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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
WASHINGTON

Letter
Circular
LC 92

Information Service, Bureau of Standards, Washington

(April 25, 1923)

RADIO SIGNALS OF STANDARD FREQUENCY AND THEIR UTILIZATION.*

The Bureau of Standards at Washington, D.C. (station WWV) is conducting a series of transmissions of radio signals of known frequency (wave length) to be used as a basis for adjusting and calibrating radio apparatus. They are transmitted at approximately monthly intervals except for a number of additional transmissions in May 1923. The accuracy of the announced values of these signals is better than three-tenths of one per cent. Definite schedules giving the frequency (wave length) to be transmitted and the exact time of the transmissions are announced in the newspapers, and also in the Radio Service Bulletin, a monthly periodical published by the Department of Commerce, for which subscriptions at the rate of 25 cents a year may be sent to the Superintendent of Documents, Government Printing Office, Washington, D.C.

General.- These signals are transmitted as follows: At an announced time, about 11:00 p.m., Eastern Standard Time, a general call is given on some previously announced frequency. This call is given for four minutes and is made, during the first half of the ~~five~~ minute period, by telephony, and during the second half by unmodulated continuous wave telegraphy. This gives listeners ample time to tune in WWV and get apparatus adjusted. The standard frequency signals start at 11:04 p.m. and are the call letters WWV repeated with very long dashes intervening. These signals are unmodulated continuous waves and are transmitted for four ~~five~~ minutes. During this time the frequency is accurately measured at the Bureau of Standards and at 11:08 p.m. the exact value is announced, first by telephony and then by telegraphy. There is then a short interval, about five minutes, during which time the frequency of WWV is shifted to the next value to be transmitted. These signals have been received and used satisfactorily in all parts of the United States east of the Mississippi River.

The apparatus used in transmitting these signals consists of a 1 kw tube transmitting set which has been designed to maintain constant frequency regardless of antenna swinging and similar effects. It is however necessary to use different antennas because of the large range of frequencies covered. For

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frequencies below 500 kilocycles (above 600 meters) a flat top T antenna having a height between antenna and counterpoise of about 130 feet is used, and for frequencies above 500 kilocycles (below 600 meters) a cage top T antenna having a height of about 70 feet above the counterpoise is used. For both antennas the antenna current is from 5 to 10 amperes.

Zero Beat Method.- It is probable that the most important application of these signals is for calibrating wavemeters used for adjusting transmitting apparatus. There are several methods that may be employed for this purpose but only one, the zero beat method, is considered sufficiently accurate for precise work. This method consists of tuning a small tube generating set to the same frequency as the incoming standard-frequency signal by means of beats in a radio receiving set between the output of the generating set and the incoming signal. When the frequency of the beat note is zero, the frequency of the generating set is then exactly the same as that of the incoming standard wave signal. The wavemeter is then tuned to resonance with the generating set and since the frequency is known corresponding to that setting of the wavemeter, a point on the calibration curve is determined.

In employing this method for wavemeter calibration the only apparatus necessary, in addition to a receiving set and wavemeter, is the small radio-frequency generating set or separate heterodyne. This generating set must produce sufficient radio-frequency current to satisfactorily operate the resonance indicating device of the wavemeter. The generating set should be located as far away from the receiving set as possible since the strong signals produced by it may block the detector tube of the receiving set and render it inoperative.

If a non-regenerative receiving set is used it will be necessary to use the local generating set as a heterodyne when tuning in the telegraph and standard frequency signals from WWV. If a regenerative receiving set is available best results will probably be obtained if it is used in a generating (oscillating) condition when tuning in the signals of WWV. After picking up the signals, the receiving set should be adjusted for maximum regeneration without generation in order to obtain high sensitivity and selectivity and the local generating set should be used as a heterodyne. If two operators are available they should both be supplied with telephone receivers so that they may both hear the signals. One operator should tune the receiving set and the other should adjust the local generating set and calibrate the wavemeter. For information regarding the calibration of wavemeters see Circular of the Bureau of Standards No. 74 and Letter Circular of the Bureau of Standards No. 75. For information regarding the design of a portable short wave wavemeter see Letter Circular of the Bureau of Standards No. 78.

