THE General Radio EXPERIMENTER

VOLUME XXI No. 6 NOVEMBER, 1946


ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

# THE NEW BROADCAST MONITORING EQUIPMENT

*Also*

IN THIS ISSUE



●EVER SINCE commercial broadcasting began in 1922, General Radio monitoring equipment has been used to measure station performance. The first General Radio frequency monitors were general purpose wavemeters, later displaced by narrow-range, more precise types as frequency tolerances were narrowed. Simple crystal oscillators were used in the late 1920's and, by 1929, temperature control was required. The direct-reading frequency-deviation meter[1] was added to the improved crystal oscillator[2] in 1932 to provide a continuous indication of magnitude and direction of transmitter frequency drift. Successive models incorporated a number of improvements, but the basic design remained unchanged until the new, postwar Type 1181-A Frequency Deviation Monitor appeared.

[1]U.S.Pat. No. 1,944,315.
[2]U.S.Pat. No. 2,012,497.

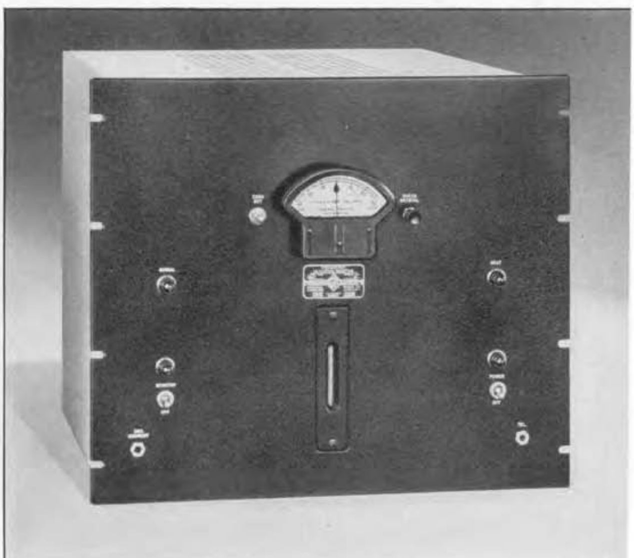


Figure 1. Panel view of the Type 1181-A Frequency - Deviation Monitor.

Development of the modulation monitor has followed a similar course. An instrument for the direct measurement of modulation percentage, the TYPE 457-A Modulation Meter[3], was introduced by General Radio in 1930. This was followed in a few years by one of the first continuously indicating modulation monitors[4], the TYPE 731. The latest model, TYPE 1931-A, embodies a number of improvements not found in older models.

The new frequency and modulation monitors are the result of many years' experience in the design and construction of this class of equipment. Designs were partially complete in 1941, but priority regulations did not permit the manufacture of broadcast monitors during the war. These new instruments are now in production, although deliveries are still hampered by material shortages. No announcement of the new monitors has hitherto been made in the *Experimenter*, although some hundreds of monitors have already been sold. The following brief descriptions may be of interest to many of our readers who are not directly connected with the broadcasting industry.

## TYPE 1181-A FREQUENCY DEVIATION MONITOR

The outstanding operating feature of this monitor is its ability to operate on a modulated signal. Hitherto, it has been necessary to couple the monitor to a point in the transmitter where an unmodulated signal was available. This often posed a problem, particularly in transmitters with low-level modulation. Operation directly from the modulated transmitter output is a considerable improvement, simplifying both installation and operation.

The system[5] for making the deviation indication independent of waveform is indicated in the block diagram of Figure 2. By means of clipping and limiting circuits, the beat frequency waveform is modified to a constant, square waveform, thus eliminating the amplitude variations caused by modulation. After suitable amplification, these square waves are applied to a discriminator circuit (or frequency meter), similar to that used on previous models, but modified somewhat for operation on square waves.

