Chemistry, Physics, Technology.

PRODUCTION OF SOUND BY RADIANT HEAT.

Since the recent publications relating to the remarkable experiments of Messrs. Bell and Taintor, which led to the construction of the photophone, by which it was demonstrated that sound could be transmitted by a beam of light, these gentlemen have continued their researches in the investigation of photophonic phenomena, and have greatly extended our knowledge.

At the time of publishing his account of the photophone, Prof. Bell announced the fact that thin disks of very many different substances emitted sounds when exposed to the action of a rapidly interrupted beam of sunlight. This led to the suspicion that sonorousness under such circumstances was a general property of all matter. The correctness of this generalization was subsequently fully verified. In the first experiments which led to this conclusion, the substances tested were placed in a test tube, the mouth of which was connected with a rubber tube, the further end of which was held to the ear, and the intermitted beam of light then focussed upon the substance in the tube. With this device excellent sonorous effects were obtained from crystals of bichromate of potassa, crystals of sulphate of copper, and from tobacco smoke. These experiments, which were made by Prof. Bell in Paris, were afterwards repeated and greatly extended in Washington by Mr. Taintor, with the modified apparatus shown in Fig. 1. In this, the materials experimented on were enclosed in a conical cavity of brass, closed by a flat plate of glass. A brass tube leading into the cavity served for connection with the hearing tube. With this apparatus Mr. Tainter examined the sonorous properties of a vast number of substances, and found that cotton wool, worsted, silk, and fibrous materials generally, produced much louder sounds than hard, rigid bodies like crystals, or diaphragms such as had hitherto been used. Furthermore, it was found that the darkest shades of silk and worsted produced the best effects. This observation suggested the trial of lampblack. A piece of smoked glass held in the intermittent beam of sunlight, with the lampblack surface towards the sun, produced a sound loud enough to be heard with attention in any part of the room.

These experiments were repeated and verified by Mr. Bell on his return from Paris. By smoking the interior of the conical cavity of Fig. 1, and exposing it to the intermittent beam, with the glass lip in position, he found the sound produced to be so loud as to be actually painful to an ear placed closely against the hearing tube. The sounds became much louder, however, when some smoked wire gauze was placed in the receiver. These extraordinary results suggested the possibility that the substances which showed marked sonorous properties under the influence of intermittent sunlight, might be capable of reproducing the sounds of articulate speech under the action of an undulatory beam used with the photophone. The experiments made to verify this suggestion succeeded with lampblack.

Fig. 2 illustrates the mode in which the experiment was conducted. A represents the diaphragm of the transmitter, and B the lampblack receiver with hearing tube. Words and sentences spoken into the transmitter in a low tone of voice, were found to be audibly reproduced by the lampblack receiver at a distance between the speaker and hearer of 130 feet. It has not yet been determined at what distance audible effects could be transmitted with this arrangement of apparatus, as much difficulty was experienced in the above experiment in keeping the light steadily directed on the receiver. The experiment proved, however, beyond question that lampblack could be successfully employed in the articulating photophone in place of the electrical receiver hitherto employed.

Fig. 3 shows an ingenious device employed by these experimenters for interrupting a beam of sunlight for producing distant effects without the use of lenses. Two similar perforated disks are employed, one of which is rapidly rotated, while the other remains stationary. A parabolic reflector is used as a receiver, in the focus of which is placed a glass vessel A containing lampblack or other sensitive substance; and to this is connected the hearing tube. The beam of light is interrupted by its passage through the two slotted disks shown at B.

The general conclusions arrived at from a great number of experiments with solid substances, are that the loudest sounds are produced from substances in a loose, porous, spongy condition, and from those that have the darkest or most absorbent colors. The materials giving the best effects are cotton wool, worsted, fibrous materials generally, cork, sponge, platinum, and other metals in a spongy condition and lampblack.

Prof. Bell explains the loud, sonorous effects produced from such substances as follows: Taking the case of lampblack as an example, a substance which becomes heated by rays of all refrangibility, he considers a mass of this substance as a sort of sponge, with its pores filled with air instead of water. When a beam of sunlight falls upon this mass, the particles of lampblack are heated, and consequently expand, causing a contraction of the air spaces among them. Under such circumstances a pulse of air should be expelled, as water is expelled by sudden pressure upon a sponge. The force with which the air is expelled must be greatly increased by the expansion of the air itself, due to contact with the heated particles of lampblack. When the light is cut off the converse process takes place—the lampblack particles cool and contract, thus enlarging the air spaces among them, and the enclosed air also becomes cool. Under these circumstances a partial vacuum should be formed among the particles, and the outside air would then be absorbed as water is by a sponge when the pressure of the hand is removed. He imagines that in some such manner as this a wave of condensation is started in the atmosphere each time a beam of sunlight falls upon lampblack, and a wave of rarefaction is originated when the light is cut off. We can thus understand, he concludes, how it is that a substance like lampblack produces intense sonorous vibrations in the surrounding air, while, at the same time, it communicates a very feeble vibration to the diaphragm or solid bed upon which it rests.

This curious fact was independently observed in England by Mr. Preece, and it led him to question whether, in Messrs. Bell's and Taintor's experiments with thin diaphragms, the sound heard was due to the vibration of the disk or (as Prof. Hughes had suggested) to the expansion and contraction of the air in contact with the disk confined in the cavity behind the diaphragm. In his paper read before the Royal Society on the 10th of March, Mr. Preece describes experiments from which he claims to have proved that the effects are wholly due to the vibrations of the confined air, and that the disks do not vibrate at all.

Prof. Bell dissents from this conclusion, and has apparently demonstrated that a real vibration of the diaphragm takes place in the case of thin disks, independently of any expansion and contraction of the air confined in the cavity behind the diaphragm.

Continuing their investigations, Messrs. Bell and Taintor experimented likewise with liquids and gases. The results obtained, however, were not very decided. In the case of liquids, the best results were obtained with sulphuric ether, ammonia, ammonia-sulphate of copper, writing ink, sulphate of indigo, and chloride of copper; and in the case of gases (which gave better results than liquids), the following vapors and gases were found to be highly sonorous in the intermittent beam: Water vapor, coal gas, sulphuric ether, alcohol, ammonia, amylene, ethyl bromide, diethylamine, mercury, iodine and peroxide of nitrogen. The loudest sounds were obtained from iodine and peroxide of nitrogen. These experiments show that sounds are produced by the direct action of intermittent sunlight from substances in every physical condition (solid, liquid and gaseous), and the probability is therefore very greatly increased that sonorousness under such circumstances will be found to be a universal property of matter.

Referring to the photophone, Prof. Bell describes some highly interesting experiments with various substances as substitutes for selenium in electrical receivers. Fig. 4 represents a form of spiral cell of tellurium which gave sonorous effects when connected in circuit with a galvanic battery and telephone and exposed to the action of an intermittent beam of sunlight. The very great molecular disturbance produced in lampblack by the action of intermittent sunlight, suggested the thought that it should produce a corresponding disturbance in an electric current passed through it, in which case lampblack could be employed in place of selenium in an electrical receiver. This turned out to be the case, and the importance of the discovery is very great, especially when we consider the expense of such rare substances as selenium and tellurium.

The form of lampblack cell which was found most effective is shown in Fig. 5. Silver is deposited upon a plate of glass, and a zigzag line is then scratched through the film as shown, dividing the surface into two portions insulated from one another and having the form of two combs with interlocking teeth. Each is attached to a screw-cap, so that the cell can be placed in an electrical circuit when required. The surface is then smoked until a good film of lampblack is obtained, filling the interstices between the teeth of the silver combs. When