that I venture to differ from him, for it seems to me, from dynamical considerations, that a second equal impulse following a first, at some time within 306 days, might either double the wabble, alter its amount, or annihilate it, according to how it was timed to take place.

If I am correct in this view, I cannot but think that the estimate of geological time falls to the ground. For even if the elevation of continents took place impulsively, we can have no possible data for judging of how the earthquakes were timed with reference to the position of the axis of rotation, and unless they were properly timed the radius of the wabble could not increase; and the increase of the radius is, I imagine, essential to Dr. Haughton's method.

But if we set aside the impulsive theory of elevation, the work contained in my paper, "On the Influence of Geological Changes on the Earth's Axis of Rotation,"[1] will be applicable; for I there considered the effects of a slow continuous elevation of continents. In that paper I show that such a mode of elevation would set up a wabble of 306 days' period in the earth's motion. But this wabble is of quite a different character from that contemplated by Dr. Haughton, for it is unsymmetrical, so that the axis of rotation coincides with the axis of figure every 306th day.

By a very simple application of a formula given in that paper, it will be found that, supposing the continuous elevation to take place at such a rate that the axis of rotation is 5 feet distant from that of figure when at its greatest distance, then the axis of figure must be travelling with reference to the solid earth at the rate of $\frac{3}{10}$ of a second of arc per annum. Thus, in 19,200 years it will have travelled over 1° or 69 miles. That is to say, Europe-Asia might have been elevated in 19,200 years without the axis of rotation ever having described a circle of more than 5 feet in *diameter*. If the elevation were then to stop suddenly a symmetrical wabble would be set up (such as that considered by Dr. Haughton), and the *radius* of this wabble could not be greater than 5 feet, and might be zero, according to the exact time of the stoppage.

This investigation makes no reference whatever to the effects of tidal friction, and there are certain considerations which lead me to believe that even the above estimate of time might be largely reduced.

The conclusion at which I arrive therefore is that the elevation of Europe and Asia might have taken place in very much less than 20,000 years without leaving behind any wabbling in the earth's motion traceable by astronomical observations. Dr. Haughton's views, if generally accepted, are of the very greatest interest to geologists, and they therefore merit the strictest examination; as I have devoted a good deal of time to this subject I thought it might perhaps be useful to write this note. Should my present criticism be incorrect, there is little doubt but that it will meet its just fate of refutation.[2]

G. H. DARWIN

EARLY ELECTRIC TELEPHONY

IN 1861 the first successful attempt at the construction of an electric telephone was made by Philip Reis, a teacher in a school at Friedrichsdorf, near Homburg. On October 26, 1861, Reis showed his instrument, which he termed a "telephone," to the Physical Society of Frankfort-on-the-Main; and on that occasion he succeeded in electrically transmitting various melodies, which were distinctly heard throughout the room. In the paper he read before this Physical Society, published in the annual report of the Society for 1861, Reis states:—"Melodies were sung, not loudly, into the transmitting apparatus placed in a hospital some 300 feet away from the audience, care being taken that no sound could be heard, by direct transmission, or by conduction along the wires. The sounds of various musical instruments were clearly reproduced, as the clarionet, horn, organ-pipe, and even harmonium and pianoforte

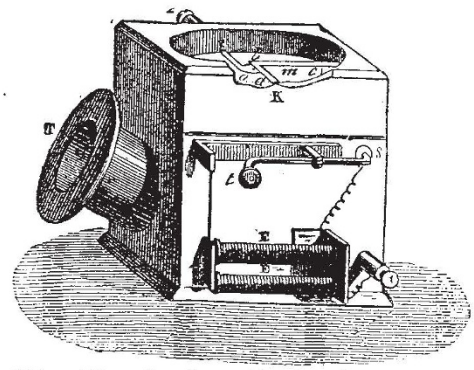

FIG. 1.—This and Fig. 2 show the usual but imperfect form of Reis's telephone. Fig. 1 is the transmitting apparatus. T represents the mouthpiece, *m* the membrane closing the upper portion of the box K, a portion of which is cut away to show the movable lever, *a b c*, resting by a projecting point *b*, on the platinum disc *a*, fixed to the centre of the membrane and connected with the binding screw 2. The arm *a b c* is metallicly connected with the binding screw 2. The key *t* closes the circuit when the instrument is in use, and the electro-magnet R E is for the purpose of receiving communications.

when the transmitter was placed on their sound-boards, provided the tones were within the compass of *f* to f''. Articulation was not reproduced equally well. Consonants, however, were in general pretty clearly heard, but not the vowels." In this report, which is entitled "Telephony by Means of Electric Currents," Reis shows how he was led to the construction of his instrument by a study of the mechanism of the organ of hearing, and of the manner whereby sounds are perceived by the human ear, and he gives a series of diagrams representing the resultant curves that would be produced by the combination of various concords and discords. Thus, he was led to perceive that "if it were possible to create, in any manner, a mode of vibration whose curve resembles that of any tone or chord, then a sensation would be produced similar to that given by the tone or chord itself." This principle, he affirms, guided him onwards.

