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COMPLEX OF METHODS, PROGRAMS, AND APPARATUS FOR AUTOMATING THERMOPHYSICAL INVESTIGATIONS

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The article describes a system of automating thermophysical experiments (SATPhE) devised at the Leningrad Institute of Precision Mechanics and Optics. It explains its possibilities as applied to problems of thermophysical investigations.

Systems of automating experimental investigations are at present widely used in various laboratories, among them also thermophysical laboratories. The appearance of these systems and their introduction into research practice was due to a number of causes, among them the increasing complexity of experimental investigations and the endeavors to extract more complete information from the experimental data. The systems of automating experiments develop and progress together with the development of computer and electronic techniques and with increasing complexity of experiments. Construction of these systems is effected in different ways; one of them is the main-line modular principle of construction, which to us seems the most promising one because of its flexibility, ease of adding on to the system and of programming [1]. Particularly convenient is this principle in automating a broad class of problems, when it is necessary to ensure ease of rearrangement of both the instrumental and the program part of the system.

At the Leningrad Institute of Precision Mechanics and Optics (LITMO) work has been carried out for years with automation of investigation of the thermophysical properties of substances, steady-state and pulsating thermal flows, contact thermal resistances, temperature fields, etc., and this led to the devising of a complex of methods, programs, and apparatus for automating thermophysical investigations whose abbreviated designation is SATPhE–LITMO. It is based on the main-line modular principle of construction and the use of Soviet-made desk computers; various programs were prepared to enable the users to process the results of a broad class of thermophysical experiments. The construction of the system by the main-line principle ensures that the system can be easily extended by adding on, or that its composition of the system can be changed during the experiments according to a program fed to the computer. The possibility of changing the composition of the system during experiments is attained by using commands of reference to the given external device, which may be an analog–digital converter (ADC) F-4221, a digital voltmeter F-30, an external memory (EM) with a capacity of 4 kbyte, a curve-drawing recorder PDP-4. The functions of selecting the hardware, and also the function of feeding the information to the computer and of obtaining it from it are realized with the aid of a controller based on microcircuits of the series K-155. A block diagram of the SATPhE–LITMO is shown in Fig. 1.

The basis of the system are two desk computers connected via a mainline expander with the hardware comprising the EM, a digital voltmeter F-30, the ADC F-4221, the curve-drawing recorder PDP-4, connected to the mainline by a digital-analog converter (DAC). The digital

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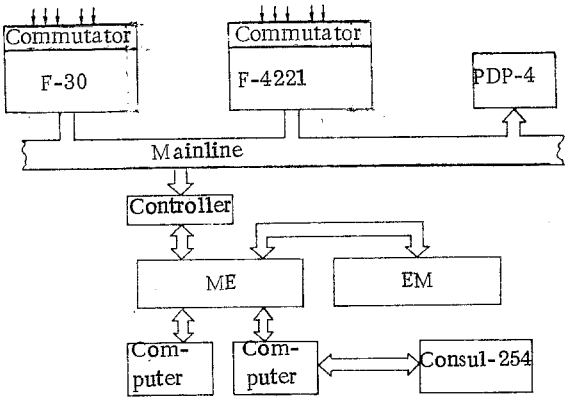

Fig. 1. Block diagram of the SATPhE—LITMO.

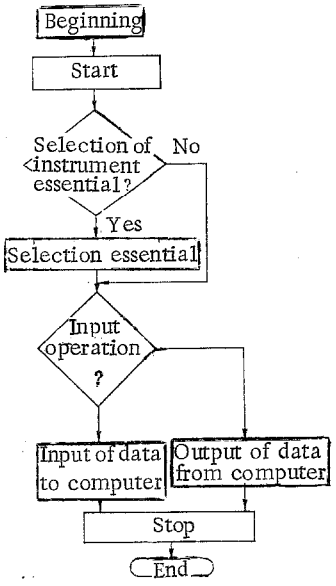

Fig. 2

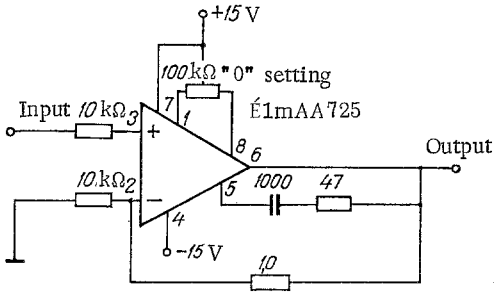

Fig. 3

Fig. 2. Algorithm of the operation of the controller.

Fig. 3. Scaling amplifier.

