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The Multipurpose Converter for Control of Parameters of Gaseous Environments

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ABSTRACT: In article questions of development of microprocessor control systems and methods of transformation of parameters of air flows on the basis of converters with optoelectronic and thermal elements are considered. The design of the multipurpose converter for control of parameters of a stream of gaseous environments is given. The mathematical model on the basis of the theory of four-pole networks is considered. Results of pilot studies are given.

KEY WORDS: microprocessor control system, gaseous environment, thermal converters, thermo resistors, semi-ring receivers of radiation, measuring scheme, thermal four-pole network, static characteristics.

I. INTRODUCTION

In the last decades for development of such important industries as heat and wind power, construction of high-rise buildings, metallurgy, the oil and gas, cotton-processing industry, food production and agro-industrial complexes and also on objects of the transport tunnels and mining mines, is required paying of importance to the solution of problems of monitoring of parameters of the external environment (to speed, temperatures, the directions, existence or lack of an air flow).

The analysis of the known publications shows that now the research works directed to obtaining exact data on various parameters and properties of controlled technological objects and also to development of microprocessor control and management systems for a condition of the technical units working in a difficult climatic and corrosive environment are carried out [1]. One of the main requirements shown to measuring means is ensuring unity of measurements, in this regard special attention is paid to improvement of converters of parameters of streams of gases. At the same time for management and control of parameters of gas streams it is necessary to use converters with broad functionality, high reliability, accuracy, speed and to the meeting strict requirements imposed from technological objects to their metrological characteristics.

For realization of these problems of control of parameters of air flows and gases, the external environment and a condition of technogenic objects microprocessor converters on the basis of the optoelectronic and thermal elements established in the form of the device on one bearing structure are very perspective. In this regard development of multipurpose converters of parameters of streams of gases on the basis of optoelectronic and thermal elements is relevant.

II. ANALYSIS OF EXISTING FILTERING MATERIALS AND RESEARCH RESULTS

Modern control and management systems for air flows demand that control units were multipurpose and allowed to control by the one design the speed, temperature, the direction and existence of air flow and also convenience of interface to microprocessor means [2].

Most fully thermal converters of term anemometrical type which have high sensitivity, especially at small speeds of streams meet these requirements for control of speed of air [3]. Functionality of the device increases by simultaneous measurement by means of thermal converters of speed and temperature of air flow, and also thanks to use of the optoelectronic converter of control of turn of a weather vane in the Cartesian coordinates in the range from 0 to 360 degrees.

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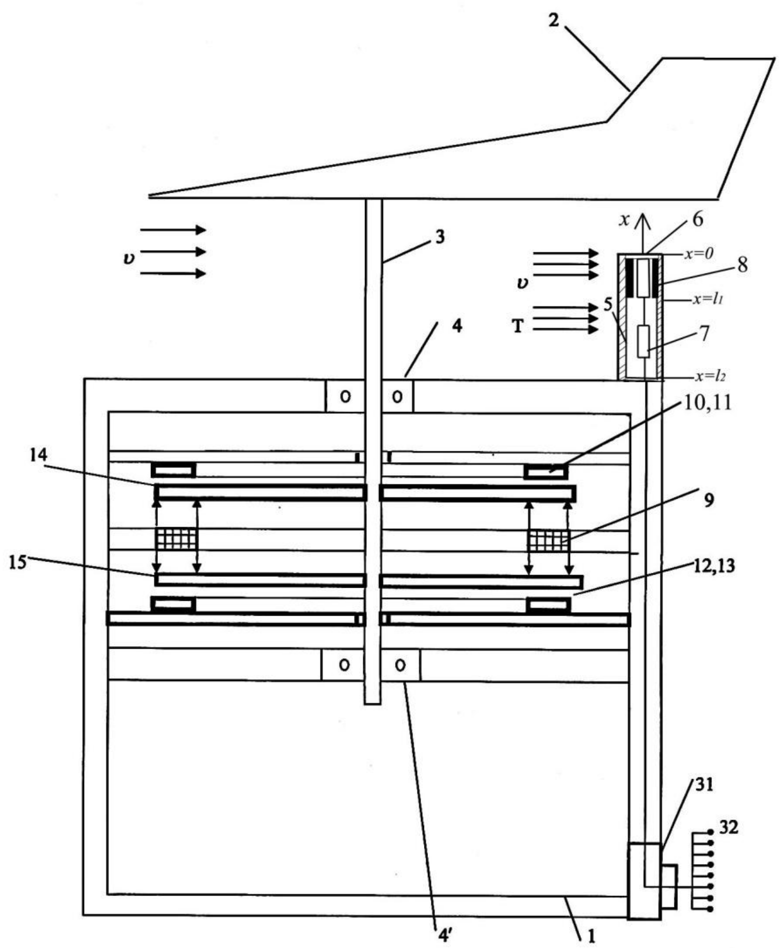

