MAGNETS.

Equipment.

30 feet No. 24 copper magnet wire.
1 small bobbin or spool (with removable iron core).
1 type BA-10 reserve dry cell (charged).
1 small piece of iron (iron nail).
1 head set, type P-11.
1 test buzzer.

Information.

Two sorts of magnets will be discussed in this Unit Operation: Permanent magnets and electromagnets.

Permanent Magnets.—Nearly every one is familiar with the permanent type of magnet. Usually, it consists of a magnetized steel

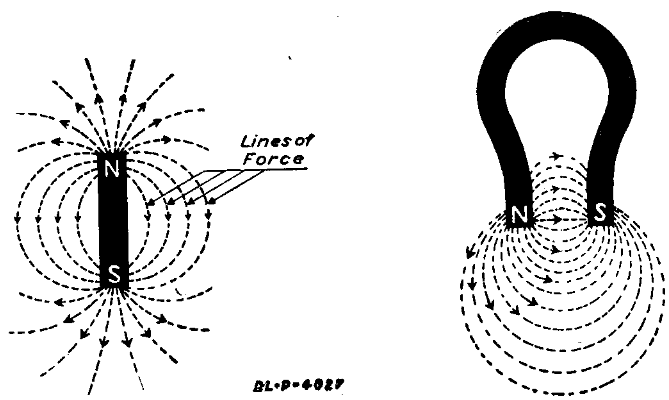

Fig. 16.—A straight bar magnet and a horseshoe magnet.

bar bent in the shape of a horseshoe. If this magnet is held near other small pieces of iron or steel the latter will be attracted and cling to it. This attraction is due to the magnetic lines of force which extend about the ends of the magnet. The area surrounding the magnet which includes these magnetic lines of force is known as the *magnetic field.* Fig. 16 shows a horseshoe type of magnet and also a bar magnet with the magnetic fields which surround each. The ends of a magnet are called the *poles.* One end is known as the *north* pole and the other end as the *south* pole.

If a piece of steel is placed across the poles of a permanent magnet and then forcibly pulled away it will be found that the piece of steel has itself also become slightly magnetized and that it will attract other pieces of iron or steel. In other words, if a piece of steel comes in contact with the poles of a magnet or is placed within the fields of a magnet, it will still retain some of the magnetism after it has been removed. In this respect steel differs from pure iron. A piece of pure iron which has been placed across the poles of a magnet will at once lose all traces of magnetism when it is pulled away.

Electromagnets.—When a wire conductor is carrying a current, a magnetic field is produced around the wire as shown in Fig. 17, A. Fig. 17, B shows the magnetic field produced when an insulated wire is wound in the form of a coil and connected to a battery. In addition to the magnetic field immediately around the circumference of the wire itself, a general magnetic field is produced about the coil formed by the wire.

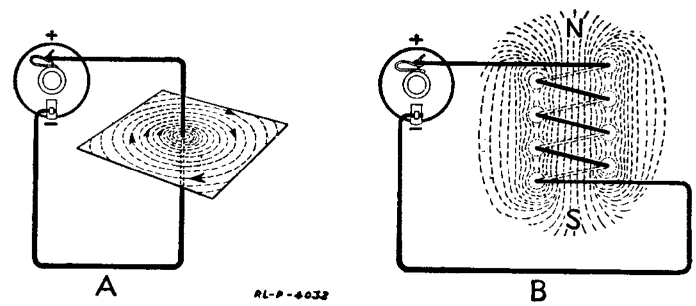

Fig. 17, A.—Magnetic field produced around a straight wire conductor.
Fig. 17, B.—Magnetic field produced around a coil of wire carrying an electric current.

Directions.

Construction of an Electromagnet.—1. Take the spool or bobbin and wind it full with magnet wire. To do this start winding at one end of the spool, leaving about 8 inches of the wire free at the beginning for a connection. Wind the turns close together and evenly until one layer has been completed. Then wind the second layer back over the first layer. Continue winding in this manner in layers until all the wire has been wound on the spool but about 8 inches, which is to be left for a connection or lead wire. Scrape off the insulation at the ends of the two short lengths of wire which have been left extending from the winding.

2. Hold the small piece of iron or the iron nail close to one end of the iron core provided and note whether or not there is any magnetic attraction between the two.

3. Place the iron core inside of the spool of wire and repeat Direction 2.

Question.

(1) *Was there any magnetic attraction between the iron core and the piece of iron in the above experiment?*

Direction.

4. Connect the leads from the coil to the terminals on the battery. Repeat Direction 2.

Questions.

