AN AUDIO AMPLIFIER

To understand this audio amplifier, it is necessary to understand atoms. Atoms make up all matter. Atoms are composed of three tiny particles, the proton, the neutron, and the electron. The proton and electron are charged. The electron has negligible weight; the proton and neutron have about equal weights.

What is a charge? When you walk across a carpet, and you touch a metal object, you get a shock. Before you got shocked, you had a charge.

There are two types of charges, positive and negative. Like charges repel, and opposite charges attract. This is similar to magnets. Like poles repel, and opposite poles attract.

Back to particles. The electron has a negative charge; the proton has a positive charge.

If we bring a proton and electron close, their attractive charges bring them closer. They never touch because of outside energy, and a frictionless environment. They orbit each other. Because the proton is much heavier, it hardly moves, and the electron swings around the proton. This is the simplest atom, the hydrogen atom.

If we add a neutron to the atom of hydrogen, we get heavy hydrogen. The neutron clings to the proton. Together, they form the center of the atom. The center of an atom is called its nucleus.

The number of protons must always equal the number of electrons to be an atom. If there is an excess, or shortage of electrons, it is called an ion.

The number of protons determines chemical properties. Neutrons help hold the nucleus together.

Suppose we add a proton, an electron, and the required number of neutrons to our hydrogen atom. Our new atom has two electrons orbiting the nucleus. The two electrons orbit with equal energy, and have equal distance from the nucleus. If we add another electron, another proton, and the required number of neutrons, we get an atom called lithium. The new electron takes an orbit outside the other electrons. Because it is shielded by other electrons, and it is further away from the nucleus, it is easily knocked off.

Such a substance with loose electrons is called a metal.

Suppose we have a wire of copper (a metal). If we add electrons to one end, and remove electrons from the other end, electrons will try to move into the area short of electrons. Electrons commonly run into copper atoms. The electron simply knocks an electron off the copper atom and takes its place.

The knocked electron goes in the same direction and speed as the electron that displaced it.

So, in effect, electrons travel through copper atoms. A massive movement of electrons in one direction is called an electric current.

The amount of electrons in motion is amperage. Voltage, or the difference in charge between two points, is the pressure.

Wattage is the amount of energy present. $W = VA$

Suppose we have a pipe. Only a certain amount of water flows through at a certain pressure. If we double the pressure, twice as much water flows through.

In electronics, it is the same way. The limiting factor is called resistance. If we double resistance, amperage is cut in half. If we double voltage, amperage doubles. So, $V = AR$ (See Figure 1A)

Resistance is measured in ohms.

What is V_2 or the voltage across our resistor? Assuming there is no other resistance in the circuit, it equals V_1.

What if we have another resistor in the circuit? (Figure 1B) Suppose $R_1 = R_2$. We know $V_2 + V_3 = V_1$. We know if $R_1 = R_2$, then $V_2 = V_3$.

Adding up... $V_2 + V_3 = V_1$

$$\begin{array}{r} V_2 = V_3 \\ \hline 2V_2 + V_3 = V_3 + V_1 \end{array}$$

Simplifying, we get $2V_2 = V_1$. So if $R_1 = R_2$ then $2V_2 = V_1$.

It appears that $V_2 = \frac{V_1 \quad R_1}{R_1 + R_2}$

What about V_3? We know $V_1 = V_2 + V_3$

Capacitors are commonly used in electronics. A capacitor consists of two metal plates, separated by a non-conductor. Each metal plate is connected to a wire. In Figure 2A, suppose we throw switch S_1 into position B. Electrons rush into P_1, repelling electrons from P_2 into (+) of the battery. This continues until the capacitor's plates have a voltage equal to the battery's voltage.

If we now throw S_1 into position A, meter A reads a small current for a small period of time.

Capacitors block regular direct durrent (Figure 2B). Suppose we apply alternating current (current in which electrons flow in one direction, then the other) to a capacitor. It charges one way, then the other. It takes current to charge a capacitor. Capacitors conduct alternating current. (Figure 2C), and block direct current.

A transformer is used in this amplifier. Transformers are usually used to charge voltage-amperage ratios in an alternating current.

Transformers do not operate on direct current. A transformer consists of two coils of wire wound around on iron core. The coil to which an alternating voltage is applied is called the primary coil. The coil from which an alternating current is drawn is called the secondary coil. When an alternating voltage is applied to the primary coil, a magnetic field that reverses every time the current reverses is set up. This produces an alternating voltage in the secondary coil (Figure 3A).

