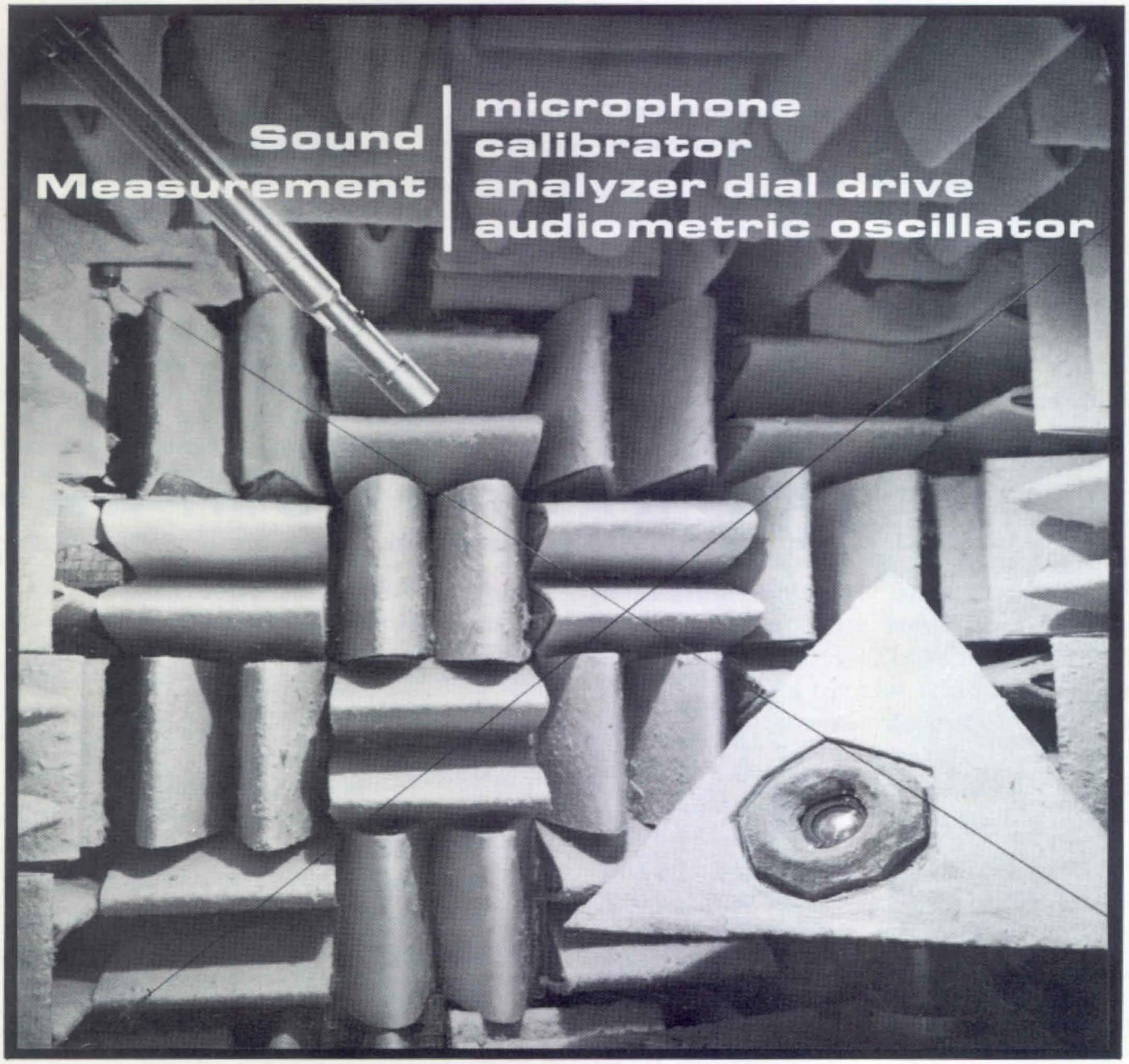
THE GENERAL RADIO

# Experimenter




VOLUME 41 · NUMBERS 5, 6 / MAY – JUNE 1967

Volume 41 • Nos. 5, 6
May-June 1967

# the GR Experimenter



Published monthly by the General Radio Company

## IN THIS ISSUE

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# THE NEW GENERAL RADIO MICROPHONE

