plished unnoticed, the pendulum can be made to swing more and more until the little weight touches the glass and produces a noise.

The mysterious part of it is that the pendulums in the other bottles, although they may vibrate or oscillate to some extent, will not swing back and forth enough to produce any noise. The pendulums of different lengths have different rates of vibration and therefore do not get the benefit of the movement or vibrations of the table, as that is timed to suit the pendulum in the bottle selected to make the noise.

Your audience can now select another bottle and you can, without being noticed, change the vibration of the table to correspond with the next bottle selected and produce the same mysterious clinking.

ANOTHER KIND OF "TO AND FRO" MOTION

We have described the more general laws of the pendulum and its vibration; but, after all, the kind of "to and fro" motion demonstrated in the next experiment is even more closely related to the Science of Sound and should be thoroughly understood.

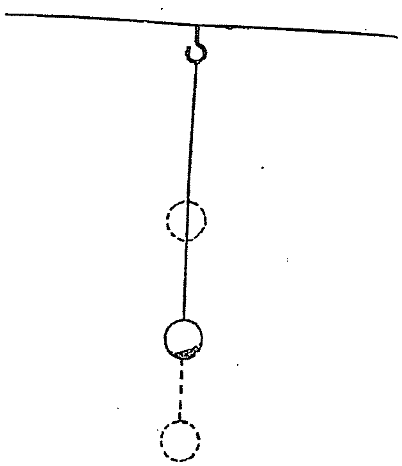

FIG. 4

Experiment No. 5. Attach an elastic or long rubber band to a ball such as a return ball. (See Figure 4.) Now, if the rubber band is attached above to some definite place, you can pull the ball directly down and let it go. What happens? The

ball vibrates up and down—that is, in line with the elastic which is holding it. This is called longitudinal vibration. Here again you will find that whether the range of vibration—that is, the amplitude—is great or small, the vibrations will be at the same rate.

The laws of the pendulum and various kinds of vibration that we have given you are going to be mighty interesting and valuable to you as you go on into the Science of Sound, for there also you will find "to and fro" motion playing the leading part.

Chapter II

ORIGIN OF SOUND

Now we are ready for our experiments and scientific research into the questions we asked in the earlier pages of this book. What is sound? What is it that comes from our throats when we talk? How does it travel to our ears?

There are three things concerning sound that are necessary before there can be any sound in the proper sense of the word. (1) Sound must begin somewhere; (2) it must travel to us;

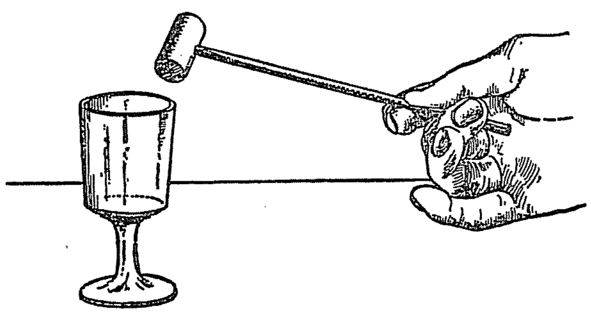

FIG. 5

and (3) it must be heard by the ear. First, let us see where sound begins.

Take a cork hammer (see Figure 5) and lightly strike the edge of a wine glass. It gives a strong clinking sound. Now put your finger on the edge of the glass. Two things should happen. First, you feel a slight tremble or vibration on your finger

and, second, the sound ceases. It should be plain to you then that the glass was vibrating and when you stopped this vibration you stopped the sound. Now let us figure out what this vibration is.

