Abstracts of Technical Articles from Bell System Sources

A Space-Time Pattern Theory of Hearing.[1] HARVEY FLETCHER. The pitch of a tone is determined both by the position of its maximum stimulation on the basilar membrane and also by the time pattern sent to the brain. The former is probably more important for the high tones and the latter for the low tones. The loudness is dependent upon the number of nerve impulses per second reaching the brain and possibly somewhat upon the extent of the stimulated patch. The experience called by psychologists "volume" or "extension" is no doubt identified with the length of the stimulated patch on the basilar membrane. This extension is carried to the brain and forms a portion of excited brain matter of a definite size. It is then this size that determines our sensation of the "volume" of a tone. The low pitched or complex tones have a large "volume" while the high pitched tones have a small one.

The psychological experience called "brightness" may be identified with the sharpness of the peaks in the vibration form of the basilar membrane as suggested by Dr. Troland. The high tones give the sense of brightness while the low tones the sense of dullness.

The time pattern in the air is converted into a space pattern on the basilar membrane. The nerve endings are excited in such a way that this space pattern is transferred to the brain and produces two similar space patterns in the brain, one on the left and the other on the right side. Enough of the time pattern in the air is sent to each of these stimulated patches to make times of maximum stimulation in each patch detectable. So when listening to a sound with both ears, there are four space patterns in the brain produced, each carrying also some sort of time pattern. It is a recognition of the changes in these patterns that accounts for all the phenomena of audition.

The Theory of Probability: Some Comments on Laplace's Théorie Analytique.[2] E. C. MOLINA. This paper is concerned with an answer to the questions "to what extent will one conversant with the *Théorie Analytique* be in touch with the present status of probability theory, and how sound a foundation will he have found therein for statistical applications of the theory?"

[1] *Jour. Acous. Soc. Amer.*, April, 1930.
[2] *Bulletin, Amer. Math. Soc.*, June, 1930.

In answer to the first question emphasis is laid on the virtual identity between Laplace's *generating function* and the Cauchy-Poincaire *characteristic function*, on the close approach of Laplace's analysis to the form of the Fourier *reciprocal* equations and to the explicit presentation by Laplace of the *Hermite polynomials* and related *Gram-Charlier* expansion. In answer to the second question, the author submits Laplace's contributions to the probability of causes and points out the distinction drawn by Laplace between the meaning of the word *limit* when used outside the domain of probability theory and its meaning when the word is attached to the observed frequency with which an event happens.

As evidence that the *Théorie Analytique* is in advance of much recent literature, and on account of its great practical value, the Laplacian method of dealing with integrands involving factors raised to high powers is outlined. In this connection attention is called to a Laplacian differential equation which contains, as a special case, the differential equation from which Karl Pearson has derived his famous system of frequency curves.

Method of Enhancing the Sensitiveness of Alkali Metal Photoelectric Cells.[3] A. R. Olpin. A technique is described for sensitizing alkali metal photoelectric cells to light by introducing onto the metal surface small amounts of dielectrics, as oxygen, water vapor, sulphur vapor, sulphur dioxide, hydrogen sulphide, air, sodium bisulphite, carbon bisulphide, etc., or some organic compound as methyl alcohol, acetic acid, benzene, nitrobenzene, acetone, etc., or some organic dye as tropæolin, rosaniline base, eosin, cyanine, kryptocyanine, dicyanine, neocyanine, etc. The marked increase in electron emission from the cathodes of cells so treated is due primarily to an increase in response to red and infrared light. Vacuum sodium cells have been produced, yielding photoelectric currents as high as 7 microamperes per lumen of white light of color temperature 2848° K and cæsium cells yielding far greater currents.

The response of these cells is proportional to the intensity of the exciting light even for light of longer wave-lengths than that to which the cell responded before treatment.

Spectral response curves are similar for all cells using the same metal as cathode. These curves differ from the curves for the pure metal by the appearance of a new selective maximum at lower frequencies. This newly appearing maximum resembles the regular maximum for the untreated metal and is due to the presence of the sulphur and air. Changes of approximately 0.8 volt are common.

[3] *Phys. Rev.*, July 15, 1930.