(2) *Does the flow of current through the coil have any effect on the iron core? Explain.*

(3) *Why is the piece of iron not attracted by the iron core when no current is flowing through the coil? (See Direction 3.)*

Information.

Electromagnet.—If a bar of iron is placed inside a coil of wire which is connected to a battery, the iron will be found to be magnetized and will attract other pieces of iron or steel. Now if the current passing through the coil is switched off, the field around the coil will disappear or collapse and the iron bar will be found to be no longer magnetized. The iron bar will remain magnetized just so long as the current is turned on, but as soon as the current is turned off the iron loses its magnetism. A bar of iron surrounded by a coil of insulated wire, as described above, is an example of an *electromagnet.* The principle of the electromagnet is made use of every day in the construction and operation of electric bells, telephones, arc lamps, motors, generators, etc.

Question.

(4) *If an unmagnetized steel core were placed inside a coil and a current sent through the coil, would the steel core retain any magnetism after the current was turned off?*

Information.

Telephone receivers.—Telephone receivers, which are necessary with every type of radio receiving set used in the Signal Corps, depend both upon the electromagnet and the permanent magnet for their operation. One of the standard types of telephone receivers for radio work is illustrated in Fig. 18.

Directions.

5. Remove one of the telephone receivers from the head band and examine it closely. Notice the two wires leading into the receiver through the holes in the case.

6. Unscrew the hard rubber cap. Carefully remove the thin iron disk (the diaphragm) by sliding it from the receiver case. Note carefully that the two sides of the disk are not colored the same and that the light colored side is toward the magnets.

Question.

(5) *Are the coils of the receiver wound with coarse or with fine wire?*

Directions.

7. Notice the permanent horseshoe magnet at the bottom of the receiver case.

NOTE.—The soft iron cores of the two coil magnets are attached by steel supports to the poles of the permanent magnets located at the base of the receiver.

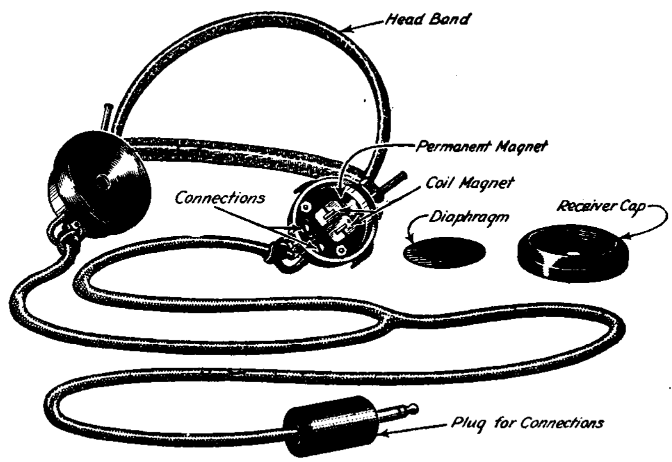

Fig. 18.—Headset, type P–11, with caps and diaphragm of one receiver removed.

Question.

(6) *If the cores of the two small electromagnets are made of soft iron, why is it that they exert a pull upon the diaphragm of the receiver?*

Directions.

8. Carefully replace the diaphragm making sure the light colored side is toward the magnets. Screw the cap on the receiver case.

Information.

The Telephone Receiver.—The action of a telephone receiver is as follows: Whether there is any current passing through the coils or not the poles of the permanent magnet exert a steady pull upon the diaphragm. This causes the diaphragm to be curved slightly inward toward the poles of the magnet, but without quite touching them. If a small current is now passed through the coils, the magnetic field produced by the coils will either help or hinder the magnetic effect of the permanent magnet, depending upon the direction of current through the coils. If the permanent magnet field is strengthened by the field of the coils, a stronger pull will be exerted upon the diaphragm causing it to move closer to the magnet poles. If the permanent magnet field is weakened by the field of the coils the magnetic pull on the diaphragm will be reduced, thus causing the diaphragm to move away from the poles of the magnet. The rapid opening and closing of a switch placed in series with a telephone receiver and battery will cause an intermittent or broken-up current to pass through the coils of the magnet. This intermittent current in turn will produce a series of back and forth motions of the diaphragm. The motions of the diaphragm will set up vibrations in the air and these vibrations will become noticeable to the ear in the form of a series of clicks. By substituting in place of the switch a make-and-break device which will interrupt the current very rapidly, a note will be heard in the receiver, the pitch of which will depend upon how rapidly the current is being interrupted.

