Portable Biomedical Air Thermostat with Remote Control

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***Abstract*—The problems of constructing a portable biomedical air thermostat based on the Peltier element are considered in this paper. The thermostat provides a temperature stabilization in the range from +20 to +40 °C, has small proportions, useful volume of 1L and the ability to mix thermostated substances. It is equipped with wireless data interface and a battery which provides autonomy up to 15 minutes.**

I. Introduction

In chemical and biological researches in the field, it is necessary to ensure the maintenance of a constant temperature in a small volume with some features of stationary thermostats. So, the following requirements were imposed:

- Temperature range: from +20 to +40°C
- Ambient temperature range: from +15 to +30°C
- Power consumption: no more than 100W
- Accuracy of temperature setting: 1°C
- Volume: 1L
- Dimensions: no more than 200 x 200 x 200mm
- Time of autonomous work: no less than 15 minutes
- Ability to use 12V DC as power supply
- Ability of stirring
- Light control
- Indication
- Wireless and manual control

II. Block diagram

The following block diagram was developed to fulfill all requirements (Fig.1). The devise has a Peltier element (1), polarity of which are controlled by relays (2), that allows not only to heat but to cool air in thermostat. Power of the Peltier element is set by Peltier element power driver (3). The core of the thermostat is microcontroller (7). It controls fans (4, 5) and light (7) through power driver (6). Four ADC channels (10) are used to connect different types of sensors. One separate temperature sensor (11) is used to measure ambient temperature. The stepper motor driver is used to supply motor for stirring. Also, the thermostat has a display (20), control panel (21), wireless connection unit (8) and battery control unit (12).

III. Body of thermostat

A) *Material*

To complete all requirements the polylactide (PLA) was chosen. This material has the following characteristics:

- Melting point: 180°C. This allows thermostating even at relatively high temperatures.
- Thermal conductivity: 0.13W/mK. Due to the low thermal conductivity (for comparison, mineral wool has a thermal conductivity of 0.8W/mK), no additional materials are required to reduce heat loses.
- Density: 1.3g/cm^3. This makes thermostat light.
- Hardness: 50MPa. This makes thermostat strong enough to withstand the impacts of mobile use.
- Polylactide is non-toxic and does not react with most of chemicals, which makes it suitable for building a biomedical thermostat.

B) *Method of fabrication*

To produce the thermostat, additive technologies (3D printing) was used. This allows creating a special structure that increases strength, also lowers thermal conductivity and reduce the usage of plastic. The internal structure of the material has spaces with air constituting 85% of the volume, which also contribute to the reduction of thermal conductivity. The main advantage of using additive technologies is the ability to quickly modify the device. This allows using the thermostat most effectively.

C) *Additional parts*

Seal inserts for tight fitting of moving parts, doors and movable table were developed from special material such as FilaFlex.

The structure of thermostat is shown in Fig. 2.

Temperature sensors of type LMT-70 have a time constant in order of a second [1], which makes it possible to react quickly to any changes in temperature. It is possible to install up to four analog temperature sensors. One of them must be selected as the master. It will be used during adjusting temperature. There are four connectors for different analog sensors located at different heights in 2 cm increments, which make possible to record the temperature gradient or calculate average value. Sensors for humidity, acidity, light, gas or vapor concentration can be connected. There is an additional