Special Note. As many of the following experiments require a tuning fork to be vibrated, we will explain different methods

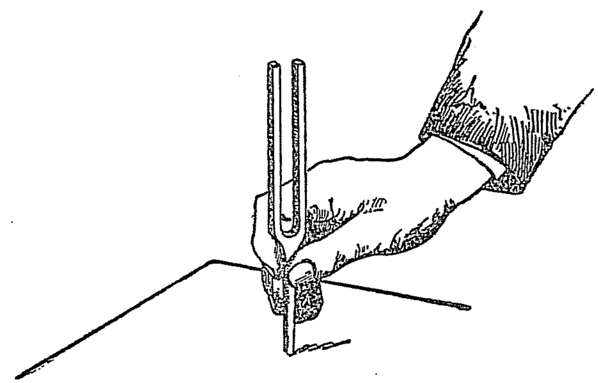

FIG. 6

of accomplishing this. Each method has its advantages for certain experiments.

1st. Hold a tuning fork by the base and strike one of the prongs sharply against the heel of your shoe or any solid object, such as a table top. You will not be able to hear much of a sound from the fork as you hold it in your hand, but if you bring it close to your ear or place it with the base firmly against a table top or box cover (see Figure 6) you will hear a clear, even tone.

2nd. Force the base of a tuning fork into a hole bored in a block of wood. Hold the block firm with the left hand and, with the right, take a wood or cork hammer and strike one prong of the fork with a sharp blow. (See Figure 7.)

3rd. Proceed as in the second method, except that instead of striking the fork with a hammer you take a violin bow, well

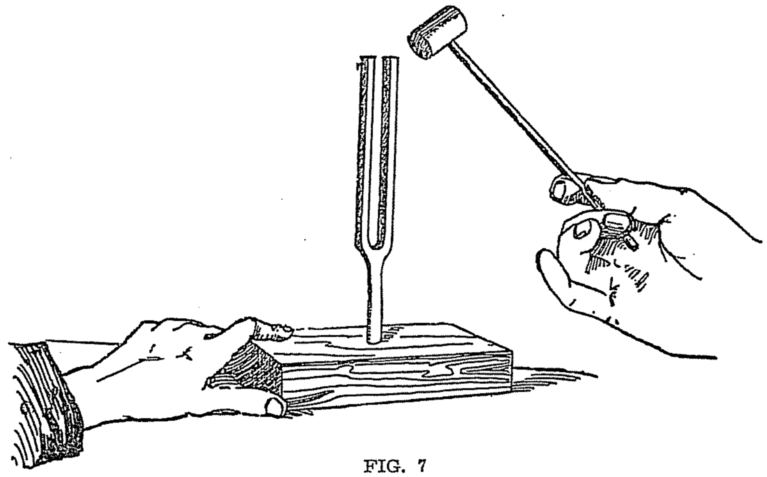

FIG. 7

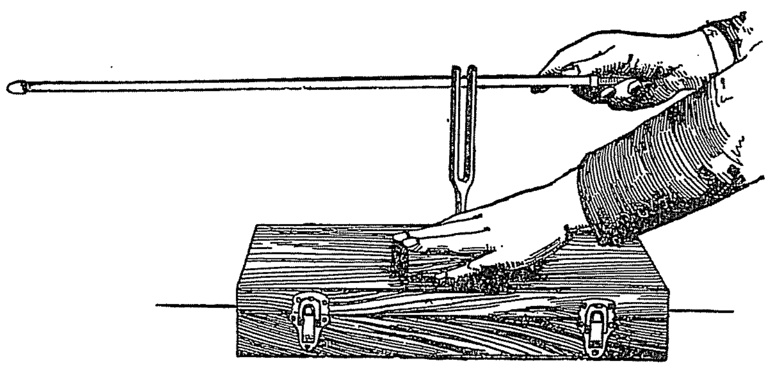

FIG. 8

resined, and draw it across the face of the tuning fork. (See Figure 8.) This will set the fork into violent vibration, and is

the method which you will find most satisfactory for a majority of your experiments.

