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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

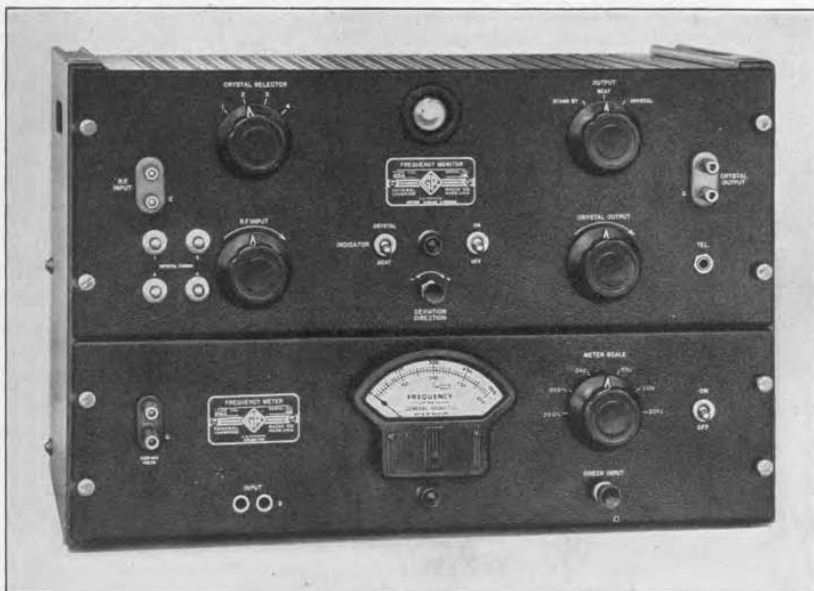
## A VERSATILE MONITOR FOR USE FROM 1.6 TO 150 MEGACYCLES

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● **THE RAPID GROWTH** of communications in the frequency range above the standard broadcast band has created a demand for monitoring equipment that is somewhat different from the types used in most standard broadcast transmitter work. In order to produce a satisfactory monitor for this service there are many factors to be considered in addition to the strictly technical ones of circuit design and physical layout.

Monitors for these frequencies will be used by a variety of radio services such as public service companies, municipal departments, railroads, airlines, highway transportation companies, high-frequency

Figure 1. View of the TYPE 1175-A Frequency Monitor with TYPE 1176-A Frequency Meter.



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broadcasting, television, and point-to-point communication. The ultimate users, therefore, will have varying degrees of technical skill, ranging from the very minimum to that of the professional radio engineer. Consequently, the monitor must be simple to operate and comparatively simple to install.

Such factors as multi-channel operation, remote monitoring, and mobile service will also influence the design; and further limitations are imposed by the wide frequency range to be covered and the different types of modulation encountered in the transmitters.

The over-all requirements for the monitor from the operating standpoint may be listed as:

1. STABILITY
2. SIMPLICITY OF OPERATION
3. MINIMUM MAINTENANCE REQUIREMENTS
4. ADEQUATE SENSITIVITY
5. EASE OF INSTALLATION
6. FLEXIBILITY

To meet these requirements, as well as the more technical ones of high-frequency monitoring, the TYPE 1175-A Frequency Monitor has been developed. When used in conjunction with the TYPE 1176-A Frequency Meter<sup>1</sup>, this monitor provides a direct indication of frequency deviation for all types of amplitude-modulated transmitters operating at frequencies between 1.6 and 150 megacycles.

The complete monitoring assembly is in two parts, as shown in Figure 1. The TYPE 1175-A Frequency Monitor contains a crystal oscillator, a buffer amplifier, a mixer, an r-f amplifier, and an output amplifier. The transmitter carrier

frequency is heterodyned with the crystal oscillator to produce a beat-frequency signal corresponding to the deviation from the assigned carrier frequency of the station. The TYPE 1176-A Frequency Meter is used to indicate the exact frequency of the heterodyne signal, or the deviation frequency in cycles per second. This instrument has six scales ranging from 200 to 60,000 cycles, full scale, in multiples of 2 and 6.

## GENERAL FEATURES

### Stability

Since the function of a monitor is to give a continuous check on the station frequency, stability of the instrument is of paramount importance. Low-temperature-coefficient crystals are used in a thermostatically controlled oven. Tube voltages are regulated to minimize the effect of varying line voltage. The crystal oscillator circuit<sup>2</sup> is one developed especially for frequency monitoring use and has excellent long-period stability.

