics of time scale clock systems and of internal and external standard comparisons are given. The systems providing the reliability of the standard operation are considered.

INTRODUCTION

In the Soviet Union the unity of time and frequency measurements on a scale of the whole country is achieved on the basis of the State primary time and frequency standard. The standard is kept in VNIIFTRI (All-Union Research Institute for Physics and Radio Engineering Measurements) situated near Moscow. It was first confirmed as the State standard in 1967. At that time, an error of frequency reproducibility was 1×10^{-11} .

Since that time, the standard parameters have been substantially improved and the standard structure has been almost completely changed.

At the present time, the standard not only reproduces frequency, but also provides a continuous clock on the National time scale. In connection with this capability, the standard includes four primary and two secondary apparatus complexes. The primary complexes are as follows:

- reproducibility system of a measure of frequency;
- time scale clock system;
- internal comparison system;
- external comparison system;

The regulated power system and the data processing system are considered to be secondary systems.

The Reproducibility System of Frequency

The reproducibility system of frequency consists of six hydrogen and one cesium frequency standards. On a regular basis, two or three times a week, the standards' frequencies are corrected on the results of their intercomparisons and on the results of comparisons with the frequencies of atomic time scale clocks. The reproducibility of an average real frequency value is taken for the main characteristic of this system. Currently, it is expressed by a relative error of the order of 1×10^{-13} . Frequency reproducibility of the cesium standard is somewhat worse than that of the hydrogen standard. The magnitude characterizing the accuracy of the metrological cesium standard is currently $(3 \text{ to } 5) \times 10^{-13}$.

The System of Time Scale Clocks.

The system of time scale clocks consists of eight atomic hydrogen masers and eight Hewlett-Packard cesium atomic beam standards model 5061A. As a rule, from four to six atomic standards of each group are operating simultaneously. The remaining atomic standards are on cold standby or preventive maintenance. Each clock forms its own time scale. Intercomparisons of all scales are carried out automatically on the comparison program with a one hour interval. Comparisons are carried out at a resolution of 10 nsec. Processing of single results is performed in two steps: Provisionally - directly by means of comparison equipment; and finally - by universal electronic computer.

The clock system provides deviation of scales of two standard semisets of the order of not more than $1 \mu\text{s}$ for three months.

Secondary Systems.

Internal comparison system is a multiplex measurement system for time and frequency measurements. Accurate frequency measurements ($F = 5 \text{ MHz}$) are carried out with the help of decade frequency multipliers (to 10^4) and frequency meters. The results are recorded on a perforated tape and digital printer.

The external comparison system incorporates a number of VLF, LF and VHF receiving devices and corresponding receiving - recording equipment. With the aid of these devices a 24-hour (10-12 times) time signal reception of such radio

stations as GBR, OMA, RBU, NAA, NVC, etc. is carried out. The comparison with the USSR secondary standards is effected by TV channels with an error of (1 to 3) μ s. For the last years a few comparisons were carried out with the help of portable clocks.

These comparisons enabled the determination of systematic delays in radio and television channels. For instance, the comparison with the help of an Oscilloquartz clock in 1974 permitted the calibration of a comparison path on short waves and took into account a systematical departure of time scales to within 1 μ s.

A system of standby energy was established for the power supply of the whole standard complex. This system consists of battery facilities, a diesel-generator and a system of automatic switching in case of an interruption of energy supply from the electrical network.

All information for operation of the standard is systematically processed on a universal electronic computer. This information includes the results of single measurements of frequency deviation of separate standards and clocks, the results of external signal reception and the results of measurements of the environment parameters.



