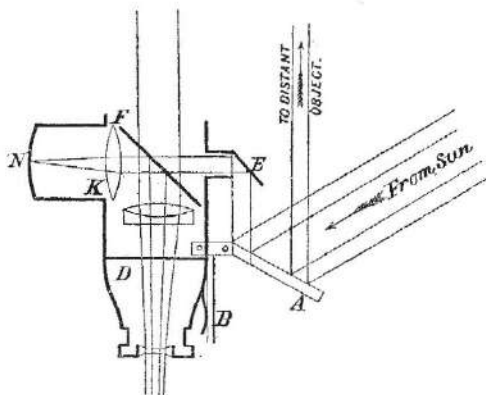


screen, *H*, which is placed in the principal focus of *K*. The rays from this image diverge in all directions, and some are taken up by the lens *K* and restored to parallelism; some of these are reflected by the unsilvered mirror, *F*, down to the field-glass, *D*, and if this is focussed for parallel rays, as is the case in looking at distant objects, an image of the sun is seen projected on the same field of view as that of the distant object. As the mirrors *E* and *F* are adjusted strictly parallel, the rays proceeding from *F* into the field-glass are parallel and in the opposite direction to those going from the mirror *A* to *E*, which form part of the same pencil as those going to the distant object. Hence the image of the sun seen in the field exactly covers the object to which the sun-flash is visible, and in whatever direction the mirror *A* is moved so as to alter the direction in which rays are reflected to the distant object, and the angle at which part impinge on *E* and are reflected through the lens *K*, the image visible in the glass moves in the same direction. Several attempts to produce this result were made by the use of mirrors and prisms, before the lens *K* was introduced, but they all failed. It was easy to make the image of the sun cover the object when the two occupied the centre of the field of view, but directly the mirror was inclined so as to direct the rays not strictly parallel to the axis of the field-glass, the apparent image diverged generally in the same direction along one co-ordinate, and in the opposite along one at right angles to it, so that nowhere, but in one line across the field, did the image lie in the desired position. The mirrors *E* and *F* are adjusted parallel once for all, by noticing the position on a screen of the small



spot of light reflected from the front of *F* as the light passes from *E* to *K*. The mirrors are moved by the adjusting screws till this spot has, to the bright reflection from the mirror *A*, the same relative position that the centre of mirror *F* has to the mirror *A*.

In actual use the field-glass is first fixed in position pointing to the object, either by holding steadily in the hand, or better by a clamp attached, by which it can be screwed into a tree or post, or fixed in the muzzle of a rifle. The instrument is turned on the barrel of the glass till the sun is in the plane passing through the two axes of the instrument, and the mirror *A* is turned till the bright image of the sun is seen on the screen *H*, through a hole left for the purpose in the side of the tube. On looking through the glass the sun's image is seen, and by then slightly rotating the instrument or moving the mirror, is made to cover the object. The mirror *A* is connected not directly to the body of the instrument, but to a lever *B*, on which it works stiffly, so as to retain any position in which it is placed. Lever *B* works easily and has a limited range of motion, to one end of which it is pressed by a spring; slight pressure with the finger moves it and its attached mirror, so as to throw the light on and off the object in a succession of long and short flashes by which letters and words may be indicated. Flashes may also be given by moving the instrument if held in the hand.

The above instrument answers well for all positions of the sun except when very low behind the observer's back. For this case another mirror is provided by which the light is reflected on to the mirror *A*.

The instrument, which is made by Cook and Sons, York, was exhibited. It was favourably criticised by the president, Prof. W. G. Adams, F. Galton, and others.

