A NEW AND QUICK METHOD FOR DETECTION OF PIEZO-ELECTRICITY AND MEASUREMENT OF THE PIEZO-ELECTRIC CONSTANTS

By KRISHNA GOPAL SRIVASTAVA

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ABSTRACT. A method using differential transformer has been developed for detection of piezo-electricity. To one of the primaries of the differential transformer the crystal is connected and to the other is connected a variable condenser and resistances in parallel. Balance is obtained at first and frequency of source is then varied. As soon as a crystal-frequency is approached a large current results in the secondary which detects the piezo-electric behaviour of the crystal. The method has been used to measure piezo-electric constant of quartz.

Formerly, two methods had been used for detecting piezo electricity in crystals. The first was due to Giebe and Scheibe, (1925) which is a click-method. The second is a bridge-method by Mason, (1943) in which the crystal is placed in one of the arms of a Wheatstone bridge and sudden changes in the rectified current are observed when the frequency of the source approaches one of the natural frequencies of the crystal. The method developed here uses a differential transformer for the purpose. The circuit arrangement is as given in Fig. 1.

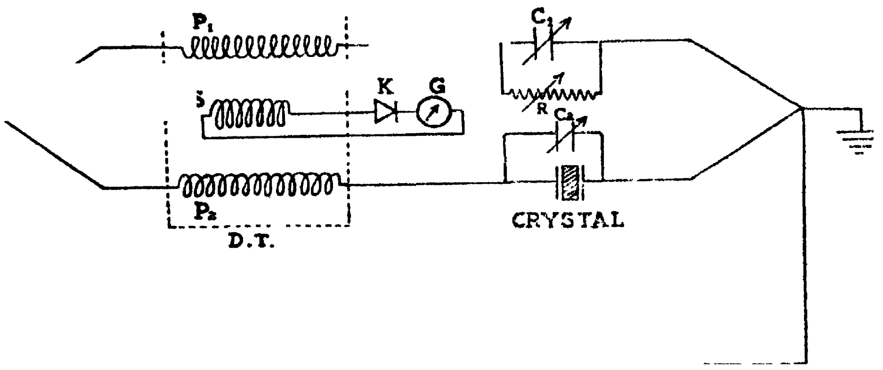

FIG. 1

D.T. is a differential transformer, which, as is well known, consists of two balanced primary coils P_1 and P_2, and a secondary coil *S*. *K* is a carborundum crystal rectifier connected to the secondary coil of the differential transformer, and *G* is a galvanometer to observe rectified currents. *T* is a signal generator which can give a signal of desired radio-frequency. In the present set-up a Ferris signal generator was used. To one of the primary coils of the differential transformer is connected a variable condenser C_1 and a resistance *R* in parallel. To the other primary coil is connected the crystal and a suitable air condenser C_2 of about 100 mmf. in parallel.

At a particular setting of C_2, which is kept constant throughout the experiment, R and C_1 are so adjusted that current in the galvanometer is zero. The frequency of the signal generator is then changed. As soon as a natural frequency of the crystal is approached a large current appears in the galvanometer which detects the piezo-electric action of the crystal.

Large current appears in the secondary circuit due to the fact that the reactance of the crystal at resonance suddenly drops to zero which unbalances the differential transformer. The reactance curve of the quartz crystal is very well known and is shown in Fig. 2, as given by Cady. It is seen from the curve that reactance passes through the zero value at both series and parallel frequencies f_s and f_p. Both of these frequencies are observed and the effective piezo-electric constant ϵ is calculated by using the bridge method (Mason 1943), from the formula:—

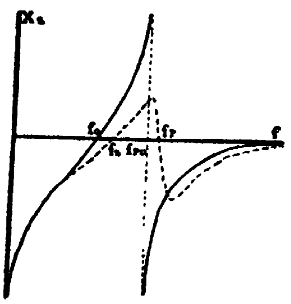

FIG. 2

$$\epsilon^2 = \frac{\pi k^2 l \rho}{\delta} \left(f_p^2 - f_s^2 \right)$$

Determination of the piezo-electric constant d_{11} was carried out using a crystal of frequency 3.9 mc. and the result agrees very well with the standard value. The value obtained is 5.2×10^{-8}. Further work at different temperatures and the determination of d_{14} is in progress.

The advantage of the present method is that easy detection and measurement of the piezo-electric constants can be made quickly. At the same time the apparatus is simple and easy to set up. It is hoped that this will also lead to the measurement of Q of the crystal and ultrasonic velocities and absorption in liquids and gases.

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DEPARTMENT OF PHYSICS
UNIVERSITY OF ALLAHABAD

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