Fig. 1. A design of the multipurpose converter for measurement of a stream of the air and gaseous environment.

The device design for measurement of speed and flow direction of the air and gaseous environment is given in fig. 1. The device consists from: buildings 1; weather vane 2; a core is axes 3; bearings 4 and 4'; a copper tube 5 in which the main 6 and additional the 7th thermoresistors and heating element 8 are placed; ring source of radiation 9; the top semi-ring receivers of radiation 10,11 and, the displaced by 90 degrees concerning them, lower semi-ring receivers 12.13; top 14 and lower 15 semi-disk optical screens; constant electric resistance 16,17,18,19,20,21,22; switch 23; electronic amplifiers 24,25,26; analog-digital converters 27,28,29; microprocessor 30; plug connector 31; output wires 32 [4].
The measuring scheme multipurpose converters for measurement of speed and flow direction of the air and gaseous environment is provided on fig. 2. In the drawing are designated: U_m is the supply voltage given to bridge schemes I, II, III; U_1, U_2, U_3 are the output voltage of bridge schemes I, II and III.
The device for measurement of speed and flow direction of the air and gaseous environment works as follows. In the presence of an air flow with a speed of V (fig. 1) the main thermoresistor 6 with heating element 8 heats up and thanks to the copper tube 5 providing good thermal contact with air enters heat exchange with a wind stream, and depending on the size of flow rate of V a certain process of heat exchange, its temperature and, therefore, electrical resistance of thermoresistor 6 are established.
In an initial state in the absence of wind speed (V = 0) I Bridge for measurement of speed of an air flow (fig. 2) is counterbalanced (U_1 =0) and at position of switch 23 in "*a*" resistance 6,7,16,17 are equal among themselves. At the same time the bridge is out of balance and its output voltage U_1 gives information about wind flow rate $U_1 = f$ (V). Further the signal of wind speed through 24 and 27 moves in microprocessor 30.

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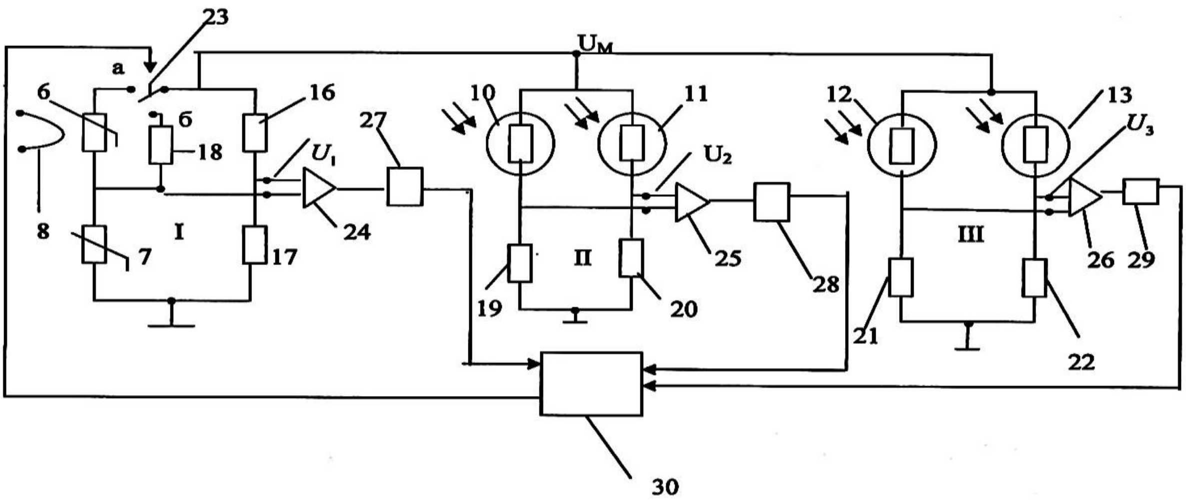

Fig. 2. The measuring scheme of the multipurpose converter for measurement of speed and flow direction of the air and gaseous environment.