## SELENIUM AND THE PHOTOPHONE<sup>1</sup>

IN bringing before you some discoveries made by Mr. Sumner Tainter and myself, which have resulted in the construction of apparatus for the production and reproduction of sound by means of light, it is necessary to explain the state of knowledge which formed the starting point of our experiments. I shall first describe the remarkable substance selenium, and the manipulations devised by various experiments; but the final result of our researches has evidenced the class of substances sensitive to light vibrations, until we can propound the fact of sensitiveness being a general property of all matter. We have found this property in gold, silver, platinum, iron, steel, brass, copper, zinc, lead, antimony, German silver, Jenkin's metal, Babbitt's metal, ivory, celluloid, gutta-percha, hard rubber, soft vulcanised rubber, paper, parchment, wood, mica, and silvered glass; and the only substances from which we have not obtained results are carbon and thin microscopic glass. We find that when a vibratory beam of light falls upon these substances they emit sounds—the pitch of which depends upon the frequency of the vibratory change in the light. We find further that, when we control the form or character of the light-vibration on selenium, and probably on the other substances, we control the quality of the sound and obtain all varieties of articulate speech. We can thus, without a conducting wire as in electric telephony, speak from station to station, wherever we can project a beam of light. We have not had opportunity of testing the limit to which this photophonic influence can be extended, but we have spoken to and from points 213 metres apart; and there seems no reason to doubt that the results will be obtained at whatever distance a beam of light can be flashed from one observatory to another. The necessary privacy of our experiments hitherto has alone prevented any attempts at determining the extreme distance at which this new method of vocal communication will be available. I shall now speak of selenium.

In the year 1817 Berzelius and Gottlieb Gahn made an examination of the method of preparing sulphuric acid in use at Gripsholm. During the course of this examination, they observed in the acid a sediment of a partly reddish, partly clear brown colour, which, under the action of the blowpipe, gave out a peculiar odour, like that attributed by Klaproth to tellurium. As tellurium was a substance of extreme rarity, Berzelius attempted its production from this deposit; but he was unable, after many experiments, to obtain further indications of its presence. He found plentiful signs of sulphur mixed with mercury, copper, zinc, iron, arsenic, and lead, but no trace of tellurium. It was not in the nature of Berzelius to be disheartened by this result. In science every failure advances the boundary of knowledge as well as every success, and Berzelius felt that, if the characteristic odour that had been observed did not proceed from tellurium, it might possibly indicate the presence of some substance then unknown to the chemist. Urged on by this hope he returned with renewed ardour to his work. He collected a great quantity of the material, and submitted the whole mass to various chemical processes. He succeeded in separating successively the sulphur, the mercury, the copper, the tin, and the other known substances whose presence had been indicated by his tests; and, after all these had been eliminated, there still remained a residue which proved upon examination to be what he had been in search of—a new elementary substance. The chemical properties of this new element were found to resemble those of tellurium in so remarkable a degree, that Berzelius gave to the substance the name of "Selenium," from the Greek word *selene*, the moon ("tellurium," as is well known, being derived from *tellus*, the earth).

Although tellurium and selenium are alike in many respects, they differ in their electrical properties, tellurium being a good conductor of electricity, and selenium, as Berzelius showed, a non-conductor. Knox discovered, in 1837, that selenium became a conductor when fused; and Hittorff, in 1852, showed that it conducted, at ordinary temperatures, when in one of its allotropic forms. When selenium is rapidly cooled from a fused condition it is a non-conductor. In this its vitreous form it is of a dark brown colour, almost black by reflected light, having an exceedingly brilliant surface. In thin films it is transparent, and appears of a beautiful ruby red by transmitted light. When selenium is cooled from a fused condition with extreme slowness it presents an entirely different appearance, being of a dull lead

<sup>1</sup> Lecture delivered at the Boston meeting of the American Association by Prof. A. Graham Bell.

colour, and having throughout a granulated or crystalline structure, and looking like a metal. In this form it is perfectly opaque to light, even in very thin films. This variety of selenium has long been known as "granular" or "crystalline" selenium, or, as Regnault called it, "metallic" selenium. It was selenium of this kind that Hittorff found to be a conductor of electricity at ordinary temperatures. He also found that its resistance to the passage of an electrical current diminished continuously by heating up to the point of fusion, and that the resistance suddenly increased in passing from the solid to the liquid condition. It was early discovered that exposure to sunlight hastens the change of selenium from one allotropic form to another; and this observation is significant in the light of recent discoveries.

Although selenium has been known for the last sixty years, it has not yet been utilised to any extent in the arts, and it is still considered simply as a chemical curiosity. It is usually supplied in the form of cylindrical bars. These bars are sometimes found to be in the metallic condition; but more usually they are in the vitreous or non-conducting form. It occurred to Willoughby Smith that, on account of the high resistance of crystalline selenium, it might be usefully employed at the shore end of a submarine cable, in his system of testing and signalling during the process of submersion. Upon experiment, the selenium was found to have all the resistance required—some of the bars employed measuring as much as 1,400 megohms—a resistance equivalent to that which would be offered by a telegraph wire long enough to reach from the earth to the sun! But the resistance was found to be extremely variable. Experiments were made to ascertain the cause of this variability. Mr. May, Mr. Willoughby Smith's assistant, discovered that the resistance was less when the selenium was exposed to light than when it was in the dark.

