БЪЛГАРСКА АКАДЕМИЯ НА НАУКИТЕ . BULGARIAN ACADEMY OF SCIENCES

КИБЕРНЕТИКА И ИНФОРМАЦИОННИ ТЕХНОЛОГИИ · Том **3**, № 1
CYBERNETICS AND INFORMATION TECHNOLOGIES · Volume **3**, No 1

София . 2003 . Sofia

Applications

Flow Transducer for Pulmonary Computer Diagnosis*

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Abstract: *The paper proposes and discusses the investigations of a flow transducer , designed with the purpose to diagnose the functions of lungs of patients at different age. Some technical features of the transducer are given and the principal scheme for its building in a computer medical research system is given.*

Keywords: *flow, flow transducer, metering bush, diffusor, air flow, pressure difference, differential pressure transducer.*

1. Introduction

The flow transducer is a basic element in medical equipments for automatic investigations of lungs diseases. The air breathed out by the patient passes through it, and this air flow is a measure for lungs capacity. The measured flow of the air exhaled is transformed into electrical signal, which is input to a computer system for its processing in the form of diagrams and computing data.

A significant number of computer systems, designed for patients lungs study, is made by different manufacturers nowadays. One of them is “Spriolite 101”, a system, in which the flow transducer is with “Fleisch Pneumotach” configuration [2]. The main shortcomings of this construction are: complex technology of fabrication and necessity in a definite type-size for each patient. The complex technology is expressed in the point that a packet of a spirally rolled thin gophering tape is mounted tightly in a cylindrical case. The separate sizes differ in the diameter of the cylindrical body, because the packet is unalterable. The main part of the air breathed out by the patient passes through the whole section of the tape packet and the determination of its flow is accomplished by the drop of the pressure in a channel with triangular section, located

* This research was supported by the Institute of Information Technologies, Bulgarian Academy of Sciences, project No 010040 "Fluid Technical Systems of Information"

closely to the wall of the cylindrical case. This technology leads to the necessity in a gamma of different device sizes, which covers the range of various lung capacities of the patients.

2. Principle of operation

The design of the flow transducer offered is characterized by the fact that there are not different type-sizes, but only one, covering a wide range of different patients' lungs capacities, respectively a large range of flow values of the air exhaled by the patients. This is achieved by a changeable metering bush with dimensions, which are defined by the necessary measurement range.

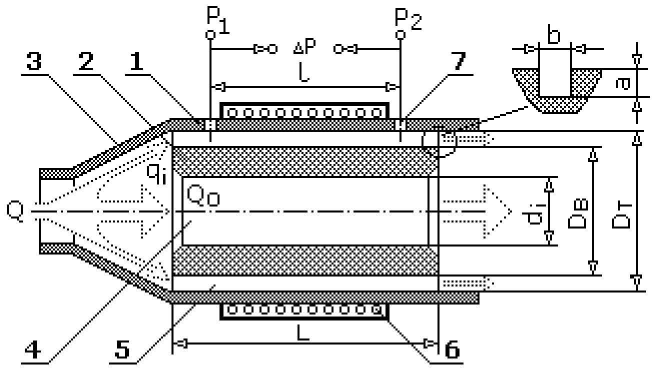

Fig. 1.

In Fig. 1 is shown a cross section of the device. Its basic part is the cylindrical body (**1**) with internal diameter D_T. A cone diffuser (**3**) is attached to it. A changeable cylindrical bush (**2**) is mounted in the case, along the axis of which a longitudinal cylindrical channel (**4**) of diameter d_i and length L is positioned. Along the periphery of bush (**2**) n rectangular channels (**5**) with internal diameter D are cut. The channels have a square cross section $a = b = 1$ mm. Two cylindrical openings (**7**) towards one of the longitudinal channels (**5**) are located in case (**1**). With their help the pressure drop from P_1 to P_2 is measured at a distance l in this channel. An electrical heater (**6**) is located around case (**1**) for drying the air exhaled by the patient to a temperature $t = (37 \pm 3)$°C.