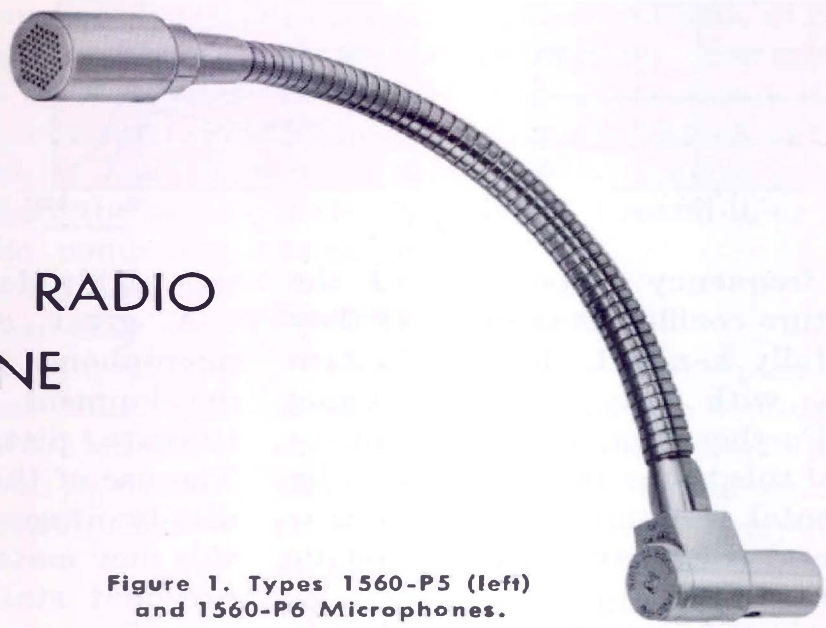

**Figure 1. Types 1560-P5 (left) and 1560-P6 Microphones.**

**If you think that piezoelectric microphones are too temperature-sensitive for precision measurements, the following article has a few surprises for you. New lead zirconate-titanate ceramic microphones have performance characteristics formerly associated only with expensive condenser microphones.**

In the continuing search for improved accuracy in sound measurements much effort has gone into improving the characteristics of microphones, because the microphone used is often regarded as the limiting factor in the accuracy of the measurement. Because of the long and continued development effort applied to the condenser microphone, particularly at the Bell Telephone Laboratories,[1] and the extensive work on its calibration in many laboratories all over the world, the condenser microphone very early gained wide acceptance as the best microphone for accurate sound measurements. This acceptance was achieved in spite of the inherent disadvantages of the condenser microphone as compared with the piezoelectric microphone, which is also widely used for sound measurements. These disadvantages are the need for a very high-input-impedance preamplifier supplying an accurately known, high dc polarizing voltage, smaller dynamic range, and greater sensitivity to the effects of humidity. There are, however, several reasons for the wide acceptance of the condenser microphone. Those units that have been carefully designed and built, such as the Western Electric 640AA Condenser Microphone, have a

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[1] E. C. Wente, "A Condenser Transmitter as a Uniformly Sensitive Instrument for the Absolute Measurement of Sound Intensity," *Physical Review*, Vol 10, 1917, pp 39–63.
E. C. Wente, "Sensitivity of the Electrostatic Transmitter for Measuring Sound Intensities," *Physical Review*, Vol 19, 1922, pp 478–503.
L. O. Sivian, "Absolute Calibration of Condenser Microphones," *Bell System Technical Journal*, Vol 10, No 1, January 1931, pp 96–115.
M. S. Hawley, "The Condenser Microphone as an Acoustic Standard," *Bell Laboratories Record*, Vol 33, No 1, January 1955, pp 6–10.

