



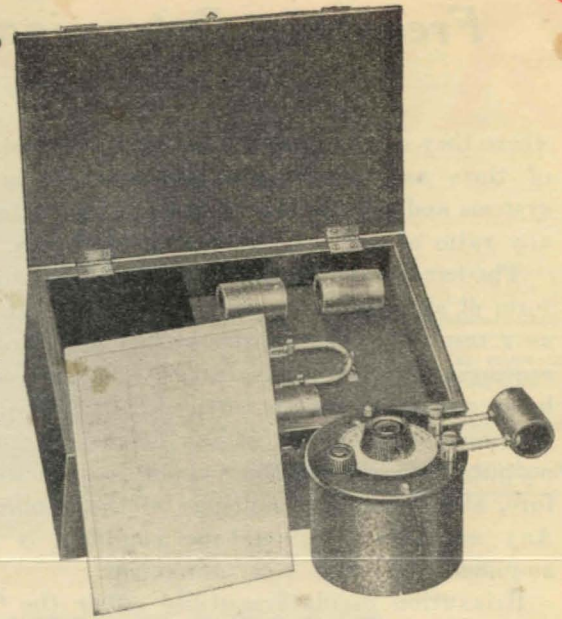
A Better Frequency Meter for the Amateur

BEFORE the amateur bands made necessary by the Washington Convention of the International Radio Telegraph Conference went into effect last January, wavemeters or frequency meters were not the absolute necessities that they are today. With not-too-tolerant commercial and military services in adjacent channels, services that are themselves required to hold closely to their assigned frequencies, it is little wonder that increased official emphasis is being laid upon the necessity of the amateur's keeping within bounds.

Realizing the necessity for such an instrument, the General Radio Company last July brought out the TYPE 558 Amateur-Band Wavemeter in which the accuracy of calibration was 0.25% over all five of the high-frequency bands. By the use of a tuning condenser designed to spread the band over the whole 180 degrees of the dial and by the addition of a specially constructed neon-tube resonance indicator, an instrument capable of unusually precise work was provided for the amateur. Later on the meters were calibrated in frequency instead of wavelength and the official title was changed to "Amateur-Band Frequency Meter."

Many users, inexperienced in making a frequency measurement upon an oscillator, failed to observe the one rule that must be followed when the meter circuit contains a resonance indicator: the coupling between the oscillator and the meter must be kept very loose. On many low-powered transmitters loose coupling could not be made to give an energy transfer sufficient to light the neon indicator. The coupling would then be tightened, but the

FIGURE 2
THE TYPE
558-P METER
CONTAINS
NO RESO-
NANCE IN-
DICATOR



frequency indicated by the meter might be considerably in error because of the mutual reaction of the meter circuit and the oscillator upon each other. The frequency meter could be made to give precise readings, but it had to be handled with care.

In order to improve upon the amateur-band frequency meter and make it easier for the non-professional user to obtain high precision without in any way affecting its utility, the resonance indicator has been entirely removed from the instrument. This requires that some indirect method of indicating resonance be used, but a number of methods are available that are extremely sensitive and leave little to be desired in precision.

The best known of these is the so-called plate-reaction method. With loose coupling between the oscillator and the coil of the frequency meter, the plate-current meter of the oscillator will "kick" as the frequency-meter circuit passes through resonance. With some oscillators the current will increase, in others it will decrease, but the kicking point can usually be picked out with little difficulty and with much looser coupling than would be needed to operate a neon indicator. It may well be emphasized that a plate-current meter is not absolutely necessary in using this method. A flashlight bulb of the proper size may be used, and, especially when the filament is biased with an external battery, it is highly sensitive to small changes in the magnitude of the plate current.

The method recommended for use wherever it is possible (it always is possible in the amateur station) makes use of a monitor heterodyne oscillator. Although seemingly the method is little used outside the college and commercial laboratories it is one that deserves to be better known among amateurs. (See "Checking Tone and Wavelength of Transmitters" by James K. Clapp, *QST*, December, 1926.) Using the fundamental or a harmonic of the oscillating receiving set as the monitor, to beat with the fundamental or a harmonic of the transmitter, the fre-

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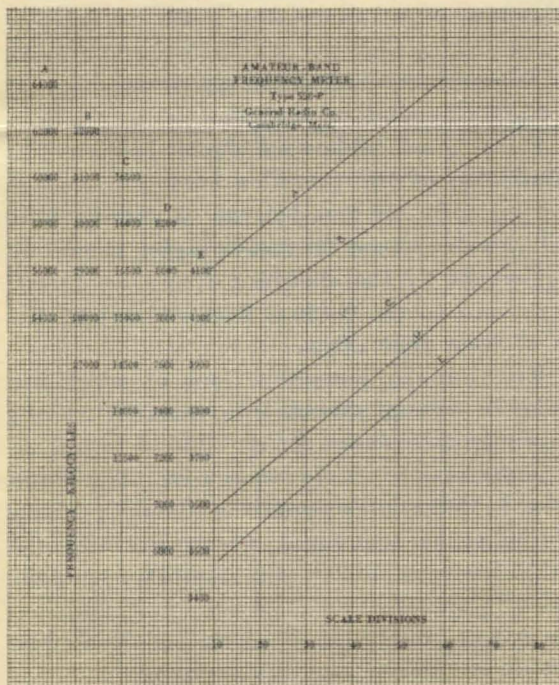