ISSN 2305-7254

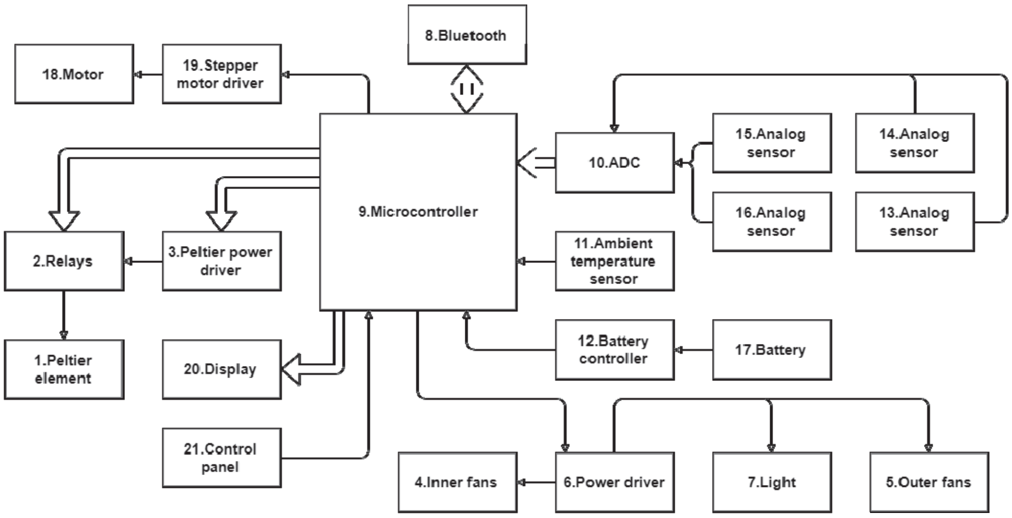

Fig. 1. Block diagram of thermostat

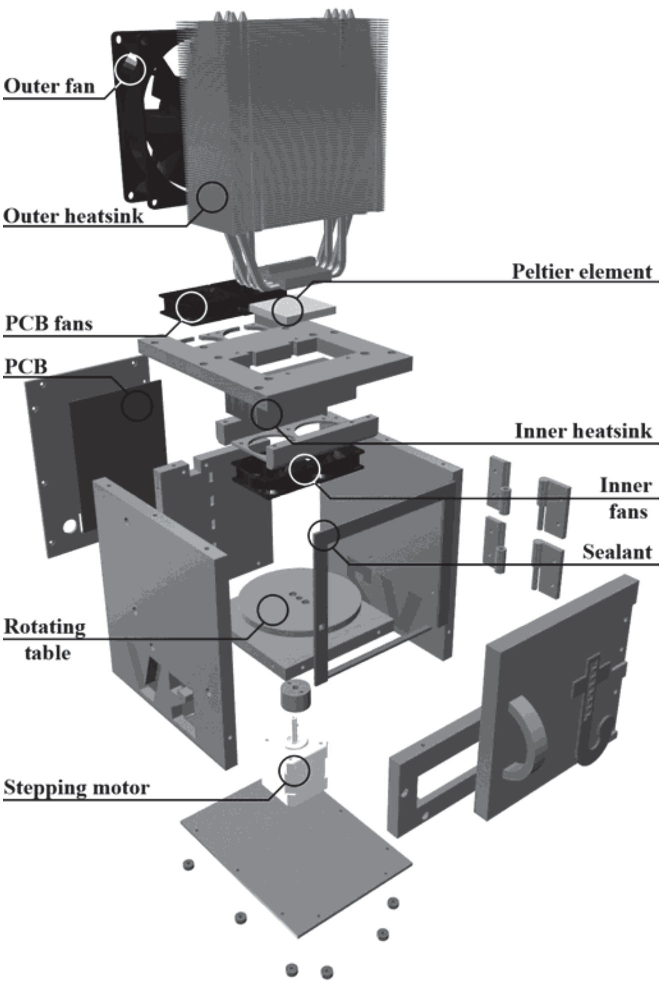

Fig.2. Structure of thermostat's body

temperature sensor located on the control board and used to measure the ambient temperature.

IV. Important features

A) Temperature measurements

B) Stirring table

The thermostat has a rotating table, which are used for stirring substances. The table is rotating by stepping motor, which is controlled by a stepping driver of type A3967 for motors up to 750mA per coil.

C) Light source

In the thermostat, there is also an adjustable light source, which can be used for carrying out photochemical reactions.

D) Autonomy

To reach the requirements the 3-cell (11.1V) 3000mAh Li-Pol battery is required. The battery controller is used to control charge level of the battery. The ability use 12V DC as power supply allows using it in cars or with additional external batteries

E) Indication and control

To control thermostat temperature the buttons on the body of the thermostat can be used. The mobile device with Bluetooth is needed to change other parameters. The application for mobile and PC was developed. Wireless interface helps to provide user with friendly interface. To see actual information the LCD display for temperature indication is used.

V. Conclusion

The developed device was produced according to the described design. Also, it was tested and showed parameters corresponding to the technical design:

- Temperature range: +20 - +40°C
- Power consumption: 84W
- Motor power: 4.8W
- Wireless communication channel Bluetooth: 2.0
- Accuracy of temperature measurement: 0.1°C
- Temperature setting accuracy: 0.5 ° C
- The volume of the chamber: 1L
- Time of autonomous work: up to 15 minutes
- Operating conditions: +15-+30°C
- Dimensions: 200x120x160mm

Acknowledgment

The author expresses sincere gratitude to the Department of Bioengineering Systems of the Saint-Petersburg Electrotechnical University “LETI” and to the Department of Environmental Physiology of the Federal State Budgetary Scientific Institution “Institute of Experimental Medicine” for their support and constant interest in this work.

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