In order to be certain that temperature had nothing to do with the effect, the selenium was placed in a vessel of water, so that the light had to pass through from 1 in. to 2 in. of water in order to reach the selenium. The approach of a lighted candle was found to be sufficient to cause a marked deflection of the needle of the galvanometer connected with the selenium, and the lighting of a piece of magnesium wire caused the selenium to measure less than half the resistance it did the moment before.

These results were naturally at first received by scientific men with some incredulity, but they were verified by Sale, Draper, Moss, and others. When selenium is exposed to the action of the solar spectrum, the maximum effect is produced, according to Sale, just outside the red end of the spectrum, in a point nearly coincident with the maximum of the heat rays; but, according to Adams, the maximum effect is produced in the greenish-yellow or most luminous part of the spectrum. Lord Rosse exposed selenium to the action of non-luminous radiations from hot bodies, but could produce no effect; whereas a thermopile under similar circumstances gave abundant indications of a current. He also cut off the heat rays from luminous bodies by the interposition of liquid solutions, such as alum, between the selenium and the source of light, without affecting the power of the light to reduce the resistance of the selenium; whereas the interposition of these same substances almost completely neutralized the effect upon the thermopile. Adams found that selenium was sensitive to the cold light of the moon, and Werner Siemens discovered that, in certain extremely sensitive varieties of selenium, heat and light produced opposite effects. In Siemens' experiments, special arrangements were made for the purpose of reducing the resistance of the selenium employed. Two fine platinum wires were coiled together in the shape of a double flat spiral in the zig-zag shape, and were laid upon a plate of mica so that the discs did not touch one another. A drop of melted selenium was then placed upon the platinum wire arrangement, and a second sheet of mica was pressed upon the selenium, so as to cause it to spread out and fill the spaces between the wires. Each cell was about the size of a silver dime. The selenium cells were then placed in a paraffine bath, and exposed for some hours to a temperature of 210 deg. C., after which they were allowed to cool with extreme slowness. The results obtained with these cells were very extraordinary; in some cases the resistance of the cells, when exposed to light, was only one-fifteenth of their resistance in the dark.

Without dwelling further upon the researches of others, I may say that the chief information concerning the effect of light upon the conductivity of selenium will be found under the

names of Willoughby Smith, Lieutenant Sale, Draper and Moss, Professor W. G. Adams, Lord Rosse, Day, Sabini, Dr. Werner Siemens, and Dr. C. W. Siemens. All observations by these various authors had been made by means of galvanometers; but it occurred to me that the telephone, from its extreme sensitiveness to electrical influences, might be substituted with advantage. Upon consideration of the subject, however, I saw that the experiments could not be conducted in the ordinary way for the following reason:—The law of audibility of the telephone is precisely analogous to the law of electric induction. No effect is produced during the passage of a continuous and steady current. It is only at the moment of change from a stronger to a weaker state, or *vice versa*, that any audible effect is proposed, and the amount of effect is exactly proportional to the amount of variation in the current. It was, therefore, evident that the telephone could only respond to the effect produced in selenium at the moment of change from light to darkness, or *vice versa*, and that it would be advisable to intermit the light with great rapidity, so as to produce a succession of changes in the conductivity of the selenium, corresponding in frequency to musical vibrations within the limits of the sense of hearing. For I had often noticed that currents of electricity, so feeble as to produce scarcely any audible effects from a telephone when the circuit was simply opened or closed, caused very perceptible musical sounds when the circuit was rapidly interrupted, and that the higher the pitch of sound the more audible was the effect. I was much struck by the idea of producing sound by the action of light in this way. Upon farther consideration it appeared to me that all the audible effects obtained from varieties of electricity could also be produced by variations of light acting upon selenium. I saw that the effect could be produced at the extreme distance at which selenium would respond to the action of a luminous body, but that this distance could be indefinitely increased by the use of a parallel beam of light, so that we could telephone from one place to another without the necessity of a conducting wire between the transmitter and receiver. It was evidently necessary, in order to reduce this idea to practice, to devise an apparatus to be operated by the voice of a speaker, by which variations could be produced in a parallel beam of light, corresponding to the variations in the air produced by the voice.