**This month's cover** — GR tests every one of its microphones for frequency response, sensitivity, capacitance, dissipation factor, leakage resistance, and linearity to 150 dB.

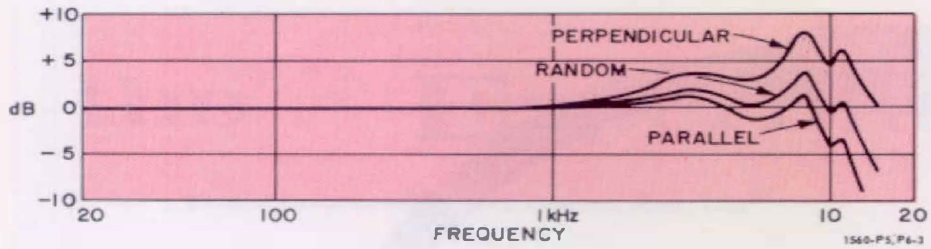


**Figure 2. Typical response curves for random, parallel, and perpendicular incidence.**

smooth frequency response, and the temperature coefficient is small. If they are carefully handled, their calibration is stable with only moderate aging effects. Furthermore, condenser microphones of this type can be calibrated by fundamental techniques in an acoustic cavity, and they have a high acoustic impedance.

Recent developments in piezoelectric microphones have demonstrated, however, that all these desirable features can now be obtained by the proper design of the piezoelectric microphone and at a lower over-all cost. Because of the additional inherent advantages of the piezoelectric microphone, we believe it will become the preferred microphone to use for acoustic measurements.

Most of the early piezoelectric microphones for sound measurements used a Rochelle-salt crystal as the sensitive element. Although stable and physically rugged, those microphones did not have a high acoustic impedance, and they could not be satisfactorily calibrated in an acoustic cavity. They also had more serious faults, because Rochelle salt is easily damaged by exposure to only moderately high temperatures (56°C), and the microphone capacitance was highly dependent on temperature.

A great advance in piezoelectric microphones was made possible by the development of the lead zirconate-titanate [2] piezoelectric ceramic element. The use of this material eliminated the disadvantages of Rochelle salt, since this new material can be obtained with excellent stability to 100°C, and the capacitance of the ceramic element is relatively independent of temperature.

The Types 1560-P3 and 1560-P4 Microphones,[3] supplied on our sound-measuring equipment until recently, use this material, and, as a result, they are stable and rugged, and their characteristics are essentially independent of normal temperature variations. They can also be calibrated by reciprocity techniques in a closed coupler.[4]

When these microphones became available, the most important reasons for using the condenser microphone were eliminated, and the Type 1560-P3 Microphone has been widely used for sound measurements. Many measurements, however, have been standardized to use the condenser microphone, which had a diameter of 0.936 inch in contrast with the 1⅛ inches of the Type 1560-P3.

Therefore, the next step in the development of the piezoelectric measurement microphone was the adoption of this standard diameter. At the same time it was found possible to obtain a significant improvement in the response characteristic.

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[2] B. Jaffe, R. S. Roth, and S. Maryallo, "Properties of Piezoelectric Ceramics in the Solid-Solution Series Lead Titanate-Lead Zirconate-Lead Oxide: Tin Oxide and Lead Titanate-Lead Hafnate," *Journal of Research of the National Bureau of Standards*, Vol 55, No 5, November 1955, pp 239–254.
[3] E. E. Gross, "Type 1551-C Sound-Level Meter," *General Radio Experimenter*, August 1961.
[4] B. A. Bonk, "Absolute Calibration of PZT Microphones," *General Radio Experimenter*, April–May 1963.

The result of this development is the new TYPE 1560-P5 Microphone, shown in Figure 1, manufactured by the General Radio Company, and now used on GR acoustical instruments. It has the same diameter and essentially the same acoustic impedance as the condenser microphone, so that it is suitable for applications where heretofore only condenser microphones have been used. Its frequency response is better than that of any previously available sensitive piezoelectric microphone and is similar to that of the WE 640AA Condenser Microphone up to 15 kHz.

