The rotary compensating converter (RCC) developed by us [1] can be used as a universal converter for measuring and adjusting rotation frequencies of various objects in the range of $10^{-8}$-$10^5$ rpm. The RCC differs from existing converters by its high precision, reliability, and minimum size. The RCC advantages are due to the fact that the measured and reference frequencies are compared directly within the converter. This makes it possible to simplify considerably the measuring circuit attached to the converter and to retain at the same time the high precision characteristic of electronic tachometers operating on the frequency-comparison principle. By simplifying its measuring circuit, the RCC overall dimensions are reduced and it is provided with a higher reliability.

The RCC schematic is shown in Fig. 1. It consists of a cascade electrical machine comprising two dynamos 1 and 2. Their rotor windings 3 and 9 are located on the same axle and interconnected, thus forming in the cascade machine single rotor 4. Reference-frequency generator 6, whose frequency $n_0$ is measured with frequency meter 7, is connected to stator winding 5 of dynamo 2, this exciting in it the magnetic field whose rotation frequency is set by means of the reference frequency $n_0$. The rotation of rotor 4 which is connected to the tested object (not shown in Fig. 1), induces current I in winding 3, which is proportional to the difference between the reference and the rotor frequencies. In flowing through winding 9 of 1, I produces in 8 voltage V. This winding is connected through filter 10 and phase-sensitive amplifier 11 to null detector 12.

Figures 2a and 2b show, respectively, the relationships of the rotor current I and voltage V at the RCC output to the rotor frequency of rotation $n$. It will be seen from Fig. 2 that I and V are equal to zero for $n = n_0$. The linear output characteristic of the second dynamo becomes nonlinear over the section $n' - n''$. Moreover, in this section the output-characteristic slope angle, which determines the RCC sensitivity, can assume large values. Henceforth the RCC investigations will be carried out at this section.

The rotation frequency $n$ of the controlled object can be measured or regulated by means of the zero method: When $n$ attains the value of $n_0$, the null detector 12 records at the RCC output a zero value of V. At this instant the value of $n_0$, which is equal to $n$, is measured on frequency meter 7. The value of $n$ can be regulated by means of the voltage V which appears at the RCC output when the rotation frequency differs from the reference one.

The RCC provides, in addition to the above zero method, also a differential and a direct measuring method. In these methods the value of V can be used directly for determining and regulating the rotation frequency of the controlled object.

The RCC circuit shown in Fig. 1 is not the only possible one. The RCC stator and rotor windings can be made for single-, two-, and three-phase, as well as in a general case for m phase operations. Therefore, the RCC windings can form various circuits shown in Table 1, where the following notations have been adopted: $S_1$ and $S_2$ for stator windings of dynamos 1 and 2; r for the winding of rotor 4; $z$ for the type of interconnection between windings 3 and 2 incorporated in RCC rotor 4. In this Table $S_1 = 1$ and $S_1 = 0$, respectively, for three- and single-phase windings; $S_2 = 1$ and $S_2 = 0$ for three and two-phase windings; $r = 1$ and $r = 0$ for commutator and differential winding connections. Table 1 shows 16 RCC circuit versions which it is necessary to investigate for determining the optimum circuit for measuring and regulating the rotation frequency. The RCC circuit consisting of three-phase stator and rotor windings (first line of Table 1) was adopt-
ed as the generalized RCC physical model from whose simplification any other circuit can be obtained. The matrix equation of the generalized RCC physical model has the form of

\[ \dot{[V]} = [R][I] + \frac{d}{dt}[M][I], \]

where \([V]\), \([I]\), \([R]\), and \([M]\) are the voltage, current, resistance, and mutual inductance matrices of the RCC circuit windings.

The coefficient \(M\) in the matrix \([M]\) depends on the position of the rotor in space. The solution of (1) presents considerable difficulties. The solution of this equation for all circuits was obtained by using the periodicity of the \(M\) coefficients for calculating standard submatrices. Analysis of results shows that the optimum RCC circuit comprises single-phase rotor windings and can be represented by the following metric equation

\[ v = \frac{3}{2} \frac{I_1 M_1 M_2 \omega^3 p_s S}{R} \cos (S\omega t + \alpha_0) \sin (\omega t + \beta_0), \]

where \(v\) is the instantaneous RCC output voltage; \(I_1\) is the reference-current amplitude; \(M_1\) and \(M_2\) are the mutual inductances between the stator and rotor windings, respectively, of the first and second dynamos; \(\omega\) is the reference-voltage angular frequency; \(p_s\) is the number of pole pairs in the second dynamo; \(S\) is the slip corresponding to the relative difference between the reference and measured frequencies; \(t\) is time; \(\alpha_0\) and \(\beta_0\) are the initial rotor-winding angular positions, respectively, in the first and second dynamos; \(R\) is the total rotor-winding resistance.

The expression (2) can be used for determining the RCC characteristics and providing optimum parameters for its dynamos. Sensitivity and measurement precision can be raised, si-