route for it, over what mountains, rivers, lakes, seas or oceans, as well as the countries traversed,—a very valuable and interesting method, by the way, as it makes it a real thing, and is not all "book-learning."

Dr. H. happened in one day, during such an exercise, and being much pleased with it, asked Mr. S. to "send 'em for a plum pudd'n!" Accordingly they started off on their travels for the flour, sugar, salt, raisins, spices, milk, etc., till they stopped, as they thought, at the end. "Go on," said our committee-man. "I can't think of anything more," said one; "Nor I," said another, till all had spoken. "Why!" said he, looking triumphantly at the master, "*where's your sass?*"

THE TELEPHONE, AND HOW TO MAKE IT.

What is a telephone?

Up go a hundred hands of the brightest and sharpest of the readers of *St. Nicholas*, and a hundred confident voices reply,

"An instrument to convey sounds by means of electricity."

Good. That shows you have some definite idea of it; but, after all, that answer is not the right one. The telephone does not convey sound.

"What does its name mean, then"? do you ask.

Simply, that it is a far-sounder; but that does not necessarily imply that it *carries* sounds afar. Strictly speaking, the telephone only changes sound-waves into waves of electricity and back again. When two telephones are connected by means of a wire, they act in this way,—the first telephone changes the sound-waves it receives into electric impulses, which travel along the wire until they reach the second telephone, here they are changed back to sound-waves exactly like those received by the first telephone. Accordingly, the listener in New York seems to hear the very tones of his friend who is speaking at the other end of the line, say in Boston.

Still you don't see how.

It is not surprising, for in this description several scientific facts and principles are involved, and all boys and girls cannot be expected to know much about the laws of sound and electricity. Perhaps a little explanation may make it clearer.

The most of you probably know that sound is produced by rapid motion. Put your finger on a piano wire that is sounding, and you will feel the motion, or touch your front tooth with a tuning fork that is singing, in the last case you will feel very distinctly the raps made by the vibrating fork. Now, a sounding body will not only jar another body which touches it, but it will also give its motion to the air that touches it, and when the air-motions or air-waves strike the sensitive drums of our ears, these vibrate, and we *hear* the sound.

You all have heard the windows rattle when it thunders loudly, or when cannons have been fired near by. The sound-waves in the air fairly shake the windows; and sometimes, when the windows are closed so that the air-waves cannot pass readily, the windows are shattered by the shock. Fainter sounds act less violently, yet similarly. Every time you speak, your voice sets everything around you vibrating in unison, though ever so faintly.

Thus, from your every-day experience you have proof of two important facts, first, sound is caused by rapid motion; second, sound waves give rise to corresponding motion. Both these facts are involved in the speaking telephone, which performs a two-fold office,—that of the ear on the one hand, that of our vocal organs on the other.

To serve as an ear the telephone must be able to take up quickly and nicely the sound waves of the air. A tightened drum-head will do that; or better, a strip of gold-beater's-skin drawn tightly over a ring or the end of a tube. But these would not help Professor Bell, the inventor of the telephone, since he wanted an ear that would translate the waves of sound into waves of electricity, which would travel farther and faster than sound-waves could.

Just when Mr. Bell was thinking how he could make the instrument he wanted, an important discovery in magnetism was made known to him—a discovery that helped him wonderfully. You know that if you hold a piece of iron close to a magnet the magnet will pull it, and the closer the iron comes to the magnet the harder it is pulled. Now, some one experimenting with a magnet having a coil of silk covered wire around it, found that when a piece of iron was moved in front of the magnet and close to it without touching, the motion would give rise to electric waves in the coil of wire, which waves could be transmitted to considerable distances.

This was just what Mr. Bell wanted. He said to himself, "The sound of my voice will give motion to a thin plate of iron as well as to a sheet of gold-beater's-skin; and if I bring this vibrating plate of iron close to a magnet, the motion will set up in it waves of electricity answering exactly to the sound-waves which move the plate."

So far, good. But something more was wanted. The instrument must not only translate sound-waves into electric impulses, but change these back again into sound-waves; it must not only hear, but also *speak!*

You remember our first fact in regard to sound: it is caused by motion. All that is needed to make anything speak is to cause it to move so as to give rise to just such air-waves as the voice makes. Mr. Bell's idea was to make the iron plate of his sound-receiver speak.

He reasoned in this way: From the nature of the magnet it follows that when waves of electricity are passed through the wire coil around the magnet, the strength of the magnet must vary with the force of the electric impulses. Its pull on the plate of iron near it must vary in the same manner. The varying pull on the plate must make it move, and this movement must set the air against the plate in motion in sound-waves corresponding exactly with the motion setting up the electric waves in the first place; in other words, the sound-motion in one telephone must be exactly reproduced as sound-waves in a similar instrument joined to it by wire.

So much for description. You will understand it better, perhaps, if you experiment a little. You can easily make a pair for yourself, rude and imperfect, it is true, but good enough for all the tests you may want to apply.

For each you will want: (1) a straight magnet; (2) a coil of silk-covered copper wire; (3) a thin plate of soft iron; (4) a box to hold the first three articles. You will also want as much wire as you can afford, to connect the instruments, and two short pieces of wire to connect your telephones with the ground. (Two wires between the instruments would make the ground-wire unnecessary, but this would use up too much wire.) The magnet and the coil you will have to buy from some dealer in electrical apparatus. They need not cost much. A small cigar-box will answer for a case.

In one end of the box cut a round hole, say three inches across. Against this hole fasten a disk of thin sheet-iron for a "diaphragm." For a mouthpiece use a small can, such as ground spices come in, or even a round paper box.

Now, on the inside of the box place the magnet, the end carrying the coil almost touching the middle of the diaphragm, and fix it firmly. Then, to the ends of the copper wire of the main coil fasten two wires—one for the line, the other for the "ground-wire."

The receiving and sending instruments are precisely alike; each answers for both purposes; but there must be two, since one must always be hearing while the other is speaking.

When you speak into the mouthpiece of one telephone, the sound of your voice causes the "diaphragm" to vibrate in front of the magnet. The vibrations cause the magnet's pull upon the diaphragm to vary in force, which variation is answered by electrical waves in the coil and over the wires connected with it. At the other end of the wire the pull of the magnet of the speaking telephone is varied exactly in proportion to the strength of the electric impulses that come over the wire, the varying pull of the magnet sets the diaphragm in motion, and that sets the air in motion in waves precisely like those of the distant voice. When these waves strike the listener's ear, he *seems* to hear the speaker's exact tones, and so, substantially, he does hear them. The circumstance that electric waves, and not sound-waves, travel over the wires, does not change the quality of the resulting sound in the least. I think you now understand Bell's telephone.—*From St. Nicholas.*

ENTHUSIASM VS. NOISE.—Some teachers object to a quiet manner in the school room, because, so they say, it indicates a "lack of enthusiasm." Herein lies a great mistake. There is no necessary connection between enthusiasm and noise; between a quiet determination to have order, and phlegmetic indifference to inattention and mischief.—*Pacific School and Home Journal.*