### Details of Construction

The microphone is enclosed in an outer brass shell with a brushed chromium plating, which maintains the same high quality of finish after years of use. The aluminum diaphragm directly behind the protective front grid drives a ceramic piezoelectric element, and the electrical output appears at pin terminals at the back of the cartridge. The air leak is also at the back.

The cartridge is available, connected directly to a 3-pin male audio connector, as the TYPE 1560-P5 Microphone or, when connected through a gooseneck to such an audio connector, as the TYPE 1560-P6 Microphone Assembly, also shown in Figure 1. It is now also supplied on the TYPES 1565-A and 1551-C Sound-Level Meters and as part of the TYPE 1560-P40K Preamplifier and Microphone Set.[5]

### Frequency Response

The microphone is designed to have a nearly flat response to sounds of random incidence. Figure 2 shows a typical response curve of the microphone for random, parallel, and perpendicular incidence. Most of these microphones follow the random-incidence curve within ±1 dB from 20 to 7000 Hz.

### Directivity

The new microphone, since it has the same size as a type L laboratory standard microphone and is similar in construction, maintains the same good omnidirectional characteristics. Up to 1000 Hz the variation in output with angle of sound incidence is small. Above 1000 Hz diffraction causes the microphone to respond more to sounds arriving normal to the diaphragm (0° or

[5] C. A. Woodward, "A New, Low-Noise Preamplifier," *General Radio Experimenter*, June 1965.