Experiment No. 6. Attach a tuning fork to a block and place on a table or box and strike one of the prongs of the tuning fork with a cork hammer. Now hold a shoe button by means

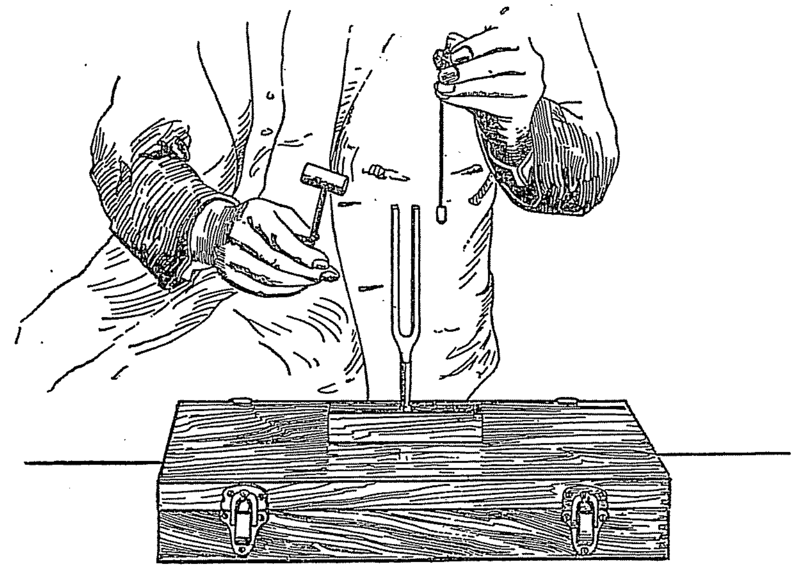

FIG. 9

of a thread (see Figure 9) against one side of the tuning fork. The resulting action of the button will prove that the tuning fork is a vibrating body and that it is moving with a "to and fro" motion like the pendulum. As the sound grows fainter the button does not rebound so far, because like the "to and fro" motion of the pendulum the vibrations or oscillations are growing smaller. This proves the theory that a **sound-producing body is a vibrating body.**

Experiment No. 7. Pick up a vibrating tuning fork and place the base of it between your teeth and feel the vibration. (See Figure 10.) Now take the tuning fork and set it in vibration

FIG. 10

by hitting it with a cork hammer and then bring it in contact with the surface of water. (See Figure 11.) To make the experiment more effective, scatter some lycopodium powder on the surface of the water. The action of the fork will then produce beautiful waves.

Experiment No. 8. Strike a bell with a cork hammer. (See Figure 12.) See if you can observe the vibration or motion of

the bell, and notice that the sound grows less as the vibration diminishes. We are certainly convinced by this time that sounds are produced by vibrations, and it should be conclusively proved to you that the motion which we studied in connection

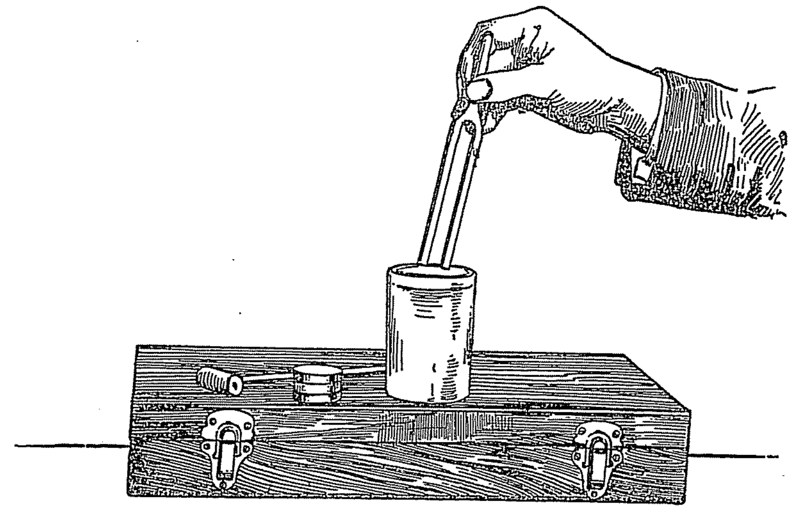

FIG. 11

with the pendulum is the same kind of motion that is producing these sounds—that is, "to and fro" motion.

