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ON THE PIEZOELECTRIC LINES OF QUARTZ CRYSTAL AND ROCHELLE SALT

By

Jiro SAKAMI

I. Introduction

In the course of studies on the nuclear quadrupole resonance of iodine, many absorption lines different from those of the nuclear quadrupole resonance have been found.[1] After those investigations, similar absorption lines were found in piezoelectric substances such as quartz crystal and Rochelle salt. These new found absorption lines were called piezoelectric lines, and the natures of these lines were investigated by the Japanese researchers and a suggestion on the mechanism was also postulated.[2]

Piezoelectric single crystals are well known to give many absorption lines due to harmonics of the natural vibration, and these lines are also well known to decrease regularly their intensities of absorption lines with increasing harmonics order. However, the above mentioned piezoelectric lines always spread in the wide ranges of the frequency with almost constant intensities.

In this investigations, the lines of the piezoelectric absorption of single crystals of Rochelle salt and quartz were observed in the frequency ranges from 18MHz to 34 MHz, and at least the presence of one series of new equidistant lines were clearly recognized in the spectrum of quartz.

2. Experimental Procedures

The apparatus used in this experiment was likely that of the quadrupole resonance. A block diagram of the apparatus was shown Fig. 1.

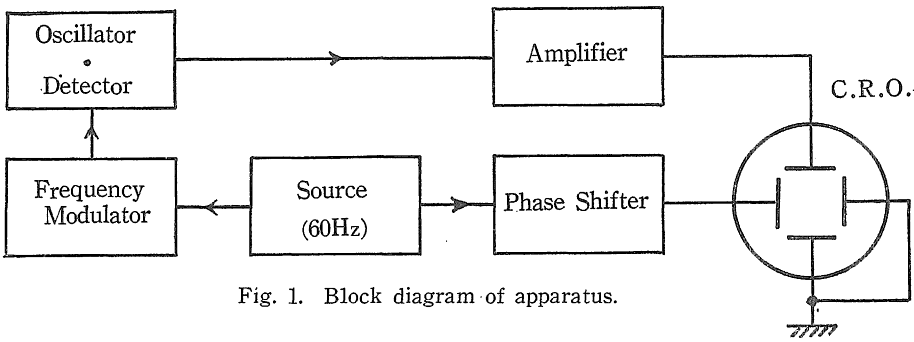

Fig. 1. Block diagram of apparatus.

The samples used in this experiments were two kinds of quartz resonators and several single crystals of Rochelle salt. One of quartz resonators has 3500KHz of fundamental frequency and the other has 5000KHz, Single crystals of Rochelle salt were obtained

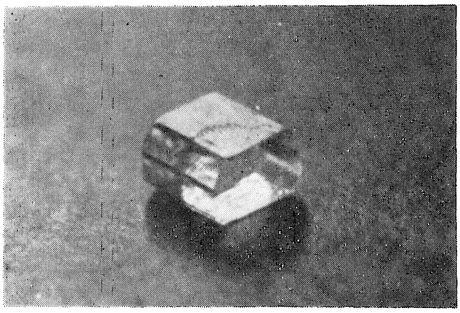

Photo 1. A single crystal of Rochelle salt.

by natural cooling method[3], and one of them was shown in Photo 1.

The method of the detection of absorption lines was as same as that of the nuclear quadrupole resonance experiment.

The absorption lines were observed cathod-ray oscilloscope, whose horizontal axis was swept by the frequency which was synchronized with the frequency of modulation. These resonance frequencies were measured accurately by the range of KH_z with the aid of a heterodyne frequency meter.

The whole apparatus, with frequency modulated superregenerative detector, is high sensitive, but owing to give many side lines this apparatus has an unavoidable disadvantage for this experiment. Accordingly, we gave up the superregenerative detector and employed a simple regenerative detector. By using this apparatus, the measurements of the spectrum lines were appreciably improved. The whole diagram of the detector circuit was illustrated in Fig. 2.

