THE USE OF THE EINTHOVEN GALVANOMETER AND A DETECTOR OF THE AUDION TYPE FOR MEASURING THE STRENGTH OF RADIOTELEGRAPHIC SIGNALS.

BY LAURENS E. WHITTEMORE.

ONE of the important determinations to be made in radiotelegraphy is the measurement of signal strength at a receiving station. Measurements of this kind are valuable in determining (1) the effectiveness of various types of antennæ and transmitters, and (2) the effect of weather conditions and of the nature of the region over which propagation takes place.

Among the experiments which have been made in the past to measure quantitatively the phenomena of radio transmission may be mentioned those of Austin,[1] Taylor and Blatterman,[2] and Marchant.[3]

In general, two methods of measurement are in use. (1) Noting the deflection of a galvanometer placed in series with a crystal detector or in shunt around a thermo-junction. (2) Shunting a telephone receiver with a variable resistance which can be adjusted until the signals are just barely audible, that is, until dashes can just be distinguished from dots. The second method has frequently been shown to be unsatisfactory.

For making quantitative measurements it is very convenient to record the signals by means of an Einthoven galvanometer and a suitable photographic device. A permanent record is thereby obtained which can be measured accurately at the leisure of the observer. A very convenient control board for use with this galvanometer is now being manufactured by Leeds and Northrup.[4]

The crystal detectors proving unreliable and the thermo-junctions too insensitive, we may turn to the more recently developed vacuum bulb detector which is sensitive and not easily thrown out of adjustment. A difficulty arises in its use from the fact that a battery of large electromotive force is used in the plate circuit. A current of about a milliampere

[1] Bul. Bur. of Stand., Vol. 7, 1911, Reprint No. 159; Vol. 11, 1914, Reprint No. 226.
[2] Proc. Inst. Radio Eng., 4, 131, 1916. (Good bibliography.)
[3] El. (London), 75, 267, 309, 1915.
[4] H. B. Williams, Am. Journ. Physiol., April 1, 1916.

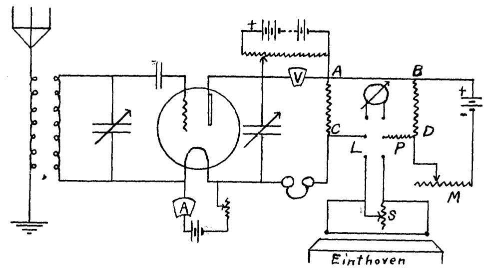

Fig. 1.

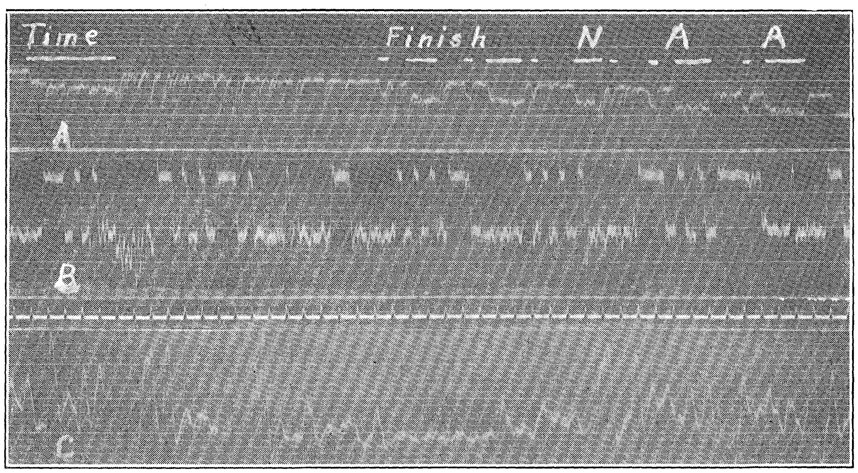

Fig. 2.

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flows in this circuit whenever the detector is in use, thus making it impossible to use a sufficiently sensitive galvanometer directly in the receiver circuit. To avoid this difficulty the arrangement shown in the accompanying diagram, Fig. 1, was used.

The current which is continually flowing through the plate circuit causes a potential drop to exist across the resistance *A–C* in the circuit. This is balanced by an equal potential drop across a resistance *B–D* in an auxiliary circuit. The two circuits are connected together at the point *A–B* and the galvanometer is placed between the two circuits at *C–D*. When no signals are being received the galvanometer should show no deflection. When signals are received the potential drop *A–C* changes, thereby creating a difference of potential between *C* and *D* and causing a deflection of the galvanometer. If this galvanometer is of the Einthoven type it will follow the variations of the current with the reception of dots and dashes. It was found convenient to keep both of the resistances *A–C* and *B–D* constant at about 2,000 ohms and to secure a balance by varying an additional resistance, *M*, in series with the auxiliary battery.

When the filament of the detector is first lighted it is necessary to wait a few minutes until the current in the plate circuit becomes steady. For the preliminary adjustment of the potentiometer circuit it is very convenient to use a D'Arsonval galvanometer of the box type. It can then be replaced by the Einthoven by means of the switch, *L*, Fig. 1.