I proposed to pass light through a large number of small orifices, which might be of any convenient shape, but were preferably in the form of slits. Two similarly perforated plates were to be employed. One was to be fixed and the other attached to the centre of a diaphragm actuated by the voice, so that the vibration of the diaphragm would cause the movable plate to slide to and fro over the surface of the fixed plate, thus alternately enlarging and contracting the free orifices for the passage of light. In this way the voice of a speaker could control the amount of light passed through the perforated plates without completely obstructing its passage. This apparatus was to be placed in the path of a parallel beam of light, and the undulatory beam emerging from the apparatus could be received at some distant place upon a lens, or other apparatus, by means of which it could be condensed upon a sensitive piece of selenium placed in a local circuit with a telephone and galvanic battery. The variations in the light produced by the voice of the speaker should cause corresponding variations in the electrical resistance of the selenium employed; and the telephone in circuit with it should reproduce audibly the tones and articulations of the speaker's voice. I obtained some selenium for the purpose of producing the apparatus shown, but found that its resistance was almost infinitely greater than that of any telephone that had been constructed, and I was unable to obtain any audible effects by the action of light. I believed, however, that the obstacle could be overcome by devising mechanical arrangements for reducing the resistance of the selenium, and by constructing special telephones for the purpose. I felt so much confidence in this that, in a lecture delivered before the Royal Institute of Great Britain, upon May 17, 1878, I announced the possibility of hearing a shadow by interrupting the action of light upon selenium. A few days afterwards my ideas upon this subject received a fresh impetus by the announcement made by Mr. Willoughby Smith before the Society of Telegraph Engineers that he had heard the action of a ray of light falling upon a bar of crystalline selenium, by listening to a telephone in circuit with it.

It is not unlikely that the publicity given to the speaking telephone during the last few years may have suggested to many



minds in different parts of the world somewhat similar ideas to my own.

Although the idea of producing and reproducing sound by the action of light, as described above, was an entirely original and independent conception of my own, I recognise the fact that the knowledge necessary for its conception has been disseminated throughout the civilised world, and that the idea may therefore have occurred to many other minds. *The fundamental idea, on which rests the possibility of producing speech by the action of light, is the conception of what may be termed an undulatory beam of light in contradistinction to a merely intermittent one.* By an undulatory beam of light, I mean a beam that shines continuously upon the selenium receiver, but the intensity of which upon that receiver is subject to rapid changes, corresponding to the changes in the vibratory movement of a particle of air during the transmission of a sound of definite quality through the atmosphere. The curve that would graphically represent the changes of light would be similar in shape to that representing the movement of the air. I do not know whether this conception had been clearly realised by "J. F. W." of Kew, or by Mr. Sargent, of Philadelphia; but to Mr. David Brown, of London, is undoubtedly due the honour of having distinctly and independently formulated the conception, and of having devised apparatus—though of a crude nature—for carrying it into execution. It is greatly due to the genius and perseverance of my friend, Mr. Summer Tainter, of Watertown, Mass., that the problem of producing and reproducing sound by the agency of light has at last been successfully solved. The first point to which we devoted our attention was the reduction of the resistance of crystalline selenium within manageable limits. The resistance of selenium cells employed by former experimenters was measured in millions of ohms, and we do not know of any record of a selenium cell measuring less than 250,000 ohms in the dark. *We have succeeded in producing sensitive selenium cells measuring only 300 ohms in the dark, and 155 ohms in the light.* All former experimenters seem to have used platinum for the conducting part of their selenium cells, excepting Werner Siemens, who found that iron and copper might be employed. We have also discovered that brass, although chemically acted upon by selenium, forms an excellent and convenient material; indeed, we are inclined to believe that the chemical action between the brass and selenium has contributed to the low resistance of our cells by forming an intimate bond of union between the selenium and brass. We have observed that melted selenium behaves to the other substances as water to a greasy surface, and we are inclined to think that when selenium is used in connection with metals not chemically acted upon by it, the points of contact between selenium and the metal offer a considerable amount of resistance to the passage of a galvanic current. By using brass we have been enabled to construct a large number of selenium cells of different forms. The mode of applying the selenium is as follows:—The cell is heated, and, when hot enough, a stick of selenium is rubbed over the surface. In order to acquire conductivity and sensitiveness, the selenium must next undergo a process of annealing.

