Lab 6
Principles of loudspeaker and microphone

This first lab session on sound differs form all later ones in that it is taught as a demonstration lab, with the teaching assistant standing behind a lab table covered with demonstration equipment and the students sitting in front, a couple of meters away so that all of them have a good view of the demonstrations. The students are instructed to keep notes but are active participants in discussing the demonstrations. The purpose of the lab is to introduce students to the nature of sound and the basic electromagnetic laws that are used in electronic sound production (loudspeaker, earphones) and sound recording (microphone, record player, tape recorder)s. The hope is that this will deepen their understanding of the experimental equipment they will use in the next few labs. Depending on the lecture schedule this lab is sometimes omitted.

a) Sound consists of rapid pressure variations. Edison invented the phonograph, which at the time consisted of a wax-covered rotating cylinder. A needle attached to the apex of a paper cone was moved up and down by sound pressure entering the cone, so the needle scratched the surface of the wax corresponding to each of the ups and downs. With time the needle moved along the axis of the cylinder to make a spiral groove in the wax. To play back the sound the process was reversed, and the needle was moved up and down by following the groove in the wax, transmitting the motion to the attached cone, thus producing audible sound. Similarly in vinyl records the sound oscillations were engraved in the grooves - it is fun if the teaching assistant attaches a record needle to a primitive paper cone and holds it carefully over a rotating record (Fig. 1).

Figure 1.

Many students enjoy a neat, terribly simple demonstration of sound transmission by a "orange juice-can telephone". Take two empty frozen-orange juice cans with a thin sheetmetal bottom. Punch two small holes in the bottom of each can and connect the cans with a string. Ask one student to hold a can close to his mouth and speak into it while a second student holds the second can to her ear. Why does it work as a telephone? Why does it work only when

the string is taught? With a very light touch a student can actually feel the bottom of the can vibrate when one speaks loudly into it. How many of the students think this is how the telephone wires in the city work? (Fig. 2)

b) Better methods: turn sound oscillations into electricity. At the receiver, amplify the electric oscillations and turn the electricity back into sound.
For a simple demonstration of electromagnetic induction, move a wire located between the poles of a C-shaped permanent magnet - detect induced current by millivolt meter connected to the ends of the wire). See Figs. 3a and 3b. One can also show the force on the same wire, when it is connected to a battery.

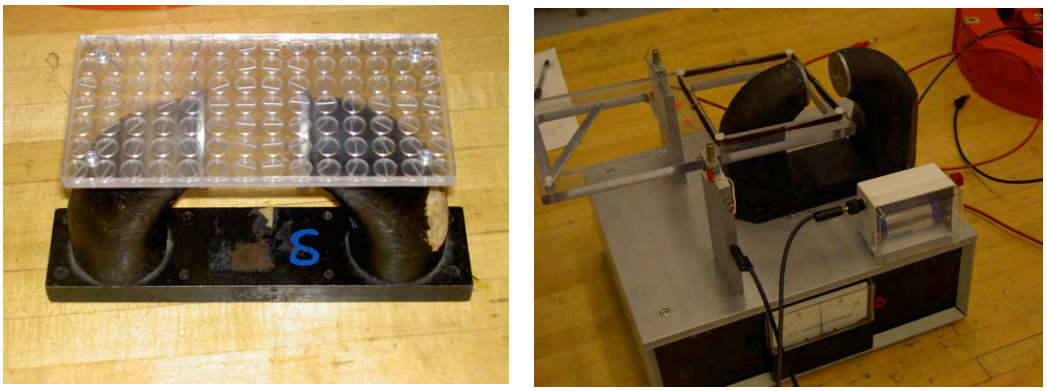

Figure 3.

c) Principle of Loudspeaker and headphones: coil in magnet. See model of speaker magnet (Fig.4). Large bass loud speaker on lecture table, connected to audio oscillator: put ball bearings inside to demonstrate motion of speaker cone, easily visible at low frequency and large volume. Role of speaker cone is to move much more air than a bare speaker coil would produce.

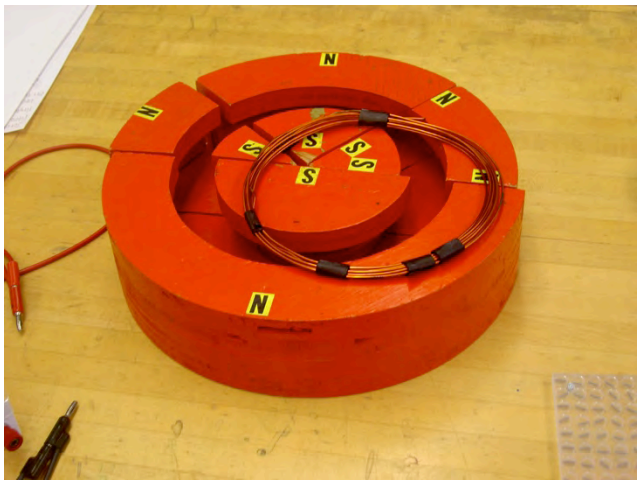

Figure 4.

d) Principle of microphone: a loud speaker can serve as microphone. Speak into bass loudspeaker connected to AC voltmeter and/or oscilloscope. Explain process. Magnetic pick-up of record player uses same principle: motion of needle moves tiny coil which is located near a magnet to produce a small electric current in the coil. Figure 5 shows a model of a magnetic stereo pickup, sensing separately the motion of the coil in two orthoganal diagonal directions.

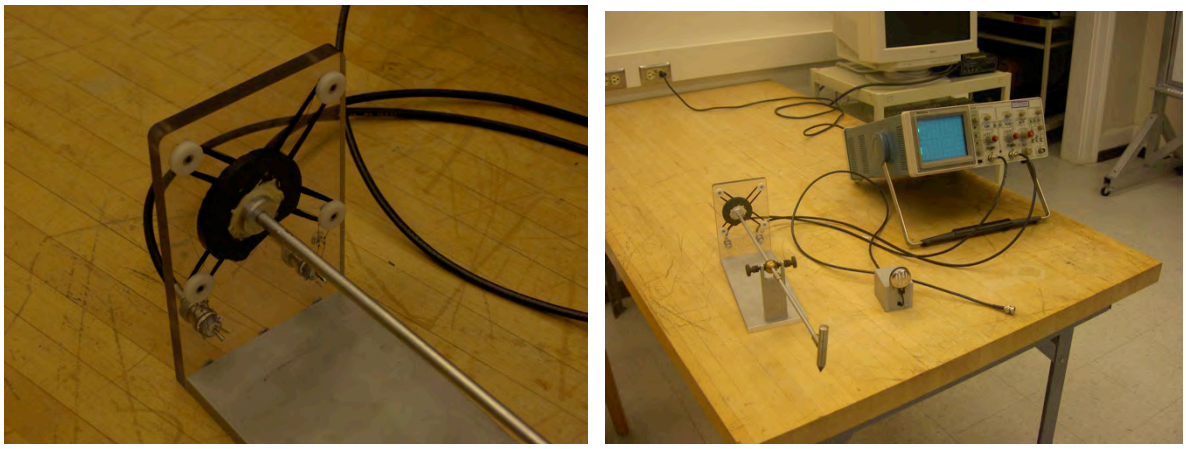

Figure 5.

Other mechanisms for speakers and microphones: ceramic speaker or ceramic microphone: some crystals bend when voltage is applied to electrodes on opposite sides of the crystal, and in turn produce electricity when beant slightly be external force (e.g. sound pressure)

A good opportunity to explain how tape recorders worked, how CD players work.