position of a maximum, a flex or a "kink," as the case may require. It is often difficult to judge accurately the position of such points. To locate maxima, the device of drawing the curve $\frac{di}{dv}$ is sometimes adopted. (i and v are the current and potential, respectively.) This is unsatisfactory, because the values of $\frac{di}{dv}$ in the vicinity of a maximum are obtained as a small difference of two large numbers.

Dymond[2] has devised a method for recording directly and precisely a curve which is practically identical with that of $\frac{di}{dv}$ plotted against voltage. A small alternating potential Δv is superposed on the potential v by means of a commutator. During one half revolution of the commutator the current has the value $i + \Delta i$; during the other half, it is $i - \Delta i$. The current is now passed through a second commutator rotating on the same shaft as the first. The commuted current is $i + \Delta i$ during the first half-cycle and $-i + \Delta i$ during the second. Thus, it is equivalent to an alternating current i superposed on a steady current Δi, and gives deflections proportional to Δi on a long-period galvanometer. Dymond suggests that a transformer or a bridge could be used to suppress the current i before the commutation, but in practice he found that this current was not large enough to injure his galvanometer and that it did not affect his readings.

This note describes a method for recording directly the curve $\frac{d^2i}{dv^2}$. Of course, the zeros of this curve give the positions of flexes of the $i - v$ curve. Suppose that an alternating potential Δv, obtained either from a transformer or from the first commutator, is superposed on v as before and that the second commutator is omitted from the circuit. Let the steady current i be carefully balanced out. Then the currents passing through the galvanometer during the first and second parts of the commutator cycle are, respectively,

$$\Delta_1 i = \frac{di}{dv}\,\Delta v + \frac{1}{2}\,\frac{d^2i}{dv^2}(\Delta v)^2 + \frac{1}{6}\,\frac{d^3i}{dv^3}\,(\Delta v)^3 + \ldots$$

and

$$\Delta_2 i = -\frac{di}{dv}\,\Delta v + \frac{1}{2}\,\frac{d^2i}{dv^2}(\Delta v)^2 - \frac{1}{6}\,\frac{d^3i}{dv^3}(\Delta v)^3 + \ldots$$

The corresponding expressions for the case of a sine wave are easily written down. The galvanometer will record $\frac{1}{2}\,\frac{d^2i}{dv^2}\,(\Delta v)^2$ with a high degree of approximation.

[2] Proc. Camb. Phil. Soc. 22, p. 405, 1924; Proc. Roy. Soc. A, 107, p. 291, 1925.

In addition to its applications to critical potential problems, which are limited only by the inconstancy of the currents to be measured, it is thought that this method may prove valuable in studying the characteristics of thermionic devices, where detecting ability depends essentially on $\frac{d^2i}{dv^2}$.

ARTHUR EDWARD RUARK
BUREAU OF STANDARDS

SPECIAL ARTICLES

THEORY OF THE PROPAGATION OF SHORT RADIO WAVES OVER LONG DISTANCES

RECENT experiments by Taylor, to be published shortly, on the transmission of radio waves of wave-length from 3,000 to 16 meters over distances up to 10,000 miles, have brought to light new facts. Those of particular interest in the present preliminary note concern themselves with the change in the intensity of the received signal with the distance from the transmitter. It has been found that for wave-lengths shorter than 50 meters the received intensity decreased as the distance from the transmitter was increased, reaching a value too small to be observed at a distance of a hundred miles or so. With further increase of distance the received signal remained undetectable until a point was reached where the received signal became strong again, rising rapidly to a maximum and thereafter decreasing rather slowly. The length of the region of silence, which we may call the "skip distance," was found to increase rapidly as the wave-length decreased, being roughly 400 miles for wave-length 32 meters and 1,300 miles for 16 meters, for daylight transmission and specified conditions of transmission and reception.

