shows the theoretical values deduced from eq. (1) and real curves the experimental results. Dotted line at 3.7 MC shows the resonant frequency of longitudinal thickness mode.

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8. Study on High Dielectric Constant Ceramics. (XVIII)

$BaTiO_3$ Ceramic Vibrator as a Filter Element

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The characteristics of $BaTiO_3$ ceramic vibrator is not good for the application as a filter element because of its ferroelectric properties and especially of its temperature coefficient of frequency constant. Authors investigated a method for improving these undesirable characteristics, and a fairly good result could be obtained. The principle of the procedure for improving the characteristics of ceramic vibrator is as follows. A $BaTiO_3$ ceramic vibrator has a large positive temperature coefficient of frequency constant amount to $2000 \sim 3000 \times 10^{-6}$ at room temperature, but ordinary elastic materials such as metal or glass, on the other hand, have negative temperature coefficient. And so, it is able to compensate the temperature coefficient by conjoining the latter to the former. The kind of material of the latter and volume percentage, in which the latter occupies in a combined vibrator, will determine the degree of compensation of the temperature coefficient. The adhesion of the other material to ceramics will be of use, at the same time, in reducing the other unstable characteristics due to the ferroelectric properties of $BaTiO_3$ ceramics.

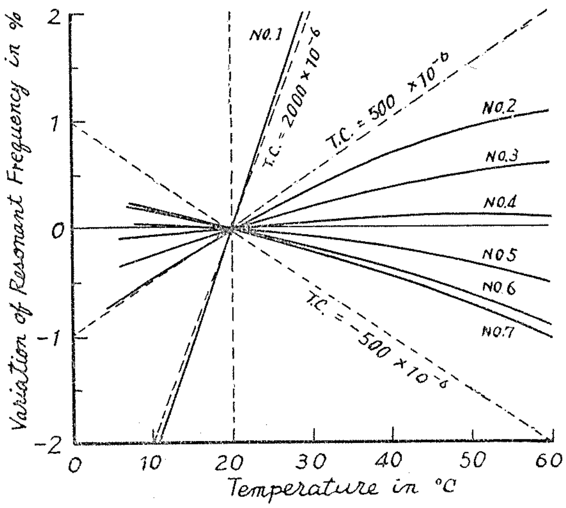

Fig. 1.

Experiments were carried about many combined vibrators having the structure of Langevin type. Fig. 1 shows the experimental results about the temperature variations of various specimens, whose dimensions are listed in Table 1, where t_b and t_m are the thickness of ceramics and metal (brass) respectively, $t_0 = t_b + t_m$, and T.C. is the mean value of the temperature coefficient at the temperature range of 20~50°C.

Table 1.

Sample	$t_b$mm	$t_m$mm	$t_0$mm	t_m/t_0%	T.C.×10^6
No. 1	2.10	0	2.10	0	+1850
No. 2	1.50	3.05	4.55	67.1	+ 300
No. 3	1.50	4.63	6.13	75.6	+ 170
No. 4	1.50	5.95	7.45	79.9	+ 34
No. 5	1.50	9.00	10.50	85.8	— 107
No. 6	0.50	5.45	5.95	91.6	— 203
No. 7	0.27	5.33	5.60	95.3	— 240

As the equivalent electric circuit of such vibrator is usually written as shown in Fig. 2, the resonant frequency f_r and the anti-resonant frequency f_a are given by

$$w_r^2 = (2\pi f_r)^2 = \frac{1}{L_1 C_1}$$

$$w_a^2 = (2\pi f_a)^2 = \frac{1}{L_1}\left(\frac{1}{C_1} + \frac{1}{C_0}\right) = w_r^2\left(1 + \frac{C_1}{C_0}\right),$$

if we set $C_0/C_1 = r$,

$$\frac{f_a^2}{f_r^2} = 1 + \frac{1}{r}.$$

From the measurement of f_r, f_a and C_0 (the damped oapacitance), the values of r, C_1, L_1 *etc.* are easily obtained. As the values of r are generally much smaller than those of quartz vibrator, such vibrators are useful for the purpose to obtain a filter with broader percentage band width.

Fig. 2 shows an example of the reactance curve of such vibrator. Various constants measured about ordinary disc type ceramic vibrator and Langevin type vibrator are listed in Table 2. Fig. 3 shows an example of attenuation characteristic of a band pass filter constructed with such small Langevin type vibrators connected in lattice type.

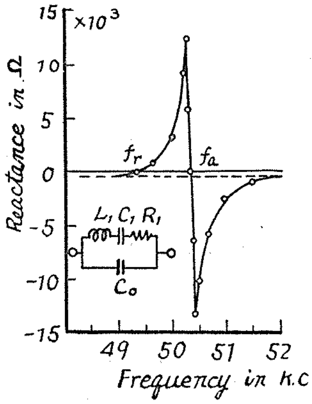

Fig. 2.

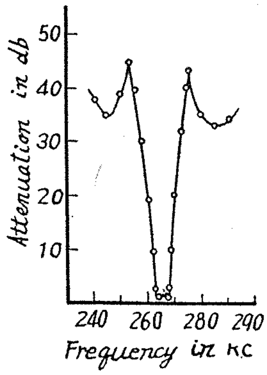

Fig. 3.

Table 2.

Const. of Vibrator	Unit	Ceramic Disc Type		Langevin Type	
		Sample 1	Sample 2	Sample 1	Sample 2
fr	κc	44.63	43.39	49.45	49.64
fa	κc	46.22	45.31	50.31	50.46
C_0	pF	6967	8081	5368	6616
Δf	κc	0.080	0.085	0.060	0.065
r		14.30	11.36	28.60	31.25
C_1	qF	487.5	71.20	187.6	211.2
L_1	mH	26.14	18.90	55.25	48.75
R_1	Ω	13.15	10.10	20.84	19.94
Q		558	511	824	764

9. Formation and Aging of Precipitates. (III)

Electron Microscopic Investigaton of Barium Sulfate Precipitates in Alcohol Solution

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Barium sulfate precipitates were formed in alcohol solution and the relations between the total concentration of $BaSO_4$, the concentration of alcohol and the solubility of $BaSO_4$ were studied.