As a further simplification of the coupling problem, the sensitivity has

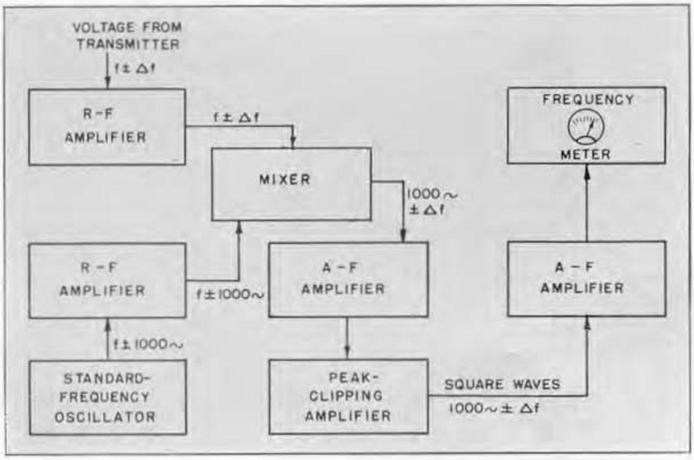



Figure 2. Functional block diagram showing the operation of the frequency-deviation monitor.

[3]U.S.Pat. No. 2,012,291.
[4]U.S.Pat. No. 2,069,934.
[5]U.S.Pat. No. 2,362,503.

been increased so that sufficient pick-up is obtained on a few feet of wire, acting as an antenna.

An aperiodic amplifier is used for the r-f signal, thus assuring sufficient voltage to saturate the square-wave generating circuits under all normal conditions of operation and for high levels of modulation. Sufficient sensitivity is provided to permit remote monitoring if a tuned antenna is used.

The constant-temperature oven in the new monitor is smaller than that used in previous models, since modern, low-temperature-coefficient crystals do not require as precise a temperature control as the older types. This leads to an appreciable saving in space, which, with other improvements in mechanical design, makes the new monitor considerably less bulky than the two-panel arrangement previously used.

Mechanically, the assembly is designed for easy access to all parts and for efficient ventilation. Chassis assemblies run vertically at each end of the panel, so that the heat generated in tubes and transformers can be carried out at the top by the natural air stream through the center of the instrument. Sub-mounted parts are accessible when cover plates are removed at the sides.

The illuminated meter is easily read at a considerable distance. Both the meter lamp and a pilot lamp are extinguished when the r-f input signal falls below the required minimum. A push button is provided for checking the crystal signal amplitude. As in previous models, a heat fuse protects the temperature-control system from burnout in case of thermostat failure.

Accuracy, convenience, and reliability were the design objectives in the TYPE 1181-A Frequency Deviation Monitor, and it meets or exceeds all F.C.C. specifications given in the Standards of Good Engineering Practice. It is now undergoing F.C.C. approval tests.

## TYPE 1931-A AMPLITUDE-MODULATION MONITOR

While operating on the same principle as previous models, the new TYPE 1931-A Modulation Monitor embodies a number of improvements.

Various circuit changes have been made to achieve greater dependability and accuracy, particularly in the flashing lamp circuit. The meter scales are illuminated and easily readable from across the transmitter room.

One new feature of considerable importance to users of high-fidelity transmitters is an additional detector circuit which provides a demodulator output with less than 0.1% distortion. Measure-

Figure 3. Panel view of the Type 1931-A Modulation Monitor.

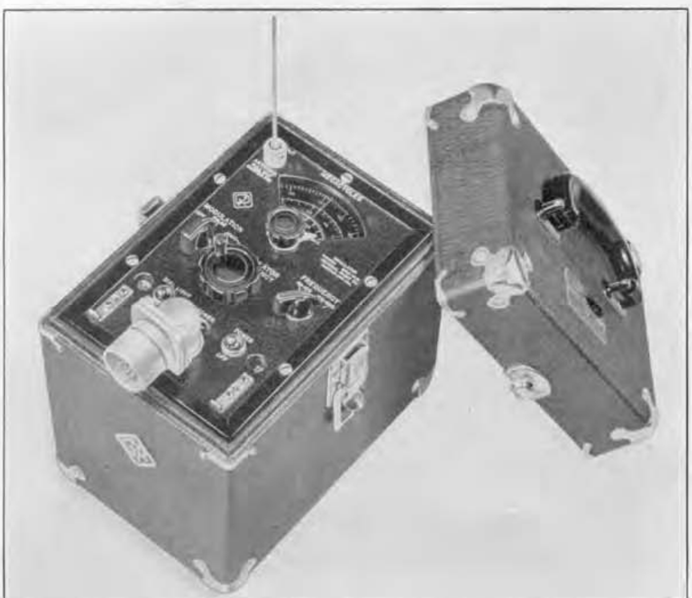
ments of audio distortion in the transmitter can be made by feeding this output to a TYPE 1932-A Distortion and Noise Meter or a TYPE 736-A Wave Analyzer. A low-impedance, 600-ohm output circuit is also provided for audible monitoring.