### Multi-Channel Monitoring

As many as four channels can be monitored with a single instrument, since facilities for four crystals are provided in the temperature-controlled chamber. For applications involving monitoring more than four channels, a series of these monitors can be mounted in a relay rack, and a single frequency meter arranged to be switched between monitors. While it is sometimes possible to substitute crystals in one monitor alone, this practice is not recommended owing to the inaccuracies involved in re-tuning the crystal oscillator circuit each time that a new crystal is substituted.

<sup>1</sup> *General Radio Experimenter*, Vol. XX, No. 9, February, 1946.

<sup>2</sup> U. S. Patent No. 2,012,497.





### Mobile Transmitters

To cover the wide frequency range (1.6 to 150 Mc) with multi-channel operation, aperiodic amplifiers are used for both crystal and input buffer stages. These have sufficient sensitivity for all local monitoring applications. For mobile-transmitter monitoring, however, sufficient sensitivity must be provided to permit remote checking. In police work, for example, it is most convenient to be able to check, directly from the main control room, the transmitter frequency of an automobile located in the adjacent repair shop or cruising along a nearby street. To do this requires sensitivity approaching that of a radio receiver. For the lower frequencies, the internal wide-band amplifiers produce the desired sensitivity, and it is only necessary to connect any convenient form of antenna directly to the input terminals of the monitor. Unless there is a danger of adjacent channel interference, the antenna system need not be tuned. If there are several transmitters located in the vicinity which are within approximately 100 kc of the station frequency, a simple form of antenna tuning will eliminate any interference.

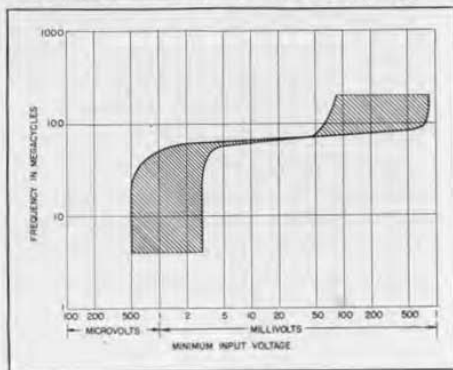
On the high-frequency channels, remote monitoring can be accomplished by the addition of a radio receiver to the monitoring system. In this case, the monitoring oscillator frequency is heterodyned with the received carrier by injecting the two signals into the receiver antenna terminals. The resulting low beat-frequency signal derived from the receiver is then measured directly on the frequency meter in the monitoring assembly. The one limitation to this system is the fact that the maximum deviation frequency that can be monitored will be determined by the bandwidth of the radio receiver's output

system. Since the frequency meter requires only about 0.25 volts or more input signal, and has a 0.5-megohm impedance, it is possible to avoid this limitation by connecting directly to the second detector in the radio receiver.

### Effect of Modulation

One of the most important features of the monitor is the fact that it will operate directly from an amplitude-modulated wave. This permits extreme flexibility in application, as previously noted. The circuits employed to produce this characteristic are not unlike those used in f-m receiving systems to discriminate against amplitude modulation, but with one important exception: the limiting circuits, instead of being placed in the radio frequency or i-f circuits, are in the low frequency circuits of the frequency-meter section. This arrangement is made necessary for several reasons. First of all, limiter circuits require relatively large signal amplitudes to work effectively, and these cannot be derived without tuned circuits or other complications at radio frequencies, but are quite simple to obtain at low frequencies. Secondly, placing limiters in the frequency-meter section permits operation over a wide range of signal amplitudes, since the

**Figure 2. Input sensitivity of the TYPE 1175-A Frequency Monitor over the normal operating range. The shaded area indicates the normal variation to be expected.**







frequency meter is not sensitive to input-signal amplitude changes over a ratio of 600:1 (0.25 — 150 volts).

While not specifically designed for television, this monitor has been successfully used to monitor television video-transmitters in the first six channels, i.e., 44 — 88 Mc.

The pulse type of amplitude modulation employed does not impair the operating characteristics of the monitor in any way.

