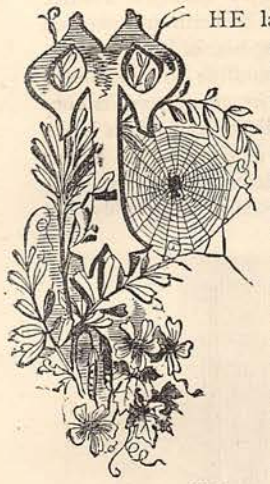
THE MICROPHONE.



THE last three years will be distinguished in the history of invention for a triad of great inventions. We have already seen* how the telephone and phonograph have originated; and to these two marvellous contrivances we have now to add a third, the microphone, which is even more marvellous, because, although in form it is the simplest of them all, in its action it is still a mystery. The telephone enables us to speak to distances far beyond the reach of eye or ear, "to waft a sigh from Indus to the Pole;" the phonograph enables us to seal the living speech on brazen tablets, and store it up for any length of time; while it is the peculiar function of the microphone to permit us to hear those minute sounds which are below the range of our ordinary powers of hearing. By these three instruments we have thus received a remarkable extension of the powers of the human ear, and an accession of dominion over the sounds of nature. We have now as great a command over sound as we have over light. For the telephone is for the ear what the telescope is for the eye, the phonograph is for sound what the photograph is for light, and the microphone finds its analogue in the microscope. As the microscope discloses to our wondering sight the rich meshes of creation, so the microphone reveals to our ears the jarring of molecular vibrations for ever going on around us, the clash of atoms as they shape themselves into crystals, the murmurous ripple of the sap in trees which Humboldt fancied to make a continuous music in the ears of the tiniest insects, the fall of pollen-dust on flowers and grasses, the stealthy footfalls of a spider upon his silken web, and even the piping of a pair of love-sick butterflies, or the trumpeting of a bellicose gnat, like the "horns of elf-land faintly blowing."

Professor D. E. Hughes, the discoverer and inventor of the microphone, was born in London in 1831. His parents were both Welsh, and emigrated to America while he was still a child. They settled in Kentucky, and there young Hughes received his education. His natural liking and capacity for physical and mathematical studies soon marked out for him his future sphere of labour, and in 1850 at the age of nineteen he was appointed Professor of Physics in the College of Kentucky at Louisville, the capital of that State. In this position he turned his attention to electricity, and five years later, in 1855, he produced his world-famous type-printing telegraph instrument, which is the parent of all subsequent telegraph instruments which print off the message in Roman characters as it is received. It was speedily adopted by the American telegraph companies, and more slowly by foreign companies. Now it is in use, under various modifications, in almost all European and in several other countries. Having first become known to fame in America, Professor Hughes is usually claimed by the Americans as a countryman, and through some error the very date and place of his birth there are often given in American publications; but we have the very best authority for the accuracy of the above facts, namely, that of the inventor himself. The success of the Hughes type-printer covered its author with titles and scientific honours, and placed him above the necessity of regular employment. He left America, and travelled from place to place. For many years past, however, he has resided privately in London, the place of his birth, an eminent example of that modesty and simplicity which is generally said to accompany true genius.

Mechanical invention is influenced to a very high degree by external circumstances. It may sound sensational, but it is nevertheless true, that we owe the microphone to an attack of bronchitis. During the thick foggy weather of last November, Professor Hughes was confined to his home by a severe cold, and in order to divert his thoughts he began to amuse himself with a speaking telephone. Then it occurred to him that there might be some means found of making the wire of the telephone circuit speak of itself without the need of telephones at all, or at least without the need of one telephone, namely, that used in transmitting the sounds. The distinguished scientist, Sir William Thomson, has of late discovered the peculiar fact that when a current of electricity is passed through a wire, the current increases when the wire is stretched or strained, and diminishes when the wire is compressed, because in the former case the resistance of the material of the wire to the passage of the current is lessened, and in the latter case it becomes greater.