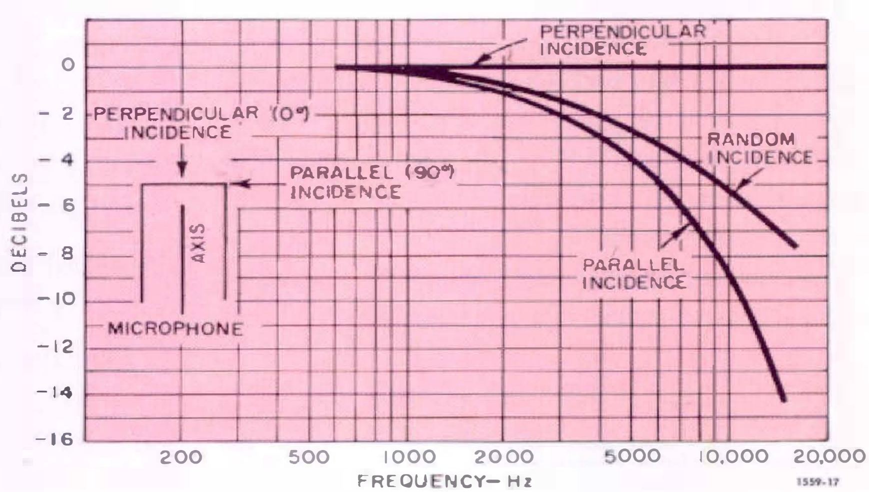



**Figure 3. Sensitivity variation with frequency for random, parallel, and perpendicular incidence.**

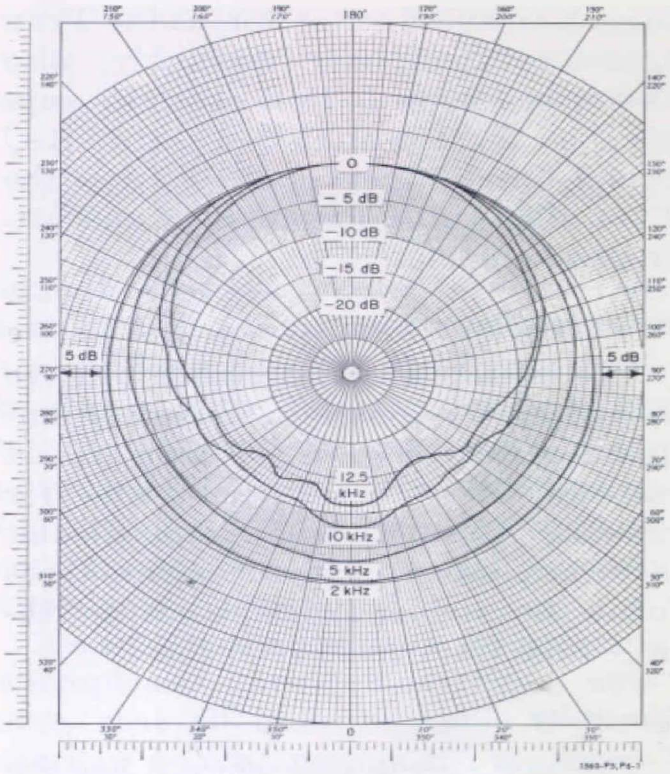



**Figure 4. Polar responses at various frequencies.**

perpendicular incidence) than to sounds from other directions. Figure 3 shows the extent of the variation in sensitivity as a function of the direction of sound incidence. Figure 4 shows polar responses of the microphone at different frequencies.

### Acoustic Impedance and Use in Couplers

The acoustic impedance presented by the microphone in a coupler is equivalent to that of an air volume of 0.45 $cm^3$ when referred to the front edge of the protecting grid. Of this equivalent volume, about 0.2 $cm^3$ is due to the compliance of the diaphragm and the ceramic element.

The mechanical resonance of the diaphragm and ceramic element structure is damped acoustically behind the diaphragm. This arrangement corrects one of the deficiencies of the earlier piezoelectric microphones, since the damping element in the new microphone is protected from dirt and mists, whereas, in the earlier ones, the damping element became clogged after long exposure to oil mists and the response of the microphone was affected. Furthermore, the response of the new microphone is not significantly affected by the gas in front of the diaphragm. It can, consequently, be used in coupler calibrations with gases other than air.[6]

As a result of the use of the standard diameter and the elimination of any significant frequency-determining element from in front of the diaphragm, this new microphone can be used in standard reciprocity calibration couplers and earphone calibration couplers designed for the type L laboratory standard microphone.[7]

Although the microphone can withstand sound-pressure levels of 160 dB re 20 $\mu N/m^2$ without damage, pressures much higher than this may ruin it. Such excessive pressures can occur if the microphone is inserted in a coupler without an adequate pressure release. This pressure release is usually a small-diameter hole in the coupler, which can be plugged after the microphone is inserted. But some devices have been built without this release, and these should be modified before use with any of these microphones.

### Electrical Impedance—Temperature and Humidity Effects—Cables

The nominal impedance of the Type 1560-P5 Microphone corresponds to a capacitance of 380 pF, in contrast to the 50 to 70 pF that is characteristic of con-

[6] S1.10 — 1966, *USA Standard Method for the Calibration of Microphones*, USA Standards Institute, New York, N. Y.
[7] Z24.8 — 1949, *American Standard Specification for Laboratory Standard Pressure Microphones*, USA Standards Institute, New York, N. Y.

denser microphones. Owing to the lower impedance of the new microphone, its output voltage is less affected by the connection of a cable than is the condenser type. The variation of capacitance with temperature is shown in Figure 5. With a 25-foot cable, this variation produces a change in actual signal voltage of only about 0.025 dB/°C. With a very long cable, the temperature coefficient increases to about 0.04 dB/°C. When the microphone is attached directly to the TYPE 1560-P40 Preamplifier, this effect is eliminated. The remaining temperature coefficient is that of open-circuit output voltage, which is less than ±0.01 dB/°C.

The sensitivity of a condenser microphone is directly proportional to the applied dc polarizing potential, and the stability of the system can therefore be no better than that of the polarizing supply voltage. Accurate monitoring of this voltage is essential for assurance that the sensitivity of the microphone system does not change. Such precautions are not necessary with the piezoelectric microphone, because no polarizing voltage is required.

The high polarizing voltage needed with the condenser microphone also makes it particularly sensitive to the effects of humidity. If moisture provides a conductive path for the polarizing voltage at the microphone, the resulting leakage current introduces excessive noise into the signal path, and the system can easily become inoperative. Because of the heat produced by the vacuum-tube amplifiers commonly used, the humidity at the microphone terminals is kept below the ambient humidity, and the above-mentioned effects of humidity have not been as widely observed as they will be when solid-state preamplifiers come into general use.

