A STRING-TYPE PRESSURE METER

R. S. Brekhov, V. P. Efimov,
M. N. Levin, and G. G. Shmakov

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The design is described of a string-type gage without cooling for pressure measurements in liquid alkali metals at temperatures within the 20-500°C range. The basic components of this gage are a single-electrode electrostatic string-type transducer, a set of bellows, a lever mechanism, and a heated housing. Within the measurement range of $0\text{-}6 \cdot 10^5$ N/m^2 the relative error of experimental gage specimens did not exceed 1% at operating temperatures.

The pressure of a liquid metal is one of the basic parameters measured in the course of testing and operating a magnetohydrodynamic device. The complexity of measuring this parameter arises from the necessity of ensuring that the gages remain accurate and reliable during a prolonged exposure of the sensor element to an aggressive medium and to a high temperature at the same time.

On the basis of a comparative analysis of various pressure gages [1-4], the electrostatic string-type device was selected as the most suitable for further improvement. Its advantages include: 1) a high degree of temperature and time stability, 2) the feasibility of producing it with the same materials that MHD channels are made of, 3) a frequency characteristic of its output signal which ensures commutation, remote transmission, and digital readout with hardly any additional error.

A functional schematic diagram of the described string-type pressure meter is shown in Fig. 1.

The force which the measured pressure p applies to the bellows is transmitted through the leyer mechanism to the ribbon-string of the single-electrode electrostatic string-type transducer [5].

The capacitance between the string and the electrode is connected, through a buffer capacitor C_p, into the circuit of the high-frequency oscillator (approximately 1 MHz) built as an extension unit. The latter is

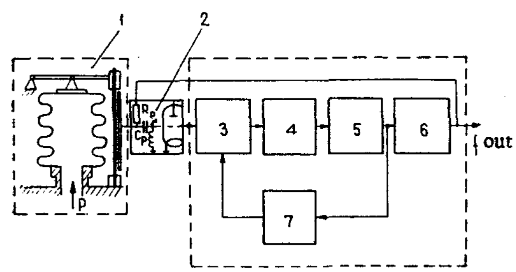

Fig. 1. Structural schematic diagram of the gage and block diagram of the measuring apparatus: 1) gage, 2) extension unit of the high-frequency oscillator, 3) mixer, 4) intermediate-frequency amplifier, 5) frequency detector, 6) low-frequency amplifier with a phase correction, 7) reference-frequency oscillator.

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Fig. 2. General view of the pressure gage.

located in a room with a normal ambient temperature and may be removed from the gage at a distance of 10-12 m. The variation in the output capacitance of the string-type transducer, caused by vibrations of the spring, modulates the frequency of the high-frequency oscillator signal at the string frequency. This signal is then transmitted along communication line to the main measuring unit of the apparatus, where it is compared in the mixer with the reference-frequency oscillator signal.

The frequency-modulated intermediate (difference)-frequency signal from the mixer passes through the intermediate-frequency amplifier to the frequency detector. The alternating component of the detector output signal, whose amplitude and frequency correspond to the string vibrations, is amplified in the low-frequency amplifier with a phase correction, and then transmitted through a buffer resistor R_p to the electrode of the string-type transducer so that the latter is set in self-oscillatory operation. The frequency of this self-sustained oscillation, which happens to be the output signal of the gage, is recorded on a standard digital frequency meter.

The constant component of the output signal from the frequency detector is used for an automatic frequency control of the reference generator, which ensures a more stable self-oscillatory operation of the string-type transducer and also simplifies the tuning procedure.

An external view of the experimental prototype pressure gage is shown in Fig. 2. The lever, the housing bracket, and the elastic hinge coupling between them have been produced integrally from a single blank. The ribbon-string has been fastened at the ends by spot-welding them through gaskets to the appropriate lever and housing surfaces.

At a distance of 0.15-0.20 mm from the string has been placed the electrode, mounted on a cantilever beam through a layer of sprayed Al_2O_3 insulation.

All metallic components of the gage have been made of grade Kh18H10T steel. The gage has been designed for operating temperatures up to 500°C.

A theoretical analysis of the temperature-dependent error of this string-type gage has shown that it remains within 0.2-0.4% per 100°C, when the design parameters are optimally selected.

An experimental study of the temperature-dependent error, made on prototype string-type pressure gages in a special liquid-metal apparatus [6], has confirmed the correctness of the theoretical results. The relative error of gage readings did not exceed 1% within the test range of $0-6 \cdot 10^5$ N/m^2 at temperatures from 200 to 500°C. The accuracy level of the instrument did not drop after 2000 h of thorough testing at temperatures within 400-500°C.

The use of the electrostatic string-type transducer in this pressure gage has made it feasible to produce, with the appropriate choice of engineering materials, an instrument suitable for 200-1100°C operating temperatures.

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