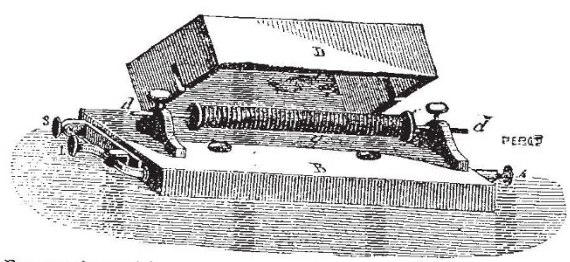

FIG. 2 is the receiving apparatus. B and D are resonant boxes, *g* is the coil through which the current passes magnetising the iron wire *d*, 3 and 4 are binding screws to which the line and return wire are attached, the circuit being closed by the key 1.

The first instrument he made was constructed of very homely materials. The bung of a beer-barrel was pierced through with a conical hole, the smaller end was then covered by a membrane, the skin of a German sausage being used for this purpose; to this was fixed, with a drop of sealing-wax, a little strip of platinum joined up to one

[1] *Phil. Trans.*, vol. 167, Pt. 1.

[2] Since this has been in type Dr. Haughton has read another paper before the Royal Society, in which he concludes, from purely geological evidence, that "the hypothesis of a shifting pole (even if permitted by mechanical considerations) is inadmissible to account for changes in geological climates." Therefore whether he agrees or not in the justice of my mechanical criticism, he seems to be of opinion that the wabbling of the earth will not give geologists much light as to the duration of geological time.

end of a small battery; a wire was adjusted near to, but not touching, the platinum strip; this wire led to the receiving instrument, and thence back to the other pole of the battery. On speaking into the conical orifice in the bung the membrane was thrown into vibration, and the attached metal strip coming into contact with the adjoining wire, momentarily completed the electric circuit. The vibrations of the membrane thus sent a corresponding series of intermittent currents into the receiver, which, in the first instance consisted simply of

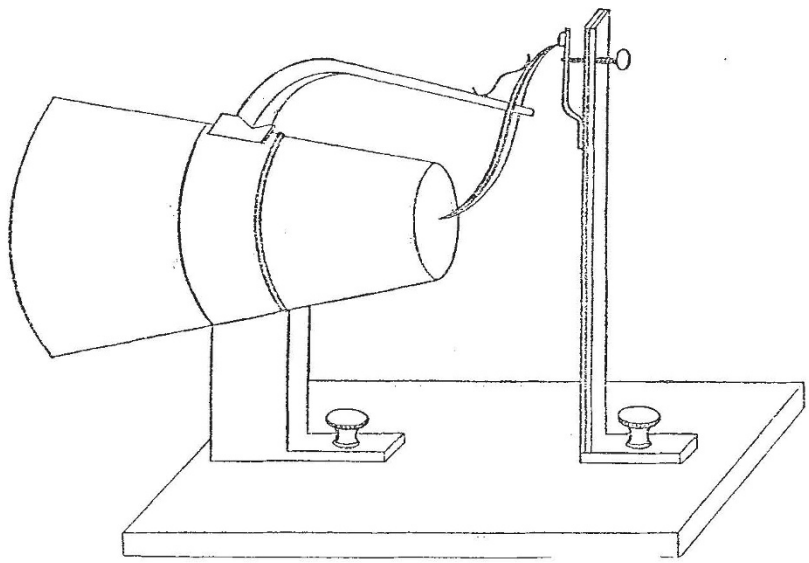

FIG. 3.—Sketch of improved form of transmitter made by Reis in his telephonic experiment (1862).

a knitting needle surrounded by a coil of wire, and placed on a violin to serve as a sound-board. Though Reis afterwards considerably improved upon his earlier instruments, the improvements do not seem generally known, and the arrangement just described is substantially that usually constructed and figured as Reis's telephone (see (Figs. 1 and 2.)