The effects of humidity on the piezoelectric microphone are much less serious, because of the absence of a polarizing voltage and because its impedance is only about one-tenth that of a condenser microphone. Its impedance is still relatively high at low frequencies, however, and prolonged exposure to extremely high humidity should be avoided. If it is exposed to 100% humidity for a matter of hours, some loss in sensitivity below 100 Hz may occur, and some increase in low-frequency background noise will accompany this loss.

When the piezoelectric microphone is used at the end of a long cable with no preamplifier, the upper sound pressure at which it can be used is not affected. The distortion from a condenser microphone, however, is affected by the impedance that terminates it. If a cable is connected between the condenser microphone and a high-impedance preamplifier, the distortion is greater than when the condenser microphone works

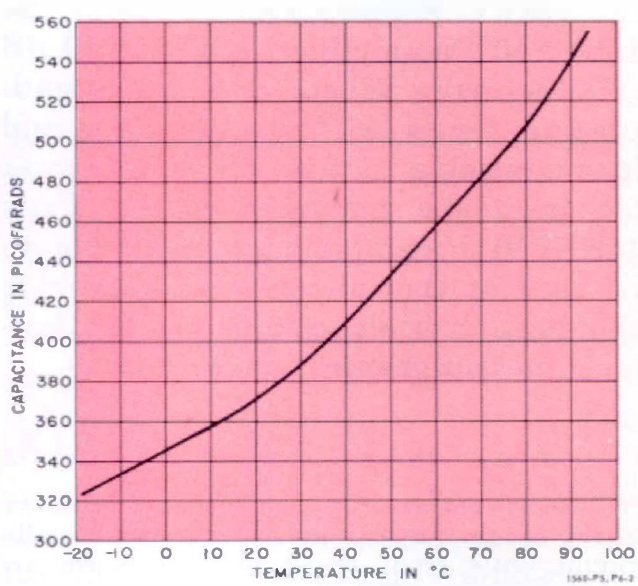



**Figure 5. Variation of capacitance with temperature.**

Basil A. Bonk received his BSEE and MSEE degrees from MIT in 1960, then joined General Radio as a development engineer in the Audio Group. There he has specialized in the development of microphone calibration systems and in the design of measurement microphones.

directly into the preamplifier. Because of this effect and the very serious loss in signal level that results when a condenser microphone is used with a cable, the microphone is almost always used directly on a preamplifier. The Type 1560-P5 Microphone, however, can be used over a wide range of sound-pressure levels without a preamplifier.

### Dynamic Range

The lower limit at which sound-pressure can be measured with this new microphone is set by the electronic system used with it and the bandwidth of the measurement system. This lower limit, when the microphone is used with the 1551-C Sound-Level Meter or the 1560-P40 Preamplifier, is about 20 dB (C-weighted). When very low sound-pressure levels are to be measured and it is advisable to position the observer far from the microphone, the Type 1560-P40 Preamplifier is available to be used at the microphone to provide the best possible conditions for low-level measurements.

The upper limit of linear operation of the microphone is set by distortion. The distortion in the electrical output is less than 1% when the microphone is exposed to a sound-pressure level of 150 dB re 20 $\mu N/m^2$. The total dynamic range is then about 130 dB for C-weighting, which is significantly larger than the dynamic range of condenser microphones.

### Conclusion

The characteristics of this new microphone are so good that the limitations on the accuracy of a practical sound measurement will almost always come from factors other than the behavior of the microphone. Some of these other factors that limit accuracy are the following: the effects of the room; of interfering objects, particularly the observer; of stray pickup; of ambient noise; of the placement and mounting of the noise source; of the microphone positions used; and of the particular space and time averaging techniques used.

The Type 1560-P5 Microphone can be used in all the ways that the highly respected condenser microphone has been used in the laboratory, and, in addition, it is well suited for use in portable field-type sound-measuring systems.