Transformers are capable of changing voltage amperage ratios of an alternating current. The formula for voltage is:

$$Vs = \frac{Ts\ Vp}{Tp} \qquad \text{(Figure 3A)}$$

Because VA = W, and W stays the same in both coils, we can find the formula for amperage. $V = \frac{W}{A}$. So, $\frac{W}{As} = \frac{Ts\ W}{Tp\ Ap}$

~~Subtracting~~ the W's, we get $\frac{1}{As} = \frac{Ts}{Tp\ Ap}$. So, $As = \frac{Tp\ Ap}{Ts}$

See Figures 3B and 3C.

So, whatever a transformer does to voltage, it does the opposite to amperage. Transformers are used to lower voltage from outlets for power supplies.

One is used in this amplifier to boost amperage for the speaker.

How can we make an audio signal stronger if all our components just make electricity weaker?

There is one component that can make a much stronger "copy" of an audio signal, the transistor. Transistors are similar to tubes in some respects. There are two types of transistors, PNP and NPN. We will talk only of the PNP type.

To understand the transistor, it is necessary to understand the diode.

A diode consists of two types of germanium or silicon in contact. (Figure 4). The two are called N type and P type. When electrons are removed from N type material it becomes an insulator. (It conducted to start with.)

When electrons are added to P type material, it becomes an insulator.

Where the two are joined, a very thin insulating barrier is formed.

When a voltage is applied so that the N type is slightly negative, and the P type slightly positive, much current flows (Figure 4A). When the voltage is reversed, so that the N type material is slightly negative, little current flows. (Figure 4B) In short, a diode permits current to flow in one direction only.

(Figure 4C, a graph)

The transistor (PNP) is a PNP device, not just PN. (Figure 5) In some cases, the PNP transistor acts like two diodes back-to-back. (Figure 5A, 5B) Suppose we set up a circuit like Figure 5A. When the variable resistor is put in position A, the transistor conducts, and meter A reads high.

Circuit 5B accounts for this wonderfully. If we move the variable resistor to B, the transistor insulates.

Going to Figure 5B, when the variable resistor is put in position A, D_1, the insulating diode, is shorted. When the variable resistor is put in position B, D_2, which is already conducting, is shorted. The insulating diode, D_2, has a big resistor in parallel with it. Therefore, little current gets through. Figure 5B partially accounts for Figure 5A.

But, the transistor does a few more things. (Figures 6A, 6B) When a battery is put so that its (+) is connected to the base of the transistor, and its (-) to the emmitter of the transistor, the transistor's amperage drops nearly to zero (Figure 6A) In a diode situation, the amperage would have risen slightly because of more voltage across the insulating diode.

In Figure 6B, where B_1 is reversed, the meter reads much amperage. In a diode situation, the amperage would have dropped slightly.

When we change B_1's voltage, current amperage going through meter A changes. However, when we make a very small change in B_1, a large change in amperage going through the meter occurs. Suppose we put a weak alternating voltage in place of B_1, and an output transformer and speaker in place of the meter (Figure 7A) Sound will be heard from the speaker. The alternating voltage drives the amperage going through the output transformer up and down, at the same frequency of the alternating voltage.

This comes out of the transformer as an exact copy of the original signal, but it is much stronger. This produces sound when applied to a speaker. This is a very simple audio amplifier. A capacitor (7B) improves fidelity. Adding a resistor (7C) improves fidelity, improves sensitivity, but lowers volume. Adding the second capacitor destroys radio frequency signals. If we replace the output transformer and speaker with a resistor, the transistor and resistor act as a voltage divider. (8A)

Because of the transistor's resistance changes with the signal, V will change with the signal. If you feed V into another transistor (8B) you get a much better amplifier. You can install another resistor in the circuit (9), and add another transistor. This third transistor is a more powerful transistor than the other two.

R_4 limits voltage in the second and first stage. R_5 and R_7 control voltage on the base of TR_3. C_3 keeps voltage in the second stage from having any <u>permanent</u> affect on the third stage. Signal voltage penetrates C_3. R_6 limits current that flows through the third stage.

You may have noticed when meter 1 goes up, meter 2 drops and meter 3 goes up, then drops if given time. Graphs A and B confirm this.