$$CH_2Cl—CH(OH)—CH_2Cl$$

was produced; this was oxidised by potassium dichromate and sulphuric acid, to dichloracetone,

$$CH_2Cl—CO—CH_2Cl,$$

which, when acted on by concentrated hydrocyanic acid, yielded dichloracetone cyanhydrin,

$$CH_2Cl—C\begin{cases}CN\\CH_2Cl\\OH\end{cases}.$$

The acid corresponding to this cyanhydrin having been produced by saponifying with hydrochloric acid, the sodium salt of this acid, viz.,

$$CH_2Cl—C\begin{cases}CO_2H\\CH_2Cl\\OH\end{cases},$$

was treated with potassium cyanide, whereby a dicyanide,

$$CH_2CN—C\begin{cases}CO_2H\\CH_2.CN\\OH\end{cases}$$

was produced. When decomposed by hydrochloric acid, this dicyanide yielded citric acid, in all respects identical with that obtained from the lemon and other fruits. The generally accepted structural formula for citric acid, viz.,

$$CH_2.CO_2H—C\begin{cases}CO_2H\\CH_2.CO_2H\\OH\end{cases}$$

is confirmed by the synthesis of Grimaux and Adam. Glycerin may be prepared from trichlorhydrin,

$$CH_2Cl—CHCl—CH_2Cl,$$

which is itself obtained by the action of chlorine in daylight on propylenic chloride,

$$CH_3—CHCl—CH_2Cl,$$

one of the products of the chlorination of propylene, $C_3H_6$. Finally this hydrocarbon, propylene, may be produced by passing a mixture of carbon monoxide and marsh gas through a red-hot tube. Inasmuch as carbon monoxide and marsh gas are easily built up from carbon, hydrogen, and oxygen, the synthesis of citric acid from these three elements is now an accomplished fact.

In connection with this synthesis, it is worthy of remark that in the last number of the Berlin *Berichte*, Kekulé announces that he has been working at the same subject, but by a totally different method. Kekulé's work is not sufficiently advanced for him to say positively that his method of synthesis is successful, but he feels justified in saying that very probably the process adopted by him has resulted in the formation of citric acid.

M. M. P. M.

## *PLANTS FROM LAKE NYASSA AND LAKE TANGANYIKA*

MR. THOMSON, who has recently returned from the expedition of the Royal Geographical Society to Central Africa, has brought to Kew a considerable collection of plants from the plateaux round Lake Nyassa and Lake Tanganyika. The plants from an elevation of 6,000 to 8,000 feet above sea-level contain a large proportion of Cape and characteristically temperate types. Amongst the former are the well-known *Dierama* (*Sparaxis*) *pendula*, *Scilla rigidifolia*, *Buphane toxicaria* (the great poison bulb of Natal and the Transvaal), a fine *Morœa* with a long tube and bright purple flowers as large as those of *Iris fœtidissima*, a *Gladiolus*, a *Pelargonium*, more than one species of *Gnidia* and *Helichrysum*, and a proteaceous shrub (probably *Faurea*, which extends to Abyssynia) with large heads of flowers. Of characteristically temperate types there are species of *Geranium*, *Rumex*, *Cerastium*, *Coalamintha*, and a *Scabiosa*, perhaps identical with our European and English *S. Columbaria*. Upon the plateaux below 6,000 feet the vegetation assumes a sub-tropical character. Here he met with a tree-fern of the genus *Cyathea*, *Agauria salicifolia*, Hook, fil, an ericaceous shrub common to Bourbon, Madagascar, and the Cameroons, representatives of *Mimulopsis*, *Hibiscus*, *Clematis*, *Phyllanthus*, *Gerbera*, *Smithia*, *Acalypha*, *Pentas*, *Thunbergia*, *Buchnera*, *Striga*, a shrubby *Spermacoce*, a curious *Loranthus* with broad leaves and tubular flowers densely clothed with yellow hairs, *Hypoxis Villosa*, several fine Dombeyas, Vernonias, and Combretums, a genus of *Hedysareæ* with flowers in heads like those of the hop, and a curious broad-leaved *Euphorbia*, with very large hand-like glands to the involucre. The specimens are well selected and excellently dried. It is probable that nearly all of them are in a condition in which their botanical position can be settled, and that although upon a hasty glance there do not seem to be any strongly-marked new generic types, a good many of the species will prove new to science. The marked northern extension of the Cape flora at comparatively high elevations in Central Africa is a fact of importance. It quite supports the theory that that flora is of great antiquity, and that what exists of it at the Cape is only a survival from a period when it was probably far more extensively diffused, though perhaps less highly specialised. It is much to be desired that travellers in Central Africa would do all in their power to collect dried specimens of the vegetation of elevations above 6,000 feet.

