and $\alpha_2$ are obtained on the reference wattmeters by adjusting the phase shifter. If the above operation is carried out correctly and carefully these values are obtained simultaneously.

After the phase shift corresponding to the given power factor $\cos \varphi$ is set, the instruments are checked in the normal way by setting the readings of the instrument under test by means of current adjustment in both series circuits. Let us stress once more that the phase shift is set under conditions of uniform phase loading, whereas any further checking can be carried out with unequal loading. In this instance it is advisable to have the facility of changing the value of the reference wattmeter calibrations (for instance, by connecting current transformers). The adjustment of the reference instrument readings then required is very simple. However, under these conditions care should be taken that the series wattmeter circuits are not overloaded, since this could occur without being noticed at power factors of the order of 0.5.

Checking instruments designed for a four-conductor network by means of three single-phase wattmeters presents no difficulties if the above considerations are taken into account.

**Literature Cited**

1. Instruction 184-54 for checking ammeters, voltmeters and wattmeters.
2. GOST (State All-Union Standard) 8476-60. Wattmeters and VAR-meters. Technical requirements.

---

**Study of an Infrasonic Generator**


Generators of infrasonic frequencies (ISF) are of considerable interest in connection with the application of frequency methods in testing automatic control systems.

The greater part of the commercial automatic systems (for instance in the chemical industry) operate in the range of 0.01 to 1 cps. Study of pneumatic and hydraulic regulators and servosystems also requires sources of harmonic oscillations of 0.01-20 cps.

The ISF generators which are now being used consist mostly of operational amplifier circuits which solve a second order differential equation:

$$\frac{d^2U}{dt^2} + \omega_0^2 U = 0.$$

The solution of this equation is a harmonic oscillation of frequency $\omega_0$ (1). Generators of this type are extremely complex, since they incorporate two integrators with stabilized supplies. The maximum period of oscillations of an ISF generator with double integration is limited by time constants, i.e., by the over-all dimensions of capacitors. The stabilization of the amplitude leads to an increased time in attaining stable oscillations.

The circuit we here propose is to a considerable degree free from these defects.

Below we describe an electromechanical ISF generator, based on a new principle, proposed by F. Rule (GDR), and provide the results of its testing.
**Method of obtaining ISF oscillations.** The generator [2] employs a moving coil system with an electrical feedback (Fig. 1). The instrument's moving system is not balanced with respect to its axis of rotation. The mechanical moment of its unbalance in a general case is:

\[ M_u = gmr \sin \alpha, \]  \hspace{1cm} (1)

where \( g \) is the acceleration due to gravity; \( m \) is the mass of the moving system; \( r \) is the distance between the system's center of gravity and its axis of rotation; \( \alpha \) is the angle between the moving system and the vertical axis at a certain instant.

This moment is balanced by moment \( M_c \), produced by the current of the moving coil which is placed in the field of a permanent magnet:

\[ M_c = \frac{Bswi}{9310} = k_e i, \]

where \( B \) is the induction in the air gap of the magnet, gauss; \( s \) is the area of the moving coil, cm\(^2\); \( w \) is the number of turns in the coil; \( i \) is the current in the moving coil, amp.

The equality \( M_u = M_c \) is obtained by means of a servosystem with a dc amplifier DCA in its feedback circuit. As transducers PT of the moving system's position (with respect to the axis of symmetry of the magnetic system SN — Fig. 1) photovaristors are used. When the whole system is rotated (including the photovaristors and the magnetic system) \( \alpha = \omega t \), where \( \omega \) is the system's angular velocity. The mechanical moment is measured according to the sinusoidal law (1).

The servosystem maintains \( M_u = M_c = \sim 1 \) at each instant. Hence:

\[ i = I_m \sin \omega t, \]

where \( I_m = \frac{gmr}{k_e} \),

and the output voltage is:

\[ V = V_m \sin \omega t. \]

Thus this system may be used as a generator of a sinusoidal voltage.

**Errors of this method.** The most important limitations of this method consist in the errors due to friction, a finite unbalance of the moving system, and the effect of the centrifugal force (at frequencies approaching 1 cps).

Equality \( M_u = M_c \) is met providing there are no parasitic mechanical moments of which the most important is the moment of friction.

In an actual system:

\[ M_c = M_v + M_f, \]

where \( M_f \) is the moment of friction.

Then:

\[ i = \frac{M_u}{k_e} \left( 1 + \frac{M_f}{M_f} \right). \]