many striking deviations from the ordinary Mongol standard. The elder Retzius had long ago distinguished four more or less marked ethnical groups in Finland itself, apart altogether from the intruding Swedes, Russians, and other foreigners. These, however, are now reduced to two only, which a careful investigation of the materials supplied by archæology, tradition, the Norse Sagas, the old national songs and philology, combined with an extensive study of a vast number of crania and living subjects, have enabled the younger writer to fix with some approach to precision.

Of the two, the Tavastian and the Karelian, he regards the latter as the genuine national type, in this differing from the commonly received opinion. The Karelians, occupying the country more to the east, are of slighter build, but better proportioned and taller than the Tavastians, of a light brown complexion, with longer head, narrower and less heavy features, long, straight, and pointed nose, dark hazel eyes, chestnut or dark hair falling in ringlets over the shoulders, open and animated expression, though still with a serious cast. The Tavastian, on the contrary, is of a much more solid, compact, and coarse build, middle size, light or ashy complexion, but always lacking the rosy tints peculiar to the Teutonic peoples, with straight silken hair of a flaxen colour, and often yellow at the tips, broad square head, short snub nose, dilated nostrils, slightly oblique greyish blue eyes, sullen and unsympathetic expression.

This description obviously corresponds far more closely with the common Mongoloid type than does that of the Karelians. Yet in the writer's opinion the latter are the true descendants of Illmarinen, the hero of the Kalevala, and the scene of his exploits is laid in the region still occupied by them. The Tavastians he regards as a distinct ethnical element of doubtful affinities, though allied on the one hand with the Esthonians of the Baltic provinces, on the other possibly with the Lapps of the Arctic regions.

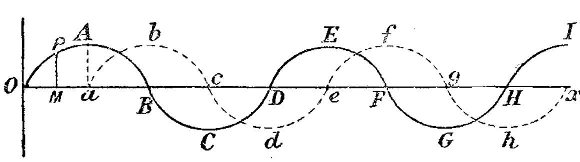
The question, as already remarked, has been advanced one stage; but much remains to be done before we can expect to see all the difficulties removed by which it is surrounded. Meanwhile it seems impossible to agree with M. Retzius, that the Karelians, rather than the Tavastians, represent the true Finnish type. Both have, no doubt, largely absorbed foreign elements. But if both are alike branches of the Mongolo-Tatar family, as has been hitherto supposed, and as their speech appears to place beyond question, it follows that of the two the Tavastians must be regarded as the nearest to the common stock. The Karelians are, of course, much the finer race, both physically and intellectually, and national prejudice may, therefore, feel inclined to regard them as the purer branch. But, ethnologists will probably be disposed to look on the improvements as due rather to a greater absorption of foreign elements, Teutonic or Slav, if not Lithuanian. They occupy a country which may well have been peopled by some of these races before their arrival, whereas the dreary lacustrine region of Tavastland must have been all but destitute of inhabitants previous to its occupation by the advanced wave of Finnish migration.

A. H. KEANE

RESEARCHES ON TELEPHONE VIBRATIONS

DR. RUDOLPH KONIG, the well-known constructor of acoustical apparatus, has recently brought before the Physical Society of Paris a research of the highest interest, upon the difference of phase which exists between the vibrations of a transmitting and a receiving telephone. In a paper published more than two years ago, Prof. du Bois-Reymond discussed the conditions which determine the intensity and the phase of different sounds transmitted telephonically; and from theoretical considerations deduced the conclusion that sounds of low pitch suffered greater loss by transmission than shrill ones, and that every simple vibration was retarded in phase by a quarter of an undulation. The former of these actions would produce an alteration in the timbre of the voice as received at the end of the line: the latter effect would remain unappreciated by the ear, since the retardation of phase was the same for waves of all periods. More recently Helmholtz has attacked the question in a paper in the *Annalen* of Wiedemann ("Telephon und Klangfarbe"), and, with a theoretical treatment of the question based upon somewhat deeper analysis, has deduced the results that all sounds are weakened by transmission in almost a constant proportion irrespective of their pitch, and that the difference of phase between the vibrations of transmitter and receiver are very small. Dr. König has endeavoured to put these conflicting speculations to the test of experiment, and with marked success.