#### Deviation Direction Test

Since the crystals are operated on exact carrier frequency harmonics and are not offset, an indicator to show the sign of the transmitter deviation-frequency is provided. A push-button switch is provided on the front panel. Depressing this switch lowers the crystal-oscillator frequency by a discrete amount. The direction of the change in deviation frequency, as noted on the frequency meter, determines the sign of the deviation. If, for example, the indicated frequency increases when the button is pressed, the deviation of the transmitter is on the high side of the assigned carrier frequency. The wide range of carrier frequencies and resultant wide range of deviation frequencies make a multi-step indicator necessary. This is achieved through the use of a three-step device on the push-button. Each step shifts the monitor crystal frequency a little more than the preceding one, and the final step is adjustable. This feature is necessary to cover the wide variety of monitoring conditions encountered. For example, one channel may operate at 2 Mc with the frequency meter set on the 200-cycle range; the next at 100 Mc, 6000-cycle range; one at 150 Mc, 60,000-cycle range; and perhaps a fourth high-frequency channel at

110 Mc, whose deviation frequency happens to be rather small and hence the frequency meter has been set to, say, the 600-cycle range. In the last case, only a very small shift in the monitor crystal frequency will be required to give an observable shift in the meter indication, and the push-button should be depressed only to the first notch. Further depression of the push-button will cause the beat-frequency produced between the station carrier and monitoring crystal harmonic to go through "zero beat" and will thus result in a false movement of the indicating meter. This condition can be avoided by depressing the push-button only one step at a time until an observable shift in the meter takes place. It is also possible to determine the sign of the transmitter deviation by making a very slight shift in carrier frequency and noting the result on the frequency monitor.

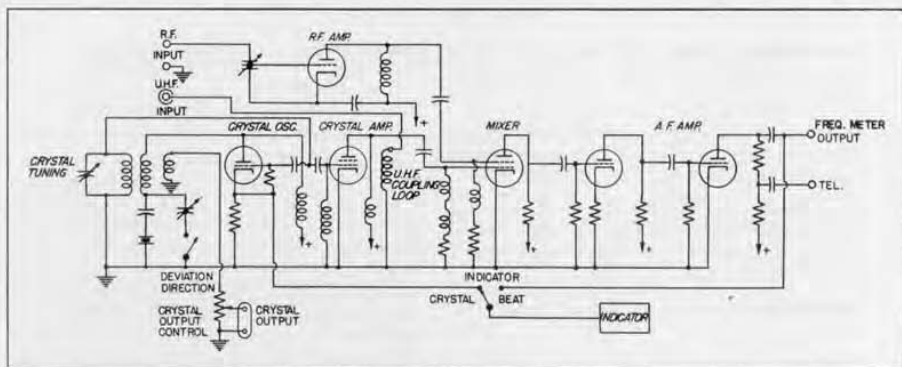
#### Other Indicators

As a guide to normal operations of the monitor, an electron-ray tube indicates the approximate amplitude of the beat frequency produced between the monitor crystal harmonic and the transmitter carrier frequency. It can also be switched into the crystal circuit to check the oscillation condition. Telephone jacks permit aural monitoring of the deviation frequency or visual checking using an external cathode-ray oscilloscope.

#### Panel

In the interests of operating ease, the panel controls are identified by suitable engraved markings, thus making their function easily apparent. Such things as instruction books are often misplaced, and under these conditions the operator must rely upon memory; panel controls are therefore kept to a minimum.





Elementary schematic diagram of the TYPE 1175-A Frequency Monitor.

## CIRCUIT DESIGN

### Input Circuit

Figure 3 is a functional schematic of the monitor. The r-f amplifier is used to obtain maximum sensitivity for the lower range of frequencies. Above its cut-off frequency the input is coupled directly to one of the mixer-tube grids. A capacitor-type input attenuator is provided to adjust the r-f input level. Four input circuits are provided, and one is automatically selected, together with the associated crystal, by means of the panel selector switch. For simplicity, only a single one is shown here. At the highest carrier frequencies, the mixer tube will not operate efficiently, and hence another system is employed. A single u-h-f coaxial input is used for this range. It is not necessary to provide more than one common input circuit, since the possibility of interference is greatly lessened at these frequencies. Coupling is achieved electromagnetically directly to the tube envelope of the crystal amplifier tube, and the tube formerly used as a mixer now functions as an additional output amplifier.

## Crystal Oscillator

The temperature-controlled crystal oven contains mounting sockets for a total of four crystals. These are relatively low frequency crystals (1.6–4.4 Mc) for maximum stability, and each is adjusted to have one of its harmonics coincide with the exact frequency of the transmitter to be monitored. The oscillator is of the tuned-grid magnetic-feedback type, and is loosely coupled to the buffer amplifier and harmonic generator. A low-impedance link-coupled circuit is brought out to panel terminals, and is provided with an attenuator. This permits a quick check to be made on receivers, tuned amplifiers, etc., using the crystal as a calibrated source of r-f.

