RADIO-FREQUENCY INSTRUMENT FOR THE REMOTE MONITORING OF FLOWING SOLUTIONS

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Radio-frequency (rf) devices for the concentration measurement of solutions in flow with the use of contactless probes are well known in analytical practice [1-3]. A common shortcoming of these devices is the restricted length of the cable connecting the probe in the monitored medium to the measurement and control units.

In the device proposed here the working oscillatory circuit with the probe connected into it can be set up at a considerable distance from the measurement and control units [4].

A schematic of the device is shown in Fig. 1. It includes a power supply section, a sinusoidal-voltage self-excited oscillator, the working circuit with the probe (cell), and the measurement circuitry. The supply section consists of a ferroresonance transformer Tr-1, two rectifiers comprising a bridge circuit with D-226 diode elements, and two stabilitrons D_4 and D_5 (types 817B and 915Zh). The supply section delivers the following voltages to the circuit: -20 V for the oscillator; $+70$ V to control the varicap for tuning of the working circuit to resonance; 5 V ac to supply the indicator light (illumination).

The sinusoidal-voltage self-excited oscillator is designed to deliver rf oscillations to the working circuit, which includes the cell. It comprises a push-pull circuit with positive feedback using P605A triode transistors T_1 and T_2. Quartz resonators K_1 and K_2 are included in the feedback loop for frequency stabilization. In the absence of the quartz resonators the frequency is stabilized by setting the oscillator to operate above a nominal frequency of 300 to 500 kHz. The resistance R_5 in the emitter circuit of the triodes T_1 and T_2 creates negative feedback and thereby reduces the nonlinear distortion. This resistance also effects temperature stabilization of the working current. The frequency of the oscillator is determined by the natural frequency of the quartz resonators, which is equal to 5 MHz in our case.

The reference voltage (detector D_1) and the voltage at the detector of the working circuit (detector D_2), which is tuned to resonance, both have the same value of 6 V. The working circuit represents a frequency-selective circuit with electronic tuning based on the use of the varicap barrier capacitance, which depends on the reverse voltage applied to it. A coax joins the output winding of the oscillator to the working circuit to supply the control voltage to the varicap.

The control voltage varies from 45 to 70 V, depending on the resonance tuning of the working circuit with the cell connected. In this case smooth tuning of the working circuit, temperature stability of the varicap, sufficient overlap with respect to the electrical parameters of the initial solutions, and the maximum possible measurement sensitivity are realized. The latter feature is attributable to the steepness of the drop at the left end of the working circuit resonance curve due to the small shift of the quasiresonance frequency.

The Q of the working circuit is increased by incomplete connection into both the circuit of the oscillator output winding and the detector circuit. For this purpose the optimum value is chosen for the coupling capacitor C_8.

The detected rf voltage is taken from the potentiometer R_9 and is transmitted to the measurement circuit. The latter represents a combination of a voltmeter with appropriate switching for tuning and subsequent preparation of the instrument for measurements of the electrical conductivity, the dielectric constant, or their sum. The poten-

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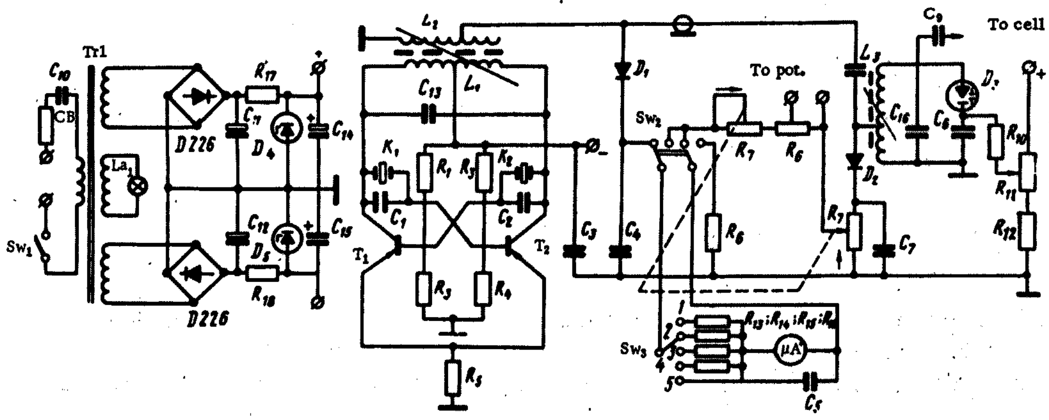

Fig. 1. Schematic of the rf instrument.

tiometer R_9 forms the load of the detector D_2 and part of the load of D_1. Simultaneously, R_9 paired with the potentiometer R_7 is used to set the null of the voltmeter. Its sensing element is an M24 microammeter with a sensitivity of 100 μA. This construction of the circuit diminishes the shunting of the working circuit and thus increases its Q.

The potentiometer R_8 is designed to transmit the signal to a recording unit. The measurement range of the voltmeter is extended by means of the selector switch Sw_3, which varies the auxiliary resistances R_{13}-R_{16}.

The rf voltage from the oscillator output winding is transmitted by a coax more than 100 m long to the working circuit and after detection is used to obtain the reference voltage. This method enhances the operational stability of the device and permits measurements at the more sensitive limits of the voltmeter.

The low output resistance of the oscillator and its incomplete connection into the working circuit permit measurements to be performed with a coax of length >100 m.

The working circuit containing the probe (cell) is mounted in a separate chassis. The other sections are fabricated as separate console units. All control knobs and the measurement head are located on the front panel.

The concentration of the investigated solution is determined from a calibration graph. First the cell is filled with a minimum-concentration solution. The toggle switch Sw_2 is set in the "tuning" position (right position in the circuit diagram). The "tuning" knob (potentiometer R_{11}) tunes the working circuit to resonance as indicated by the maximum deflection of the voltmeter pointer, the toggle switch Sw_2 is set in the "operate" position (left position in the circuit diagram), and the "set null" knob (potentiometer R_9) sets the voltmeter null value. Then the measurements are carried out with solutions of increasing concentration, and the calibration graph is plotted.

The instrument can be used for the remote automatic monitoring of aqueous solutions of acids, salts, bases, mixtures of two solvents with different dielectric constants, or electrolytes in an organic solvent. It can be used to monitor the progress of a reaction by proper design of the immersible probe and the incorporation of thermal compensation elements.

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