In Dingler's *Polytechnisches Journal*, vol. 169 (1863), p. 29, is a report on Reis's improved telephone by Legat, inspector of telegraphs in Cassel, &c. This report was originally printed in the *Journal* of the East German Telegraph Company for 1862. Considerable modifications are here shown in both transmitter and receiver. The membrane is formed of a collodion film and is not loaded with any metal

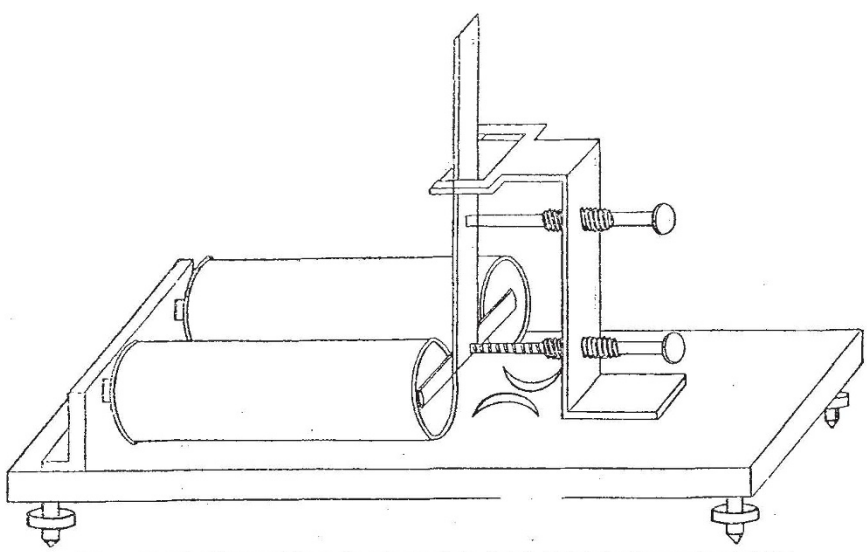

FIG. 4.—Sketch of improved form of receiver made by Reis in his telephonic experiments (1862).

contact-breaker. A light S-shaped arm, supported a little above its centre, so as to move freely in a vertical plane, abuts at the lower end against the membrane, and at the upper against the contact pin (Fig. 3). The circuit is completed through the cross-piece which supports the S-shaped lever; the least outward motion of the membrane would thus break the contact, and in this way very feeble vibrations were able to be transmitted. The receiver consisted of, practically, a horse-shoe magnet fixed horizontally on a sound board; the movements of a light iron keeper, adjustible by a spring before the poles of the magnet, reproduced the original sounds (Fig. 4). Here it will be noticed a molar motion of the iron has replaced the molecular motion first employed. A much louder sound is thus

obtained, and by bringing the iron keeper near to, or even into gentle contact with the magnet, every grade and rate of simple vibration could be reproduced, as the present writer is able to testify.

With this instrument Reis obtained better results and even transmitted imperfect articulation. Legat speaks of single words in reading and speaking being indistinctly heard; but any sudden modulation of the voice as in surprise, interrogation, &c., was clearly reproduced. Still more definite is the following statement, occurring in an article on Reis's improved telephone in No. 15 of Böttger's *Polytechnisches Notizblatt* (1863):—"The experimenters could even communicate to each other words, only such, however, as they had already heard frequently." In confirmation of this the present writer has received a letter from Dr. Messel, a name well known to chemists, who was a former pupil of Philip Reis and an eye-witness of his early experiments. Dr. Messel states—"There is not the shadow of a doubt about Reis having achieved imperfect articulation; I personally recollect this very distinctly and could find you many others who were witnesses of the same fact."[1]

As an interesting sequel to this historical note it should be mentioned that in 1865 Mr. S. Yeates, the skilful instrument maker of Dublin, introduced some modifications in one of Reis's instruments he had purchased, of the usual early form, which enabled him to obtain the distinct articulation of several words. The modifications were twofold: (1) the knitting needle receiver was replaced by an electro-magnet and movable keeper, as Reis had already done, though unknown to Mr. Yeates (see Fig. 5); and (2) a drop of very slightly acidulated water

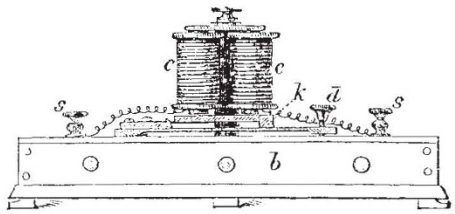

FIG. 5.—Yeates's receiver for Reis's telephone. Upon the sounding box *b* an electro-magnet *cc* is supported by the brass pillar seen behind. A light iron keeper *k* is fastened at one end by a steel spring to a wooden bridge, which can be raised or lowered by the screw *d*, so that the keeper can be brought almost into contact with the electro-magnet. The circuit is completed by the binding screws *s s*.

was placed between the contact pin and the metal disc on the membrane. The intermittent character of the current was thus abolished, and a very near approach made to the true principle of an articulating telephone, namely, the employment of a *continuous current* of varying strength. This instrument was shown in November, 1865, at a meeting of the Dublin Philosophical Society, and some members of that society who were then present have testified to their remembrance of the fact that several words were transmitted fairly well. It is to be regretted that at the time Mr. Yeates did not pursue the matter further, nor give a wider publication to the success he obtained.