The input air with a flow Q is divided into two flows – a basic one Q_0 and a secondary q_i. The main flow passes through the central channel (4) with a diameter d_i, and the second one – through the peripheral channels (**5**). When the secondary flow passes through the peripheral channels, a pressure difference $\Delta P = P_1 - P_2$ is created in each one of them, and the common flow Q is defined with its help. An experimentally defined characteristics $Q = f(\Delta P)$ is given for each size d_i. The pressure difference produced can be transformed into electrical signal with the help of a differential fluid-to-electrical transducer and this signal is used as an input value to the computer information processing system.

The design of the flow transducer suggested enables the enclosing of a wide range of values of the flow Q at given ΔP with the help of only one case of the device. For this purpose a set of cylindrical bushes with equal length L and different diameters d_i should be available.

3. Main characteristics

The airflow along the length of the rectangular channels with a constant section can be regarded as established and isothermal. The channels on their turn can be considered as laminar resistances, their pressure losses being connected with the air friction along the channel walls. In order to determine the mass flow in each one of the rectangular channels, Puasel's formula could be applied with some approximations:

$$q_i = \frac{\pi d^4 \rho}{128 \mu l}\left(P_1 - P_2\right), \quad (1)$$

where d is the conditional diameter of the channel section;

$\rho = \frac{P_1 + P_2}{2RT} = \frac{Pc}{RT}$ – average density of the air in the channel;

$P_1 - P_2 = \Delta P$ – difference in the static pressures of the air at the points measured along the channel l;

$\mu = 17{,}2.10^{-6} + 49{,}4.10^{-9}.t$ – dynamic viscosity of the air ($\mu = 17{,}94.10^{-6}$ at t = 37°C);

At small values of ΔP, the value $\frac{\pi d^4 \rho}{128 \mu l} = K$ is constant and it characterizes the channel admittance. Then expression (1) could be recorded in its short form:

$$q_i = K\Delta P. \quad (2)$$

The reciprocal value of the admittance K shows the pneumatic resistance of the channel Rn.

$$\Delta P = \frac{1}{K} q_i = Rnn_i\ . \quad (3)$$

Table 1 gives the experimental results for several modifications (FM) of the transducer suggested.

Table 1

Type	Approximate flow rate, ml/s			Linear, ml/s; Range, mm H_2O	Linearity, % L.R
	2 mm H_2O	6 mm H_2O	10 mm H_2O		
FM-1-13	1100	2400	2800	200–2600; 0.1–6.5	0.8
FM-2-12	800	1800	2600	180–2500; 0.08–9	4.9
FM-2-20	2600	3900	5400	2100–5400; 1.3–10	3.6
FM-2-24	3100	5900	>8000	2200–7200; 0.6–8	2.7

It can be seen from Table 1 that configuration FM-1-13 is with the best features. The technical data for this configuration are: d_i= 13 mm; D_T = 35 mm; l = 22 mm; a = b =1 mm.

In order to accomplish complete functional study of patient's lungs, the transducer is included in a system with a principal scheme shown in Fig. 2.

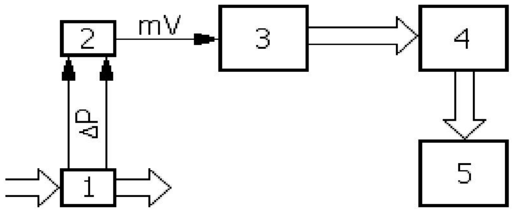

Fig. 2. 1– transducer of flow $\Delta P = f(Q)$; 2 – differential fluid-to-electrical transducer of pressure into electrical voltage; 3 – computer system for information processing; 4 – registering device; 5 – analysis of the results obtained

4. Conclusion

On the basis of the experimental results it is proved that the design of the flow transducer proposed can be successfully applied in measuring and converting flows at low pressure drops, including its use in medical investigations of lungs functioning in people and animals. The construction and the technology of the meter are maximally simplified, which leads to its low cost.

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Преобразувател на дебит за белодробна компютърна диагностика

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(Р е з ю м е)

Предложена и изследвана е конструкция на преобразувател на дебит, който може да се използва при диагностициране на функциите на белите дробове на пациенти от различни възрасти. Дадени са някои технически данни на преобразувателя и е предложена принципна схема за включването му в компютърна система за медицински изследвания.