An Experiment in Ultrasonics for Undergraduate Students

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For a number of years the field of ultrasonics has been exclusive territory for research, but improvement in technique and more general interest makes it possible and desirable to introduce undergraduate students to this topic.

A modified form of Kundt's tube similar to that used by Pierce was used to measure the wavelength of ultrasonic waves and thus determine the velocity of such waves set up by a quartz crystal of known frequency.

The resonating chamber (See Fig. 1) was made from a piece of iron water pipe 2½ inches in diameter and 6 inches long, fitted with end pieces. The one end piece carried a crystal holder and two binding posts. The other end piece held a screw which carried the reflector. A micrometer screw

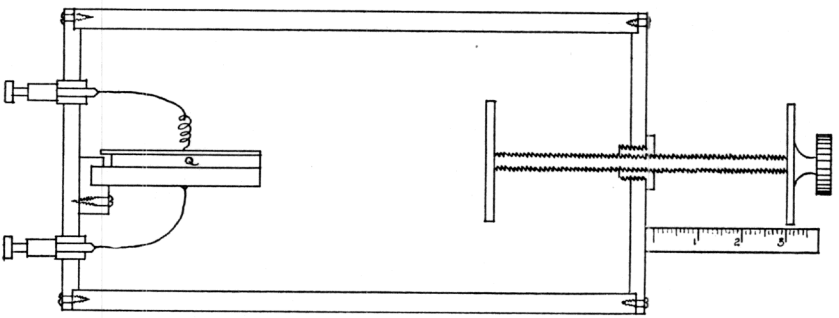

Fig. 1.—Resonating Chamber.

of one millimeter pitch with a range of 40 millimeters and a head graduated in 100 divisions is a standard piece supplied by the apparatus companies and serves admirably for this purpose. A brass disk about four centimeters in diameter soldered to the end of the screw formed the reflector. A scale graduated in millimeters was also attached parallel to the screw. The crystal holder was a brass platform about 8 cm x 4 cm x .4 cm which carried a frame of cork to inclose the crystal at the sides and back. The end toward the reflector was left open. The top or upper electrode was a sheet of aluminum as big over as the crystal and about a millimeter thick. A copper wire soldered to the lower electrode connected it to one of the binding posts. The connection to the upper electrode was made by a "cat-whisker." While in operation it is advisable to raise the reflector end of the chamber slightly to prevent the crystal from sliding forward.

A power unit for operation from an A. C. line was built as shown in Fig. 2. This gives a range of plate potentials from 60 to 500 volts. Crystals suitable for this work usually require a plate potential of from 240 to 300 volts when a '47 tube is used as a triode with tuned plate circuit. The crystal was connected between plate and grid as shown in Fig. 3. Thick crystals are desirable because they set more air in motion but they are more difficult to set into vibration. For such crystals a feed-back coil of 50 turns placed at the end of the inductance is important, but is not needed for

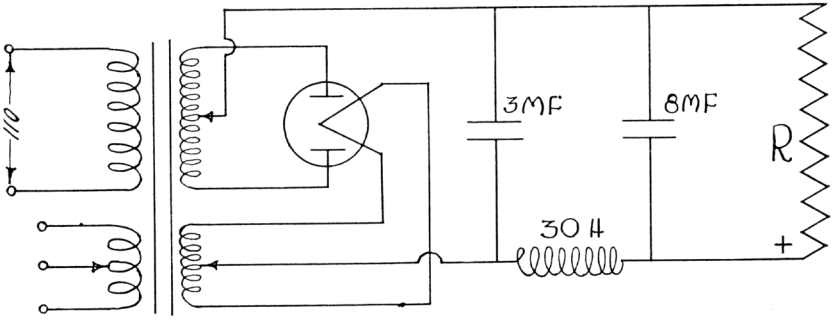

Fig. 2.—The Power Pack.

smaller crystals. The capacity used varied from .0004 to .002 microfarad and the inductance from 4 to 14 millihenries depending upon the crystal used. A radiofrequency 0-100 milliammeter was used in the capacity branch of the tank circuit.

When the crystal is set into vibration and the reflector moved toward or away from the crystal, the resonance points are readily detected by the reaction of the milliammeter. It is not possible to determine the exact point of resonance but by moving the reflector through several resonance points and computing the mean wavelength this error and that due to inaccuracies in the screw are largely eliminated. With this apparatus the following results were obtained from a crystal vibrating at 57.6 kc/sec.

Reflector Positions		Length of 11 half-waves
3.93	37.18	33.25 mm
3.99	37.19	33.20
4.02	37.25	33.23
3.99	37.20	33.21
4.00	37.27	33.27
3.96	37.25	33.29
3.97	37.15	33.18
3.96	37.23	33.27
3.97	37.08	33.11
3.96	37.12	33.16

Mean wave length .604 cm
Frequency 57600
Temperature 22.2° C
v_t = 34790 cm/sec.
v_o = 33460 cm/sec.

If inlet and outlet tubes are attached to the end pieces of the chamber the velocity may be measured in other gases.

The total cost of this apparatus will not exceed $50 exclusive of the quartz oscillators. But the financial outlay for them need not be high if they are produced by student enthusiasm and patience. It is not difficult to build a small cutting and grinding outfit. A piece of Brazilian quartz can be bought for about three dollars from which crystals having frequencies as low as 40 or 50 kc/sec. can be cut. These can be calibrated with sufficient accuracy with a home-made frequency meter which may not add greatly to the cost but may require considerable patience, or they may be sent to the Bureau of Standards for calibration.

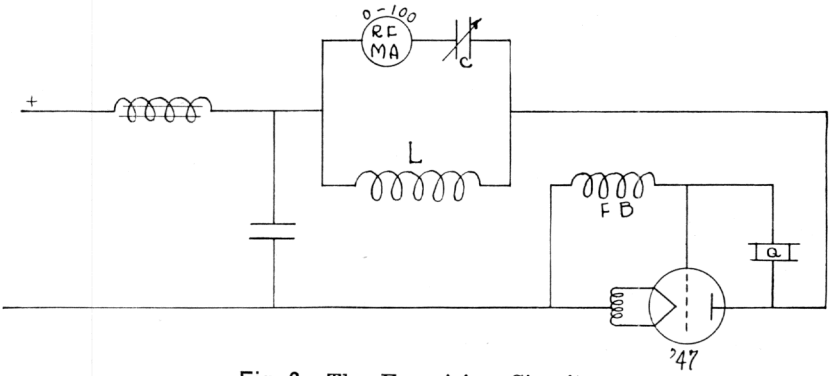

Fig. 3.—The Energizing Circuit.