Now it occurred to Professor Hughes that, if this be so, it might be possible to cause the air-vibrations of sound to so act upon a wire conveying a current as to stretch and compress it in sympathy with themselves, so that the sound-waves would create corresponding electric waves in the current, and these electric waves, passed through a telephone connected to the wire, would cause the telephone to give forth the original sounds. He first set about trying the effect of vibrating wire in which a current flowed, to see if the stretching and compressing thereby produced would affect the current so as to cause sounds in a telephone connected up in circuit with the wire—but without effect. He could hear no sound whatever in the telephone. Then he stretched the wire till it broke altogether, and as the wire began to rupture he heard

* CASSELL'S FAMILY MAGAZINE, for February and June, 1878.

a distinct grating in the telephone, followed by a sharp "click," when the wire broke asunder, which indicated a "rush" of electricity through the telephone. This pointed out to him that the wire might be sensitive to sound when in a state of rupture. Acting on the hint, he placed the two broken ends of the wire together again, and kept them so by the application of a definite pressure. To his joy he found that he had discovered what he had been in search of. The imperfect contact between the broken ends of the wire proved itself to be a means of transmitting sounds, and in addition it was found to possess a faculty which he had not filled with lead-shot or black oxide of iron, or "white bronze" powder under pressure; a metal watch-chain piled in a heap. Surfaces of platinum, gold, or even iron, pressed lightly together give excellent results. Three French nails, two parallel beneath and one laid across them, or better still a log-hut of French nails, make a perfect transmitter of audible sounds, and a good microphone. Because of its cheapness, its conducting power, and its non-oxidisability, carbon is the most select material. A piece of charcoal no bigger than a pin's-head is quite sufficient to produce articulate speech. Gas-carbon operates admirably, but

THE PENCIL MICROPHONE.

anticipated—it proved to be sensitive to very minute sounds, and was in fact a rude microphone. Continuing his researches, he soon found that he had discovered a principle of wide application, and that it was not necessary to confine his experiments to wires, since any substance which conducted an electric current would answer the purpose. All that was necessary was that the materials employed should be in contact with each other under a slight but definite pressure, and, for the continuance of the effects, that the materials should not oxidise in air so as to foul the contact. For different materials a different degree of pressure gives the best results, and for different sounds to be transmitted a different degree of pressure is required. Any loose, crazy, unstable structure, of conducting bodies, inserted in a telephone circuit, will act as a microphone. Such, for example, as a glass tube the best carbon is that known as willow-charcoal, used by artists in sketching, and when this is impregnated with minute globules of mercury by heating it white-hot and quenching it in liquid mercury, it is in a highly sensitive microphonic condition. The same kind of charcoal permeated by platinum, tin, zinc, or other unoxidisable metal is also very suitable; and it is a significant fact that the most resonant woods, such as pine, poplar, and willow, yield the charcoals best adapted for the microphone. Professor Hughes' experimental apparatus is of an amusingly simple description. He has no laboratory at home, and all his experiments were made in the drawing-room. His microphones are formed of bits of carbon and scraps of metal, mounted on slips of match-boxes by means of sealing-wax; and the resonance pipes on which they were placed to reinforce the effect of minute

sounds, were nothing more than children's toy money boxes, price one halfpenny, having one of the ends knocked out. With such childish and worthless materials he has conquered Nature in her strongholds, and shown how great discoveries can be made. The microphone is a striking illustration of the truth that in science any phenomenon whatever may be rendered useful. The trouble of one generation of scientists may be turned to the honour and service of the next. Electricians have long had sore reasons for regarding a "bad contact" as an unmitigated nuisance, the instrument of the evil one, with no conceivable good in it, and no conceivable purpose except to annoy and tempt them into wickedness and an expression of hearty but ignominious emotion. Professor Hughes, however, has with a wizard's power transformed this electrician's bane into a professional glory and a public boon. Verily there is a soul of virtue in things evil.