Since the generation of crystal harmonics does not depend upon tuned circuits, multi-channel operation can be achieved without complexity. Crystal frequencies are selected to avoid possible interference between transmitters whose frequencies might fall at, or near, exact multiples of the same crystal fundamental.

— C. A. CADY



## SPECIFICATIONS

**Carrier Frequency Range:** 1600 kc to 150 Mc.

**Accuracy:** With TYPE 376-M Quartz Plate, 0.002%.

**Quartz Plate:** No crystals are included in the price. See price list below. Crystals are ground to a sub-multiple of the channel frequency.

**Power Supply:** 105 to 125 volts, 50 to 60 cycles. By changing connections on the power transformer, the monitor can be operated from a 210- to 250-volt line.

**Power Input:** 75 watts, including temperature control.

**Accessories Supplied:** All tubes; multipoint connector; spare fuses; spare pilot lamps; power cord.

**Vacuum Tubes:**

1—type 6AC7                    1—type 6J5  
1—type 6AG7                   1—type 6X5  
1—type 6E5                     1—type 7A8  
1—type 6SN7GT                1—type 0D3/VR150

All vacuum tubes are supplied.

**Panel Finishes:** Standard General Radio black crackle. Certain standard grays which can be processed in quantity can be supplied at a price increase of \$10.00\*.

**Mounting:** Standard 19-inch relay-rack panel. Walnut end frames are available for adapting the instrument for table mounting. (See price list below.)

**Dimensions:** Panel, 19 x 7 inches; depth behind panel, 11 $\frac{1}{4}$  inches.

**Net Weight:** 22 pounds.

Type		Code Word	Price
1175-A	Frequency Monitor.....	TIPSY	\$285.00*
376-M	Quartz Plate.....	LABOR	50.00*
ZFRI-410-P1	End Frames for Type 1175-A.....	ENDFRAMDAY	15.00 Pair*
ZFRI-710-P5	End Frames for Type 1175-A mounted with Type 1176-A as a single unit.....	ENDFRAMGAS	15.00 Pair*

This instrument is manufactured and sold under the following U. S. Patents:  
1,967,185    2,012,497

Patents and patent applications of G. W. Pierce.

Patents of the American Telephone and Telegraph Company.

## TYPE 1176-A FREQUENCY METER

A description of this instrument will be found in the *Experimenter* for February, 1946.

Type		Code Word	Price
1176-A	Frequency Meter.....	TIMID	\$230.00*

This instrument is manufactured and sold under U. S. Patent No. 2,362,503 and patents of the American Telephone and Telegraph Company.

\*Add 10% to above prices.

REPRINTS AVAILABLE  
ON IRON-CORED COIL ARTICLES

We shall have available shortly a reprint of the several articles on iron-cored coils that have appeared in the *Experimenter*. The pamphlet will include a cardboard Q template, a full-size plot of effective vs. measured air gaps and the complete text of the following articles:

L. B. Arguimbau, "Losses in Audio-Frequency Coils," November, 1936.

P. K. McElroy and R. F. Field, "How Good is an Iron-Cored Coil?" March, 1942.

P. K. McElroy, "Those Iron-Cored Coils Again," December, 1946, and January, 1947.

This reprint brings together for easy reference a valuable fund of information on coil design and should be a welcome addition to the engineer's technical data file.

A copy is yours for the asking.



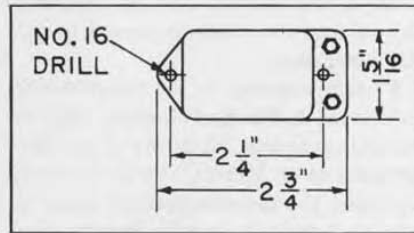




## NEW SIZES IN PRECISION FIXED RESISTORS

To complete the 1-2-5 distribution of resistance values in three decades of the resistance range covered by TYPE 500 resistors, three new units have been added: 20 ohms, 2,000 ohms, and 5,000 ohms. These handy resistors are excellent standards for use at audio- and low-radio frequencies. They are sealed in molded phenolic cases and are provided with both screw-type and plug-type terminals. The complete range of values is listed below, and most sizes are in stock.

All units are adjusted within 0.1%, except the 1-ohm size, which is adjusted within 0.25%.