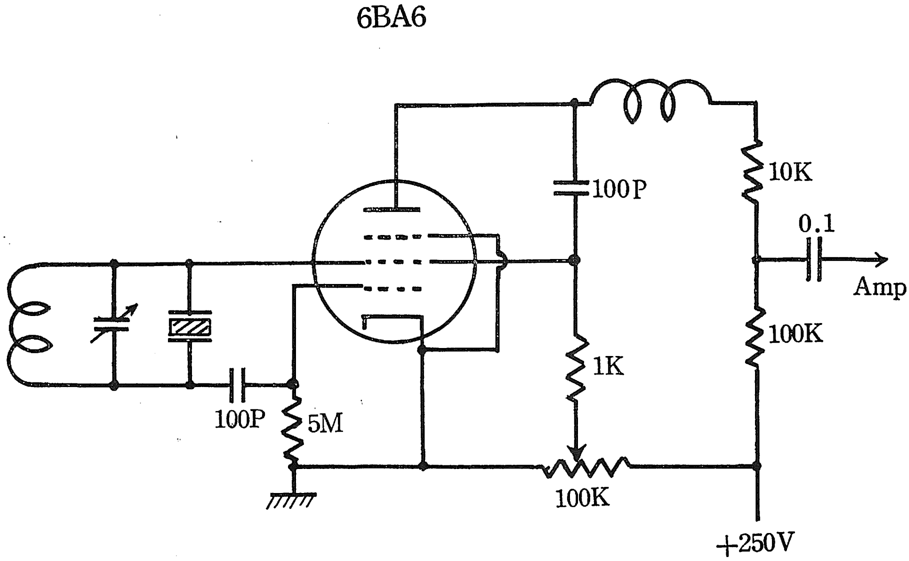

Fig. 2. Circuit diagram of the regenerative detector.

3. Experimental Results

The observed patterns of the absorption lines were shown in Photo 2 and Phto 3. Photo 2 is an observed pattern from a singl crystal of Rochelle salt which was already shown in Photo 1. The frequency was swept from the left to the right between 32.89 MH_z and 33.02MH_z in Photo 2, and Photo 3 is the observed one from 3500 KH_z quartz resonator which is 0.5mm in thickness and $1.5\times1.5mm^2$ in area. Likely as the former

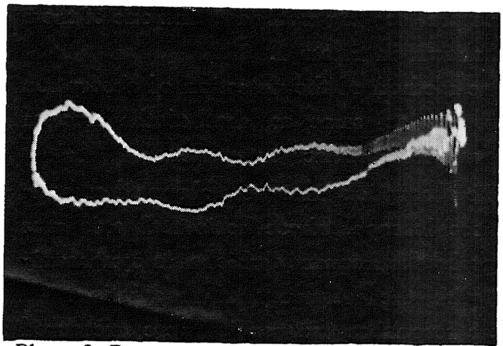

Photo 2. Pattern for the absorption lines of a single crystal of Rochelle salt. The beat shown at the right end is one of 33.02MHz.

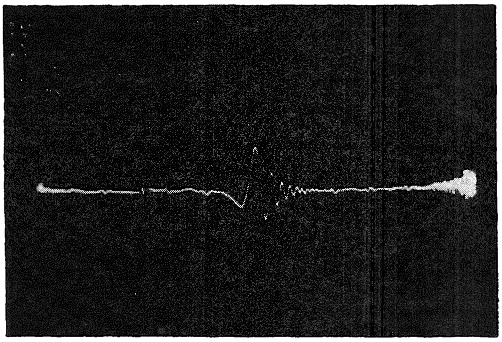

Photo 3. Pattern for the absorption lines of the 3500KHz quartz resonator. The frequency was swept from the left to the right between 32.246 MHz and 32.378 MHz. The beat shown at the right end is one of 32.378MHz.

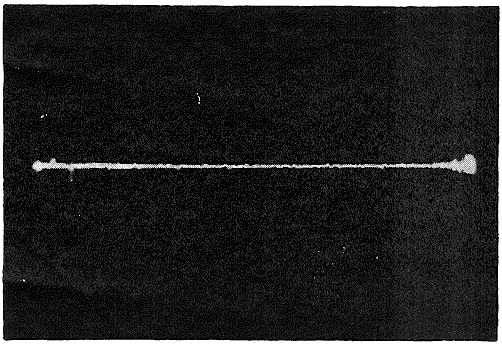

Photo 4. Pattern for the 3500KHz quartz resonator immersed in oil. The beat shown at the right end is one of 32. 378MHz.