Since only very small currents are available, from a radio receiving set, a great many turns of insulated wire must be wound on the telephone receiver magnets in order to produce a magnetic field strong enough to cause a movement of the diaphragm. A fine wire is used in order that the necessary number of turns may be wound in the small space provided. Since the wire is very fine the resistance of the coils is high. For example, the resistance of the type of receivers shown in Fig. 18, is approximately 1,100 ohms.

The receivers used in a head set are connected in series. In this case the total resistance of the receivers is 2,200 ohms.

Directions.

9. Connect one of the phone cord terminals to one of the dry-cell terminals. Place the receivers on the head. Touch the other terminal of the dry cell several times with the remaining cord terminal.

Question.

(7) *What happens when this is done?*

Information.

The Electric Buzzer.—The buzzer is another electrical device which utilizes the electromagnet. The buzzer shown in Fig. 19 is the type used in conjunction with radio sets. It consists of a composition base, upon which is mounted a small two-coil electromagnet, the core of which is made of soft iron. Directly in front of the poles of the magnet is a strip of spring steel which is fastened to a part of the magnet support. A set-screw terminal is provided on this part of the support. A small piece of silver or alloy metal is fastened to a spring structure attached to the strip of spring steel. This small piece of low-resistance metal is known as a contact. The spring-steel strip is called the vibrator or armature of the buzzer. A second contact is provided on the end of a thumbscrew mounted directly in front of the contact on the vibrator. The support of this contact screw is provided with a small-screw terminal. A third thumbscrew is used to adjust the tension of the spring vibrator.

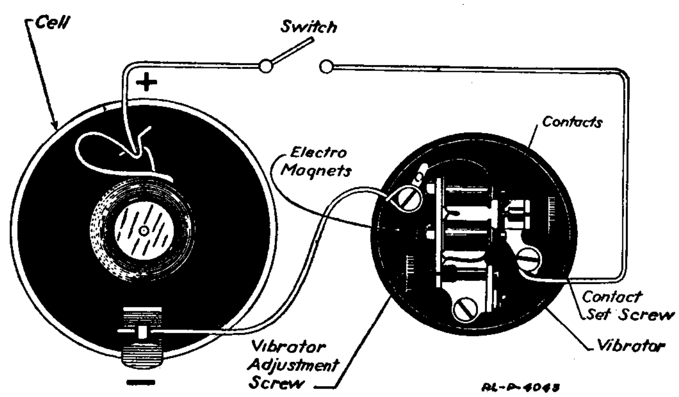

Fig. 19.—Test buzzer with cap removed to show parts and method of connecting to dry cell.

The wire connections of the buzzer are as follows: One end of one of the coils is connected to the screw terminal at the base of the buzzer. The other end of this coil is connected to an end of the second coil, thus placing the two coils in series. The other end of the second coil is connected to the vibrator.

Directions.

Connecting and Operating a Buzzer.

10. Examine the buzzer thoroughly. Trace the connections from the coils. Notice the various adjustment screws.

11. Adjust the thumbscrew controlling the tension of the vibrator arm, so that about one thirty-second of an inch space exists between the poles of the magnets and the vibrator. Adjust the contact thumbscrew in front of the vibrator so that it just makes contact

with the vibrator. Connect one terminal of the dry cell to one terminal of the buzzer as shown in Fig. 19. Connect one end of a lead wire to the other terminal of the battery. Touch the vibrator terminal with the other end of the lead wire.

Question.

(8) *What happens when the vibrator terminal is touched with the end of the lead wire?*

Direction.

12. Connect the lead wire to the terminal of the contact screw located in front of the vibrator.

Question.

(9) *What happens when the above connection is made?*

Direction.

13. With the buzzer still running try adjusting the set screws on the buzzer and notice the pitch of the note obtained with each adjustment.

Information.

The Action of a Buzzer.—The action of a buzzer is as follows: When the switch in Fig. 19 is closed, the current passes through the positive lead to the contact screw, through the contact screw and vibrator, then through the coils in series, and back through the negative lead to the dry cell. When the current passes through the magnet coils the iron cores of the magnet become magnetized and attract the vibrator or armature. This attraction pulls the armature away from the contact thumbscrew and thus causes the circuit to be broken. As soon as the circuit is broken the electromagnets lose their magnetism and no longer attract the armature. The tension of the armature causes it to return to its original position, that is, resting against the contact screw. This movement results in the circuits again being completed and the armature again is attracted to the magnets. This action is repeated over and over again, causing the armature to emit a sound or note.

Question.

(10) *Upon what does the speed at which the armature vibrates depend?*