Figure 1. The main apparatus hall of the time service

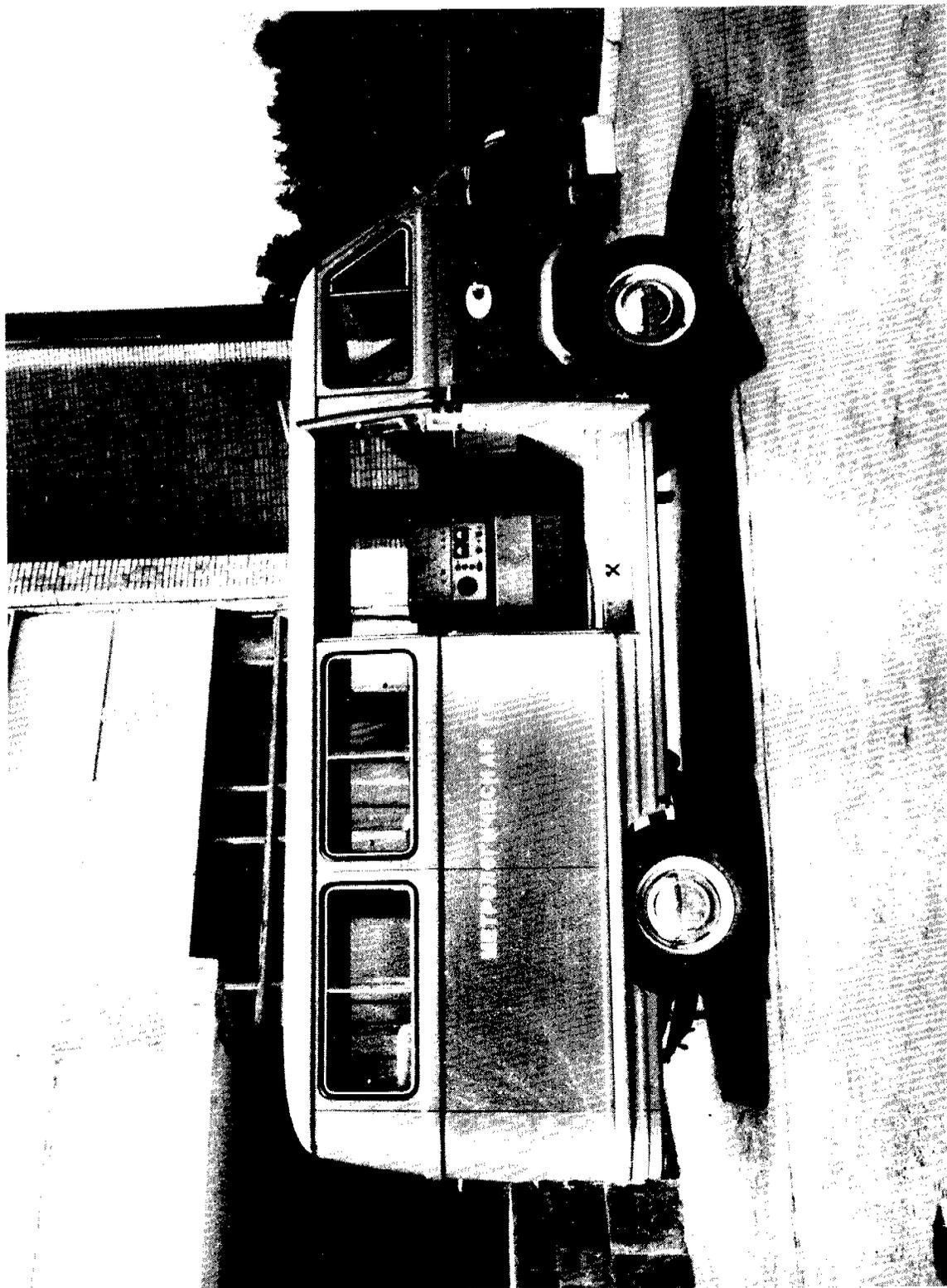


Figure 2. Portable comparison standard.