If the reaction of the wavemeter on the local generating set is sufficiently great to change its frequency, this will be evidenced by the production of beats and it will be necessary to loosen the coupling of the wavemeter with the generating set. Little reaction by the wavemeter on the local generating set is to be expected if a sensitive device is used on the wavemeter as a resonance indicator. A sensitive thermogalvanometer or a hot-wire ammeter not requiring more than 100 milliamperes for full scale deflection is very satisfactory as an indicator. It will be advisable to keep the deflection down to below-half-scale deflection, since this can be read accurately and will permit the use of a looser coupling than the larger deflections.

Local Generating Set.- Sufficient power can be obtained from a five-watt tube in a Hartley circuit, as shown in Fig.1. Inductor "A" is a 3½ inch tube of suitable insulating material about 4½ inches long, wound with 55 turns of No. 16 B & S gauge double cotton covered copper wire with taps taken out from every fifth turn. This coil is used for frequencies (wave lengths) from 500 to 2000 kilocycles (600 to 150 meters). Inductor "B" consists of 200 turns of No. 22 B & S gauge double cotton covered copper wire on a tube about 5 3/4 inches in diameter and about 9 inches long. Taps are made on turns as shown in diagram. This coil is used for wave lengths from 300 to 3000 meters. The plate voltage may be secured from several 22½ volt "B" batteries connected in series. Satisfactory operation can be obtained on voltages from about 100 to 400 volts. It is desirable to completely shield the generating set by placing it in a box lined with copper window screening which should be grounded. A long handle may be attached to the variable condenser control to obtain fine adjustment and reduce body capacity effects.

Resonance Click Method.- Another method which is considered fairly satisfactory is the resonance click method or some of its variations. (See L.W.Austin, Journal Washington Academy of Science, 14, p.498, Aug. 19, 1918). In this method the wavemeter is coupled with the inductor of the receiving set in a generating (oscillating) condition which has been tuned to produce zero beat with the incoming signal. The setting of the wavemeter is varied until a click is heard in the telephones of the receiving set. This click is caused by the sudden absorption of power from the receiving set circuit by the wavemeter.

In measuring the frequency (wave length) of a signal by this method, it is necessary to use a regenerative receiving set in a generating (oscillating) condition, tuned to produce zero beat with the signal. The wavemeter is brought up close to the inductor of the receiving set and its setting varied until a click is heard in the telephone receivers. If the coupling of the wavemeter to the receiving set is too close, the click will

probably be heard with different settings of the wavemeter, depending upon whether the capacity of the wavemeter circuit is being increased or decreased. These clicks will approach each other as the coupling is loosened and a coupling will be found where only one click will be heard. This coupling should be used for the measurements.

This method can be used for measuring the frequency (wave length) of telephone broadcasting stations or other stations (receiving set in a non-generating condition) by noting the sudden decrease of signal intensity as the wavemeter is tuned to the frequency of the incoming signal. To obtain accurate results it is necessary to use very loose coupling.

Calibration of Receiving Sets.- These signals may also be used for frequency (wave length) calibration of receiving sets. For this purpose it is only necessary to plot a curve showing the relation between tuner setting and frequency (wave length) or to mark the frequency (wave length) corresponding to different settings directly on the dials. Care should be taken to note the settings of the dials of the coupling control and the regeneration control when the calibration is made, and these same settings should be used when any reference is made to this calibration because a change in either coupling or regeneration may cause a change in frequency.

In calibrating a single-circuit receiving set it must be remembered that a change of antennas or any change in the antenna constants after the set has been calibrated will destroy the accuracy of the calibration. A coupled circuit tuner may be used on different antennas with little change in accuracy since the secondary circuit calibration will remain practically constant with changes in antenna constants. The calibration of most receiving sets should be considered as only approximate since there are so many possibilities for error.

Department of Commerce,
Washington, D.C.