The validity of Einstein's equation precludes the possibility of explaining the new maximum in the spectral response curve for a treated surface by a "Raman shift" of the incident light frequencies, even though the separation of these maxima is equal to certain well-known vibration-rotation frequencies of the dielectric molecules. It may be that the natural frequency of the alkali metal atom is diminished by the vibration frequency of the complex atom in which it is incorporated.

The Lindemann formula for the frequency of the selective photoelectric maximum $[2\pi\nu = (ne^2/mr^3)^{\frac{1}{2}}]$, primitive though it seems in the light of modern theory, has always given values for the pure metals in close agreement with experimental determinations. The n term is determined by the valence of the substance, a choice of unity being used for the monovalent alkali metals corresponding to an electron revolving around a singly charged ion. A choice of 2, 3,—for divalent, trivalent,—substances corresponds to electrons revolving around doubly, triply-charged ions. Under certain conditions the alkali metals manifest different valencies, such for instance, as those exhibited in the oxide series Na_2O_2, Na_2O, Na_3O, Na_4O. These compounds can be prepared in vacuum and are light-sensitive. Spectral response curves for such cells exhibit all the selective maxima always separated from it by the frequency of a well-known line in the vibration-rotation spectrum of the dielectric molecules, usually the 1.5μ line so characteristic of oxygen-hydrogen, carbon-hydrogen or nitrogen-hydrogen linkages. The long wave limit shifts an amount agreeing with the separation of the maxima.

With a cell so designed that the cathode could be sensitized in a side chamber and then slipped into its proper place (thus keeping the anode free from light-sensitive materials), stopping potentials were obtained for electrons, liberated by monochromatic light, from a sodium cathode before and after treating it with sulphur vapor and air. For light of wave-lengths ranging from λ3500A to λ8000A falling on the treated cathode, the electron retarding potentials are found to vary linearly with the frequency of the exciting light, thus establishing the validity of Einstein's photoelectric equation for composite surfaces. From the slope of the straight line depicting this relationship, the value of Planck's constant h is found to be 6.541×10^{-27}, significant to three figures. An almost identical value is obtained for untreated sodium. The apparent stopping potentials, or voltages at which the photoelectric currents become zero are the same before and after the sulphur and air treatment. The voltage at which the current just saturates is always greater after treatment than before. This is a measure of the change in contact potential of the cathode called for by the Lindemann formula when the value of n is chosen to agree with the valence of the metal. Data are presented showing this condition to be general for the alkali metals, a maximum response to red or infrared light being dependent upon the formation of a subvalent compound, as a suboxide.

Attention is called to seemingly analogous phenomena in the fields of photoelectricity, photography, fluorescence and absorption.

Some Problems in Short-Wave Telephone Transmission.[4] J. C. SCHELLENG. In this paper are discussed certain phases of short-wave telephony, primarily, though not entirely, from the point of view of the transmitter. The field strengths which the transmitting station must provide at the receiver are considered. Typical data are given showing results obtained in transmission from Deal, New Jersey, to England. This is followed by a discussion of requirements and limitations of the transmitting antenna. The gains which arrays may reasonably be expected to provide are considered. The phenomenon of non-synchronous fading at nearby points is examined as to its bearing on the dimensions and performance of directive arrays. Other directional properties of the transmitting medium are also considered. Attention is then directed to the transmitting equipment, particular attention being given to the high-power part of it. Requirements, rather than circuit details, are emphasized. These include stability of operation, flexibility, and freedom from amplitude distortion, and phase and frequency modulation. The results of tests in which some of these matters were considered quantitatively are given.

A Chronographic Method of Measuring Reverberation Time.[5] E. C. WENTE and E. H. BEDELL. Reverberation time measurements are generally made with the ear and a stop watch in the manner devised by Prof. Wallace Sabine. Surprisingly consistent results can be obtained by this method in a reverberation chamber, where the rate of decay of sound is slow and where disturbing sounds are absent. But such measurements present difficulties if the room is noisy or if the reverberation time is short. Also it is recognized that uncertainties may be introduced because of the fact that the threshold of hearing varies between individuals and with time in the same person. It was with the object of overcoming these difficulties that the electrical method described in this paper was devised. This method does not differ essentially from that of Sabine except that an electro-acoustical ear of controllable threshold sensibility is substituted for the human ear.

[4] *Proc. I.R.E.*, June, 1930.
[5] *Jour. Acous. Soc. Amer.*, April, 1930.