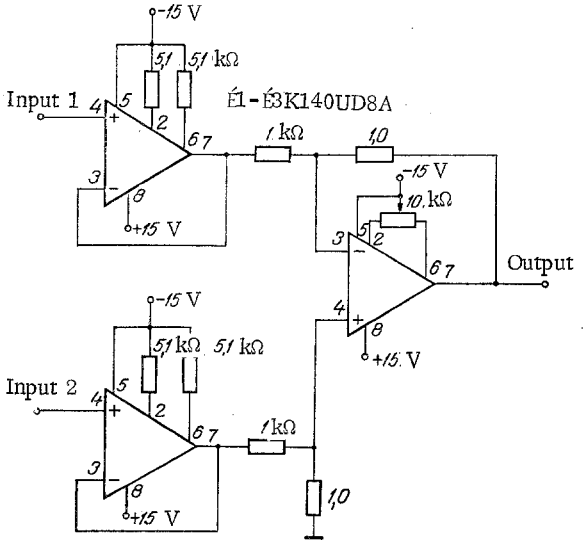

Fig. 4. Differential amplifier.

voltmeter and the ADC are connected with the experimental devices by commutators of analog signals. The results obtained during the investigations are printed by the printer CONSUL-254.

The algorithm of operation of the controller is shown in Fig. 2. If, according to the program fed to the computer, it is essential to select an instrument with which the computer has to be connected, the controller establishes the connection with the instrument whose address is given by the program. If a selection is not required, the data are received (transmitted) by the device with which a connection had been established previously. Furthermore, if the computer gave an input command, the instrument transmits the data via the controller to the computer, if an output command was given, it receives the data from the computer. The timing of input–output is governed by a timer. Thus, like in any other system constructed on the mainline principle, to the computer one external instrument differs from any other only by the address code and the basic function it fulfills (input–output); this makes it easy to add on to the system.

The source of information on a process in progress in a thermophysical experiment may be signals from the most variegated sensors, e.g., thermocouples, thermopiles, resistance thermometers, heat-flux sensors, etc. Coupling of SATPhE–LITMO with these variegated sensors is done by different types of normalized amplifiers. Figures 3 and 4 show a scaling amplifier and a differential amplifier, respectively. The scaling amplifier is used for coupling the SATPhE–LITMO with thermocouples, the differential amplifier for coupling with resistance thermometers that are part of bridge circuits. The scaling amplifier has as its main component an integral microcircuit mAA-725 (Czechoslovakia) ensuring zero drift of less than 1 μV/°K; this makes it possible to use it for coordinating the SATPhE–LITMO with thermocouples. The differential amplifier is based on three microcircuits type K140UD8 with large input resistance; this makes it possible to use it for work with symmetrical highly resistive sources, e.g., bridge circuits.

The fact that there are two computers makes it possible simultaneously to collect and process information and check the course of the experiment. The exchange of data between the computers is effectd bia the external memory. For instance, in experiments concerned with the investigation of temperature pulsation on the surface of a body immersed in a fluidized bed, the data from the ADC F-4221, recording the temperature pulsation, are received with the aid of one of the computers, and then they are transmitted to the external memory. From the external memory the data are demanded and received by the other computer and processed, while the first computer at the same time receives the subsequent body of data.

To ensure the possibility of realizing the most variegated experiments with the aid of SATPhE–LITMO, it was necessary to provide programs for thermophysical investigations consisting of the following principal blocks.

1. Block of programs for data collection. This block contains programs for gathering data and recording them on magnetic tape (MT), programs for gathering data and storing them in the external memory, and programs for exchanging information between the computer memory and the external memory.

2. Block of programs for preliminary processing of the experimental results. This block contains the programs of analysis and exclusion of gross errors, for filtering the obtained data, for interpolation and approximation of the data, and for correlation and spectral analysis of the data.

3. Block of programs for obtaining the final results of the experiment. It provides the thermophysical characteristics in which the researcher is interested.

The use of SATPhE–LITMO provides considerable advantages when compared with the traditional research methods. Firstly, since digital measuring instruments are used, the accuracy of a single measurement is considerably greater, especially in the recording of rapidly proceeding processes. For instance, when the temperature pulsations in a fluidized bed are measured with the aid of a loop oscillograph, the error of a single measurement attains 2%, whereas when SATPhE–LITMO is used, the error does not exceed 0.5%. Secondly, when SATPhE–LITMO is used, the experimenter is relieved of the necessity of carrying out primary processing of the data, which includes their numbering and statistical processing, as well as providing the final results of the experiment. This is possible because programs and mathamatical apparatus for a broad class of thermophysical investigations have been worked out, and this greatly reduces the time needed for investigations.

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