HOW WE MAKE SOUNDS WITH OUR THROATS

The apparatus that Nature has provided for making sounds with our throats is very simple and easily understood.

In our throats are two cords, known as the vocal cords, and when we talk air waves from the lungs throw these cords into vibration, producing the different sounds. The wonderful part of the mechanism is that we can produce so many sounds with only two cords, the human throat being so constructed that the cords can be lengthened or shortened by means of muscles. Tubes leading from these cords, in conjunction with the lips, enable us to produce almost any sound.

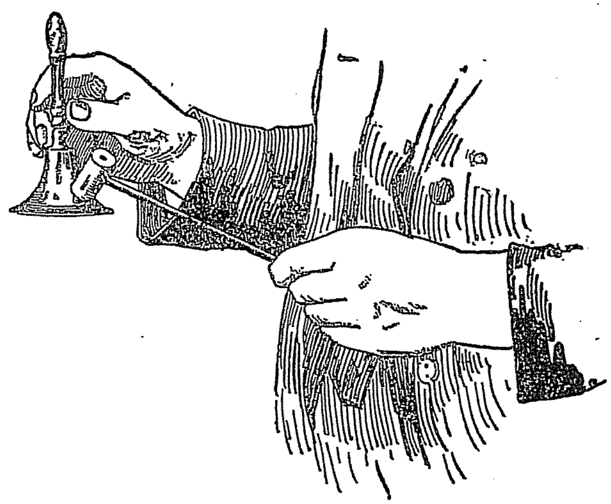

FIG. 12

VIBRATION OF AIR COLUMNS

We have discovered now that sound is produced by vibrating bodies. You should know that it is also produced by the vibrations of columns of air contained in tubes and pipes, as in many musical instruments. There are three classes of air instruments or mouth-piece instruments by means of which columns of air are vibrated in the instruments themselves.

1st. We have the instruments in which the air is blown

across the sharp edge of the opening, such as the whistle, the flute and the pipe organ. (See Figure 13.)

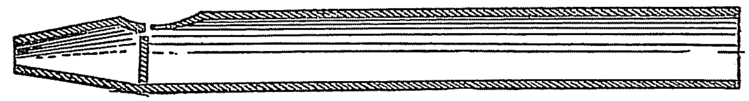

FIG. 13

2nd. We have air instruments in which the sound is produced by blowing air past a thin tongue, known as a reed. (See Figure 14.) The reed opens and closes the air column.

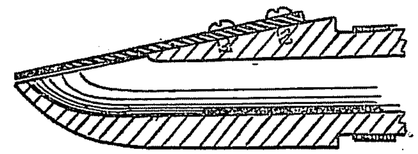

FIG. 14

3rd. There is that air instrument used in all bands, known as the cornet, where sound is produced by vibration of the lips on the mouthpiece. (See Figure 15.)

MUSICAL FLAMES

There are probably no prettier experiments in the study of sound than those in which tones are obtained from tubes by means of a flame.

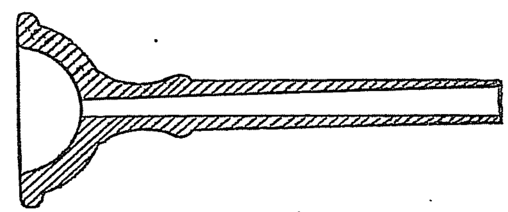

FIG. 15

Procure a glass tube about ¼ of an inch in diameter and 6 inches long. Bend this tube at right angles and, by means of a staple, fasten it to a small board under a tripod covered with wire gauze. (See Figure 16.) Connect the bent glass tube to a gas jet and make a light, holding a match over the wire gauze. Adjust the pressure of the gas and the position of the bent glass tube until a blue flickering flame is obtained. Now place another tube, about 2 inches in diameter and of almost any length, over the flame and

