Abstracts of Bell System Technical Papers Not Appearing in this Journal

New Methods and Apparatus for Testing the Acuity of Hearing. HARVEY FLETCHER.[1] This paper presented before the American Otological Society, classifies hearing tests in four groups according to their purpose.

1. Industrial or those made for determining the fitness of a candidate for employment. In certain types of work it is particularly important that a prospective employee meet a definite requirement for acuity of hearing. Tests made in the army and navy for various branches of service are conspicuous examples of this kind of test.

2. Educational or those made for determining the degree of hearing of school children both in the public schools and in the schools for the deaf for the special purpose of determining the proper methods to be used in their education.

3. Clinical or those made for assisting the physician to make a proper diagnosis of the cause of deafness.

4. Research or those made to determine new facts about both normal and abnormal hearing.

It is highly desirable that a single scale be used for representing the degree of hearing which is independent of the method used and which has a general application to the four purposes enumerated. Such a scale is proposed and it is shown how the commonly made voice test, watch tick, acoumeter, coin click and tuning fork tests can be expressed in terms of hearing loss units on this scale.

The paper is concluded by summarizing the different methods for testing the acuity of hearing which are as follows: (1) voice tests, (2) phonograph audiometer, (3) hearing loss for speech calculated from audiogram, which audiogram may be obtained in three ways, (a) tuning forks (constant initial amplitude), (b) tuning forks (comparison with hearing of tester), (c) pitch range audiometer.

The Relation Between the Loudness of a Sound and Its Physical Stimulus. J. C. STEINBERG.[2] Experiments with many types of sounds have shown that the loudness of a sound is a function of its

[1] *The Laryngoscope*, Vol. XXXV, No. 7, July, 1925.
[2] *Physical Review*, Vol. 26, pp. 507–523, Oct., 1925.

energy frequency spectrum and its level above the threshold of hearing and that if this relationship be represented as

$$L=\frac{10}{3}\log_{10}\left[\sum_{i=1}^{i=k}(W_iP_i)^{2/r}\right]^{r^2},$$

sounds whose calculated values L are equal will appear equally loud to the average normal ear. P_i is the r.m.s. pressure of the ith component of the sound wave. The weight and root factors W and r, respectively, are functions of the sensation level, which is synonymous with the term loudness as formerly used and is defined as

$$S=10\log_{10}\left[\sum_{1}^{k}P_i^2\Big/\sum_{1}^{k}P_{oi}^2\right]$$

where P_{oi} is the r.m.s. pressure of the ith component when the complex sound is at the threshold of hearing. In case the components in a narrow band of frequencies Δn are not resolved their energy must be integrated to obtain the energy of the equivalent single component. The root factor r is inversely proportional to the ratio of the minimum perceptible increase in energy to the total energy. For intensities near the threshold, the weight factors are equal to the reciprocals of the minimum audible pressures. Curves are given showing the values for W for various frequencies at various sensation levels, also the values of r as a function of S. As the intensity is increased the weight factors give greater weight to the lower frequencies; hence, even though the amplitude of the sound wave be increased without distortion, the ear will perceive both an increase and a distortion. This effect is due to the non-linearity of the ear.

Binaural Beats. C. E. Lane.[3] By introducing a tone of frequency f into one ear and another tone of frequency $f+N$ into the opposite ear, where N is less than 5 or 6 cycles, two kinds of binaural beats are obtained. Objective binaural beats are heard for most values of f within the audible frequency range, provided there is the proper difference in amplitude between the two tones. For telephone receivers as sound sources, this difference for best beats is about 55 TU and for the same receivers supplied with sponge-rubber cushions about 62 TU. These beats are heard because the louder tone is conducted through the head to the ear of the weaker tone and the two tones there are about equally loud. Subjective binaural beats are heard for frequencies below 800 or 1,000 cycles when the tones at the

[3] *Physical Review*, Vol. 26, No. 3, Sept., 1925.

two ears have about the same amplitudes, differing by not more than 25 TU. Data obtained with 22 observers are summarized. The evidence indicates that these beats are not due to cross conduction but are of central origin and the result of the sense of binaural localization of sound by phase. If the beats are slow (less than 1 per sec.) they are generally recognized as an alternate right and left localization, though some observers may report one or more intensity maxima during the beat cycle. Such maxima are explained as the result of one's interpreting the sound as louder when localization is more definite. Fast beats (more than 1 per sec.) are generally recognized as an intensity fluctuation. They are explained by assuming that the sound appears louder when the phase relations are such that it is normally best localized in the position toward which the attention is directed. This explanation is supported by observations made with a constant source rotating around the head of a listener.

