THE General Radio EXPERIMENTER

VOLUME XII NO. 5 OCTOBER, 1937

ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

Also IN THIS ISSUE

A PEAK-READING POWER-LEVEL INDICATOR FOR MONITORING BROADCAST AND SOUND RECORDING CIRCUITS

● THE SHORTCOMINGS of existing types of power-level indicators are matters of common knowledge to both the chief engineer and the man who "rides the gain" in the monitoring booth. Old-style, sluggish indicators, however well they may read the r-m-s average of power levels, are useless for indicating the rapid surges of power in speech and music transmission. These sudden peaks of short duration cause circuit overload with its attendant transmitter distortion and light-valve clash in sound recording. The newer high-speed meter movements, on the other hand, follow the minor level fluctuations so faithfully that the eye has difficulty in interpreting the readings, and their continued use results in eyestrain and fatigue.

The ideal meter characteristic is one having a fast upswing so that true amplitude indications are obtained on the shortest pulses of speech and music, while a slow return movement makes it possible to observe the peak amplitude and eliminates the fatiguing erratic motion characteristic of the rapid return swing.

This arrangement, used in modern broadcast modulation monitors, was originally agreed upon as a result of conferences on broadcast modulation monitors sponsored by the Federal Communications Commission. Attending the conferences were representatives of the Com-

Figure 1. Panel view of the Type 686-A Power-Level Indicator

FIGURE 2. Photograph of the indicating meter. The main scale is black on a yellow background. The decibel scale is red. Two lamps behind the panel illuminate the scale

mission, the broadcasters, and leading manufacturers of radio instruments. Tests and demonstrations of different types of meter movements were made through the courtesy of Bell Telephone Laboratories in New York City. These conferences were the basis of the Federal Communications Commission specifications for modulation monitors. The desirability of this type of monitoring indication has been amply demonstrated by the modulation monitors, and this has served to emphasize the need for a similar system in audio-frequency monitoring. Among the advantages of such a system are:

(1) A more accurate indication of peaks is obtained.

(2) The meter is easy to read without eyestrain.

(3) Because it gives the same type of peak indication as does the modulation monitor, audio-frequency power-level readings can be interpreted in terms of percentage modulation and *peak readings accurately checked between the studio and the transmitter.*

(4) By adding a 0-to-100 scale like that on the percentage modulation meter, the reading of the power-level indicator can be made to coincide with that of the modulation monitor.

(5) The psychological effect is excellent in that the meter seems to show the audio wave as it sounds to the ear from a monitoring loudspeaker or headphones.

TYPE 686-A POWER-LEVEL INDICATOR*

General Radio's new TYPE 686-A Power-Level Indicator, shown in Figure 1, has the high-speed, slow-return meter movement just described. Designed to meet a set of rigid specifications for electrical performance, it registers faithfully and follows accurately the peaks occurring in speech and music. Particular attention has been given to mechanical features such as ease of reading and accessibility of tubes and other component parts.

CIRCUIT

The circuit is that of a full-wave vacuum-tube voltmeter with a linear preamplifier. Since the input impedance is resistive and constant with amplitude, no distortion is introduced into the channel across which it is connected. This impedance is greater than 15,000 ohms, resulting in an insertion loss of less than 0.15 decibel. Consequently, a negligible amount of power is absorbed from 500-ohm transmission lines.

METER

The indicator is a large high-speed Weston Model 643 Meter. The needle reaches its maximum deflection in approximately 0.15 second which means that it will respond to the shortest pulses occurring in most speech and music circuits. The mechanical damping

*This instrument has been developed in collaboration with the Columbia Broadcasting System. Their assistance in design and testing is gratefully acknowledged.

stops the swing at maximum amplitude with no appreciable overshoot, and an electrical delay circuit, composed of capacitance and resistance, allows it to return slowly toward zero. In this way the meter registers accurately each peak, but appears to "float" on the peaks without erratic movement.

The meter scale, shown in Figure 2, is printed in simple bold figures on a soft yellow background. The main scale, reading from 0 to 100, can be used to indicate per cent modulation, per cent of modulation capability, per cent utilization of channel, or percentage of any arbitrary limit. An auxiliary scale reading in decibels is also provided. The scale is illuminated from behind the panel so that it is easily read in dark monitoring booths. The upper range of the scale above 100 is colored red as a warning against small overloads.

RANGE

A wide operating range is provided. Zero decibels on the meter, which is about three-quarters of the way upscale, correspond at greatest sensitivity to an operating circuit level as low as −20 decibels. A level of −40 decibels represents a deflection of about ¼ inch and is easily readable. The maximum level is +33 decibels. The operating level of the instrument is adjustable by means of a 10-step switch in 2-decibel steps and a key-switch multiplier.