As at temperature change also thermo resistor 6 resistance changes, for compensation of this change is used thermo resistor 7, which reacts only to stream temperature. For measurement of temperature of a stream switch 23 is turned to position "*б*", the signal from microprocessor 30 arrives on the constant resistance 18 of the bridge measuring scheme I. Bridge scheme I with thermo resistor 7 will control only temperature of T of an air flow. Thanks to a copper tube 5, in which thermo resistors 6, 7 and heating element 8 are placed, the good thermal contact with air flow is provided and are protected 6,7 and 8 from an atmospheric precipitation and other influences.
Thus, bridge measuring scheme I with thermo resistors 6, 7 and heating element 8 allows to measure by means of switch 23 speed, at connect of contact of switch 23 in the provision "*a*", and stream temperature, at connect of contact of switch 23 in the provision "*б*". Further in both cases the output signal of U1, amplifies electronic amplifier 24 and via analog-digital converter 27 moves on microprocessor 30, which periodically obtains information on the speed of V and temperature of T of an air flow.
In the initial direction of an air flow the weather vane 2 with axis 3 adopts the provision as shown in fig. 1 and at the same time are adopt the relevant provisions optical semi-disk screens 14 and 15, in relation to semi-ring photoresistors 10,11 and 12,13 (fig. 3 *a* and *c*). In bridge measuring scheme II with semi-ring photoresistors 10 and 11 there is identical blackout of their resistance on half. At equality of these resistance to other resistance of the bridge 19 and 20, the output voltage of II Bridge it will be equal to zero ($U_2 = 0$). But in bridge scheme III (fig. 2) with photoresistors 12 and 13 because of full blackout of photoresistor 13 - its resistance will be maximum, full lighting of photoresistor 12 - its resistance will be minimum. At equality of resistance of other shoulders 21 and 22 output voltage of Bridge U_3 will have the maximum value with the sign "+". These values of tension of bridges of U2 and U3 can be displayed on the computer screen in the form of the vector chart, as shown in fig. 3 *c*. Postponing on axes U_2 and U_3 of a projection of their valuesU_2' u U_3', we receive the vector image of the direction of an air flow at the relevant provision of a weather vane 2. At change of the direction of wind, for example counter clockwise, the weather vane 2 by means of an axis - a core 3 will turn optical screens 14 and 15.
On the screen of the computer there will be corresponding output voltage of U_2' u U_3' (fig. 3 *c*) and their vector sum will give information on the real direction of an air flow by means of OA vector. In fig. 3, d, e, f, g, h, I, j, k, l arrangements of photoresistors 10,11,12,13 and optical screens 14.15 and also received on the screen of the computer, the image of a vector at turn of a weather vane 2 by 90,180 and 270 degrees counter clockwise in relation to the initial direction of an air flow are shown.

