AUTOMATED ULTRASONIC ANEMOMETER–THERMOMETER FOR MEASURING THE TURBULENT CHARACTERISTICS IN THE GROUND ATMOSPHERIC LAYER

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A compact meteorological device for measuring meteorological parameters (pressure, humidity, wind velocity, temperature) and turbulent characteristics of the atmosphere is described in the paper. The device enables one to measure the velocity of viscosity and a turbulent flow of heat, the Obukhov––Monin scale, and structural functions of temperature C_T^2 *and wind velocity* C_V^2*.*

Ultrasonic anemometer are frequently used in studying the turbulent characteristics in the ground layer of the atmosphere and interaction between the atmosphere and ocean.[1–5] Therefore, it is of great importance to increase the measurement accuracy by taking account of the effect of distortions brought about in a turbulent flow by sensors and anemometer construction,[6] spatial averaging, and minimizing the distortions in recent approaches.[4 7]

The absence of moving parts, relatively small constant of time, selective sensitivity to the desired component of velocity, and possible measurements of temperature fluctuations[4] make this device convenient and reliable for studying the propagation of optical and acoustic waves in the atmosphere since fluctuations of wave amplitude and phase, especially, in an acoustic range strongly depend on spatial distribution of field fluctuations of meteorological elements: wind velocity, temperature, and humidity.[8,9]

To measure them, a meteorological system on the basis of ultrasonic anemometer–thermometer, which allowed the measurements of mean and fluctuation (turbulent) characteristics of wind velocity, temperature as well as pressure and relative humidity of air, was constructed in the Institute of Atmospheric Optics with regard to the previous experimental findings. A block diagram of the meteorological system is depicted in Fig. 1.

The system has an orthogonal arrangement of axes with the base $L = 24.5$ cm, transponders of diameter $d = 12$ mm, a built–in microcomputer, and pressure and humidity sensors. An analog unit is placed in a tube of diameter $\varnothing = 4$ cm which is joint with an aerodynamically shaped box. There are a microcomputer, a modem, and pressure transducers in this box. An "Intel" microprocessor I 8085 provides measurements, previous processing, and output of values of meteorological parameters in a two–problem mode of operation. The first problem which is of paramount importance is to measure the instantaneous velocity of wind in three perpendicular directions and temperature with measurement frequency of the order of 36 Hz. The second problem is to measure the humidity and pressure and to output the calculated values of meteorological parameters through the radio modem over the commutation line to a user. It is actuated by timer or user. The system has six modes of operation, five of which are working and one is diagnostic. In the first mode, the rate of outputting a file of meteorological parameters is 10, in the second mode – 1, and in the third mode – 0.1 Hz. In the fourth mode, the rate is set by a user, and in the fifth one the temperature values are outputted with 20–Hz rate.

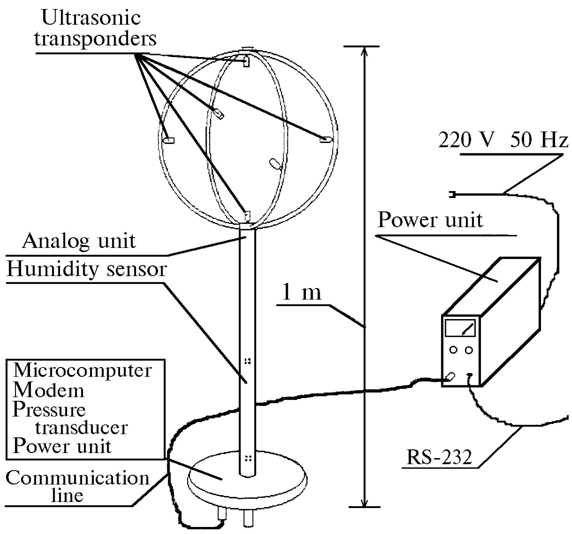

FIG. 1. Block diagram of automated ultrasonic anemometer–thermometer.

All units of the system and modes of operation are checked and tuned in the diagnostic mode. The file of meteorological parameters consists of a two–byte heading, 4 to 14 bytes of information, and a two–byte cyclic control code. The scale value of the low order in measuring velocity is 2 cm/s, in measuring temperature it is 0.008°C, the measurement error in air relative humidity is not higher that 10%, and in air pressure it is ± 2 Torr. The power consumption is 2 W, and mass is below 3 kg. The system has been successfully tested under field conditions where following tests were made:

– consideration of wind shading with ultrasonic sensors of the meter (correction for shading);

– effect of humidity on the accuracy of determination of temperature fluctuations;

– determination of structural characteristics of temperature C_T^2 and wind velocity C_V^2 fluctuations using a sole meter.

The results of tests revealed that the device is close to the known models DAT–300 (Kaijo Denki Inc., Japan) and SWS 211/3 K (Appl. Tech. Inc., USA) in its meteorological characteristics.

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