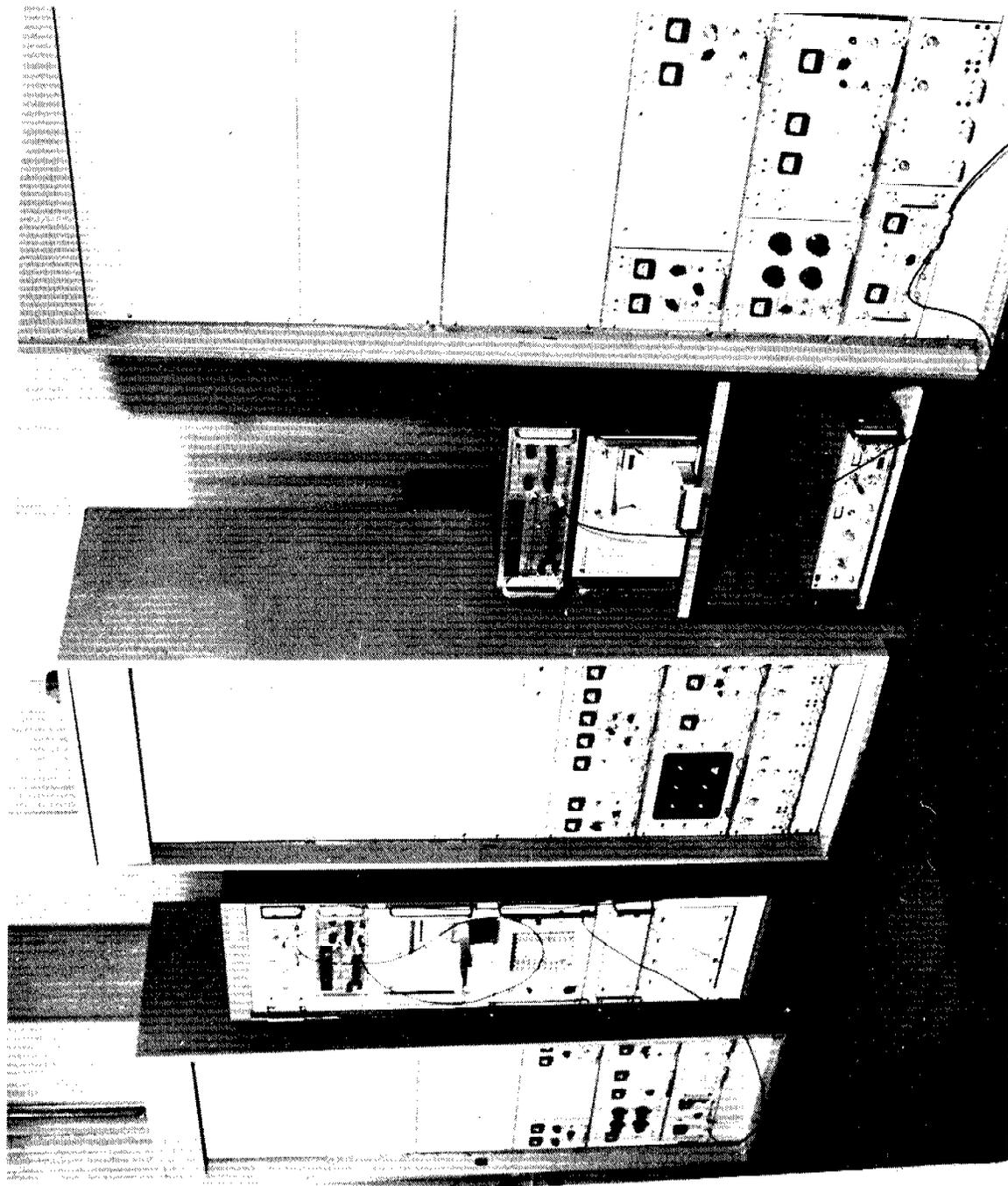


Figure 3. A set of hydrogen time-scale keepers of the USSR State standard.

