Recent Advances in Wireless Measuring Instruments

An Instrument for Determining Logarithmic Decrement of Transmitters

By Herbert T. Wade

THE efficiency of wireless telegraph apparatus depends in large measure on the nature of the electromagnetic waves sent out from the transmitting station, and the laws of the United States which govern the commercial, amateur and marine practice of radio telegraphy specify in particular that the waves must be of such form that the logarithmic decrement for a complete oscillation as employed with land or sea stations shall not exceed two tenths, except when sending distress signals or messages relating thereto. The logarithmic decrement is a mathematical expression for the measuring of the decay of a train of waves, being a constant ratio for any oscillation to the next succeeding one, and this should be made as small as possible so that the series may closely approach the conditions of a persistent oscillation of a single frequency. This is an ideal condition, permitting of the use of a much more selective receiving apparatus, thus enabling sharper tuning with a consequent minimizing of interference caused by the waves from other stations.

In the testing and adjusting of a wireless installation there are many occasions when it is desirable to measure the logarithmic decrement and the length of the waves emitted. When this work is done by a Government inspector or under conditions of ordinary test, it is desirable to have a direct-reading instrument and one that can be operated with a maximum of convenience in such situations as on shipboard. Accordingly, an ingenious and efficient instrument for this purpose has been devised by Mr. Frederick A. Kolster, physicist of the United States Bureau of Standards at Washington, D. C., which has received the well merited honor of a silver medal from the Panama-Pacific Exposition. This instrument is now issued as part of the regular equipment to the radio inspectors of the Bureau of Navigation, United States Department of Commerce, and is also extensively used by the United States army and navy.

In the Kolster instrument, which is known as a decremeter, there is an ingenious combination of a hot-wire ammeter, an adjustable condenser, various inductances, and a series of indicating devices which enables the logarithmic decrement to be read directly, as well as the wavelength of the signals sent out by the transmitting station, or, when connected with a receiving apparatus, the waves received from a distant station.

The logarithmic decrement from the mathematical discussion of the fundamental equation used in radio telegraphy can be written in terms of the constants of the circuit, or in other words, the logarithmic decrement $d = \pi RC\omega$; also $d = \frac{\pi R}{L\omega}$ where R represents the resistance, C the capacity, and $\omega = 2\pi$ times the frequency of oscillation. By another formula the sum of the logarithmic decrements in two circuits which are loosely coupled or able to act on each other inductively can be expressed in terms of a change in capacity and current. Now if the capacity can be adjusted in such a way as to be measured and the current indicated by some form of ammeter whose readings are proportional to the square of the current, then, by determining the logarithmic decrement of the circuit formed by the decremeter and its accompanying coils, the decrement of the aerial or transmitting circuit can be readily obtained. By changing the values of the capacity, thus altering the current or energy in the circuit, a series of points may be determined from which a resonance curve can be drawn to indicate the decrement involved

in the special length of wave that is being sent out. What Mr. Kolster has done in his new instrument is to attach to a variable condenser of novel design a single, predetermined scale giving values of the logarithmic decrement corresponding to various percentage changes of capacity throughout the range of capacity of the condenser, as defined by a formula originally evolved by V. Bjerknes. He has ingeniously determined the proper shape for the movable plates or surface of the condenser in order to produce a variable capacity whose change in value is constant throughout the range of motion of the moving surface. In this condenser the stationary plates are semi-circular, but the movable surface is designed in accordance with a geometrical law deduced from the Bjerknes equation. The rotary condenser is constructed with the fixed capacity connected and parallel with it, so chosen as to give the desired ratio between the maximum and minimum capacity of the combined condensers, and to furnish a calibration curve by which a predetermined scale can be attached to the rotary condenser. The movement of the index of the rotary condenser is magnified by means of gearing connected to the condenser shaft, and the final graduations for the scale are evolved from the formula, duly computed and permanently marked.

In measuring the logarithmic decrement with the new instrument, the rotary condenser is first set at the position of complete resonance where the ammeter dial indicates a maximum of current in the circuit of the instrument itself, which is inductively coupled to the antenna circuit. This maximum deflection is reduced to one half its value by turning the knob which decreases or increases the capacity of the rotary condenser. Then the decrement scale, which may be rotated independently, is set at zero and clamped so that when the condenser is again varied it will rotate with it. Starting at the zero setting with the hot wire

instrument reading one half the maximum deflection the condenser is varied continuously in one direction until the needle of the hot-wire instrument makes a complete maximum deflection and back again to one half deflection. The scale reading opposite the index mark O , is the value of $d_1 + d_2$; d_1 being the decrement of the circuit under test, and d_2 the known decrement of the instrument. The arrangement of the circuit of the instrument is shown in the accompanying diagram. I is a single coil which may be connected in the circuit under test, as for example the aerial circuit of a radio transmitter, and in practice is a single loop which is connected at the corner of the instrument. L is the inductance coil of the decremeter circuit and is so arranged that the mutual inductance between it and the coil I can be easily varied, but it is essential that the degree of coupling between the circuit under test and the decremeter circuit be small. C_v is the variable condenser to which the decremeter scale is attached through gears, and parallel with C_v is the small condenser C_f which remains fixed in value after proper adjustment. H represents the hot-wire ammeter or indicating device the scale of which is so marked that the readings are proportional to the square of the current passing through it. A crystal detector D is provided, and the wave length of distant stations may be measured by using telephone receivers T . The buzzer circuit RBE containing various resistance coils may be connected to the instrument for purposes of calibration.

Inasmuch as the capacity of the variable condenser of the decremeter varies according to a definitely known law, it is possible to attach a wavelength scale which will indicate wavelengths directly, and this scale is arranged so that it can rotate about the shaft of the variable condenser independently, but remains stationary when the condenser is rotated. A pointer is attached to the shaft of the condenser and travels over the scale as the condenser rotates. Several coils are supplied with the instrument and the position of the wavelength scale is adjusted to correspond with the particular coil employed. By various adjustments of the scales the pointer on the shaft will point to the wavelength when resonance is obtained as indicated by the maximum reading of the hot-wire ammeter. The instrument may be used as a receiver with the detector and telephones, or as a transmitter using the buzzer, but in the latter instance the wavelength scale requires a correction supplied from a calibration curve for wavelength ranges below the 90 deg. position of the condenser. The instrument, which occupies the space of and is encased to resemble the ordinary dress suit case, has been found particularly practicable and useful both for its portability and its accuracy, and its use is an essential feature of the extensive wireless inspection of merchant vessels undertaken at various American ports by officers of the Bureau of Navigation.

In connection with the decremeter described above there has been developed by Mr. Kolster a combination receiving outfit which includes a decremeter, wavemeter and receiver, which will add materially to the convenience of the work of inspection, inasmuch as it can be installed in the offices of the Government inspectors for the purpose of measuring wavelengths of distant ships and shore stations, and thus save in many instances considerable time and trouble. It consists of a selective receiver which lends itself to great ease of operation and indicates directly the wavelength received. It also comprises a direct-reading wavemeter and decremeter for station use.

Fig. 1.—Diagram of connections

Fig. 2.—Top view showing general arrangement

W = Wavelength scale.
C = Condenser scale in degrees.
D = Decrement scale.
H = Scale of hot-wire instrument.
S = Short circuit release.
A = Knob operating variable condenser.
B = Clamping screw.
Z = Zero adjusting screw.
cd = Terminals for series connection.

Calibrated receiving set for measuring the wavelength of incoming signals

The mechanism of the Kolster Decrementer and the coupling spools

A portable Kolster Decrementer of the type employed by radio inspectors