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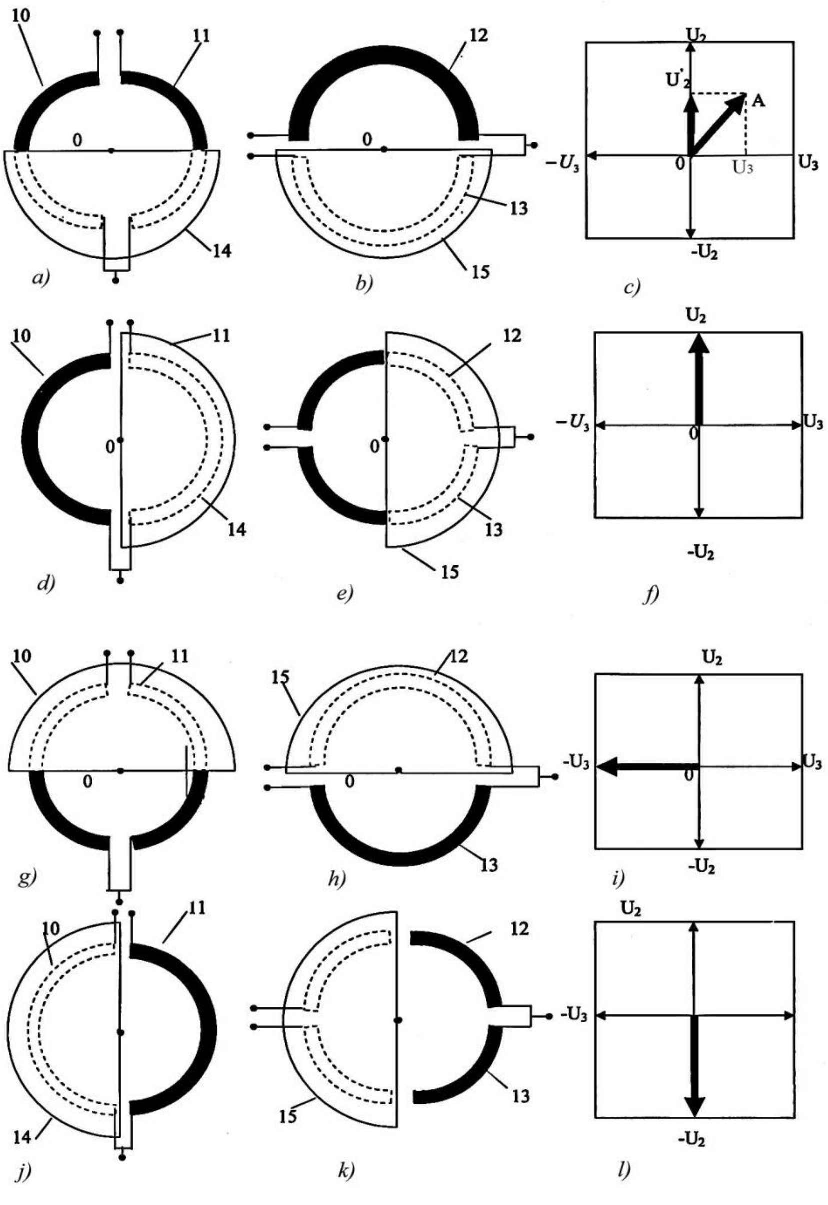

Fig. 3. Layouts of the top receiver of radiation and mobile optical screen.

III. LITERATURE SURVEY

Let's consider mathematical model of the thermal converter of speed of term anemometrical type (fig. 1) for determination of interrelation between the speed of an air flow V and distribution of temperature $T(x)$ along a heat conductor 5. For this purpose we will present the thermal system of the converter in the form of the thermal four-pole network that will allow to analyze effectively a thermal system consisting of two sites l_1 and l_2 (fig. 1).
In a matrix form the equation of the thermal four-pole network with the distributed source of heat registers in a look:

$$\begin{vmatrix} T(x) \\ \Phi(x) \end{vmatrix} + \begin{vmatrix} T_q(x) \\ \Phi_q(x) \end{vmatrix} = \begin{vmatrix} A(x)B(x) \\ C(x)D(x) \end{vmatrix} \begin{vmatrix} T(0) \\ \Phi(0) \end{vmatrix} \quad (1)$$

или в операторной форме

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$$\begin{vmatrix} T(x,p) \\ \Phi(x,p) \end{vmatrix} + \begin{vmatrix} T_q(x,p) \\ \Phi_q(x,p) \end{vmatrix} = \begin{vmatrix} A(x,p) B(x,p) \\ C(x,p) D(x,p) \end{vmatrix} \begin{vmatrix} T(0,p) \\ \Phi(0,p) \end{vmatrix} \quad (2)$$

where: $T(x,p)$, $\Phi(x,p)$ - temperature and heat stream; $T_q(x,p)$, $\Phi_q(x,p)$ - the distributed sources of temperature and heat stream; $T(0,p)$, $\Phi(0,p)$ - values of temperature and heat flux at the beginning and at the end of a heat conductor; $A(x,p)$, $B(x,p)$, $C(x,p)$, $D(x,p)$ - parameters of the thermal four-pole network. On the basis of (1) for the thermal converter it is possible to write the equation of distribution of $T(x)$ along the site, at a constant heat flux $q(x) = q =$ const.