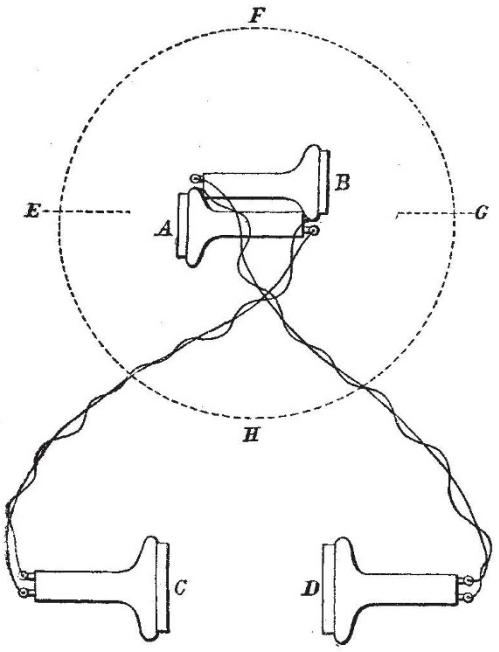
## *GRAHAM BELL'S EXPERIMENTS IN BINAURAL AUDITION*

PROF. GRAHAM BELL has published in the *American* (quarterly) *Journal of Otology* a memoir on some experiments relating to binaural audition, read by him last autumn at the session of the American Association for the Advancement of Science. Some of his observations confirm the work of previous observers, but are of additional value in affording a more systematic examination of some of the phenomena than has hitherto been attempted. The following summary of the results obtained by him will therefore be of some interest.

When we close one ear and listen to sounds through the other only, there seems to be a onesidedness about them, as there is about objects perceived by one eye. When both ears are employed simultaneously a sort of stereoscopic effect of audition is perceived. Sounds assume a "solidity" which was not perceptible so long as one ear alone was employed. The difference between *monaural* and *binaural* audition is especially well marked when we attempt to decide by ear the *locality* of a particular sound. Whatever power a single ear may possess of determining the direction of a source of sound, both ears are certainly much more effective for this purpose.

The following experiment, designed to produce artificially the stereophonic phenomena of binaural audition, was therefore devised by Prof. Bell while in this country in 1878. Four telephones were arranged, as in the figure. The telephones A and B in one room; C and D in another. The mouthpieces of A and B were turned away from one another like the auricles of a person's ears, and the diaphragms were about as far apart as the tympana of the two ears. The expectation was that a person holding C and D to his ears should not simply hear speech when any one was talking near A and B, but that he should be able to perceive the *direction* of the speaker's voice relatively to A and B. In fact, the listener's ears were, as it were, electrically prolonged to A and B respectively. The sensations produced were decidedly novel; but not exactly such as had been expected. Using various sources of sound—speaking, ringing a loud dinner-bell in various parts of the room, &c.—it was found that the location of the sound could be determined to a limited extent. The

general result was as follows : imagine a globe, E, F, G, H, in the interior of which are the telephones A and B ; let E and G be the two poles, and imagine the usual meridian lines and parallels of latitude. It was found as the result of the experiments that the observer at C, D could determine with tolerable accuracy the *latitude* of a sound made near A, B, but that *he had no idea whatever of its longitude.* In a later experiment two Blake transmitters were employed. They were placed back to back at about five feet from the ground in the open air. The receiving telephones were indoors, whence the speaker could be observed. The results of observation coincided with those already described. In order more closely to imitate the natural arrangement of the ears the transmitters were then set so that the diaphragms were at 45° to each other. A sound made at H here produced a feebler effect than one made at F; and *after a few experiments* the ear seemed to be able to distinguish whether the speaker were in front of, or behind the transmitters. Unfortunately the two transmitters were not equally sensitive, and the ear had to get accustomed to the slight inequality in the intensity




of the transmitted sounds. Prof. Bell suggests that the sensations experienced by deaf persons might be studied by persons possessed of normal hearing powers by purposely using transmitters of unequal power, or by introducing artificial resistances into the circuits.