We simply heat the selenium over a gas stove and observe its appearance. When the selenium attains a certain temperature, the beautiful reflecting surface becomes dimmed. A cloudiness gradually extends over it, somewhat like the film of moisture produced by breathing upon a mirror. This appearance gradually increases, and the whole surface is soon seen to be in the metallic, granular, or crystalline condition. The cell may then be taken off the stove, and cooled in any suitable way. When the heating process is carried too far, the crystalline selenium is seen to melt. Our best results have been obtained by heating the selenium until it crystallises, and continuing the heating until signs of melting appear, when the gas is immediately put out. The portions that had melted instantly recrystallise, and the selenium is found upon cooling to be a conductor, and to be sensitive to light. The whole operation occupies only a few minutes. This method has not only the advantage of being expeditious, but it proves that many of the accepted theories on this subject are fallacious. Our new method shows that fusion is unnecessary, that conductivity and sensitiveness can be produced without long heating and slow cooling; and that crystallisation takes place during the heating process. We have found that on removing the source of heat immediately on the appearance of the cloudiness, distinct and separate crystals can be observed under the microscope, which appear like leaden snow-flakes on a ground of ruby red. Upon removing the heat,

when crystallisation is further advanced, we perceive under the microscope masses of these crystals arranged like basaltic columns standing detached from one another, and at a still higher point of heating the distinct columns are no longer traceable, but the whole mass resembles metallic pudding-stone, with here and there a separate snow-flake, like a fossil, on the surface. Selenium crystals formed during slow cooling after fusion present an entirely different appearance, showing distinct facets.

We have devised about fifty forms of apparatus for varying a beam of light in the manner required, but only a few typical varieties need be shown. The source of light may be controlled, or a steady beam may be modified at any point in its path. The beam may be controlled in many ways. For instance, it may be polarised, and then affected by electrical or magnetic influences in the manner discovered by Faraday and Dr. Kerr. The beam of polarised light, instead of being passed through a liquid, may be reflected from the polished pole of an electro-magnet. Another method of affecting a beam of light is to pass it through a lens of variable focus. I observe that a lens of this kind has been invented in France by Dr. Cusco, and is fully described in a recent paper in *La Nature*; but Mr. Tainter and I have used such a lens in our experiments for months past. The best and simplest form of apparatus for producing the effect remains to be described. This consists of a plane mirror of flexible material—such as silvered mica or microscope glass. Against the back of this mirror the speaker's voice is directed. The light reflected from this mirror is thus thrown into vibrations corresponding to those of the diaphragm itself.

In arranging the apparatus for the purpose of reproducing sound at a distance any powerful source of light may be used, but we have experimented chiefly with sunlight. For this purpose a large beam is concentrated by means of a lens upon the diaphragm mirror, and, after reflection, is again rendered parallel by means of another lens. The beam is received at a distant station upon a parabolic reflector, in the focus of which is placed a sensitive selenium cell, connected in a local circuit with a battery and telephone. A large number of trials of this apparatus have been made with the transmitting and receiving instruments so far apart that sounds could not be heard directly through the air. In illustration I shall describe one of the most recent of these experiments. Mr. Tainter operated the transmitting instrument, which was placed on the top of the Franklin schoolhouse in Washington, and the sensitive receiver was arranged in one of the windows of my laboratory, 1325 L street, at a distance of 213 metres. Upon placing the telephone to my ear I heard distinctly from the illuminated receiver the words: "Mr. Bell, if you hear what I say come to the window and wave your hat." In laboratory experiments the transmitting and receiving instruments are necessarily within earshot of one another, and we have, therefore, been accustomed to pooling the electric circuit connected with the selenium receiver, so as to place the telephones in another room. By such experiments we have found that articulate speech can be reproduced by the oxyhydrogen light, and even by the light of a kerosene lamp. The loudest effects obtained from light are produced by rapidly interrupting the beam by the perforated disk. The great advantage of this form of apparatus for experimental work is the noiselessness of its rotation, admitting the close approach of the receiver without interfering with the audibility of the effect heard from the latter; for it will be understood that musical tones are emitted from the receiver when no sound is made at the transmitter. A silent motion thus produces a sound. In this way musical tones have been heard even from the light of a candle. When distant effects are sought another apparatus is used. By placing an opaque screen near the rotating disk the beam can be entirely cut off by a slight motion of the hand, and musical signals, like the dots and dashes of the Morse telegraph code, can thus be produced at the distant receiving station.