The TYPE 1931-A Amplitude-Modulation Monitor is approved by the F.C.C. and has been assigned Approval No. 1555.

## A WIDE-RANGE U-H-F TEST OSCILLATOR

One of the instruments developed for the armed services by General Radio during the war was a low-power, portable, u-h-f oscillator which was used for making rough field checks of the alignment, calibration, and performance of several types of wide-range radar-intercept receivers. These receivers, covering the frequency range from 40 to above 1000 Mc, were used in the radar-countermeasure program for monitoring and locating enemy radar stations, for setting a jamming transmitter on the frequency of an enemy radar, and for many other purposes. Consequently, large numbers of them were installed on ships, in aircraft, and at ground positions. In order to attain maximum performance from the receivers, it was found desirable to test them frequently under actual operating conditions, as installed in a ship or aircraft. Since it was usually impractical to transport bulky test equipment to the operating site, the test instrument had to be a single small unit, simple to use and capable of operating from a wide variety of power sources. The unit developed by General Radio to fulfill this requirement was later manufactured by the Fairchild Camera and Instrument Company* to General Radio drawings, and bore the service designation, TS-47/APR Test Oscillator.

As can be seen from the panel view in



*David W. Moore, Jr., "Test Oscillator TS-47/APR," *Radio News*, May, 1946.

Figure 1. View of the instrument in its cabinet with cover removed.

Figure 1, the oscillator was unusually small and compact. The unit shown, containing a tunable oscillator, a modulator, an a-c power supply, and a built-in antenna, was housed in a moderately well-shielded case. The dimensions were only 10″ x 8″ x 11″ overall and the weight about 15 pounds. Oscillator tuning was controlled by a single knob, and the dial indicated the operating frequency directly within ±1%. The frequency range between 40 and 500 megacycles was covered on the fundamental of the oscillator with a maximum output of at least 5 mw at frequencies below 400 Mc and a somewhat lower output at higher frequencies. The output signal was rich in harmonics, and relatively strong usable signals were present up to frequencies of about 1500 Mc. Since only rough performance checks were required, no provision was made for monitoring the power output, but a simple output control was included. In order to make the instrument as generally useful as possible, internal circuits were provided for amplitude modulating the carrier with a 1000-cycle sine wave or a fairly long pulse.

## R-F CIRCUIT

Since simplicity was a prime factor in the design of the instrument, a very elementary r-f circuit was chosen. Basically it consisted of a plate-modulated oscillator whose output was fed to an output connector or an antenna through a coaxial cable. The coupling between cable and oscillator was accomplished by means of a rotatable loop which served as the output control.

In the frequency range covered by the instrument, a butterfly circuit[1,2,3] has several characteristics which make it a logical choice for use as the oscillator resonator. Some of these characteristics are:

1. A butterfly is capable of tuning over very wide frequency ranges at relatively high frequencies, thus minimizing the complexity of band switching problems.

2. With a butterfly of the proper design, wide-range oscillators usually can be made to operate up to about 80% of the natural resonant frequency of the oscillator tube.

3. The frequency of oscillation is varied simply by a single control.

4. A butterfly circuit has no sliding contacts carrying large r-f currents.

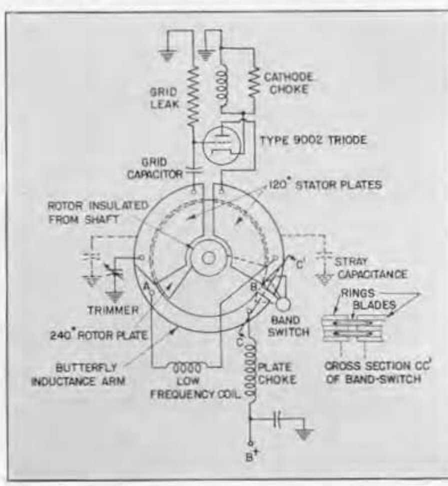
5. The unit is small and compact.

In order to keep the size of the oscillator at a minimum and to simplify the installation of a band changing switch, a semi-butterfly of the type shown in Figure 2 was selected.