The commonest and at the same time one of the most sensitive forms of the microphone is that represented in the figure; it is called the "pencil microphone" from the pencil or crayon of carbon, C, which forms the principal part of it. This pencil may be of mercurialised charcoal, but the ordinary gas-carbon, which incrusts the interior of the retorts in gas-works, is usually employed. The crayon is supported in an upright position by two little brackets of carbon, A and B, hollowed out so as to receive the pointed ends in shallow cups. The weight of the crayon suffices to give the required pressure on the contacts, both upper and lower, for the upper end of the pencil should lean against the inner wall of the cup in the upper bracket. The brackets are fixed to an upright board of light, dry, resonant pine-wood, attached to a base-board of pine as shown. The base-board is with advantage borne by four rounded india-rubber feet, which insulate it from the table on which it may be placed. To connect the microphone up for use, a small voltaic battery, say three cells (though a single cell will give surprising results), and a Bell speaking telephone are necessary. A wire is led from one of the carbon brackets, say B, to one pole of the battery, and another wire is led from the bracket A, to one terminal screw of the telephone, and the circuit is completed by a wire from the other terminal of the telephone to the other pole of the battery. If now the slightest mechanical jar be given to the wooden frame of the microphone, to the table, or even to the walls of the room in which the experiment takes place, a corresponding noise will be heard in the microphone. By this sensitive arrangement we can play the eaves-dropper on those hidden vibrations of matter for ever trembling around us. If a feather or a camel-hair pencil be stroked along the base-board, we hear a harsh grating sound; if a pin be laid upon it, we hear a blow like a blacksmith's hammer; and, more astonishing than all, if a fly walk across it we hear its tramping like a charger, and even its peculiar trumpeting, which has been likened, with some allowance for imagination, to the snorting of an elephant. And it should not be forgotten that the wires connecting up the telephone may be lengthened to any desired extent, so that, in the words of Professor Hughes, "the beating of a pulse, the tick of a watch, the tramp of a fly can then be heard at least a hundred miles from the source of sound." If we whisper or speak distinctly in a monotone to the pencil, our words will be heard in the telephone; but with this defect, that the *timbre* or quality is, in the present state of the instrument, lost, so that it is impossible to recognise the speaker's voice. But although a single pencil microphone will under favourable circumstances transmit these varied sounds, the best effect for each kind of sound is obtained by one specially adjusted. There is one pressure best adapted for minute sounds, another for speech, and a third for louder sounds. A simple spring arrangement for adjusting the pressure of the contacts is therefore an advantage, and it can easily be applied to a microphone formed of a small rod of carbon pivoted at its middle, with one end resting on a block or anvil of carbon underneath. The contact between the rod and the block in this "hammer-and-anvil" form is, of course, the portion which is sensitive to sound.

The microphone is a discovery as well as an invention, and the true explanation of its action is as yet merely an hypothesis. It is supposed that the sonorous vibrations have the power to cause an expansion and contraction of the microphonic substances, which, at the point of contact between them, has the effect of increasing or diminishing the conducting avenue by which the current passes.

The applications of the microphone are already of some importance. Dr. B. W. Richardson is engaged in fitting it for auscultation of the heart and lungs; while Sir Henry Thompson has successfully used it in those surgical operations, such as probing wounds for bullets or fragments of bone, in which the surgeon has hitherto relied entirely on his delicacy of touch for detecting the jar of the probe on the foreign body. There can be no doubt that in telegraphy, in the science of physiology, and in the art of surgery, the microphone will prove a valuable aid.

Science seems to show that every physical process is reciprocal, and may be reversed. With this principle in our minds, we need not be surprised that the microphone should not only act as a *transmitter* of sounds, but that it should act as a *receiver* also. Mr. James Blyth, of Edinburgh, recently announced that he had heard sounds and even speech given out by a microphone itself when substituted for the telephone. His transmitting microphone and his receiving one were simply jelly-cans filled with cinders from the grate. It then transpired that Professor Hughes had previously obtained the same remarkable effects from his ordinary "pencil" microphones. The sounds were extremely feeble, however, but the transmitting microphones proved the best articulating ones. Professor Hughes has now constructed an adjustable hammer-and-anvil microphone of gas-carbon, fixed to the top of a resonating drum, which articulates fairly well, although not so perfectly as a Bell telephone. No doubt, a means of improving both the volume and dis-

tinctness of the articulation will soon be forthcoming, and then we shall be able to hold telephonic communication solely by means of microphones. The marvellous fact that a little piece of charcoal can, as it were, both listen and speak, that a person may talk to it so that his friend can hear him at a similar piece a hundred miles away, is a miracle of nineteenth-century science which far transcends the oracles of antiquity.