It may be well, perhaps, to indicate the elementary considerations which led du Bois-Reymond to predict the existence of this hitherto unobserved difference of phase. The currents by which sounds are carried from the transmitter to the receiver in the Bell telephone are induction currents, excited in a coil of insulated wire by the vibrations of the iron diaphragm in front of the permanent magnet which serves as a core. The intensity of these induced currents is greatest when the vibrating diaphragm is moving with the greatest velocity. But the maximum *velocity* of the diaphragm does not occur at the moment when the *displacement* of the diaphragm is greatest. To non-mathematical readers this fact may be explained by reference to the movements executed by a simple pendulum. As the pendulum swings backwards and forwards the "bob" comes absolutely to rest at the moment when its displacement to one side or the other is the greatest, and it moves with the greatest velocity when it passes through the "point of rest" mid-way between its two extreme positions. Mathematically, the matter is equally simply stated. The displacement of a body executing a simple harmonic motion is determined by an equation of the form $u = a \cos \frac{2\pi t}{T}$, where the values of u pass through a regular series of maximum and minimum values as t increases. These successive values are geometrically represented by the heights of the ordinates of the well-known harmonic curve or *sinusoid*, the distances along the horizontal axis O x being proportional to the times. Thus the telephone diaphragm originally at rest begins to move towards the magnet under the influence of the voice. The displacement, which at the origin is nothing, increases until at A it becomes a maximum. Owing to its elasticity the diaphragm flies back, and passing rapidly through its point of starting suffers a displacement in an opposite sense. These movements are graphically represented on the harmonic



curve by the passage of the curve across the axis at B to its minimum or greatest negative displacement at C, the curve recurring from the point D. Now the equation which represents the *velocity* of the moving point will be obtained from the equation of the displacement by differentiating with respect to time. This gives us an equation of the form—

$$\dot{u} = -\frac{2a\pi}{T}\sin\frac{2\pi t}{T} = \frac{2a\pi}{T}\cos\left(\frac{2\pi t}{T}+\frac{\pi}{2}\right),$$

which is, neglecting the constant coefficient of amplitude, geometrically represented by another harmonic curve of identical form, but shifted on so that it begins at a point *a*, or a quarter of the length of the curve O O from the origin. In this second curve the heights of the ordinates represent the varying velocities of the diaphragm, the velocity being nothing at *a* when the displacement at A is a maximum, and being at a maximum at *b* when the diaphragm in flying back passes through its point of rest or has no displacement. Now of these two curves the former corresponds in phase to the movement of the diaphragm of the transmitting telephone, while the second curve corresponds to the variations of velocity, and therefore of the current transmitted, and consequently also corresponds to the motions of the diaphragm of the receiving telephone. Hence it is easy to understand that there exists a difference of phase of one-quarter of an undulation between the movements of the diaphragms of the transmitting and receiving telephones, which will be either a retardation or an apparent acceleration of phase according to the sense in which the transmitted currents traverse the coil of the receiving telephone. These considerations apply only to the telephone of Bell or its modification by Gower, in which the vibrations of the transmitting diaphragm generate the current. They do not apply to the transmitters of Edison and Hughes, which merely regulate the current. In these instruments the strength of the current is proportional to the *displacement*, not to the *velocity;* hence there is no retardation of phase.

The memoir of Helmholtz, which, by introducing certain considerations respecting the mutual inductive actions exercised upon one another by the individual turns of wire in the coil of the telephone, arrived at a somewhat different conclusion, and was principally devoted to the question of the timbre of the transmitted sounds. The previous researches in physiological acoustics of this distinguished physicist had shown that differences of phase affecting individual tones of a compound "clang" do not produce any effect which the ear can detect. This important law the present writer has, however, shown elsewhere to be true only when one ear receives the sound, and to hold no longer in the case of binaural hearing. The equations of Helmholtz indicated the unexpected result that the difference of phase between the vibrations of transmitter and receiver was a quantity so small that practically it might be altogether disregarded, and he arrived at the conclusion that all sounds were transmitted by the telephone with an equal proportionate degree of intensity independent of their pitch, and therefore with unaltered timbre. Here again, however, the writer of this article has shown that the relation between the thickness and diameter of the vibrating diaphragm affects the distribution of the magnetism induced in it by the magnet, as to whether it is lamellar or radial in character, and that this distribution has influence on the timbre of the sound emitted by the receiving telephone, the notes of higher pitch being better given by the disk in whose magnetisation the lamellar distribution preponderates, while the lower ones are better given with a preponderating radial magnetisation. The whole question of timbre of the emitted sounds requires further careful study.