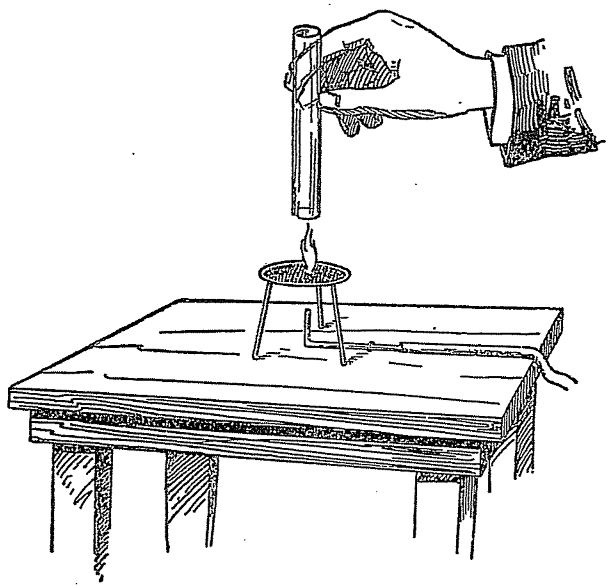

FIG. 16

you will at once hear loud musical tones. By trying tubes of different lengths, you will get many fascinating results.

As you may have concluded already, the sounds are produced by vibrations of the air within the large glass tube.

Chapter III

TRANSMISSION OF SOUND

Now that we have traced sound to its beginning, it is natural to ask, "What carries this sound to our ears and how?" The simple question of what carries sound brings us to a lot of interesting and important experiments.

A very simple experiment that you may not be able to do, but may be fortunate enough to see done in a laboratory, proves conclusively that sound is transmitted by our old and important friend, the air or the atmosphere. We have proved that its source is a vibrating body and by this experiment we can prove that it is carried from the point of vibration to the ear by the air.

Experiment No. 9. An electric bell is suspended in a jar. (See Figure 17.) Now if an electric current sets the bell in vibration, sound is produced. If, by means of an air pump, the air in the jar is pumped out, still keeping the bell in vibration, gradually the sound becomes fainter and fainter until a vacuum is created, when the sound will be entirely silenced. Therefore, **sound will, evidently, not be carried in a vacuum, but it will travel through air.**

CAN SOUND BE CARRIED BY ANY OTHER SUBSTANCE THAN AIR?

We will answer this and then you can demonstrate it yourself by a series of experiments that are quite interesting. THE SOUND OF A VIBRATING BODY CAN BE TRANSMITTED BY ANY SUB-

STANCE—GASEOUS, LIQUID OR SOLID. We have just demonstrated to you that they are transmitted by air, which is a gas, and that this is the most common method for sound transmission.

By Liquid. We are all familiar with the distinctness of sounds made under water. Every boy that has gone in swimming has at some time or other hit two stones together under water and noticed how the sound has been transmitted so distinctly. Therefore sound can be transmitted by liquids —water is a good example.

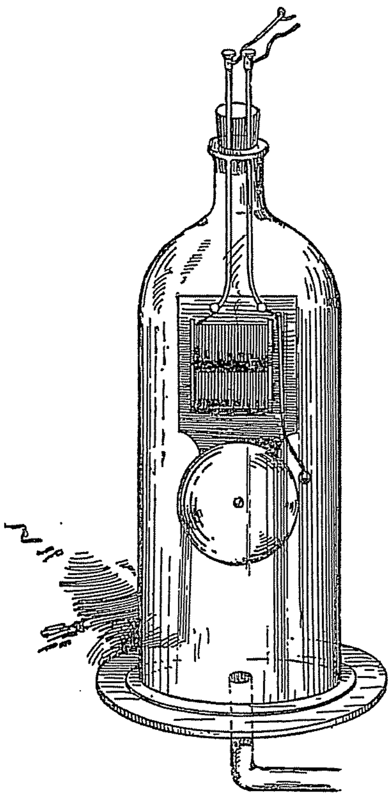

FIG. 17

By Solids. You have probably tried the stunt, which most boys are familiar with and which I often tried when a boy, of listening for the sound of a train through the rail by putting your ear upon the rail before the train had come into sight and long before you could hear it through the air. Or you have noticed the effect of a man striking a blow on a rail quite a way up the track. Put your ear to the track and notice how soon the sound is heard and, when you take your ear away, it takes quite a few seconds longer for it to reach your ear through the air.

