NOTATION

a, thermal diffusivity; λ, thermal conductivity; α, heat-transfer coefficient; θ, relative temperature; δ, wall thickness; τ, time; C, electrical capacity; R, electrical resistance; R', leakage resistance; K = R/R', coefficient; T = RC, time constant; n, number of nodal points of the grid; U, voltage; p, Laplace operator; x, coordinate; Δx, discretization step of the coordinate; $\overline{X}(\tau)$, vector of state of the object; $Y(\tau)$, vector of observation of the object; $\overline{U}(\tau)$, control vector; $\overline{\Theta}(\tau)$, vector of the unknown parameters; $\overline{\varepsilon}(\tau)$, $\overline{\xi}(\tau)$, vectors of measurement noise; ^, estimate.

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AUTOMATIC SYSTEM OF IDENTIFYING THERMOPHYSICAL PARAMETERS OF OBJECTS ON THE BASIS OF SOLUTION OF INVERSE HEAT-CONDUCTION PROBLEMS

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The article examines an automated system of determining the parameters of heat exchange and the thermophysical characteristics of the investigated objects on the basis of the solution of inverse heat-conduction problems (IHCP).

Improving the quality and effectiveness of thermophysical research entails the necessity of devising and introducing modern means of automating such research. In accordance with the material of [1], automatic systems of scientific research (ASSR) are based on obtaining and using models of objects, phenomena, and processes. The methods and algorithms for processing the experimental data, based on the solution of the corresponding IHCP, are at present one of the most universal methods of experimental thermophysics, and they are the natural basis of the mathematical provisions for the planned ASSR of thermal processes. Planning ASSR must take into account the special features, not only of the studied thermal processes and objects, but also of the algorithms for solving the IHCP connected with the solution of boundary problems described by differential equations in partial derivatives.

The selection of the structural schema and the organization of the work of ASSR, of the parameters of heat exchange and of the thermophysical characteristics of the investigated objects (carried out at the Institute of Technical Thermophysics, Academy of Sciences of the Ukrainian SSR) are based on the use of standard schemata of the control computer complexes (CCC) SM-3 and SM-4 described in [2]. The principal requirements that ASSR have to fulfill are the following: a) sufficiently rapid operation of the channel sensor—amplifier—commutator—ADC—IM which, in view of the programming provisions, has to amount to at least 500 Hz; this makes it possible to record reliably the readings of 20-30 thermocouples under the nonsteady conditions of the highly forced process of heat exchange (thermal flux on the surface of the investigated object $a_f > 10^5$ W/m^2); b) sufficiently rapid operation (at least 20,000 operations per second) and capacity of the IM (at least 10 Kbytes) of the digital processor that is part of the ASSR. Figure 1 shows the structural schema of an ASSR that makes it possible to investigate in regimes of actively affecting the object. The complex is based on the CCC SM-4 embodying the processor SM-4P with a speed of 800,000 operations per second and an IM with a capacity of 56 Kbytes. The connection with the hardness is effected in the

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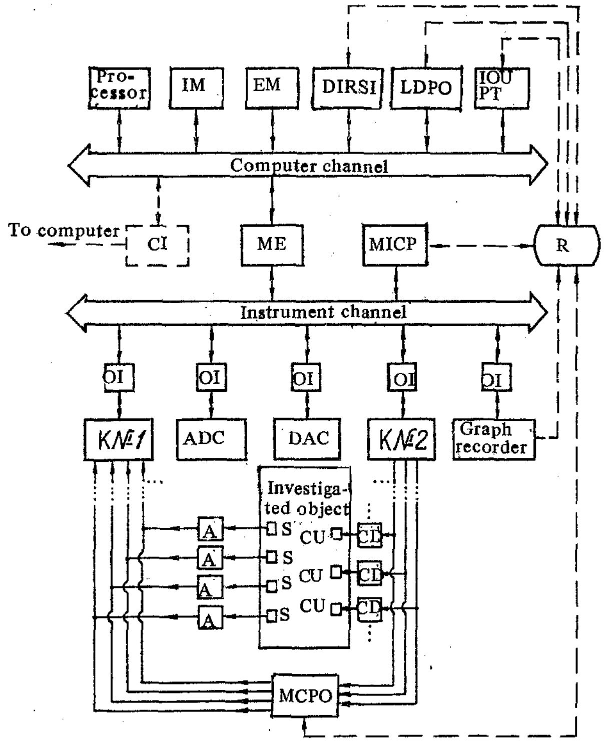