The experiments which M. König has executed entirely confirm the *à priori* reasoning of du Bois-Reymond as to the existence of a difference of phase. Instead of using two vibrating diaphragms, Dr. König takes two tuning-forks accurately tuned to unison, each of them being placed in front of the magnet of a telephone whose disk has been removed, and which are united in the usual manner by wires. The first of the forks being set into vibration with a violin-bow, the second immediately begins to vibrate. The phase of each of the forks is next observed. This has been done in several ways: firstly, by direct comparison of each fork in turn with the vibration-microscope; secondly, by applying the well-known optical method of Lissajous, compounding together the two vibrations rectangularly by throwing a ray of light on to small mirrors attached to the two forks, and reflected from one to the other and then on to a screen. The figure thus produced exhibited unmistakably a difference of phase of an exact quarter of an undulation. A further experiment on compound tones was made with the same general arrangements; two forks, differing by three octaves, being made to take up, one as transmitter the other as receiver, sounds whose higher vibrations were eight times as rapid as the fundamental tone. Here again the difference of phase experimentally found for the higher tone was one quarter of a vibration.

Incidentally two very important facts have been observed by Dr. König. In experimenting he found that a tuning-fork, vibrating in front of the magnet of a telephone *whose circuit is closed*, comes to rest in a much shorter time than the same fork vibrating freely away from the telephone; also that this weakening of the sound is greater in proportion as the distance of the fork from the pole of the magnet is smaller, and also is greater for small amplitudes of vibration than for large ones. These results are not without interest in their bearing upon Mr. Edison's recent attempt to construct a dynamo-electric machine, in which the moving parts should be attached to a large vibrating tuning-fork instead of to a rotating axis. Doubtless the inventor's idea was to get rid of the friction accompanying rotation; for, as the vibrations of the tuning-fork are very nearly simple harmonic motions, and as the simple harmonic motion is the only type which can be propagated without loss by friction through a body, the motions of whose parts are coincident in phase, it might be anticipated that there would be less waste of energy in a "harmonic" engine than in a rotatory one. The important fact however remained behind that by far the greatest part of the work of driving a dynamo-electric machine was not spent in overcoming friction, but in doing the work of moving closed conductors across a magnetic field, a work which, to produce an equal amount of current, requires equal power, whether the motion be one of rotation or of "harmonic" vibration. Many years ago Foucault demonstrated the reality of this resistance to motion by spinning his gyroscope between the poles of an electromagnet; and with a Gramme machine, and also with a Holtz machine, the increased effort necessary to sustain rotation when work is being done is a familiar fact. Dr. König has now demonstrated the existence of a similar phenomenon in the case of the vibrations of the tuning-fork, which comes much sooner to rest when it is doing electrical work than when it is doing no work.

SILVANUS P. THOMPSON

ON THE EOCENE FLORA OF BOURNEMOUTH

On several previous occasions these columns have called attention to the eocene plant remains obtained at Bournemouth. The Palæontographical Society has undertaken their publication, but as this must be spread over many years, it may not be undesirable to note from time to time the principal additions to the flora as they come to light.

The specimens which I have collected this year may reach about a thousand. Among the more important are two from the marine beds east of Boscombe. One is a portion of the stem of a cactus measuring two feet three inches by three inches, showing eighty bosses of spines cleared from the matrix. A section which I have made of this presents a flattened ellipse in which the pulp is replaced by sand and the woody stem has sunk down to the lower side, though still preserving the characteristic radiating structure. The cuticle is now thin and glossy black, and bears the spines, varying from two to a dozen on each boss, arranged in the usual spiral