But between the best of the results obtained by Reis and others in the direction of articulation, and the splendid achievements of Prof. Graham Bell, there is unquestionably a very wide step. In the sensitive and beautiful instrument discovered by Prof. Bell, the voice of the speaker generates thrills of magneto-electricity, which, being strictly proportional to the sonorous vibrations, reproduces the voice and its expression in the receiver in a fairy-like far-away whisper. Nevertheless it must be borne in mind that it is unlikely the telephone of the future will employ the voice to generate the driving power, but only to modulate the flow of a current obtained by coarser means. It is in this direction that Reis worked, and though his method was faulty in the employment of an intermittent current, the same cannot be said of the arrangements adopted by Mr. Edison, of New Jersey. And inasmuch as Mr. Edison has already discovered and brought to a practical issue such remarkable additions to our knowledge as quadruplex telegraphy, the electro-motograph, and the phonograph, we have, in these achievements, the earnest of success to those excellent telephonic investigations wherein Mr. Edison has already won an enduring fame.

W. F. BARRETT

P.S.—Since writing the foregoing article, the publication of which has been for some time delayed owing to the crowded state of the columns of NATURE, my attention has been drawn to a claim made by Mr. John Cammack, to be the first inventor of the electric telephone. From this it would appear that in the early part of 1860 Mr. Cammack made and exhibited an electric telephone, whilst a student in the Royal School of Medicine, Manchester. A photographic copy of the original drawing of the instrument has reached me, and so far as this goes it embraces not only the intermittent current used by Reis, but the principle of the continuous current of varying strength employed by Bell and Edison. In fact, if Mr. Cammack can furnish historical proof, the arrangement shown in his drawing, with its explanatory note, is identically the same as the method, long after independently invented and patented by Prof. Graham Bell.[1]

W. F. B.

ACTION OF LIGHT ON A SELENIUM (GALVANIC) ELEMENT

IN the course of a series of experiments on the electrical behaviour of selenium, undertaken with a view to remove, if possible, the difficulties in the way of constructing constant resistances of this material, I have had occasion recently to investigate the effects of surface tension due to light.

I find that the action of light on crystalline selenium (annealed at 200° C.) is much more striking when the selenium forms one element of a galvanic couple than when it acts as a resistance.

The most convenient arrangement which I have found for observing this, is to make up a couple consisting of (1) a plate of selenium hanging suspended by means of a platinum wire, and (2) a strip of platinum foil, in distilled water. The potentials of the two poles are not very different, and any change in the electro-positiveness of the selenium is at once very apparent.

The first selenium-platinum element which I constructed behaved as follows:—

In the dark the element gave a steady electromotive force of about 0·1 volt, the selenium being *positive* to the platinum. On admitting daylight to the selenium plate it instantly became *electro-negative* to the platinum, showing an electromotive force of 0·05 volt in that direction. That is to say the selenium had become 0·15 volt more electro-negative by the action of the light than it was in the dark.

[1] My best thanks are due to Dr. Messel for much information concerning Reis and for a reference to his papers in the journals alluded to.

[1] Perhaps the word "claim" is too strong, as I observe Mr. Cammack speaks very modestly of the idea he so early sketched out. Such ideas are of course valueless in a practical sense, unless brought to the test of experiment, and this Mr. Cammack seems only partly to have done; this too is just where Prof. Bell succeeded; by his persistent experiments overcoming all obstacles and affording by the way a striking illustration that facts may after all upset the strongest *à priori* conclusions. In connection with this remark the following passage from the last edition of a well-known work on Mental Physiology (p. 632), is not without interest:—"Everyone who accepts as facts, merely on the evidence of his senses, or on the testimony of others who partake of his own beliefs, what Common Sense [with capitals] tells him to be much more probably the fiction of his own imagination—even though confirmed by the testimony of hundreds affected with the same epidemic delusion—must be regarded as the subject of a 'diluted insanity.'" Yet Baron Münchausen's trumpet has been outdone by the phonograph: the "fiction of imagination" by a fact "confirmed by the testimony of hundreds." However as these latter have "merely the evidence of their senses to offer," we presume they are all the victims of "a diluted insanity," if the reasoning of the eminent author be accepted.