A butterfly resonator, which is normally a two-terminal network, is well suited for use with a triode tube in a

[1] E. Karplus, "The Butterfly Circuit," *General Radio Experimenter*, Vol. XIX, No. 5, October, 1944.
[2] E. Karplus, "Wide-Range Tuned Circuits and Oscillators for High Frequencies," *Proceedings of the I.R.E.*, Vol. 33, No. 7, July, 1945, pp. 426-441.
[3] U. S. Patent No. 2,367,681.

Figure 2. Diagram of the r-f oscillator showing general construction of the butterfly and the band switch.



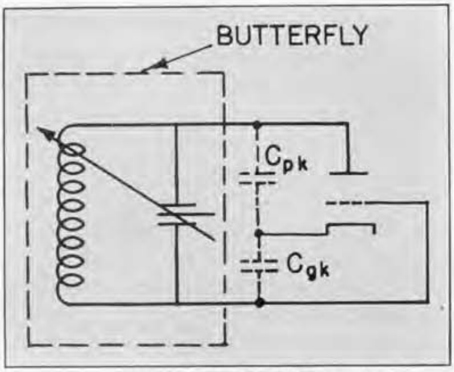



Figure 3. Basic r-f oscillator circuit.

modified Colpitts oscillator circuit in which the interelectrode tube capacitances form the feedback circuit. A basic schematic of the circuit is shown in Figure 3.

The Type 9002 Miniature Triode was selected as the oscillator tube because it was a preferred type and because of its relatively high natural resonant frequency, small size, and low power requirements. Since continuous coverage is not possible with the butterfly resonator at frequencies higher than about 80% of the natural resonant frequency of the tube, the upper frequency limit was fixed by this choice of tube.

A semi-butterfly resonator is actually a parallel resonant circuit which has a capacitive branch and an inductive branch. From Figure 2 it can be seen that the capacitive branch is made up mainly of the capacitance from one stator section to the rotor in series with the capacitance from the rotor to the other stator section, and that the inductance of the arm between points A and B constitutes the main portion of the inductive branch. As the rotor is turned in the counterclockwise direction from the position shown in the figure, the capacitance from the right-hand stator section to the rotor decreases, thus decreasing the total effective capacitance. The rotor also advances along the inductance arm, partially shielding it magnetically and hence reducing its inductance. As the result of the decrease in inductance with decreasing capacitance, a much wider tuning range is obtained than can be produced by varying the capacitance alone. In this butterfly a 2.25 to 1 change in inductance over the tuning range was obtained.

In spite of the advantage gained from the variation of both L and C in a butterfly, it was found to be impractical to cover the entire band from 40 to 500 Mc in one step, and it was necessary to break it into two bands. The high-frequency band from 115 to 500 Mc was covered with the resonator acting as a butterfly as described above. However, for the 40 to 115 Mc band, the butterfly inductance arm was open-circuited by means of the band switch which placed a low-frequency coil across the capacitance sections of the butterfly as shown in Figure 2. In the low-frequency band, the inductance remained fixed and the tuning was accomplished by means of the variation in capacitance alone.

The design of the band switch was important, as the inductance it introduced in its closed position had to be small compared to the minimum inductance of the inductive arm of the butterfly, or the tuning range would have been appreciably reduced. The losses it introduced in the circuit also had to be small to avoid reducing Q below the value required to sustain oscillation. Therefore, it was constructed of a multiple set of blades which interleaved the rings forming the inductance arm as shown in Figures 2 and 4. Each blade consisted of two spring leaves which were compressed when the blade was between the rings and made a rigid, low-loss, low-inductance connection.

In the type of Colpitts circuit used, the whole oscillator circuit, including the cathode of the tube, is floating with respect to ground and connections were made to the cathode, heaters, and plate through chokes. However, a choke is not an infinite impedance, and it was found that a "hole" in the oscillations occurred over a narrow frequency band, which appeared to be caused by a resonance in the circuit consisting of the cathode lead inductance, the choke impedance, and the stray capacitances of the stator sections to the shield. Although the frequency at which the hole appeared could be shifted by changing the reactance of the choke, a practical choke design was not found which would shift it out of the desired range. The hole was eliminated by connecting a resistor across one of the chokes as shown in Figure 2, to reduce the Q of the undesired resonance.

