Pulsating pressures should be included among the most important parameters encountered in the testing of power-generating machines. Until recently it was considered that it is sufficient to measure pressure pulsations up to 3 kHz.

However, it was found by studying the dynamic processes in machines that it is necessary to extend considerably the range of the measured pressure-pulsation frequencies up to 10 kHz and to produce a hydraulic pulsator with a higher frequency range than that of existing ones.

Below we describe such a hydraulic pulsator.

A massive metallic base carries a column consisting of eight piezoceramic discs. These discs are made of lead zirconate-titanate Тсгп-19 with a diameter of 67 mm and a thickness of 2 mm. The piezoceramic discs with copper foil spacings, which also serve as lead-out conductors, are assembled into a packet whose side surface is coated with a 340-20 filler (on the basis of epoxy resin). The piezoceramic packet is pressed against the casing by means of a membrane provided with a double-sided packing. The column carries at the top a hydroacoustical waveguide-concentrator in the shape of an exponential horn. The concentrator flange provides a hermetrical sealing of the membrane to the base.

The concentrator's upper end is connected to an exchangeable resonator tube terminated in a measuring head which is provided with special places for mounting a reference and tested pressure transducers.

The internal cavity of the waveguide concentrator and the resonator is filled with distilled water.

The cavity under the membrane which carries the piezoelectric transducer is filled with transformer oil. The pressure of this oil in the membrane cavity and of the distilled water in the working cavity of the resonator are maintained at the same level by means of a separating tank. The piezoceramic transducer is supplied with 100 V from a power amplifier fed by an audio generator. The current consumed by the hydraulic pulsator at 20 kHz does not exceed 5 A.

A concentrator consists of a solid of revolution whose internal cross-sectional area varies exponentially. It has the shape of an axially symmetrical horn which is filled with water and has an internal diameter D determined as:

$$D_x = D_0 e^{x}$$
TABLE 1

<table>
<thead>
<tr>
<th>Concentrator with $l_c = 0.6$ m</th>
<th>$l_T = 0.5$ m</th>
<th>$l_T = 1$ m</th>
<th>$l_T = 1.5$ m</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_1 = 0.6$ m, $n_1 = 16$</td>
<td>$I_2 = 1.1$ m, $n_2 = 35$</td>
<td>$I_3 = 1.6$ m, $n_3 = 48$</td>
<td>$I_4 = 2.1$ m, $n_4 = 63$</td>
</tr>
</tbody>
</table>

\[
\beta = \frac{\ln k_c}{l_c} = 2.5 \cdot 10^{-2} \text{ (1/cm)},
\]

where $k_c$ is the concentrator's amplification factor equal to $k_c = D/d = 4.1$; $l_c$ is the length of the concentrator (56 cm); $d$ is the diameter of the concentrator's output cross section (30 mm).

The length $l_c$ of the concentrator is related to frequency, gain, and the speed of sound by the equation:

\[
l_c = \pi \frac{c}{f} \sqrt{1 + \frac{\ln k_c}{2\pi n}},
\]

where $n$ is the number of liquid pressure waves along the concentrator length, $c$ is the speed of sound $= 1.4 \cdot 10^5$ cm/sec.

The resonant frequency for a half-wave concentrator ($n = 0.5$) is 1400 Hz.

The purpose of the concentrator consists of using the small pressure pulsation amplitudes obtained at the output of the concentrator to produce standing waves in the resonator's liquid column, thus obtaining large pressure amplitudes in the measuring head and as many as possible resonant frequencies in the line spectrum.

The resonator is made in the form of a thick-walled pipe filled with water. Thus, it represents a hydroacoustical line with distributed parameters and has a line spectrum of resonant frequencies.

The hydraulic pulsator works at the resonator's natural frequencies. Their number within its working range of 1.4 to 21 kHz can be determined from the resonance conditions of a pipe closed at both ends.

Such conditions with varying frequency occur at the instants when a given number of quarter wavelengths fit into the resonator length.

According to the resonance frequency equation

\[
f_c = k \frac{c}{l_T},
\]

where $k$ is a consecutive series of numbers 0.5, 1, 1.5, 2, 2.5, 3, etc. The last term of the arithmetic series of resonant frequencies is

\[
f_n = \frac{c}{l_T} \left[0.5 + (n - 1) d\right]
\]

where $d = 0.5$ is the constant of the arithmetic series, $n$ is the number of terms equal to that of resonant frequencies.