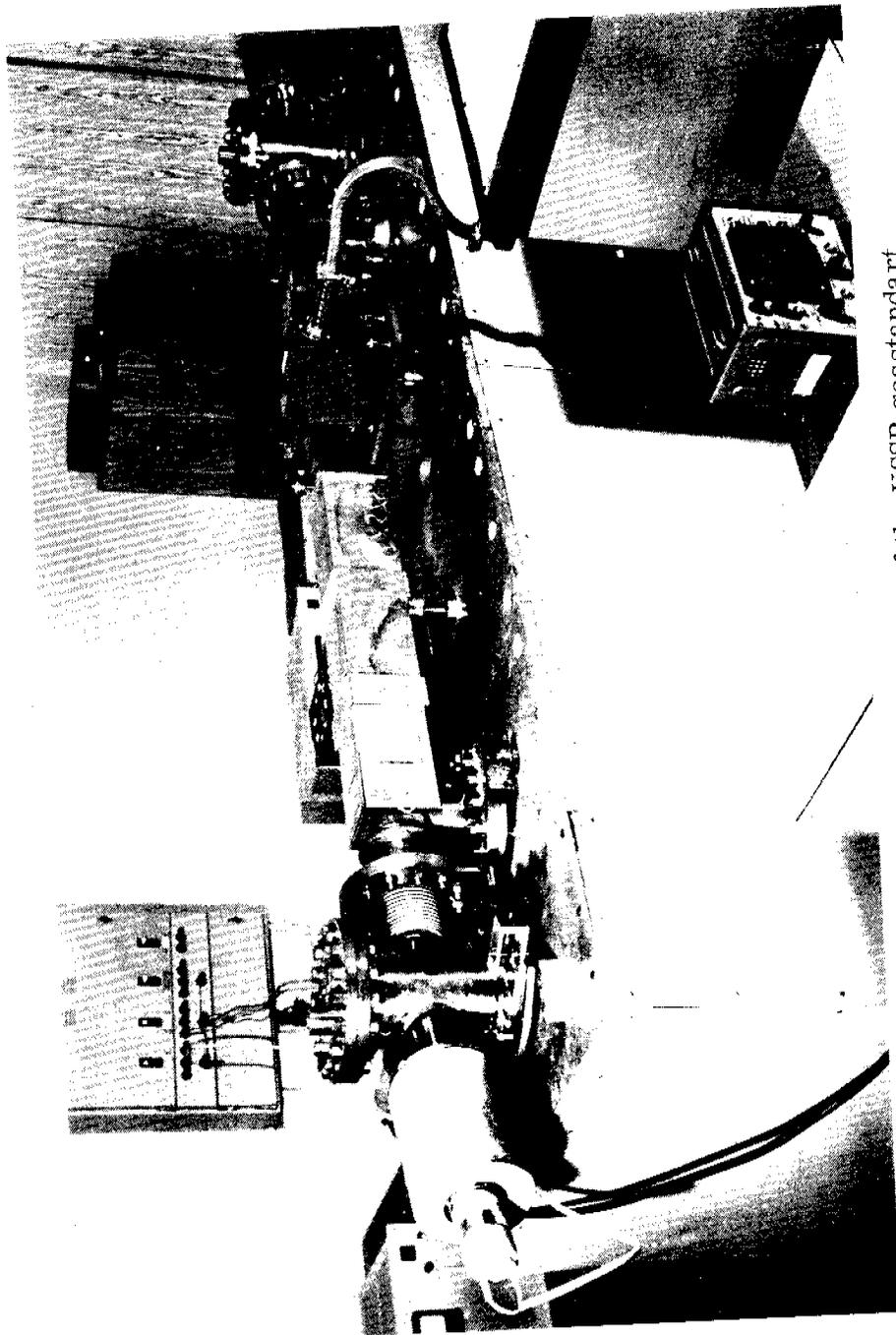


Figure 4. Cesium frequency Reper of the USSR gosstandart.

QUESTION AND ANSWER PERIOD

DR. HELLWIG:

With respect to the hydrogen and the cesium devices, first of all on the cesium device, was it designed and constructed at your laboratory? How long is it and such parameters?

TRANSLATOR:

He said the hydrogen apparatus has been working about five years. The cesium metrological system, they started a year or so ago. They have had practical results for about six months from their research. He says because of this, he cannot give you an exact reading on the accuracy of it, only approximately 3 to 5 X 10⁻¹³.

They have good accuracy with the hydrogen work, 2 X 10⁻¹² accuracy. The reproducibility is 1 or 2 X 10⁻¹³.

DR. COSTAIN:

There is a difference between our hydrogen primary standards and our cesium primary standards. We think our cesium is by far the best, but our measurements at the moment indicate that the hydrogen frequency decreases at a rate of more than 1 part in 10¹² per year, and this is no doubt characteristic or partly the fault of our old machines.

I would be interested to know if in subsequent years you have a comparison between your standards.

TRANSLATOR:

He says it is true that the hydrogen system is not as good as the cesium system today. They were not able to break down their accuracy to the degree they required as far as the units are concerned. They did make a measurement in the last year, a cesium unit, and the accuracy of this is 3 or 5 units in 10⁻¹³. These data are in good agreement with the National Standard data, both for West Germany and Canada.

DR. WINKLER:

Could you leave the microphone with Dr. Costain, because I would like to ask him a question and that is, in regard to

your last comment, did I understand that you said the hydrogen frequency seems to decrease after all allowances have been made for wall shift and possible chemical changes in the wall coating? Would you elaborate on that statement?

DR. COSTAIN:

Essentially, the past year in an autotuned pair, and one is decreasing at a rate faster than the other. We presume it is changes due to the wall shift, but we have not in fact made the measurements. The results in rate now seem a little higher than the cumulative rate over the past five years.

MR. ALLAN:

Mr. Iljin, you indicated good agreement with the Canadian primary cesium standard and the West German primary standard. If I understand you correctly, this would mean that you would say the international second used by the BIH is too short or too high in frequency by about 1 part in 10^{12} , if I understood you correctly.

TRANSLATOR:

Correct. He says he has an accuracy now of about 1.6×10^{-12} .