OTHER DESIGN FEATURES

No power transformers or filter choke coils are used. Therefore, the instrument cannot induce 60-cycle hum into surrounding high-gain amplifiers by inductive pickup. All tubes are easily accessible from back of relay rack. The input may be connected to a terminal board in rear or to normal-through standard double patch-cord jacks at front of panel. This feature is especially useful when the instrument, although permanently connected in one channel, is desired to check another system which cannot be patched in through the regular patchboard. The power input terminals are shown at the right of Figure 3. The attachment is designed to hold BX cable which can be wired directly to the terminals shown. —Arthur E. Thiessen

Figure 3. Rear view of the power-level indicator with dust cover removed. Note that all tubes are easily accessible from the rear

SPECIFICATIONS FOR TYPE 686-A POWER-LEVEL INDICATOR

Power-Level Range: Zero decibels on the meter scale (100 on black scale) will represent from −20 to +30 decibels, depending on attenuator setting. Total over-all calibrated range −40 to +33 decibels. All ratings are for a zero level of 6 milliwatts in a 500-ohm line. Calibration at other zero levels or for other line impedances can be supplied on order.

Frequency Characteristic: The frequency response is flat within one decibel from 60 to 10,000 cycles; within two decibels from 40 to 12,000 cycles.

Vacuum Tubes: Five all-metal tubes are used, easily accessible from back of panel:

3 — Type 6F5
1 — Type 6H6
1 — Type 25Z6

Calibration: The instrument is precalibrated at the factory, and any change resulting from tube replacements can be easily corrected by the user.

Power Supply: 115 volts alternating current, 50 to 60 cycles.

Mounting: Standard relay-rack mounting, 19 inches by 5¼ inches; depth behind panel, 8½ inches; black crackle panel finish.

Net Weight: 23½ pounds with tubes and accessories.

Type		*Code Word*	*Price*
686-A		ANGER	$195.00

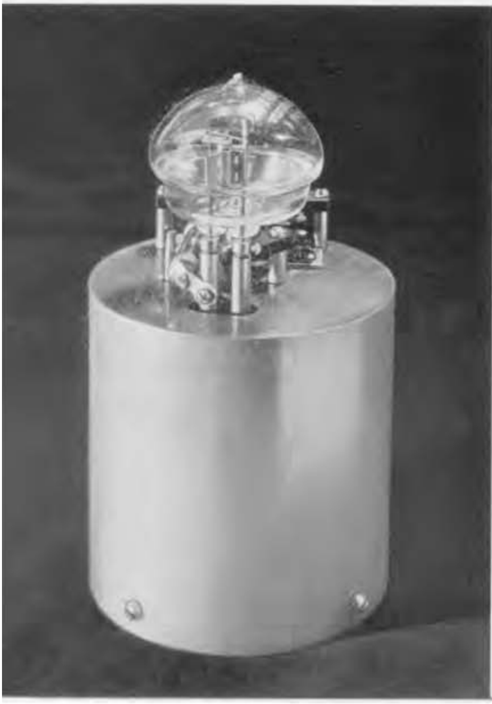
This instrument is licensed under patents of the American Telephone and Telegraph Company, solely for utilization in research, investigation, measurement, testing, instruction, and development work in pure and applied science

AN ULTRA-HIGH-FREQUENCY OSCILLATOR

• **THE WIDENING FIELD** of usefulness for ultra-high frequencies in radio communication has naturally stimulated the development of equipment for making measurements at those frequencies. Measurements of such factors as reactance, resistance, dielectric constant, permeability, and power factor are necessary both to prove the acceptability of existing designs and to provide a basis for the development of new designs and the application of new materials.

A prerequisite for measurements at any frequency is a satisfactory power source. The author, a member of the staff of the Department of Electrical Engineering at the Massachusetts Institute of Technology, has developed for this purpose the ultra-high-frequency oscillator described here. The work was a joint research project of M. I. T. and the General Radio Company.

— Editor



Vacuum-tube oscillators for operation at ultra-high frequencies have received considerable attention in the last few years. Improved vacuum tubes have permitted the use of circuits which govern the frequency of oscillation to a much greater degree than is possible at these frequencies with the older and more conventional tubes. Several tank circuits for frequency stabilization have been developed, notably the parallel-wire and coaxial transmission lines and the Kolster toroid. None of these, however, meets all the requirements for a satisfactory laboratory source. These requirements are as follows: (1) A high degree of frequency stability under varying external conditions, (2) a confined

Figure 1. The complete oscillator consisting of tank circuit and vacuum tube. The over-all height is 7 inches

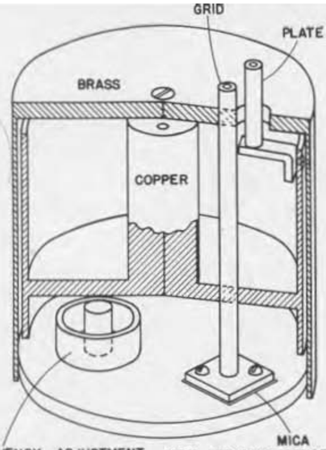


FIGURE 2. Sectional view of the tank circuit showing details of assembly

electromagnetic field, (3) ample output for use as a source for high frequency measurements, and (4) a convenient physical size. A good compromise between these conflicting requirements has been achieved in a new oscillator utilizing a vacuum tube[1] especially designed for the ultra-high frequencies coupled to a lumped concentric-element tank circuit.