$$T_1(x) = T_1(0) ch\gamma_1 x + \frac{q}{g(1 - ch\gamma_1 x)} \quad (3)$$

and along the site $l_1 \leq x \leq l_2$

$$T_2(x) = T_2(l_1) ch\gamma_2 x - z_2 \Phi_2(l_1) sch\gamma_2 x \quad (4)$$

In a point x takes place equality of temperatures and their derivatives

$$\left.\frac{dT_1(x)}{dx}\right|_{x = l_1} \quad \left.\frac{dT_2(x)}{dx}\right|_{x = l_2} \quad (5)$$

As a result of the solution of the equations it is received

$$T_1(x) = \frac{q}{g_1}\left(1 - \frac{ch\gamma_1 x}{ch\gamma_2 l_1 + \frac{\gamma_2 sch\gamma_1 l_1}{\gamma_2}}\right) \quad (6)$$

$$T_2(x) = \frac{\gamma_1}{\gamma_2}\left[\frac{q}{g} - T_1(0)\right] sch\gamma_1 l e^{-(x-l_1)\gamma_2} \quad (7)$$

The analysis of expressions (6) and (7) in terms of increase in sensitivity allows to draw the following conclusions:

1) the site expediently to make from materials with great value of r and the minimum of d_1;

2) the thermo sensitive element needs to be established on the site closer to a face part of a heat conductor at $x = 0$;

3) length of the site has to provide performance of a condition of $q(x)$ = const on the site of arrangement of a thermo sensitive element;

4) length of the site has to provide the minimum impact of temperature change of a support.

III. EXPERIMENTAL RESULTS

Static characteristics of the multipurpose thermal converter of termo anemometrical type are given in fig. 4.

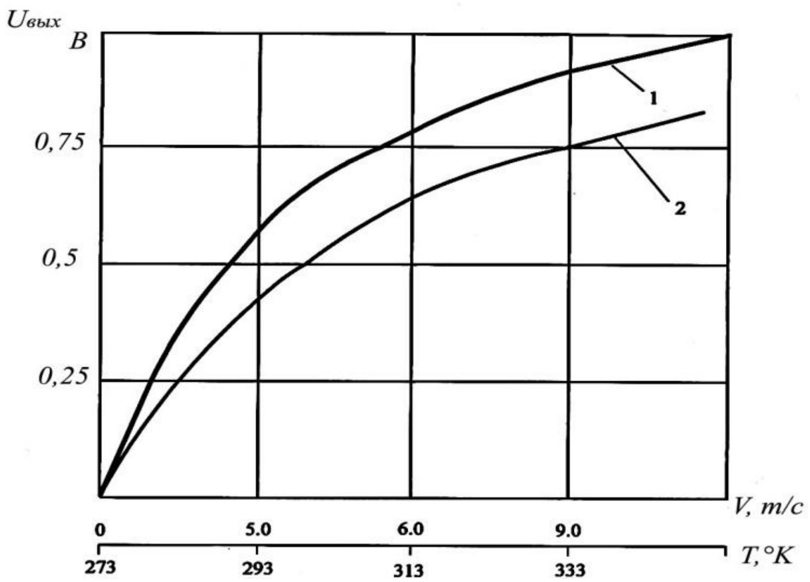

Fig. 4. Static characteristics of the thermal converter:
1 – at control of flow rate; 2 – at control of temperature of a stream.

V. CONCLUSION AND FUTURE WORK

Thus, in bridge measuring scheme I the main thermo resistor 6, supplied with heating element 8 and switch 23, has an opportunity to serially connect to a shoulder of the bridge scheme thermo resistor 6 or constant resistance 18. It is provided a possibility, by means of additional thermo resistor 7 to carry out compensation of impact of temperature change of air at measurement of speed and to separately measure air flow temperature. Application of a ring source of the radiation 9, located between the top and lower semi-ring photo resistors 10,11,12,13, connected in a ring 2 and displaced on 90 degrees relatively each other, and arrangements of the semi-disk optical screens 14,15 fixed on axis 3, between a source of radiation and photo resistors 10,11,12,13, allows to receive on the screen of the computer the full image of the direction of wind in the range of 0-360 degrees in a vector form.

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