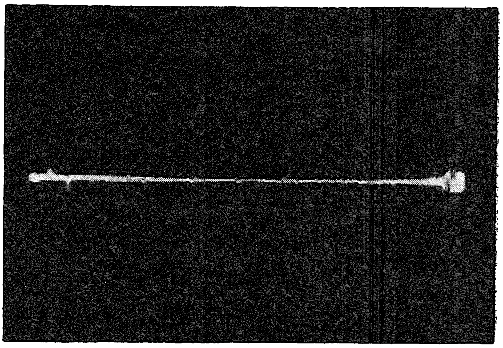

Photo 5. Pattern for the 3500 KHz quartz resonater immersed in pure water. The beat shown at the right end is one of 32. 378MHz.

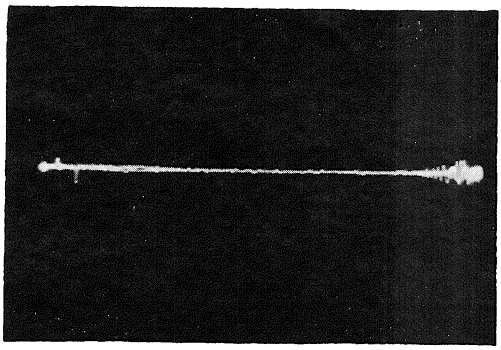

Photo 6. Pattern for the 3500KH, quartz resonator immersed in ethyl alchohol. The beat shown at the right end is one of 32. 378MHz.

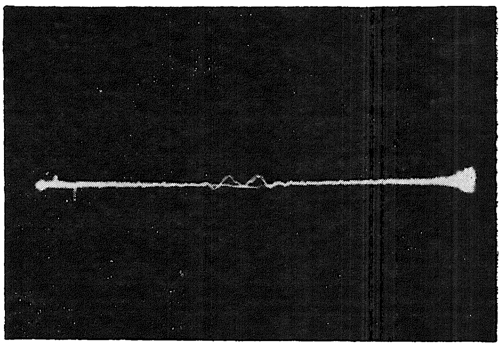

Photo 7. Pattern for the 3500KHz quartz resonator immersed in ethyl alchohol after ten minutes from the evaporation. The beat shown at the right end is one of 32.378MHz.

experiments, the frequency was swept from the left to the right between 32.246MHz and 32.378MHz. The absorption lines obtained from the quartz crystal were far sharper than those of the Rochelle salt. When the quartz crystal was immersed in oil (oil cedarwood) the almost every absorption lines were disappeared, but the hermonics lines were not so, and this fact was shown in Photo 4 in comparison of Photo 3. And also, the similar phenomenon was observed when the quartz crystal was immersed in pure water or ethyl alcohol. Photos 5 and 6 respectively show these patterns in comparison of the both cases (immersed or not).

When ethyl alcohol evaporates from the surface of the quartz crystal, however, the absorption lines appeared gradually, and the pattern of Photo 6 recovered perfectly to that of Photo 3 after half an hour. Photo 7 shows the patterns after ten minutes from the evaporation.

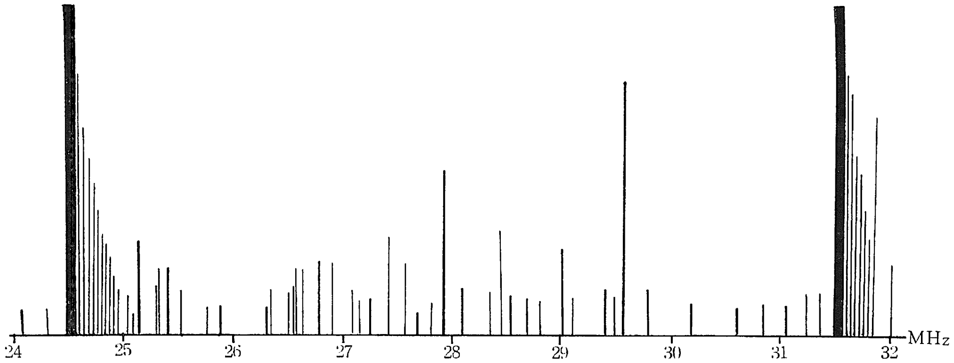

Fig. 3. Absorption lines of 3500KHz quartz resonator.

A part of the spectrum of absorption lines is arranged in Fig. 3. As the spectrum consisted so many lines, the classification of the lines into a fixed series seemed to be very difficult. But one series was found and it had equidistant sharp lines with the wides of 440KHz.

On the spectrum for the quartz resonator of 5000KHz fundamental, the similar series were also observed with the wide of 400KHz.

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3) T. Miyawaki : Research Reports of the Matsue Technical College 3 (1968) 29