This tank circuit consists of an outer containing-cylinder with a cylindrical piston-shaped insert. Referring to Figures 2 and 3, it is perhaps simplest to consider the oscillatory tank circuit as an L-C circuit, whose capacitance is that formed by the outer cylinder and the large inner copper tube, and whose inductance is that obtained by the field surrounding the inner copper rod. The dimensions of the tuned circuit are sufficiently small in comparison with the wavelength to permit its treatment as a lumped circuit.

The effectiveness of this oscillatory circuit for frequency stabilization is the result of the low losses in its component elements and of its connection to the vacuum tube in such a manner as to appear as a circuit with elements of low reactance. For the oscillator illustrated, which has an outside diameter of slightly more than 4 inches, the tank capacity is

[1]Kelly, M. J., and A. L. Samuel, "Vacuum Tubes as High Frequency Oscillators," *E. E.*, Vol. LIII, No. 11, Nov., 1934, pp. 1504-1517.

FIGURE 3. The concentric-element tank circuit taken apart. The outer brass shell is shown on the left, the inner copper cylinder on the right. The brass disc in the foreground closes the brass cylinder after the copper insert has been placed in position. The small copper cylinder, located eccentrically on a shaft passing through the disc, was used in conjunction with the large copper cylinder to form a small, variable condenser for the adjustment of the frequency to a particular value. The grid-blocking condenser made of a brass plate, separated from the brass disc by a thin mica sheet, is the support for the grid rod.

about 130 $\mu\mu$f, and the tank inductance, about 18cm (18×10^{-9}h). At its operating frequency of 100 Mc the Q of the resonant circuit is approximately 2500.

The properties of this oscillator which are of interest here are the effect on the frequency of oscillation of variations in electrode voltages and other external conditions, the effect of loading, and the drift in frequency during the warming-up period.

The change in the frequency of oscillation produced by a variation in the applied plate voltage is given in Figure 4. There is also given in the same figure a similar curve obtained when the oscillator was connected to a resistive load so as to produce 4 watts output to the resistor with a plate-circuit efficiency of 20% at a plate voltage of 400 volts. The stability for the loaded condition is naturally not so good as that obtained for the oscillator unloaded because of the increased losses of the complete system, but it is much better than the stabilities of earlier types of oscillators for this frequency region[2].

Because of the method used in the measurement of these changes in frequency, these results contain no appreciable drift effect and can be considered as essentially dynamic measurements. That is, the effect of physical changes in the oscillator as a result of varying thermal conditions was minimized in order not to mask the effect of dynamic changes in the tube parameters.

A rapid variation of the applied filament voltage produced only a very small shift in the frequency. However, a slow variation in the filament voltage which permitted the thermal equilibrium of the filament to readjust itself produced a change in frequency opposite in sense to, and somewhat greater in magnitude than, that produced during the rapid variation of the plate voltage shown in Figure 4.

The ambient temperature coefficient of frequency of the oscillator has been made less than the temperature coefficient of expansion of the individual metals which are used in the tank circuit. This reduction has been accomplished by the proper utilization of the differing temperature coefficients of expansion of brass and copper to produce a tank

[2]Dennhardt, A., "Ueber Mehrrohrschaltungen für sehr hohe Frequenzen," *Zeitschrift für Hochfrequenztechnik*, Vol. XXXV, No. 6, June, 1930, pp. 212-223.

Wenstrom, W. H., "An Experimental Study of Regenerative Ultra-Short-Wave Oscillators," *Proc. I. R. E.*, Vol. XX, January, 1932, pp. 113-130.