At the upper end of the frequency range, the operating frequency is largely dependent on the tube capacitances. Therefore, in order to compensate for changes in tube capacitance when the oscillator tube is replaced, a small adjustable trimmer capacitor was connected from one stator section to ground.

Mechanically, the butterfly stator was mounted on three insulating posts as shown in Figure 4, and was covered by an insulating plate that performed the dual function of supporting the oscillator tube socket and of clamping and aligning the two stator sections of the butterfly. The insulated rotor shaft turned in a set of ball bearings mounted in a casting below the butterfly. However, it was found that quarter-wave resonance occurred in the shaft circuit near the upper end of the tuning range, and it was necessary to ground the upper end of the metal shaft with a grounding strap as shown in Figure 4 in order to shift the spurious resonances out of the operating range.

The orientation of the output coupling loop was adjusted by a knob on the panel and was arranged to have its minimum and maximum coupling to both the butterfly inductance arm and the low frequency coil at approximately the same position. The power from the coupling loop was fed through a coaxial

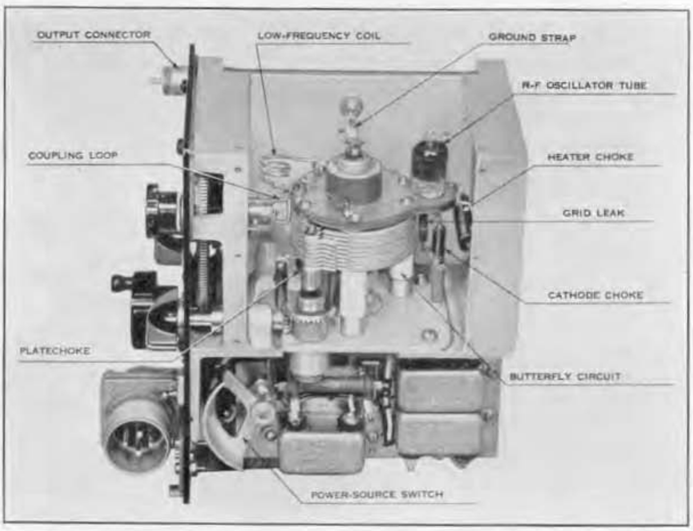



**Figure 4. Interior view of the instrument with shields removed.**

transmission line to the modified type N connector located on the panel. This connector was constructed in a novel manner as it could be used as a standard connector or an antenna. For use as an antenna, the center conductor was pulled out to any desired length up to 6 inches, as illustrated in Figure 1. The center conductor was formed of a tightly coiled spring and hence was not damaged by bending.

## MODULATOR AND POWER SUPPLY

The modulator was somewhat unconventional, consisting of a single tube which could be made to produce sine wave or pulse modulation. For sine wave modulation, a conventional Hartley circuit was used with the primary of the modulation transformer acting as the tuning inductor in the resonant circuit. For pulse modulation, the transformer was connected to form an oscillating circuit with an abnormally large amount of feedback and a natural frequency of about 7 kc, determined by stray capacitances. The grid resistance was so chosen that only one cycle of 7 kc oscillation occurred before the grid blocked. The first half cycle, which was positive, plate-pulsed the r-f oscillator. Although a long pulse was produced by this modulator, it was found to be adequate for many field testing purposes.

For maximum utility in its intended application, the instrument was designed to operate at all of the supply voltages and frequencies then in use by the Allied military services: 80, 115, and 230 volts, at frequencies between 50 and 2600 cycles. Provision was also made for operation from external batteries. A selector switch made the proper connections for the various types of power sources, and the type of power required was indicated on a drum attached to the switch which was visible through an opening in the panel.

## MECHANICAL FEATURES

In order to facilitate quantity production and to simplify maintenance, unit construction was used throughout. The whole oscillator assembly was made one removable unit and the power supply and modulator section was another unit. Connections were made between units by means of jumper wires connected between adjacent terminal strips.

Other mechanical features contributed materially to the utility and acceptability of the instrument. Among these was an edge-illuminated frequency dial which could be read regardless of external lighting conditions.

The unit was adapted for mounting in a standard ATR rack, and the whole assembly was shock mounted within its carrying case, a feature that made it possible for the instrument to withstand without damage the severe conditions of military use. —R. A. SODERMAN

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PRINTED IN U.S.A.