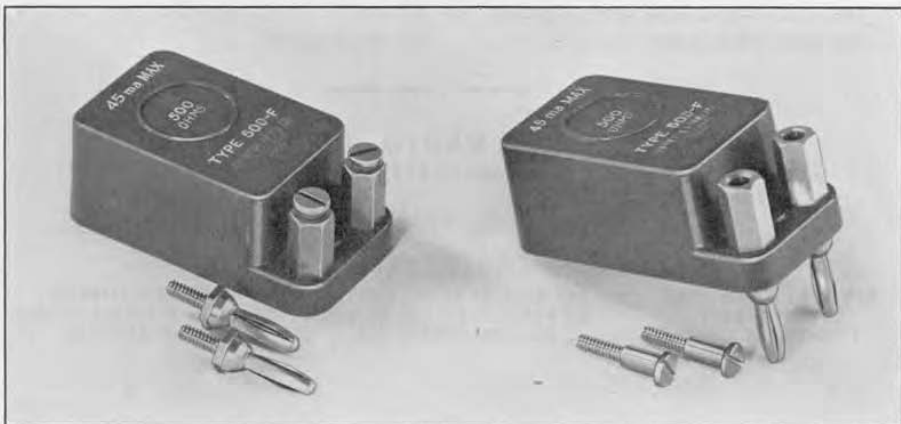
Over-all base dimensions of TYPE 500 Resistor.

### SPECIFICATIONS

Type	Resistance	Maximum Current	Code Word	Price
500-A	1 ohm	1.0 a	RESISTBIRD	\$2.50
500-B	10 ohms	310 ma	RESISTDESK	2.50
500-K	20 ohms	220 ma	RESISTFILM	2.50
500-C	50 ohms	140 ma	RESISTFORD	2.50
500-D	100 ohms	100 ma	RESISTFROG	2.50
500-E	200 ohms	70 ma	RESISTGIRL	2.50
500-F	500 ohms	45 ma	RESISTGOAT	2.50
500-G	600 ohms	40 ma	RESISTGOOD	2.50
500-H	1000 ohms	30 ma	RESISTHYMN	2.50
500-L	2000 ohms	22 ma	RESISTBELL	2.50
500-M	5000 ohms	14 ma	RESISTPIPE	2.50
500-J	10,000 ohms	10 ma	RESISTMILK	2.50

Add 10% to all prices listed.

View of TYPE 500 Resistor, showing how the terminals can be adapted for either screw-type or plug-in terminals.





## MISCELLANY

This venerable publication is in its twenty-first year, making it a Methuselah among radio and electronic journals. Such a claim to antiquity gives us an excuse to look back in the dusty files to find out what happened in our childhood days.

Twenty years ago in the *Experimenter* — Volume 1, No. 8, February, 1927 — the feature article, "A Study of Coil Resistances at 40 Meters," by L. B. Root, described the measurement of losses in a series of single-layer coils. Results were plotted as a function of wire size and of form factor. Measurements were made on the TYPE 353 Radio-Frequency Measuring Set, a remote ancestor of today's precise bridges, that flourished in the laissez-faire days before residual impedances were invented.

Another article described the TYPE 383 Portable Capacity Bridge for measuring small capacitances, such as those between the electrodes of a vacuum tube. Tubes in those days had a maximum of three electrodes, and grid-plate capacitances were about 10  $\mu\mu\text{f}$ .

Accuracy requirements were less stringent and frequency ranges more limited twenty years ago. Then as now, however, General Radio was making the radio industry's measuring equipment and GR instruments were standard in the radio laboratory.

The international aspect of General Radio's business is one from which we derive a good deal of pleasure. Contacts with businessmen in other countries are invariably stimulating, and they foster an international, rather than a strictly national, viewpoint on contemporary affairs. Most of our foreign representatives have handled General Radio products for a number of years, and with them we have built up a personal as well as a business interest. Since the war many of them have visited this country, as previously mentioned in this column. Two more that we have recently had the pleasure of welcoming back to our plant are Mr. Robert T. Ting, General Manager of the China Scientific Instrument Company, Shanghai, who have represented us for over fifteen years; and Mr. V. G. Motwane, Managing Director, Eastern Electric and Engineering Company, Bombay, our representatives in India for more than ten years.

Other recent visitors from abroad include Dr. B. J. O'Kane of the General Electric Company, Ltd., England; Mr. C. W. Goyer, Chief Engineer of the Broadcasting Department of the Government of India; Major Chen Ya-Sun, Ordnance Corps, Chinese Army; Mr. David Rich, Managing Director, Taylor Electrical Instrument Co., Ltd., Slough, Bucks, England.

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