We have made experiments, with the object of ascertaining the nature of the rays that affect selenium. For this purpose we have placed in the path of an intermittent beam various absorbing substances. Prof. Cross has been kind enough to give me his assistance in conducting these experiments. When a solution of alum or bisulphide of carbon, is employed, the loudness of the sound produced by the intermittent beam is very slightly diminished; but a solution of iodine in bisulphide of carbon cuts off most, but not all, of the audible effect. Even an apparently opaque sheet of hard rubber does not entirely do this. When the sheet of hard rubber was held near the disk interrupter the

rotation of the disk interrupted what was then an invisible beam, which passed over a space of about twelve feet before it reached the lens which finally concentrated it upon the selenium cell. A faint but perfectly perceptible musical tone was heard from the telephone connected with the selenium. This could be interrupted at will by placing the hand in the path of the invisible beam. It would be premature, without further experiments, to speculate too much concerning the nature of these invisible rays; but it is difficult to believe that they can be bent rays, as the effect is produced through two sheets of hard rubber containing between them a saturated solution of alum. Although effects are produced as above shown by forms of radiant energy which are invisible, we have named the apparatus for the production and reproduction of sound in this way "the photophone," because an ordinary beam of light contains the rays which are operative.

It is a well-known fact that the molecular disturbance produced in a mass of iron by the magnetising influence of intermittent electrical current can be observed as sound by placing the ear in close contact with the iron. It occurred to us that the molecular disturbance produced in crystalline selenium by the action of an intermittent beam of light should be audible in a similar manner without the aid of a telephone or battery. Many experiments were made to verify this theory without definite results. The anomalous behaviour of the hard rubber screen suggested the thought of listening to it also. This experiment was tried with extraordinary success. I held the sheet in close contact with my ear, while a beam of intermittent light was focussed upon it by a lens. A distinct musical note was immediately heard. We found the effect intensified by arranging the sheet of hard rubber as a diaphragm, and listening through a hearing-tube. We then tried the crystalline selenium in the form of a thin disk, and obtained a similar, but less intense effect. The other substances which I enumerated at the beginning of my address were now successively tried in the form of thin disks, and sounds were obtained from all but carbon and thin glass. We found hard rubber to produce a louder sound than any other substance we tried, excepting antimony, and paper and mica to produce the weakest sounds. On the whole we feel warranted in announcing as our conclusion that sounds can be produced by the action of a variable light from substances of all kinds, when in the form of thin diaphragms. We have heard from interrupted sunlight very perceptible musical tones through tubes of ordinary vulcanised rubber, of brass, and of wood. These were all the materials at hand in tubular form, and we have had no opportunity since of extending these observations to other substances.

I am extremely glad that I have the opportunity of making the first publication of these researches before a scientific society, for it is from scientific men that my work of the last six years has received its earliest and kindest recognition. I gratefully remember the encouragement which I received from the late Prof. Henry at a time when the speaking telephone existed only in theory. Indeed, it is greatly due to the stimulus of his appreciation that the telephone became an accomplished fact. I cannot state too highly also the advantage I received in preliminary experiments on sound vibrations in this building from Prof. Cross, and near here from my valued friend Dr. Clarence J. Blake. When the public were incredulous of the possibility of electrical speech, the American Academy of Arts and Sciences, the Philosophical Society of Washington, and the Essex Institute of Salem, recognised the reality of the results and honoured me by their congratulations. The public interest, I think, was first awakened by the judgment of the very eminent scientific men before whom the telephone was exhibited in Philadelphia, and by the address of Sir William Thomson before the British Association for the Advancement of Science.

At a later period, when even practical telegraphists considered the telephone as a mere scientific toy, Prof. John Peirce, Prof. Eli W. Blake, Dr. Channing, Mr. Clarke, and Mr. Jones, of Providence, Rhode Island, devoted themselves to a series of experiments for the purpose of assisting me in making the telephone of practical utility; and they communicated to me from time to time the result of their experiments with a kindness and generosity I can never forget. It is not only pleasant to remember these things, and to speak of them, but it is a duty to repeat them, as they give a practical refutation to the often repeated stories of the blindness of scientific men to unaccredited novelties, and of their jealousy of unknown inventors who dare to enter the charmed circle of science. I trust that the scientific favour which was so readily accorded to the telephone may be extended by you to this new claimant—the photophone.