CHURCH CHIMES WITH A SILVER SPOON

Experiment No. 10. The following is an extremely pleasing, interesting and novel experiment in sound transmission:

Take a silver spoon and tie a string to it, as per illustration. (See Figure 18.)

Wrap one end of the string around one finger and the other

FIG. 18

end around another finger and place them in the ears. Then let the spoon hit the edge of the table and a very beautiful sound will be heard in the ears, just like the chimes of a church clock.

This is a very fascinating experiment and one worth while, as you will be amazed by the results. Those standing around you hear practically no sound at all, while the sound waves will be transmitted through the string to your ears in a most fascinating manner.

By substituting a tuning fork for the spoon, you will be able

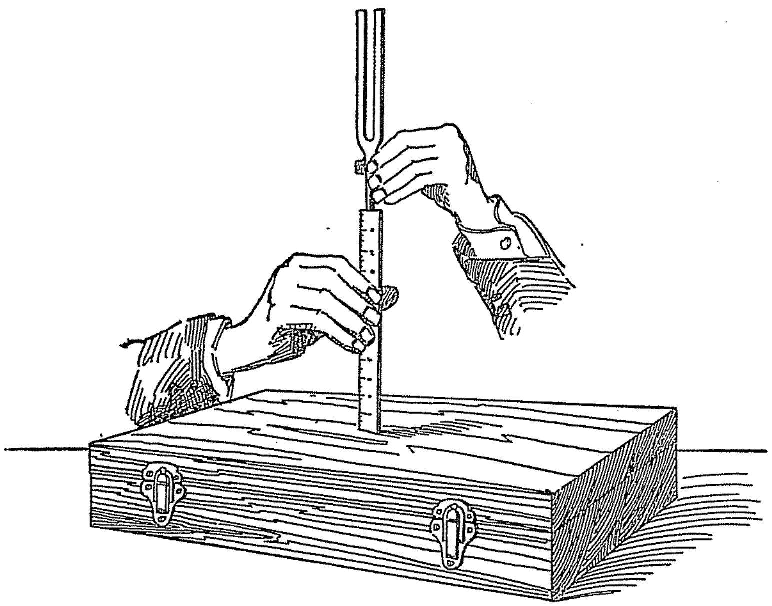

FIG. 19

to get the same result in an even greater degree. The tone may be heard for a much longer time than when the spoon is used.

Experiment No. 11. A very satisfactory method of proving that sound travels more readily through solids than through the air is as follows:

Cause a tuning fork to vibrate by hitting one prong against a

table top and place it firmly on the top end of a ruler, the bottom end of which is resting on a box cover. (See Figure 19.) The vibrations of the tuning fork in this case are transmitted down the ruler, causing the entire box cover to vibrate and giving a loud, clear tone.

Experiment No. 12. The same effect can be obtained, except in a lesser degree, by using a piece of string instead of the

