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Physiology. — *"On reinforcement of sound and soundselection by means of microtelephone-apparatus"*. By Prof. H. ZWAARDEMAKER.

(Communicated in the meeting of May 31, 1913).

Of the innumerable sonorous vibrations with which the air and the soil are pervaded, only those whose period is comprised between 10 and nearly 22000 per second, are lying within the limit of our audition. Exactly midway between them lies the "a d'orchestre". The pitch of musicians remains middle tone, even when age has deprived us of a half octave at the extremities. This is no longer so in pathological cases, when large pieces of various lengths are generally cut off on the bass- and on the discant-side.

Among the benefits man derives from his audible scale none excels that of hearing speech-sounds. Compared with this the services our hearing renders for our safety, for technical purposes, for enjoying the pleasures of art etc. are relatively slight. Now there is no part of the scale of such moment to the most important of all functions of our sense of hearing as a small portion just beyond the "a d'orchestre", stretching from b_1 to g_2 (BEZOLD). Extending it a little further, we get the zone to which local telephones are tuned, viz. a_1 to e_3. This portion of the human scale must be in good condition, in order to secure a proper function of our sense of hearing speech-sounds.

By confining myself to the speechzone a_1 to a_3 I have been able to simplify considerably the researches that have occupied me for a couple of years and either concerned the sound of speech in buildings or the use of hearing-apparatus. For this narrow field full knowledge is required of every single tone.

Regardless of resonance an objective measurement of sound can be performed alike for all pitches and impulses after Lord RAYLEIGH's mode of arrangement. Devised in 1882 it had been worked out theoretically by W. KÖNIG in 1891 and put into practice by ZERNOW in 1907.

This method consists in placing a very small mirror (circular, 3 m.m. in diameter) obliquely to the plane of soundwaves. It is hung by a fine quartz fibre and is kept stationary by a small magnet attached to the back of it. As soon as the sound flows past the mirror in progressive waves or in often repeated pulses, the disc takes up a position parallel to the wave-front, just like a straw on the surface of a river. This occurs with a force proportional to the energy of the sound and ceteris paribus expressed in the torsion of the fibre and in the magnetic force.

The formulae show, that in order to attain a high degree of sensitiveness the size and the weight of the mirror should be as small as possible. I also found, that we can do without the magnet if we replace the quartz fibre by a flattened Wollaston-wire [1]). The sensitiveness can moreover be considerably increased by conducting the sound to the mirror through a short tube whose width and length are in the ratio of at least 2 : 5. The mirror is placed just in front of the aperture of the tube. The diameter of the mirror should not be much longer than the width of the aperture, so as to cause the sound-wave to bend completely round the disc. The position of the mirror is effected entirely by the pulses falling upon it on both sides, not by the sound pressure, which is too feeble for it.

The instrument discussed just now, enables us to arrange the mirror so as to prevent resonance. Only the afferent tube may possibly resonate. Its length is 6 c.m. and its width is a finger's breadth. On this account I chose a mirror of 5 mm., slightly to the detriment of the sensitiveness. Considered as an open organ pipe the peculiar tone of the tube lies somewhere near e_4 and is beyond the speechzone.

Aided by such an instrument it is quite easy to determine the reinforcement of sound and the sound selection of micro-telephone-apparatus.

First of all we intend to examine technical apparatus such as the common telephone or that used by people hard of hearing. Here element, microphone and telephone are in circuit with each other (induction apparatus being inserted only for long-distance telephony). The conducting tube replaces the ear. As close as possible, free from all foreign sound disturbances, the telephone is placed before the tube that transmits the sound to the mirror, which is placed obliquely in the plane of the soundwave. No sooner does the telephone sound than the mirror shows deviation, and a beam of light directed onto it, is caught up on the scale placed at some distance. The amplitude indicates the torsion of the fibre, i. e. the force that was counteracted by the energy of the sound, while the tone continued.

The following illustrations represent the amplitudes generated by a row of almost uniform stopped pipes, half tone for half tone, with the aid of telephone and microphone fed by two volts.

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[1]) Heraeus sent us on application such a wire of 8 μ thickness. The attendant Stellema procures still more suitable wires by flattening round Wollaston wires with a hammer.

It will be seen that the discant of the speech zone is more intensified than the bass.

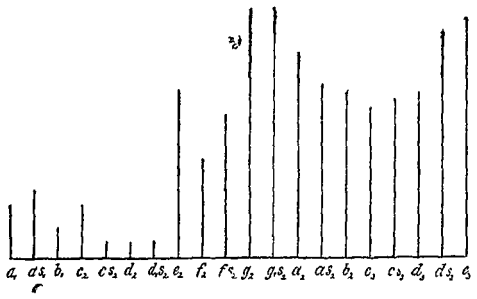


Fig. 1. Relative intensity of sound of a technical micro-telephone apparatus noted tone for tone (max. amplitude called 100).

The sound conveyed to the mirror by the telephone is more intense than that caught up by the microphone. So the circuit appears to intensify the sound. An increment of the available acoustic energy results from a decrement of the energy afforded by the accumulator. By elaborate experimentation this reinforcement can be determined directly. It may also be promptly done in a rough and ready way, if a second measuring mirror apparatus is put in operation.