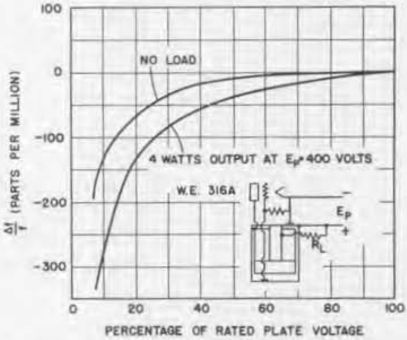


FIGURE 4. Change in frequency produced by a variation in applied plate voltage. The upper curve is taken at no load, the lower with a load of 4 watts

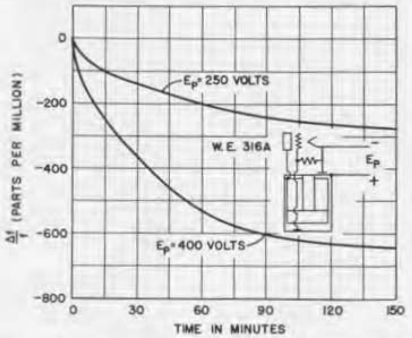


FIGURE 5. Drift in frequency of oscillation during warming-up period at plate voltages of 250 volts and 400 volts

capacitance with a negative temperature coefficient which approximately balances the positive temperature coefficient of the inductance. By this means, an ambient temperature coefficient of frequency of less than 5 parts per million per degree Centigrade is readily achieved.

The drift in frequency of oscillation during the warming-up period for the unit illustrated is given in Figure 5. This drift, which is approximately proportional to the input power to the plate circuit, is primarily a result of changes in the spacing of the tank condenser because of the temperature differential developed in the oscillator. By a change in the design of the given tank circuit, this drift can be materially reduced. However, to accomplish this reduction, the physical size should be increased, or the resultant frequency stability during varying electrode voltage conditions will be lessened. Thus, for a given application of this type of oscillator, unless compensation means are used, a design which effects the best compromise for that application should be adopted.

—Arnold Peterson

TYPE 418-G DUMMY ANTENNA

● **TENTATIVE SPECIFICATIONS** for a new standard dummy antenna for receiver testing have been adopted by the I.R.E. Standards Committee on Radio Receivers. Previously two dummy antennas were recommended to simulate the characteristics of a standard receiving antenna. One of these, intended for use between 540 and 1600 kc, consisted of a series circuit containing 200 $\mu\mu f$, 20 μh, and 25 Ω; the other, for use at higher frequencies, was a 400-ohm series resistance.

The new standard dummy antenna approximates both these characteristics. Its minimum impedance is 220 ohms, mainly resistive, at 2200 kc. The impedance approaches 400 ohms resistive at higher frequencies. The circuit constants and the impedance characteristic of the antenna are shown in Figure 1.

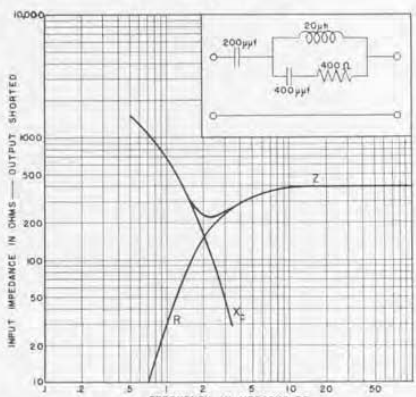


Figure 1. Resistance, reactance, and impedance characteristics of the Type 418-G Dummy Antenna

The new Type 418-G Dummy Antenna is designed to these specifications. It is mounted in a cylindrical metal case, with plug and jack terminals to fit the Type 605-A Standard-Signal Generator and its output cable.

SPECIFICATIONS

Dimensions: (Length) 4⅛ x (diameter) 1⅜ inches, over-all.

Net Weight: 6 ounces.

Type	*Code Word*	*Price*
418-G	DITCH	$10.00

Figure 2. Photograph of the dummy antenna

MISCELLANY

● **THIS YEAR'S** unusually brisk season of transatlantic travel was augmented on the week-end of September 19 by the return of General Radio's treasurer and the departure of its president. Mr. Richmond, returning from several weeks in western Europe, brings a full quota of photographs, including several excellent views of our foreign sales agencies. Mr. Eastham, leaving for a vacation of about three months, plans to spend some time in eastern Europe.

● **TYPE 686-A POWER-LEVEL INDICATOR**, described in this issue of the *Experimenter*, was designed by A. E. Thiessen and Frederick Ireland.

● **IF YOU ARE ATTENDING** the Rochester Fall Meeting of the Institute of Radio Engineers, be sure to call at the General Radio booth. Measuring and test instruments for manufacturers of receivers and parts will be on display, and a staff of GR engineers will be in attendance.

● **MR. ROBERT F. FIELD** held his annual house party for GR engineers on the week-end of September 19 at Lake Winnipesaukee, New Hampshire. Nineteen attended and made full use of the available facilities for sailing, swimming, tennis, badminton, and other outdoor sports. A Saturday guest was Electronics' Editor, Keith Henney, whose Leica was much in evidence. Those familiar with Mr. Henney's prowess in the field of portraiture will be interested in the marine scene shown above. His erstwhile portrait victims at General Radio wish him all possible success in this new field.

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