Abstracts of Technical Articles from Bell System Sources

Theory of the Detection of Two Modulated Waves by a Linear Rectifier.[1] CHARLES B. AIKEN. In this paper there is developed a mathematical analysis of the detection, by a linear rectifier, of two modulated waves. Solutions are obtained which are manageable over wide ranges of values of carrier ratio and degrees of modulation. These solutions are of greater applicability and are more convenient than those previously obtained, and give a full treatment of the action of an ideal linear rectifier under the action of two modulated waves.

The development is first made in terms of the derivatives of zonal harmonics of an angle which is directly related to the phase difference between the carriers. As these derivatives are tabulated functions the solution is convenient.

The solutions are limited by the condition that $K < (1 - M)/(1 + m)$, K being the carrier ratio, M the degree of modulation of the stronger carrier, and m that of the weaker. Two methods of attack are developed, one of which is applicable when K is small and M and m large, and the other when M and m are small and K large.

The cases of identical and of different programs are both considered and a number of curves are given showing the magnitudes of various output frequency components under typical operating conditions.

In the latter part of the paper the phase angle between the carriers is set equal to μt so that a beat note exists. There is then considered the effect of a noise background on the reception of signals on shared channels, and it is shown that much less "flutter" effect and much less distortion of the desired signal will result from the use of a linear rectifier than from the use of a square-law rectifier under the same conditions.

Finally, brief consideration is given to heterodyne detection and to "masking" effects.

Thermionic and Adsorption Characteristics of Thorium on Tungsten.[2] WALTER H. BRATTAIN and JOSEPH A. BECKER. Variation of thermionic emission of tungsten with surface density of adsorbed thorium.—Thorium was deposited on a tungsten ribbon by evaporation from a thorium wire. A study was made of the dependence of the thermionic

[1] *Proc. I. R. E.*, April, 1933.
[2] *Phys. Rev.*, March 15, 1933.

emission on the two parameters: T, the temperature, and f, a quantity which is proportional to the amount of thorium on the tungsten surface. At a fixed temperature 1274° K it was found that as the amount of thorium on the tungsten surface was increased, the thermionic emission increased to a maximum, then decreased, and asymptotically approached a constant value. For the maximum, f is defined to be 1.0. The maximum value and the final constant value of the emission current were respectively 5.7×10^5 and 5.7×10^4 times the value of emission current characteristic of clean tungsten. Moreover the final constant value of the emission agreed to within a factor of 2 with the value characteristic of clean thorium. From $f = 0.0$ to $f = 0.8$ the relation between the emission current and f satisfied the following empirical equation

$$\log_{10} i = -3.14 - 6.54 \epsilon^{-2.38 f},$$

where i is the emission current in amperes per cm². For $0.8 < f < 2.0$, the values of emission currents are tabulated. For any fixed f, the emission obeys Richardson's equation. All the Richardson lines for $0 < f < 1$ intersect in a common point at an extrapolated temperature of 12,500° K, and for $f \geq 1$ the lines intersect in a common point for which the temperature is 3250° K. These results obtained by depositing thorium on a tungsten ribbon have been compared with results obtained from thoriated tungsten wire. Thoriated tungsten wire can be activated by diffusion of thorium from the interior to the surface. For a while every atom that diffuses to the surface sticks to it so that f increases linearly with the time; later when evaporation is no longer negligible the rate of accumulation, df/dt, gets less and less; a steady state is reached when the diffusion rate equals the evaporation rate. It is unnecessary to assume "induced evaporation" to explain these results.

Variation of emission from thoriated tungsten with applied field.—It was found that for both the ribbon and the thoriated tungsten wire the dependence of emission on applied field changed as f was varied. For the thoriated tungsten wire the dependence of the thermionic constants A and b on applied field was most pronounced for $0.3 < f < 0.6$.

Evaporation and migration of thorium on tungsten surface.—Evaporation and migration of thorium on the tungsten surface were studied. The evaporation rate depends on the temperature and the fraction of the surface covered (f). For $0.2 < f < 1.0$ the rate of evaporation is approximately an exponential function of f. At 2200° K and $f = 0.2$ the rate of evaporation was 10^{-4} layers/sec. and at $f = 0.8$ was 31×10^{-4} layers/sec. It was found that thorium could be deposited on one side of the tungsten ribbon and then made to migrate to the other side of the ribbon. This migration occurred at an appreciable rate above 1500° K and was not complicated by evaporation up to 1655° K. It was found that the migration coefficient depended on f as well as on T. For a given set of conditions an approximate value of the heat of migration was calculated to be 110,000 calories per mol.

Diffraction of Electrons by Metal Surfaces.[3] L. H. GERMER. Fast electrons scattered from polished metal surfaces do not form diffraction patterns. A strong Debye-Scherrer pattern is produced, however, by electrons scattered from a surface which has been mechanically roughened in such a manner that electrons are able to pass directly through projecting irregularities. Small ridges extending from wires, which have been drawn through an imperfect die, also give rise to a diffraction pattern. These experiments indicate: (1) that there is no considerable layer of amorphous material (Beilby layer) on a polished metal surface, and (2) that Debye-Scherrer diffraction patterns are formed only by transmitted electrons. Fast electrons scattered at a small glancing angle from an etched polycrystalline surface form a diffraction pattern if the surface appears mat or roughened, but no pattern is formed if the surface shows metallic luster. Here again diffraction patterns appear to be produced only by transmission. A probable explanation is given for the fact that diffraction rings are not formed by electrons scattered from smooth polycrystalline surfaces.

Perfect Transmission and Reproduction of Symphonic Music in Auditory Perspective.[4] F. B. JEWETT, W. B. SNOW and H. S. HAMILTON. The demonstration in Constitution Hall, Washington, on April 27th, of the perfect transmission and reproduction in full auditory perspective of a symphony concert produced in Philadelphia by the Philadelphia Orchestra and transmitted to Washington over underground telephone wires, marked the completion of several years' work by the research and engineering forces of the American Telephone and Telegraph Company and Bell Telephone Laboratories.

In this paper is a foreword by Dr. Jewett. The features of the demonstration and some description of the equipment are presented by Mr. Snow. Mr. Hamilton discusses some of the details of the complex line circuits used in the electrical transmission of the music.

[3] *Phys. Rev.*, May 1, 1933.
[4] *Bell Telephone Quarterly*, July, 1933.

A New Reverberation Time Formula.[5] W. J. SETTE. The earliest work relating decay of sound in an auditorium and the acoustic absorption of the surfaces was done by W. C. Sabine who developed the formula which has recently been shown to be applicable to only "live" rooms. More recently Fokker in Holland, Schuster and Waetzmann in Germany and Eyring in this country derived an expression to hold for "dead" rooms also. The assumption of continuous absorption at the auditorium boundaries made in the Sabine formula was replaced by the conception of intermittent absorption, which is more in accord with actual conditions of decay.

Both of these formulae presuppose in their derivation uniform distribution of energy at each incidence, although Eyring observed that ordered states would necessitate assigning proper weights in computing the average surface absorption. The new formula is based on a similar assumption, but shifts the point of view to another kind of uniform distribution. Instead of each surface receiving a proportional share of the total energy in the room at each reflection, it is assumed that any ray of sound, after repeated reflection will have struck any one surface in proportion to the ratio of the area of that surface to the total room surface. This formulation of the process of decay leads to an alternative reverberation equation and some further extension of reverberation theory. The new equation is, of course, necessarily specialized and limited to those instances where the fundamental assumptions are fulfilled, as is brought out in the body of the paper.

[5] *Jour. Acous. Soc. Am.*, January, 1933.