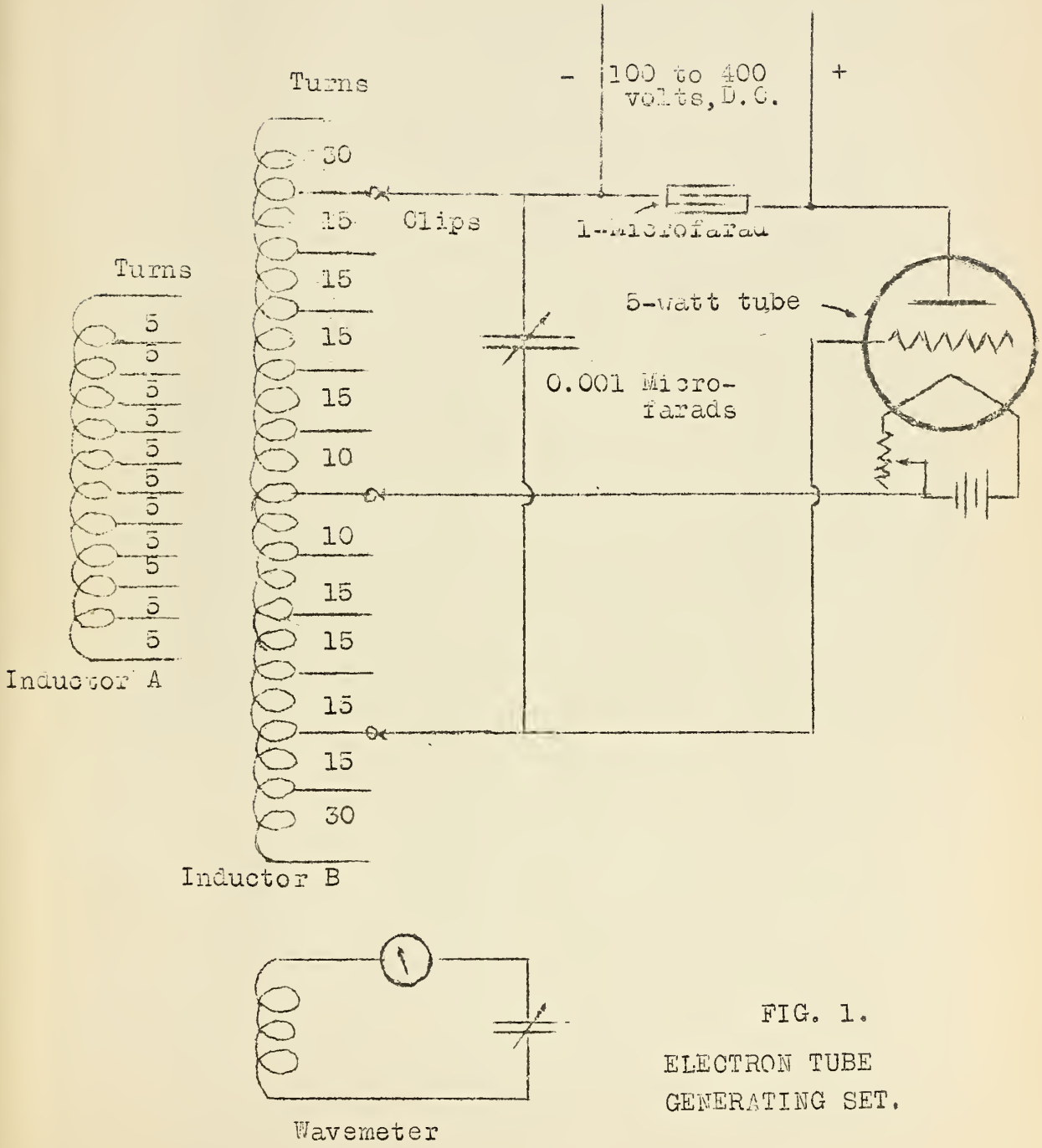

FIG. 1.

ELECTRON TUBE
GENERATING SET.