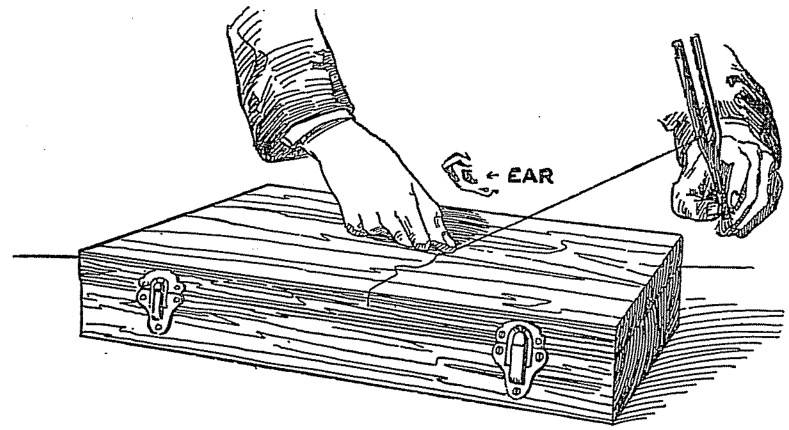

FIG. 19A

ruler. Tie one end of the string around the tuning fork and hold the other end firmly against a box cover with the thumb of your left hand. (See Figure 19A.) Holding the tuning fork in your right hand, set it in vibration and then draw the string tight. By placing your ear close to the end of the string which is pressing against the box, you will be able to hear the tone of the tuning fork quite distinctly. The fact that this sound is being transmitted down the string may be proved by lifting the end of the string off the box, in which case the sound is not nearly so loud. The reason for this is that when the string is pressing against the box cover, the entire cover vibrates just as in the case of the preceding experiment, causing a louder tone. When the end of the string does not press against the box cover, the resonance of the box does not come into play and therefore the sound is not so loud.

The old Indian method of listening for the advance of an enemy on horseback was to place his ear on the ground. Put your ear to a telegraph pole and you can hear the hum of the wires, whereas you cannot hear it through the air. Take a long stick of wood or, better still, a section of a gas pipe and place your ear at one end and have some one lightly scrape the other end with a piece of metal; and although with the ear away from the piece of wood or pipe the scraping cannot be heard, it is quite audible while the ear is at the end. These are all familiar instances of the transmission of sound through solids.

HOW TO MAKE A TOY TELEPHONE

Experiment No. 13. Take two tin boxes. Pierce the center of each of the boxes and, through the holes, put a stout cord or string and stretch it as per illustration. Now this is a very simple kind of a toy telephone, and yet is demonstrated quite conclusively and effectively how nicely sounds will travel through solids—that is, down the string by means of vibrations (the "to and fro" motion). This "to and fro" motion, which is caused by the vibration on one of the tin cans, sets the string in vibration which transmits the sound from one to the other. In this way two may talk much further apart and much more distinctly than they could through the air. (See Figure 20.) Any boy can rig up a telephone without very much expense and have great fun with it. You can elaborate on this apparatus considerably and make quite a unique telephone.

From the foregoing experiments you can readily see that some

substances are better conductors of sound than others. Both water and iron or steel are very much better conductors than air.

Most of the sounds we hear, however, come through the air, and even though we receive sounds which have traveled through solids as we have described, these sounds must travel

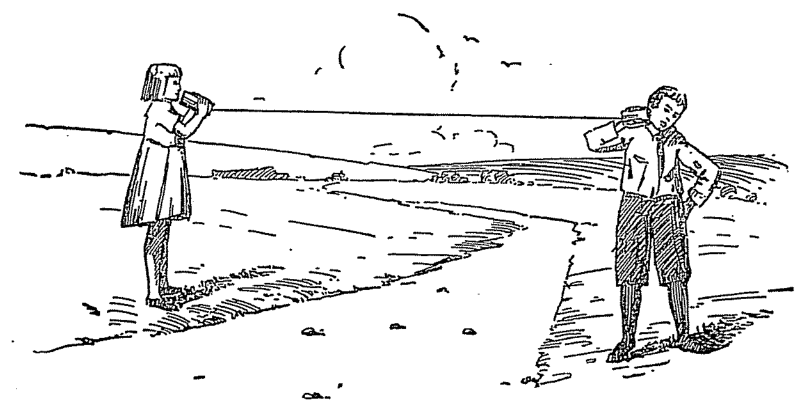

FIG. 20

a little way through the air to reach our ears. Is it not strange that Nature has provided the air as the principal medium for carrying sound when it is such a poor conductor?

WHY SOUNDS CAN COME THROUGH THICK WALLS

By this time you can readily understand why it is that sounds can be relayed through thick walls, if such a wall is a good conductor of sound. If a wall is constructed of materials that are good sound conductors—such as wood—the sound will be relayed through, regardless of its thickness. Sometimes sounds cannot be heard through walls, owing to the fact that they have