It also occurred to Prof. Bell that the telephone might afford a means of ascertaining to what degree the human ear normally has the power of appreciating the *direction* of sound. For this purpose a number of telephones were hung up in different parts of a summer-house, and were connected with a switch-board so that an interrupted current from a rheotome in a distant place could be sent through any one at will. A person stationed at the middle of the summer-house, with his eyes closed, and holding his head perfectly still, was required to indicate the point from which the sound seemed to emanate. The indicated direction usually differed considerably from the true direction, and it was found that the observer soon came to recognise each individual telephone by its particular timbre. To obviate this a single telephone was hung up in different parts of the summer-house during the absence of the observer. This was very laborious ; nevertheless a long series of experiments were carried out, and their results carefully set down in a series of eight tables. Five young men were employed as observers, the power of each of their ears being previously ascertained by an independent test. The experiments thus carefully made and tabulated are still too few, and in Prof. Bell's opinion too imperfect in several respects, to admit of accurate generalisation ; but some deductions are unmistakable. The tables establish beyond dispute (*a*) that the perception of the direction of a source of sound is less perfect by a single ear than by both ears; (*b*) they disprove the idea that direction cannot be appreciated by monaural observation ; (*c*) they show that the direction of sound is more accurately defined as it approximates to the axial line of the ears [this entirely negatives Steinhäuser's theory of binaural audition]; (*d*) that the indications are proportionately at fault as the true source is in any other direction, the angular error sometimes amounting to 180° when the source is 90° from the axial line! (*e*) the perception of direction is absolutely unreliable when the source of sound is at the nadir with respect to the observer. It should however be remembered that in experiments thus made in an apartment reflexion of the sound comes into play, and partially vitiates any general deductions by introducing slight though unknown complications.

The method adopted by Prof. Bell to measure the relative hearing power of the separate ears was as follows :—Two flat coils of wire were placed upon a long wooden rod which passed through their centres. One of these coils, the "primary," was a fixture, and was put in circuit with a battery and a vibrating interrupter in a distant room. The other coil, the "secondary," was joined up to a telephone. When placed close to the primary the induced current produced loud sounds ; the observer, holding the telephone to his ear, was then directed to slide the secondary coil away from the primary until he ceased to hear anything. The distance between the two coils was then measured. It will be seen that this arrangement anticipated to some extent the sonometer of Prof. Hughes.

We venture to hope that Prof. Bell will continue these interesting researches in this promising, and hitherto almost unexplored field. S. P. T.

## *THE GEOLOGY OF THE LIBYAN DESERT*[1]

IN his very interesting anniversary address before the Academy of Sciences in Munich Dr. Zittel has brought together all the known facts concerning the geology of the northern districts of Africa, in a manner which is calculated to render the greatest service to his fellow-workers in science. The address, with its accompanying map and numerous explanatory notes, constitutes indeed by far the best monograph on North African geology which has yet appeared. The author not only reviews the works of the various travellers who have furnished materials bearing upon the question, from Browne and Hornemann to Fraas, Rohlfs, and Schweinfurth, but what is of far more importance, gives the results of his own accurate study of the rocks and fossils collected and brought home by recent investigators. The general results arrived at by Dr. Zittel are as follows.

To the east of the Nile rises a mountain range composed of highly crystalline rocks—granite, diorite, and hornblendic gneiss. The peaks of this range rise to heights varying from 5,000 to 8,000 feet.

The oldest stratified rocks of the district appear to be of Cretaceous age. Lying upon the axis of crystalline rocks, and also covering wide tracts of country to the south of the Great Desert, is found the Nubian sandstone

[1] "Ueber den geologischen Bau der libyschen Wüste. (Festrede gehalten in der öffentlichen Sitzung der k. b Akademie der Wissenschaften zu München zur Feier ihres einhundert und einundzwanzigsten Stiftungstages.) Von Dr. Karl A. Zittel.