When determining the electrical conductivity of solutions by the high-voltage conductometry method its interrelationship with one of the electrical parameters of the metering circuit of the transducer is used. The selection of the frequency of the oscillator \( \omega \) and of the construction of the metering cell of the transducer precedes finding this interrelationship—the static characteristic of the transducer.

Most common in the practice of high-frequency conductometry are transducers with a Q-meter metering circuit [1]; in particular, Q-meters can be used [2-4]. In this case the static characteristic of the transducer establishes the correspondence between conductivity of the solution in the cell and the quality factor of the oscillatory circuit \( Q \).

The methods of calculating the static characteristics of Q-meter transducers are based on the results of analyzing the active component of conductance (resistance) of an equivalent circuit of a two-electrode cell (Fig. 1a) [5, 6]. The analysis is carried out on the assumption that the elements of the circuit (Fig. 1b), \( R \), \( C_1 \), and \( C_2 \), are linear and do not depend on \( \omega \). The resistance of the walls is neglected. Depending on the metering circuit of the transducer, a parallel (Fig. 1c) or series (Fig. 1d) variant of the equivalent circuit of the cell is used.

The admittance of the equivalent circuit of the cell consists of real \( G_p \) and imaginary \( B_p \) components, each of which is described by the expressions [5, 6]

\[
B_p = \frac{\omega \omega C_1 + \omega^2 C_1 C_2 (C_1 + C_2)}{\omega^2 + \omega^2 (C_1 + C_2)^2},
\]

\[
G_p = \frac{\omega \omega^2 C_1^2}{\omega^2 + \omega^2 (C_1 + C_2)^2},
\]

where \( \lambda = 1/R \) is the conductivity of the solution being analyzed in the cell, \( S \).

In Q-meter measurements it is assumed that the output signal of the transducer is proportional to the values of the function \( G_p(\lambda) \), which has an extremum for the conductivity

\[
\lambda_{\text{max}} = \omega (C_1 + C_2),
\]

and the value of \( G_p(\lambda) \) corresponding to (3) will be

\[
G_p^{\text{max}} = \frac{\omega C_2^2}{2(C_1 + C_2)}.
\]

The point of inflection of \( G_p(\lambda) \) takes place when

\[
\lambda_{\text{int}} = \sqrt{3} \omega (C_1 + C_2).
\]

The character of the experimental static characteristics corresponds to that obtained analytically [5-7], and this serves as grounds for using Eqs. (2)-(5) in quantitative calculations. On the basis of analyzing (2)-(5), recommendations are given for selecting the design parameters of the capacitance cell [5-8]. For example, for large \( C_1 \)
Fig. 1. Contactless cell of the capacitance type and its equivalent circuits: \( C_1 \) and \( C_2 \) capacitances governed by the dielectric properties of the material of the cell walls and solution, \( F \); \( R \) resistance of solution, \( \Omega ; C'_{e} \) and \( G_p \) equivalent capacitance and conductance of parallel equivalent circuit of cell; \( C''_e \) and \( R_e \) equivalent capacitance and resistance of series equivalent circuit of cell.

Fig. 2. Static characteristics of a high-frequency conductometer for \( C_1 = 162 \) pF and various values of \( g, S \).

one expects the possibility of a unique determination of conductivity in a sufficiently wide range without a substantial change of sensitivity. The case when \( C_1 \to \infty \) is identified with a change to contact conductometry. Since in this case, according to (2), \( G_p = \nu \) and \( \lim_{C_1 \to \infty} \frac{\partial G_p}{\partial \nu} = 1 > \frac{\partial G_p}{\partial \nu} \), the conclusion of a greater sensitivity of the contact conductometry method in the entire range of measurable conductivities was made.

Quantitatively the results of analyzing \( G_p (\nu) \) and the experimental static characteristics of the Q-meter transducer do not agree, and for large \( C_1 \) a qualitative comparison of the results becomes difficult. One of the main causes of this consists in that, in an analytical description of the static characteristics of a transducer, its metering circuit is not taken into account.

Henceforth we will limit ourselves to an analysis of the most common case — the connection of a cell into a parallel oscillatory circuit. Since the values of the static characteristics of the transducer are proportional to the Q of the oscillatory circuit, its equation will be sought in the form \( Q = f(\nu) \).

We will consider a circuit composed of parallel-connected elements — \( L \), \( g \), \( C_v \), \( G_p \), and \( B_p \), where \( L \) is the inductance of the circuit; \( g \) is the equivalent conductance of the circuit with the cell disconnected; \( C_v \) is the capacitance of a variable capacitor required for resonance tuning of the circuit upon a change of \( B_p \) in accordance with (1). In this case, for the Q of an oscillatory circuit with a cell,

\[
Q = \frac{1}{\omega L [G_p (\nu) + g]} = Q_0 \frac{g}{G (\nu) + g},
\]

where \( Q_0 \) is the quality factor of the oscillatory circuit with the cell disconnected.

Developing \( G_p (\nu) \) according to (2), we obtain

\[
Q = Q_0 g \frac{\nu^2 + \nu_{\text{max}}^2}{\nu_0^2 C_1^2 + g [\nu^2 + \nu_{\text{max}}^2]}
\]

When \( \nu \to 0 \) and \( \nu \to \infty \)

\[
Q = Q_0.
\]

An analysis of (7) shows that \( Q = f(\nu) \) has an extremum at a conductivity related with the transducer parameters by Eq. (3); the point of inflection in the idealized case \((g = 0)\) is absent.

Equating \( d^2 Q / d\nu^2 = 0 \), we obtain the equation for determining the point of inflection:

\[
\nu_{\text{inf}}^3 - 3\nu_{\text{inf}} \nu_{\text{max}}^2 - \frac{\omega^2 C_1^2}{g} \nu_{\text{max}}^2 = 0.
\]