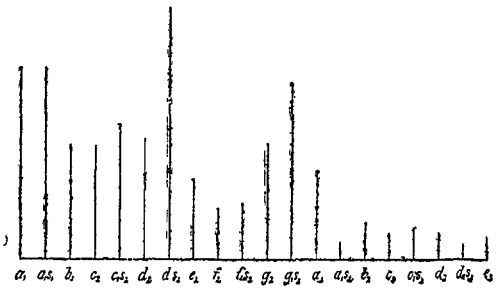
This additional apparatus is provided with the trumpet of a dictating phonograph. It is so sensitive that, even though the scale be placed at $^1/_3$ m. only and though a diaphragm of a phonograph has been inserted, a unit of the scale represents one millierg of acoustic energy per second. Such an instrument is competent to register the amplitudes of whispers even, let alone those of spoken words.

In a series of experiments carried out with Dr. Reuter I invariably used 16 monosyllabic words of the sort called isozonal and aequi-intense, because their component speechsounds fulfil certain requirements. We are now in a position to utter these words twice, once with and once without a micro-telephone. The difference in the amplitudes can then be noted. In both cases the intensity of our voice can be registered on the scale, which is furnished with a trumpet and is placed by the side of it. It appears then, that the words spoken with a micro-telephone produce on an average amplitudes exceeding 20 to 30 times those produced without insertion of the electric circuit, which exalts the acoustic energy.

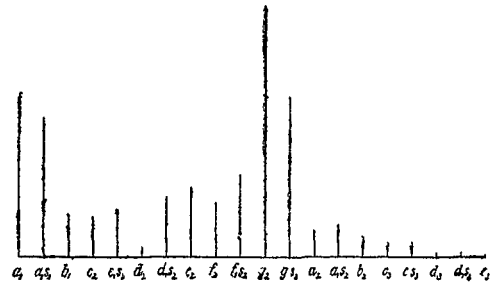
The reinforcement recorded here, occurs with either apparatus of the technique. It is remarkable that, as regards tone-selection, the latter are so constructed as to reinforce the discant of the speechzone more than the bass. It seemed to me, that a greater variety should be aimed at in this respect. I, therefore, combined the microphones and the telephones that were at my hand, in order to obtain this

variety in toneselection. My experience has been represented graphically lower down.

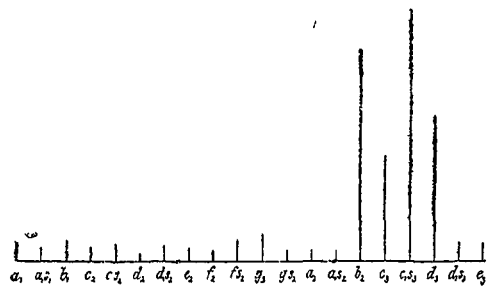
It appeared to me, that for this selection the telephone proved to be of greater use than the microphone. This prevalence is determined



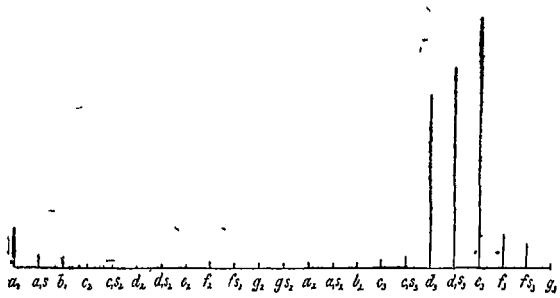
Large telephone-plate.



Middle-sized telephone-plate, thickness 0.11 m.m.



Telephoneplate of 0.16 m m. thickness



Thickness of plate 0,24 m m.

Four special combinations of microphone and telephone of different tone-selection. (Max. amplitude for each apparatus called 100).

by the size and the thickness of the membrane, which is quite a natural thing, considering that the membrane vibrates all over ("en masse") with the greatest excursion in the centre. The technique damps it to a certain extent in various degrees of efficiency (damping caused by air and by induction). In circuit with this telephone is the microphone varying considerably as to the number and the size of the carbon granules. Without exception I used for the microphones coal-membranes tuning with the telephone diaphragm selected beforehand, and I regulated the damping by selecting granules of a particular size. This can easily be managed, so that harmony for a broad zone may readily be effected, which is requisite for a proper reinforcement and audibility to be guaranteed by the circuit.

The graphic representations show, that much can be attained in the indicated way even with the present means. If the technique could be improved so as to enable us to apply the principles here brought forward, I doubt not but telephony in private houses, in churches and in assembly-rooms would be made subservient to a much greater number of pathological organs of hearing than the attainable means allow, seeing that hitherto only reinforcement was the object of experimenters and that a reinforcement not always in a zone of sufficient breadth. A new field of research opens up when the zones of reinforcement are extended to different portions of the speechzone a_1 to e_3. Every ear will then be able to select an apparatus complemental to what it lacks.

Chemistry. — "*On the synthesis of amido-oxalylbiuret*

$$\begin{array}{l} CO\,NH_2 \\ | \\ CO\,NH\,CO\,NH\,CO\,NH_2 \end{array}$$

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By Dr. J. Th. Bornwater. (Communicated by Prof. A. P. N. Franchimont).

(Communicated in the meeting of June 28, 1913).

In 1911, I showed that oxalyldiureid is not identical with the compound obtained by Grimaux (Bull. 32 (1879) p. 120) on heating parabanic acid with urea and which in the German literature is called wrongly oxalyldiureid, although Grimaux rightly calls it "amide d'un acide oxalylbiurétique".