The articulating telephone was the forerunner of the phonograph and microphone, and led to their discovery. They in turn will doubtless lead to other new inventions, which it is now impossible to foresee. We ask in vain for an answer to the question which is upon the lips of every one—What next? The microphone is likely to be very useful in strengthening the sounds given out by the telephone, and it is probable that we shall soon see the three inventions working unitedly, for the microphone may make the telephone sounds so powerful as to enable them to be printed by phonograph as they are received, and thus a durable record of telephonic messages would be obtained. Reports also reach us from the other side of the Atlantic of a "megaphone" or ear-trumpet, which is for the ear what the opera-glass is for the eye, and of a "microtasimeter," based on the microphone principle, for measuring minute pressures, and extremely low temperatures, such as one-millionth of a degree Fahrenheit. An "antiphone," or contrivance for screening off sound and producing silence, even as light may be excluded to produce darkness, is a desideratum which may very soon be realised. We can now transmit sound by wire, but it will yet be possible to transmit light, and see by telegraph. We are apparently on the eve of other wonderful inventions, and there are symptoms that before many years a great fundamental discovery will be made, which will elucidate the connection of all the physical forces, and will illumine the very framework of nature.

J. MUNRO, C.E.

TRY BARMOUTH.

AS I was casting about for a sea-side resort that would be likely to meet my ideal and the requirements of my family doctor, I accidentally heard of "Aber Mawddach," or Barmouth. When my doctor had advised me for my health's sake to try a change of air and scene, and "get to the sea-side," my head had become dizzy with thoughts of stuffy boarding-houses and ill-cooked meals, noisy bands and ill-tuned barrel-organs, melting heat and fine dresses. I was told, however, that a sojourn at this obscure Welsh town would expose me to none of these discomforts, but that it would so benefit me as that I should return completely restored. Who could resist so fascinating a picture? I could not, and I therefore determined to go.

Living in a town in the centre of England, the choice of a route was attended with some little difficulty; but I at length came to the conclusion that my tastes as well as my pocket would be best suited by the Great Western Railway. I therefore proceeded to the Midland Metropolis, and started thence from Snow Hill station, having booked through to Barmouth. Travelling *viâ* Wolverhampton and Shrewsbury we enter the Principality at the north-east, the first station of importance at which we stop being Ruabon—a quaint old town that affords in its surroundings some indication of the nature of the splendid Mid-Wales district through which we shall shortly pass. Ruabon is an important junction on the Great Western Railway, and as we take our seats in the train at the siding we pass by groups of "trippers," whose constant use of the second person singular, as we used to say at school, indicates their Lancashire origin, and whose well-filled provision baskets are a no uncertain guide to the capacity of their digestive organs. In other parts of the station there are tourists from Chester, Liverpool, and towns north; Shrewsbury, Wellington, and other towns south; also from the Midlands and places more remote, all seeking pleasure or health. While we wait there is a band of music outside the station, escorting a string of important-looking personages to one of those feasts in which friendly societies of most orders delight; while in our carriage a class of Sunday scholars take their seats, bent on a three days' excursion, under the guidance of their teacher, who seems to know every inch of the neighbourhood.

At length the well-known signals are given, the "staff" is handed to the guard—for the line between here and our destination is a single one—and we make a start. Plunging at once into the valley of the Ceirog, we pass Plasmadoc, the residence of the super-Protestant member for Peterborough, through Acrefair, Chwarele, and Trevor, to Llangollen (oh! the Welsh pronunciation, "Langothlen"), with its celebrated Maid, its ever-lovely vale, and its neighbourhood so rich in beauties and in memorable associations of Owain Glyndwr. Shortly after leaving Llangollen we reach a station whose name-board bears the following amazing announcement—"Glyndyvrdwy." The tickets being examined here, I once inquired the name of the place. "Glyn—" (something), muttered the official. "What is it?" I repeated. "Glyndoo—" was all I could catch this time. "What did you say?" I again asked. "Glyndoodysir," he angrily replied all in a breath, banging the door to violently—as I