For quantitative work it is essential that the detector be put in the same condition of sensitiveness for the successive tests. The detectors of the vacuum bulb type are well arranged in this respect, for it is possible by means of an ammeter in series with the filament and a voltmeter across the battery of the plate circuit to reproduce the conditions in these circuits whenever desired. It is also important to keep the tuning and coupling conditions constant.

A check can be had on the detector by setting up an auxiliary or substitute antenna circuit and exciting this with a constant frequency buzzer in order to give in the detector circuit a current of about the same magnitude as that due to the received signals.[1]

Even after a comparatively steady current has been set up in the receiver circuit (observable with the D'Arsonval galvanometer) a very slow increase or decrease may take place due, perhaps, to fluctuations in the temperature of the bulb, resulting in a drift in the line of photographic signals as in Fig. 2, *A*. In order to bring the galvanometer back to zero

[1] A most excellent arrangement of circuits for this purpose is given by Marchant in the Journal of the (British) Institution of Electrical Engineers, *53*, 329, 1915. Abstract, El., *74*, 621, 1915.

it is necessary to adjust the series resistance, M, which consists, conveniently, of a dial type resistance box in connection with a fairly large sliding contact, or otherwise continuously variable, resistance. The deflection caused by the signals is not affected by this adjustment.

The sensitiveness of the apparatus may be decreased for recording strong signals or atmospherics by shunting the galvanometer as at S or including a series resistance, P.

Attention may be called to the fact that detector bulbs with lime cathodes have been found rather irregular in their behavior.[1] The newer bulbs of the tubular type seem to be very stable if the filament is not maintained at too high a temperature.

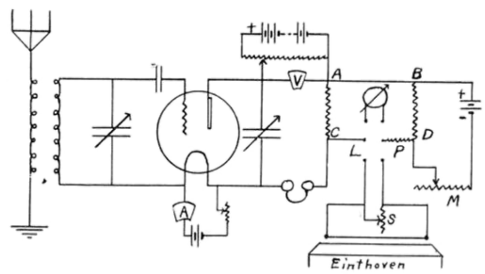
The photographs reproduced in Fig. 2 were obtained by the author by the use of the arrangement described in this paper. In this figure time increases toward the right and the deflection of the galvanometer is down, the zero position being above. A is a photograph of the time dash and signature signals sent out at 10 P.M., eastern time, May 24, 1916, by the U. S. government station (NAA) at Arlington, Virginia, whose distance from this station (9XP) is about 1,000 miles. B shows the beginning of the weather report sent out from Arlington on the evening of April 4, 1916. It reads, USWB — S m(issing). Atmospherics, at times making the signals somewhat difficult to translate, may be seen in A and B, while in C (11:15 P.M., March 21, 1916) the atmospherics are so strong as to completely overshadow any signals. The shadow of the time indicator marking fifths of seconds may be seen between B and C. The parallel lines, one millimeter apart, are for convenience in measurement and are caused by rulings on the cylindrical lens in front of the shutter of the camera.

This method of measurement seems especially applicable for taking data such as is being gathered by the British Association for the Advancement of Science, through its committee for radiotelegraphic investigation, for obtaining quantitative information regarding the influence of the weather on atmospherics and signal strength.

I am indebted to Dr. T. Townsend Smith, following whose suggestion the arrangement above described was developed, and to Dr. Ida Hyde, of the department of physiology of the University of Kansas, who was so kind as to put the Einthoven galvanometer at my disposal.

BLAKE PHYSICAL LABORATORY,
UNIVERSITY OF KANSAS.

[1] Willows, El., 74, 742, 1915.



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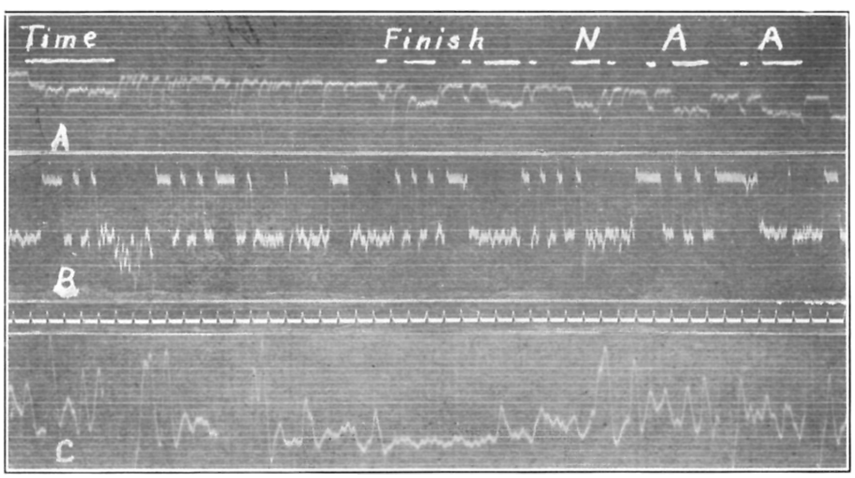

Fig. 2.