Thermal marker flowmeter with a closed feedback loop

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1. Introduction

In marker instruments, substances are used which are additionally introduced into the fluid, or the values of physical quantities characterizing the fluid state are locally changed. By investigating the motion of so produced marker, the kinematic parameters of fluid flow can be determined. In practice, thermal markers with moderate parameters are preferably used, due to their noninvasive character.

2. Thermal marker flowmeter with an open feedback loop

In the thermal marker flowmeter with an open feedback loop, thermal markers are generated at a constant frequency forced by generator 1 (Fig. 1). The preceding edge of each of the pulses of monovibrator 2 opens gate 11 for pulses incoming from quartz-stabilized clock generator 10. Amplified in power amplifier 3, the pulse from monovibrator 2 heats up, for the time T_E, the emitter wire of the thermal marker – the heater R_E.

The heater heats up the fluid flowing around it, thereby producing a flowing thermal marker. The thermal marker reaches the resistance element R_D connected into a bridge system composed of the resistors R_1, R_2, R_k and R_D. The signal of unbalancing of the bridge, supplied from the source 4 (voltage or current type), undergoes amplification in differential pre-amplifier 5, then low-pass filter 6 eliminates high-frequency harmonic components, and then, after having been amplified in amplifier 7, the signal is differentiated in system 8 and sent to zero-function detector 9. Gate 11 is closed for clock pulses by the pulse coming from the zero-function detector. Clock pulses passed through gate 11 are counted by counter 12. The system can also incorporate digital linearizer which will convert the counted values of τ_M into the values of the fluid volume flux Q.

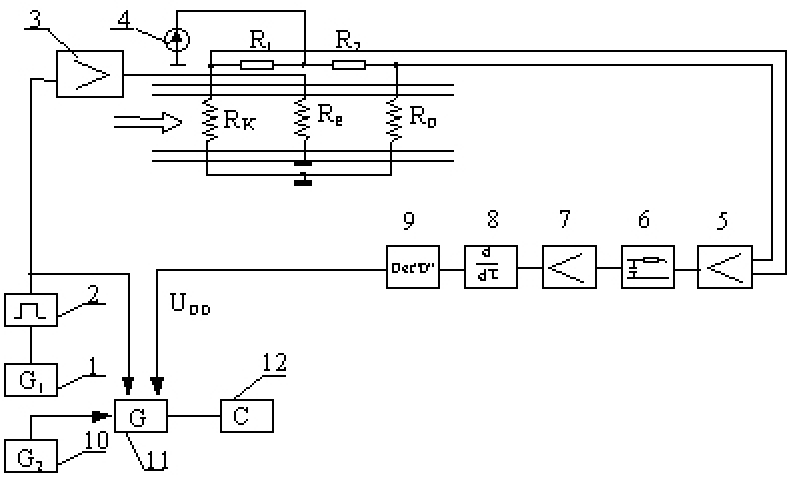

Fig.1. A flow diagram of the thermal marker flowmeter with an open feedback loop.

3. Thermal marker flowmeter with a closed feedback loop

The instrument described under par. 2 can operate also with a closed feedback loop. To create a closed feedback system out of the flowmeter shown in Fig. 1, the output of zero-function detector 9 should be connected with the input of monovibrator 2 (Fig. 1), which closes the feedback loop.

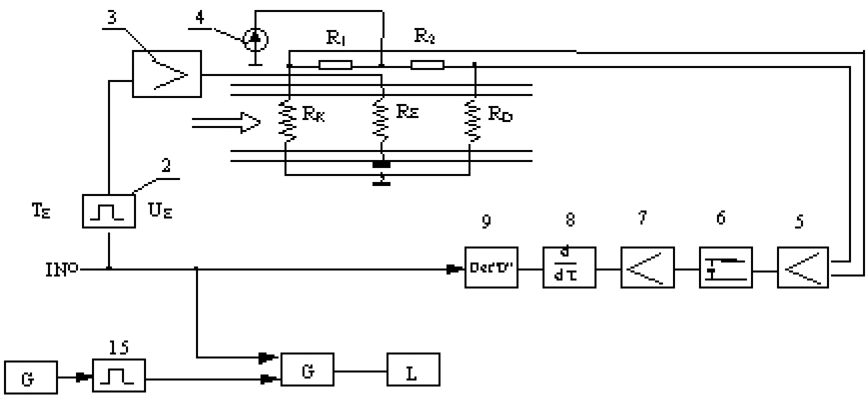

Fig.2. A flow diagram of the thermal marker flowmeter with a closed feedback loop.

Figure 3 shows example oscillograms of the voltage U_F for different values of the fluid volume flux. In spite of the emitter being supplied with the rectangular voltage pulse, the voltage variations after the U_F filter resemble sinusoidal oscillations.

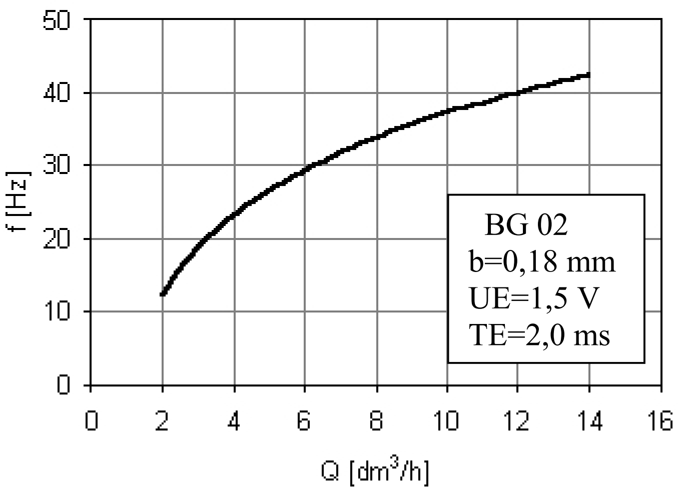

Fig. 3. Example oscillograms of the voltage U_F for the marker flowmeter with a closed feedback loop.

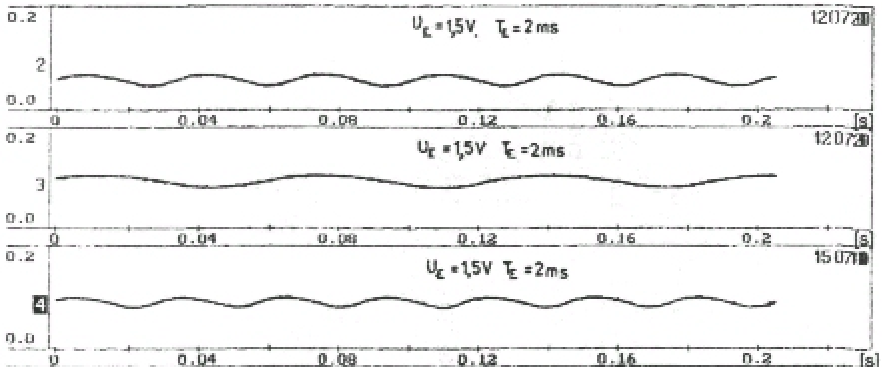

Fig. 4. Example stationary characteristics of the processing of the marker flowmeter with a closed feedback loop.

Figure 4 shows an example stationary characteristics of flowmeter processing, $f = f(\dot{Q})$. Note the nonlinearity of this characteristics. It may result from the superposition of successive thermal markers.

3. Comparison of the both instrument versions

The marker flowmeter with an open feedback loop is characterized by the "linear" processing function $\tau_M = A \cdot \frac{1}{\dot{Q}} + B$ and small errors. Thus, it excels the instrument with a closed feedback loop.

References

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