FIGURE 3.
EACH IN-
STRUMENT
IS INDIVIDU-
ALLY CALI-
BRATED

File Courtesy of GRWiki.org



Frequency Determination

(Concluded from page 2)

where they can be made to perform satisfactorily. Most of them are synchronous motor-driven tone-generator systems and are capable of being designed to give nearly any ratio of motor to generator frequency.

The harmonic amplifier is designed to distort the waveform of an alternating voltage impressed upon its input, as a result of which harmonics of the impressed voltage appear in the output circuit. It has the advantage of being quiescent; that is to say, when the applied voltage is removed, no voltage of any frequency appears in the output; the only possible output frequencies are, therefore, always integral multiples of the applied frequency. Any non-linear vacuum-tube amplifier is a harmonic amplifier, at least to a certain extent.

Relaxation oscillators utilize either the "cut-off" or the negative resistance characteristics of such devices as neon tubes, carbon arcs, and the usual forms of vacuum tubes to sustain oscillations in a circuit comprising a direct-current source, resistances, and condensers. The output of such oscillators is rich in harmonics. If a second oscillation of higher frequency be injected into the circuit, the relaxation oscillation may assume a frequency which is a submultiple of the injected frequency.

Although the neon tube is simplest, its control by the injected voltage is not as stable as that obtained from the multivibrator. The control of a multivibrator is not affected by variations in the magnitude or frequency of the injected voltage or the applied voltages on the tubes over reasonably wide ranges. This inherent stability of the system, together with the comparatively large output it is capable of delivering, makes it an excellent frequency converter for a multiplying or a dividing system.

By overloading, the output waveform of a vacuum-tube oscillator may be distorted to produce a relatively large number of harmonics, so that it may also be operated as a frequency multiplier or divider, under the control of an injected voltage; however, the control is less stable than that obtained in either type of relaxation oscillator previously mentioned.

The practical importance of the systems outlined above may be summarized by stating that each is capable of being operated in such a manner as to derive by frequency division, from a high-frequency working standard, lower frequencies which are suitable for operating a counting mechanism. Further, due to the large number of harmonic frequencies in the output, it is perfectly feasible to combine the functions of the conversion equipment with those of the timing system, in a single assembly, by frequency multiplication.

III

The foregoing outline has necessarily been brief, but it has emphasized most of the fundamental concepts involved in frequency measurements. Here it may well be pointed

out again that the system under discussion has been a perfectly general skeleton upon which the elements of existing and proposed systems may be draped for easy classification. Most of the important system elements have been mentioned for the purpose of showing how they fit into the complete structure, but for detailed information on specific systems, the reader is referred to the papers and bibliographies appearing in the American and foreign technical periodicals (the *Proceedings of the I. R. E.*, in particular).

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frequency meter is next coupled rather loosely to it. As the frequency meter dial is swung past the frequency of the transmitter a change in the pitch of the beat note can be heard in the telephone receivers. The coupling between the transmitter and the frequency meter is then loosened until the variation in the beat note becomes almost inaudible. The setting of the frequency meter at which the beat note changes in pitch is the frequency of the transmitter. With this method it is possible to check the meter against standard frequency transmissions from such a station as WWV.

This raises the question of the accuracy of the TYPE 558-P Frequency Meter (the type number for the new meter without a neon indicator). Its calibration in the laboratory is made to within 0.25%, but how long that accuracy can be maintained depends in large measure upon the treatment that the instrument receives. The TYPE 224 Precision Frequency Meter costing ten times as much as the TYPE 558-P Meter is calibrated with the same accuracy, but it will retain that calibration longer and, because of its micrometer scale, be capable of a more precise setting than the little fellow. The TYPE 558-P Meter is carefully packed before shipment, and, if it is not roughly handled or subjected to extremes in temperature, the original calibration should hold closely. Even the calibration of the precision frequency meters is guaranteed for only six months; and it follows that the less sturdy amateur-band frequency meter should be checked by reference to the standard frequency transmissions or returned to the General Radio Company for recalibration at least that often.

There are five coupling inductors, four of which are wound on bakelite tubing threaded to insure that the spacing between turns remains fixed. The 5-meter inductor is a simple loop of heavy brass rod. The TYPE 558-P Frequency Meter is shipped in a strong packing case, in addition to the storage box supplied with the instrument. Each one is individually calibrated to within 0.25%.

Its price is \$18.00, \$2.00 less than the old TYPE 558 Neon-Tube Meter. The code word is WOMAN.