## SCIENTIFIC SERIALS

*The Quarterly Journal of Microscopical Science*, July, contains—F. M. Balfour, on the structure and homologies of the germinal layers of the embryo (with woodcuts).—On Hubrecht's researches on the nervous system of nemertines (with a plate) abstract of,—A. G. Bourne, on the structure of the nephridia of the medicinal leech (with two plates).—Prof. Ray Lankester, on intra-epithelial capillaries in the integument of the medicinal leech (with a plate); and on the connective and vasifactive tissues of the same (with two plates).—Dr. H. Gibbs, on the use of the Wenham binocular with high powers.—On the structure of the spermatozoon.—P. H. Carpenter, on some disputed points in Echinoderm morphology.—Prof. Pouchet, on the origin of the red-blood corpuscles (translated from the *Revue Scientifique*).—Prof. Ray Lankester, on *Limnocoedium sowerbii*, a new trachomedusa inhabiting fresh water (with woodcuts and two plates) [for an abstract *vide* NATURE, vol. xxii. p. 147].—Notes and memoranda.—*Proceedings of the Dublin Microscopical Club* for November and December, 1879.

*Revue d'Anthropologie*, tome iii. fascic. 3 (July).—Prof. J. Delbos, of Nancy, gives a brief report of the discovery, made in 1869, of a number of human skeletons in the loam beds of Bollwiller (Haut-Rhin). His paper, which describes the general geognostic character of the soil in which these remains were found, is followed by a detailed description, by Dr. René Collignon, of each of the seven distinct skeletons that have been recovered. Of these, five were adult males, two females, and one a child of about seven. In general characteristics they resemble the Cannstatt remains.—Dr. Béranger-Féraud, whose position in Senegal as Médecin-en-chef de la Marine gave him favourable opportunities of studying the habits of the natives, has drawn up an interesting report of all that is known on the spot in regard to the mysterious sect of the Simos, which exercises an important influence on the tribes of the west coasts of Africa, from Cape Vert as far as the Gabon settlements on the equator. The Simo of these regions is the dreaded Mombombo of other races.—Dr. Gustave Lagneau's paper, "De quelques Dates reculées," is a scholarly dissertation on the community of race traceable in the Belgæ, Galli, and Germani, and on the evidence supplied in reference to the period of their immigration into Celtic lands by the introduction of a dolichocephalic character, in addition to the purely brachycephalic type observable in the skulls of Celtic and Kimmerian races. In discussing the question of the occupation of Western Europe by Iberians, M. Lagneau enters at length into the historical and anthropological grounds for accepting the testimony of Plato and others as to the defeat of those tribes by a powerful race, the Atlantæ, and the existence of a great western continent, or archipelago, the submerged Atlantis, from which the latter peoples made their inroads on West Africa and West Europe.—M. Martinet's enumeration of the prehistoric monuments of Berry deserves special notice for the interesting information it supplies in reference to the so-called "Mardelles," a kind of conically shaped excavations, the purport of which has not been determined, and which, although found elsewhere, as in Normandy, Provence, &c., is of exceptional frequency in Berry, where between 300 and 400 have been explored. In diameter they vary from 20 to 100 metres, in depth from 50 centimetres to 8 metres. Traces of ashes, calcined animal bones, and coarse potsherds, with a few broken flints, have been found at the bottom of these depressions, of which several are generally ranged in a line near natural or artificially constructed caverns.

*Journal de Physique*, August.—Experimental researches on rotatory polarisation in gases, by M. H. Becquerel.—Magnetic rotatory power of liquids and of their vapours, by M. Bichat.—Experiments on flames, by M. Neyreneuf.

*Journal of the Franklin Institute*, August.—The limitations of the steam-engine, by W. D. Marks.—Economical cut-off in steam-engines, by S. W. Robinson.—The involute of the circumference of a circle, by J. J. Skinner.—Holman's new compressorium and moist chamber, by J. A. Ryder.

*Rivista Scientifico-Industriale*, No. 15, August 15.—Periodic spontaneous movement of the stamens of *Ruta bracteosa*, D.C., and of *Smyrnum rotundifolium*, by Dr. Macchiati.—Synthesis of meteorological observations in Modica and Syracuse on the fall of meteoric powders, from the end of 1876 to April 16, 1880, by Prof. Lancetta.

No. 16, August 31.—On types of rocks, by Prof. de Stefani.