Effect of Tension Upon Magnetization and Magnetic Hysteresis in Permalloy. O. E. Buckley and L. W. McKeehan.[4] Wires of five nickel-iron alloys containing 45, 65, 78.5, 81 and 84 per cent. Ni, 60 cm. long and 0.1 cm. in diameter, were studied by a ballistic method, for tensions up to 10,000 lb. per in.^{2} and fields up to saturation (10 to 20 gauss). Permalloy with 81 per cent. Ni is nearly indifferent to tension in its magnetic behavior; permalloy with less nickel is more easily magnetized and has less hysteresis when under tension, while 84 per cent. permalloy is more difficultly magnetized and has greater hysteresis when under tension. The saturation values are independent of the tension. In 78.5 per cent. permalloy, under a tension of 3,560 lb. per in.^{2}, saturation is reached at only 2 gauss (and is practically complete at 0.2 gauss) and the hysteresis loss is only 80 ergs per cm.^{3} per cycle, so small that it may be regarded as due to slight inhomogeneity rather than to any essential features of the magnetization process. *Relation to crystal orientation.* X-ray examination proves that this abnormally low loss is not due to any peculiar orientation of the crystal axes as the crystals are found to be oriented at random. Magnetostriction behavior can be deduced from these results. Above 81 per cent. Ni, permalloy contracts like Ni while below 81 per cent. Ni, permalloy expands like Fe.

Demagnetizing factor for a wire with a length 600 times the diameter, was determined experimentally and found to vary from a maximum of 1.6×10^{-4} to a low value, the changes being like these previously described by Benedicks for iron.

[4] *Physical Review*, Vol. 26, No. 2, Aug., 1925.

A Contribution to the Theory of Ferromagnetism. L. W. McKeehan.[5] *Relation of permeability and hysteresis to atomic magnetostriction.*—In permalloy, it has been found that magnetostriction changes sign at about 81 per cent. Ni, hysteresis losses can be made vanishingly small near this composition, and these effects are not due to the special alignment of crystals. It is suggested that in every ferromagnetic material the process of magnetization involves (1) intra-atomic changes, presumably changes in the orientation of electron orbits, governed by quantum dynamics and independent of environment; and (2) inter-atomic changes (stresses and strains). The inter-dependence of the inter-atomic changes and the intra-atomic changes is conveniently described as atomic magnetostriction. On this view, hysteresis loss and magnetic hardness are due to the energy required to produce, in succession, the local deformations associated with changes in the magnetization of single atoms or small groups of atoms. High initial permeability and low hysteresis loss in permalloy are explained as resulting from locally compensatory atomic magneto-strictions of the nickel and iron atoms in small groups. The fundamental differences in the magnetic behavior of Fe, Ni and Co are attributed to differences in their atomic magnetostrictions. Other differences are attributed to differences in the mechanical properties which alter the energy expended when atomic magnetostriction takes place.

Induction from Street Lighting Circuits: Effects on Telephone Circuits. R. G. McCurdy.[6] Synopsis.—This paper discusses series street lighting circuits from the point of view of their relations to nearby telephone circuits. These lighting circuits often have a much greater inductive influence in proportion to the amount of power transmitted than have most other types of power distribution or transmission circuits. This is due to the relatively large distortion in wave shape of voltage and current on certain types of these lighting circuits, and to the unbalanced voltages to ground which occur with series layouts. Three general types of lighting circuits are discussed. These are a–c, arc circuits, d–c, arc circuits supplied by mercury arc rectifiers, and alternating-current incandescent circuits. Of these, the incandescent type of circuit, in which the lamps are equipped with individual series transformers or auto-transformers, is the most important in this respect. Measures for reducing interference from these circuits are discussed.

[5] *Physical Review*, Vol. 26, No. 2, Aug., 1925.
[6] *A. I. E. E. Journal*, Vol. 44, pp. 1088–1094, Oct., 1925.

Power Distribution and Telephone Circuits. Inductive and Physical Relations. H. M. TRUEBLOOD and D. I. CONE.[7] Consideration of the relation between power distribution and telephone systems is naturally involved in the comprehensive review of the problems of the rapidly expanding power distribution networks in this country. Pending the completion of studies now being actively carried on in this comprehensive review, a preliminary and qualitative discussion is given.

Situations of exposure fall into three groups determined by the character of the area served. (1) "downtown" districts; (2) residential urban districts; (3) rural districts. The major problems arise in the second group. A wide variety of arrangements characterize both systems, and require consideration.

Among technical features, coefficients of induction for close exposures, shielding action of metallic cable sheaths for both power and telephone circuits, and "ground potential" effects, are distinctive problems. Where both classes of circuits are in cable with suitable precautions as to grounding, interference is rarely to be anticipated.

Noise induction from power-distribution circuits is chiefly from residuals, which occur on single-phase branches of polyphase circuits, or where triple harmonics or load-current unbalances are introduced by grounding neutrals, or where admittances to ground of phase wires are unequal. Residual currents are largest in systems having multiple-grounded neutrals, both load currents and triple harmonics occurring. Approximate resonance at triple harmonic frequencies between the inductance of station apparatus and power cable capacitance has characterized several situations. Various single, two and three-phase arrangements are compared from the induction standpoint.

The closely related matter of unbalances in the telephone plant is briefly discussed.

[7] *Journal of the A. I. E. E.*, Vol. XLIV, No. 12, Dec., 1925.