In a simple theoretical explanation of these facts we distinguish two portions of the wave propagated from the transmitting antenna, one of which clings to the surface of the earth and decreases rapidly in intensity with the distance until it is lost, and the other which moves in an upward direction and experiences reflection from the Heaviside layer. This layer is assumed to be a dispersive medium with a critical frequency corresponding to a wave-length between 100 and 200 meters. This critical frequency results from the motions of the electrons in the earth's magnetic field as suggested by Appleton and by Nichols and Schelling. When plane polarized radiation with electric vector in the plane of incidence is reflected from such a medium into air anomalies will occur at the Brewster and Snell angles, the reflected intensity being zero at the Brewster angle and 100 per cent. at the Snell angle. It is assumed that the portion of the wave propagated upward is polarized with electric vector in the vertical plane and that the "skip distance" marks approximately the Snell angle of total reflection from the Heaviside layer. When Snell's law was incorporated in a Lorentz dispersion formula with one critical frequency, there resulted a relation between the dispersion constants and the height of the Heaviside layer, the skip distance and the wave-length of the radiation. The substitution of observed values into this equation determined the various constants, and with these constants the equation was found to agree with other observed skip distances within the error of measurement. The height of the Heaviside layer above the earth during broad daylight came out about 150 miles and the number of electrons per c.c. 10^5. These are reasonable values and in accord with estimates of these quantities from other sources. The values do not depend at all critically upon the exact value chosen for the fundamental wave-length, changing only by a few per cent. when this is changed from 120 to 200 meters, for example. The reason for this lies in the nature of the dispersion equation and is brought about by the fact that the wave-length region below 50 meters is considerably removed from the fundamental wave-length. Various facts and details of fading are explainable on the theory. Absorption of the radiation has been considered, as well as the effect of the earth's magnetic field in rotating the plane of polarization of the wave.

A theory of reflection is perhaps scarcely tenable in the form just outlined, for the optical constants of the air in all probability merge gradually into those of the Heaviside layer. As a result of this the radio wave, instead of being sharply reflected at the layer, is bent along a curved path. Without further detail, suffice it to say that this modification of the simple theory may be made and still retain practically the same agreement with the observed skip distances and about the same values of the height and dispersion constants of the Heaviside layer. The theory therefore supplements without disturbance the accepted ionic refraction theory of long wave transmission developed by Eccles, Larmor and others.

A. HOYT TAYLOR
E. O. HULBURT

NAVAL RESEARCH LABORATORY,
"BELLEVUE," WASHINGTON, D. C.,
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CROWNGALL IN RELATION TO NURSERY STOCK[1]

As far back as records are available to the writers, it appears that a large percentage of apple nursery trees propagated by the root grafting method have been affected by enlargements, or overgrowths, most of which ordinarily develop about the union of stock and cion. Much difference of opinion has existed both as to the cause of these enlargements and their effects upon the plants. Following the discovery by Smith and his coworkers[2, 3] of the causal relation of *Bacterium tumefaciens* Smith and Town. to the production of galls, "tumor strands" and "secondary tumors" on various plants, and their demonstration of its parasitism on the apple, the enlargements so commonly found about the unions of apple root grafts have been rather generally attributed to the action of this organism, and the sale of crown-galled apple trees has been prohibited by law in many states. However, in recent studies of crowngall, Riker[4] and Robinson and Walkden[5] have succeeded in inducing the development of "tumor strands" and "secondary tumors" only in the region of rapid elongation near the growing points of their experimental plants. This work appears to minimize the potential importance of "tumor strands" and "secondary tumors" in relation to apple nursery stock. In view of the many important gaps in the knowledge of crowngall and of the importance to the fruit industry of the questions involved, various groups and individuals have cooperated in organizing a research project,[6] the aim of which is to investigate certain aspects of the crowngall problem, with special reference to its bearing upon the fruit industry.

One of the first lines of work started was an attempt to differentiate crowngall of apple from other

[1] Approved for publication by the director of the Wisconsin Agricultural Experiment Station.

[2] Smith, E. F., Brown, N. A., and Townsend, C. O., "Crown-gall of plants: its cause and remedy," U. S. Dept. Agr., Bur. Plant Indus. Bul. 213, 215 p., illus., 1911.

[3] Smith, E. F., Brown, N. A., and McCullock, L., "The structure and development of crown gall: a plant cancer," U. S. Dept. Agr., Bur. Plant Indus. Bul. 255, 60 p., illus., 1912.

[4] Riker, A. J., "Some morphological responses of the host tissue to the crowngall organism," *Jour. Agr. Res.*, 26: 425–437, illus., 1923.

[5] Robinson, W., and Walkden, H., "A critical study of crown gall," *Ann. Bot.*, 37: 299–325, illus., 1923.

[6] This project, which is supported financially by the American Association of Nurserymen and individual nurserymen in cooperation with the Iowa State College of Agriculture and Mechanic Arts and the University of Wisconsin, is being administered by the Crop Protection Institute through a committee consisting of Drs. I. E. Melhus (chairman), G. W. Keitt and M. F. Barrus. Coordinated research programs are in progress at the Iowa State College of Agriculture and Mechanic Arts and the University of Wisconsin.