

a suitable range the wave length of the beam will change and the different planes will in turn produce point patterns. By observing the accelerating voltages at which the point patterns are produced, the crystal structure can be determined. This method has the advantage that the intensities can be measured directly with an immobile collector, also that of great intensity since the electrons are focussed at a point instead of being distributed in a ring. The low penetrating power of the electrons will not cause difficulties as the electrons will be reflected instead of being transmitted.

A camera has been built on this principle, figure 2.

MAGNETIC EFFECT ON A VIBRATING QUARTZ CRYSTAL EXCITED PIEZO-ELECTRICALLY

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INTRODUCTION

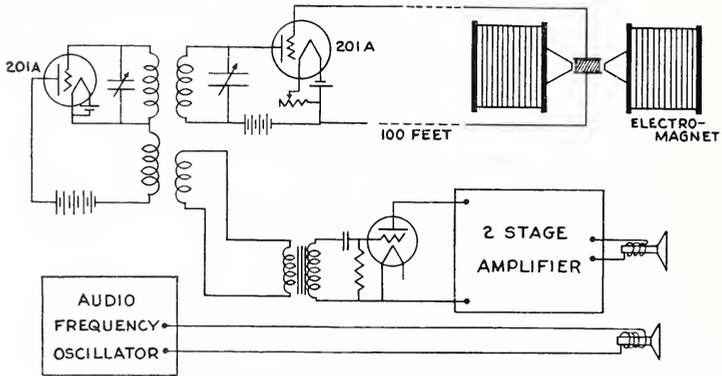
Work carried on during the last few years has been quite exhaustive in determining the various properties of quartz. Its wide use in oscillators of constant frequency has necessitated a knowledge of the various factors which control its natural frequency. Much work has been done and many articles have been written regarding temperature effects.¹ None, to the knowledge of the writer, has appeared regarding a magnetic effect. It was therefore thought advisable to investigate this possibility.

DESCRIPTION OF APPARATUS

The apparatus used in investigating the magnetic effect consisted of four vacuum tube circuits and an electromagnet. One of the vacuum tube circuits acted as a piezo-electric oscillator, the improved Pierce circuit being used. Two of the vacuum tube circuits were Hartley oscillators, one for radio frequencies, the other, using an iron core coil, for audio frequencies. The other radio circuit was a three stage amplifier and detector. The piezo-electric oscillator was coupled inductively to the Hartley radio frequency oscillator, which was in turn inductively coupled by means of a coil and an input transformer to the audio amplifier detector. A loud speaker was connected to the output terminals of the amplifier. By adjusting the frequency of the Hartley oscillator to within 1,000 cycles of the frequency of the piezo-electric oscillator, a beat frequency electric current was produced which, after passing through the amplifier, was converted by means of the loud speaker to acoustic energy in the form of a sound wave whose frequency was the same as that of the beat frequency current. A telephone receiver was connected in the plate circuit of the Hartley audio oscillator which

¹ Paul Vigoureux. Quartz Resonators and Oscillators, p. 19.

converted the energy of the audio frequency plate current into acoustic energy in the form of sound waves of the same frequency as the plate current. By adjusting the frequency of the Hartley audio oscillator to within a few cycles of the note from the loud speaker an audible beat note between the two tones was detected by the ear. This beat note, by suitable adjustment, was made to have a frequency of from 10 to 30 cycles per minute, which enabled one to count them easily. Any change in the frequency of either of the three oscillators was readily detected by a corresponding change in the frequency of the beat note of the sound waves. A complete circuit diagram of the set-up is shown in the following figure.



PROCEDURE AND RESULTS

The crystal used was a bar of quartz whose length in the t direction was 9 cm., breadth in the o direction 2.6 cm., and thickness in the e direction 1 cm. The natural frequency was 30 K.C. The crystal was mounted with its brass electrodes between the poles of the electro-magnet so that the magnetic lines of force were in the t direction. Upon closing the switch controlling the current to the electro-magnet an abrupt increase in the number of beats per second was observed. This increase could be obtained only when the magnetic lines of force were in the direction of the greatest motion. For when the crystal was orientated to permit the magnetic lines of force to be in the e and o directions no increase in the number of beats was observed upon closing the switch. The fact that the effect was obtained with the field only in one direction eliminated the possibility of the abrupt change being caused by an electro-magnetic coupling, as no changes were made in the apparatus during the various trials except the orientation of the crystal in the various directions.

To eliminate all possibility of coupling and to determine whether the field strength increased or decreased the effect, the crystal leads were extended about a hundred feet to a larger electro-magnet in a room on the next floor. The experiment was repeated and the same results obtained. No appreciable difference due to the stronger field was observed. In the first case the field was about 1,500 gauss and in the second case about 4,500 gauss. Several sets of data were taken by counting the

beats for ten second periods with the magnet current flowing and with it off. The difference between these readings gave the increase due to the field. The average for all the sets was 5 cycles increase for the ten second periods, making an average increase of 0.5 cycles in 30,000. Crystals of 40, 70 and 100 K.C. natural frequency were tried, but each gave negative results.

DISCUSSION OF RESULTS

When a quartz bar is caused to expand and contract as in a piezoelectric oscillator, electric charges of first one sign and then the other are liberated on the faces at the extremities of the electric axis. Since the charges change sign at a rate equal to the natural frequency of the crystal there must be a transfer of electricity of some kind or other. This transfer is supposedly made by a change in the internal structure of the crystal. This would involve a motion of the atoms, which being charged would constitute a minute electric current. The conductor of such a current when placed in a magnetic field would experience the usual thrust perpendicular both to the direction of the current and to the magnetic lines of force. Also according to modern theories of atomic structure the atom consists of electrons which rotate around a positive nucleus. These rotating electrons really constitute a current. The magnetic field would affect the direction of this current and thereby distort the normal orbits of the electrons. The net result of these two effects might be to change the modulus of elasticity and hence the natural frequency of the crystal.

ACKNOWLEDGMENTS

The writer wishes to acknowledge his indebtedness to Dr. A. L. Foley, who suggested the problem, and who followed its progress with kindly interest and helpful counsel. He is also grateful to the other members of the Department of Physics at Indiana University who aided in various ways.

EFFECT OF SOUND ON SPACE CURRENTS

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The object of the following investigation was to find a desirable method of measuring sound intensity. It was thought if sound could, somehow or other, be used to modify space currents in air, it might be possible to eliminate some of the objections to previous methods of measuring sound intensity. Three different methods were tried: (1) The effect of sound on the path of the electron current given off from a hot Nernst filament; (2) the effect of sound in modifying the amount of space current given off from a fine hot platinum wire; (3) the effect of sound on electron radiation.