Fig. 1. Structural schema of the complex of ASSR of thermophysical parameters: IM) internal memory; EM) external memory IZOT 1370-I12 (capacity 2.4 Mbytes); DIRSI) device for the introduction and representation of symbol information ES 7168; LDPO) letter and digital printout DZM-180; IOU PT) input and output units, punched-tape SPTP (photocounter) and SM 6204 (perforator); CI) interface module with the computer; ME) channel expander; MICP) independent manual instrument control panel; R) researcher (operator); OI) object interface; K) commutator F799/2 [3] (100 channels); ADC) analog-digital converter F4890 [4]; DAC) digital-analog converter TsAPT-5-14/2 [4]; A) amplifier F7024 [4]; S) sensors; CU) control units; CD) control devices; MCPO) manual control panel for the object.

standard of aggregate means of electrical-measurement techniques (ASÉT) with "common bus" interface. The investigated object may be any product under conditions of steady or non-steady heat exchange.

To determine the thermophysical characteristics (thermal conductivity and specific volumetric heat capacity) of the investigated materials under conditions of arbitrary one-sided heating regime based on the solution of IHCP, we suggest a specially designed unit (Fig. 2) of cylindrical design with an easily replaced specimen of the investigated material and thermocouple for multiple use. The design of the upper half is analogous to the lower half (shown in Fig. 2) except that it does not contain thermocouples and the socket. The specimen is heated from the side of the left-hand end face by a gas burner, an electric heater, or other sources of heat. While heating is in progress, a special clamp presses the upper and lower halves of the unit together. For processing the data of temperature measurements, the mathematical model of a rod, heat-insulated along the lateral surface, is used, and as boundary conditions the conditions of the first kind (readings of the outer thermocouples) are taken. The algorithm for solving IHCP presented in [5] makes it possible to reconstruct the thermophysical characteristics in dependence on the temperature in a range determined by the level of the experimental temperatures.

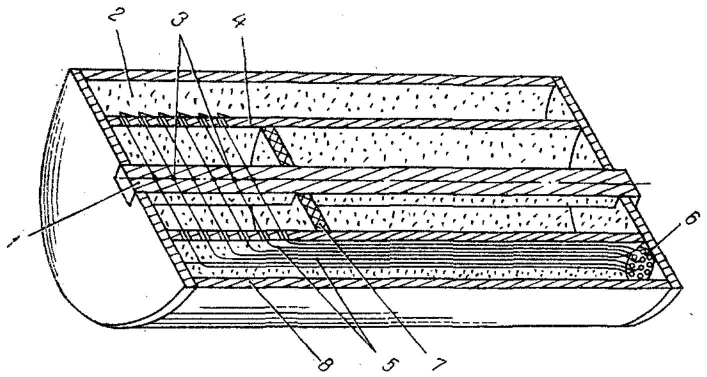

Fig. 2. Diagram of the unit for thermal research with test specimens (lower half): 1) specimen; 2) asbestos packing; 3) thermocouples; 4) equalizing pipe; 5) thermocouple terminals; 6) electric socket; 7) split washer; 8) housing.

The functional interaction of the separate units and the entire schema of ASSR was tested on the basis of the measuring and computing complex IVK-8 [2]. The results of recording nonsteady signals — the analogs of temperature measurements — showed that the IVK-8 does not provide great possibilities: with a view to the programming provisions, its maximum interrogation frequency of the input channels amounted to 7 Hz.

The suggested ASSR together with an analog processor may be used as a hybrid computer for the effective solution of complex heat exchange problems (including also complex IHCP). The investigated object is an electrical model of the thermal process (e.g., an R–R grid) which realizes the solution of the direct problem of heat conduction, and the control device is an analog memory device. The realization of the algorithm for solving the corresponding IHCP is taken over by the digital processor of the ASSR.

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