— B. A. Bonk

### Editor's Note

The design of this microphone was started by B. B. Bauer and A. L. DiMattia of CBS Laboratories and was completed by the author at the General Radio Company.

## SPECIFICATIONS

**Frequency Response:** Typical response is shown in the accompanying plot. Deviations of individual units from the typical response are approximately ±0.3 dB from 20 to 1000 Hz and ±1 dB up to about 7000 Hz.

**Sensitivity:** −60 dB re 1 V/$\mu$bar nominal.

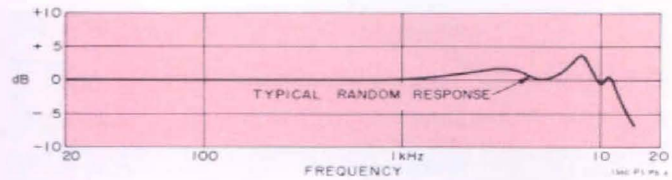
**Temperature Coefficient of Sensitivity:** Approximately −0.01 dB/°C.

**Internal Impedance:** Capacitive; Type 1560-P5, 390 pF at 25°C, nominal; Type 1560-P6, 425 pF at 25°C, nominal. Temperature coefficient of capacitance: 2.2 pF/°C over range of 0 to 50°C.

**Environmental Effects:** Microphone is not damaged by temperatures from −40 to +60°C and relative humidities of 0 to 100%.

**Terminals:** Microphones fit 3-terminal microphone cable connector. For hum reduction both microphone terminals may be floated with respect to ground.

**Cartridge Dimensions:** Diameter 0.936 ± 0.002 in. (23.7 mm), length 1⅛ in. (29 mm).




**Net Weight:** Type 1560-P5, 2 oz (60 g); Type 1560-P6, 8 oz (0.3 kg).

**Shipping Weight:** Type 1560-P5, 1 lb (0.5 kg); Type 1560-P6, 3 lb. (1.4 kg).

| *Catalog Number* | *Description* | *Price in USA* |
|---|---|---|
| 1560-9605 | 1560-P5 Microphone | $60.00 |
| 1560-9606 | 1560-P6 Microphone Assembly | 85.00 |

# NEW FIVE-FREQUENCY SOUND-LEVEL CALIBRATOR

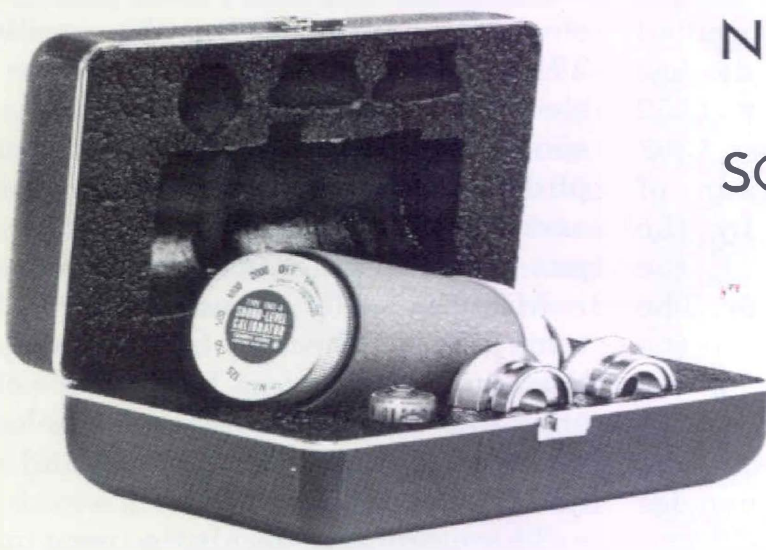


**Figure 1. Type 1562-A Sound-Level Calibrator in storage case, with snap-in adaptors.**

One of our lighter-spirited publications suggests that, for a day-to-day check on sound-level-meter calibration, one may hold the instrument at arm's length and say, in an even voice, "I feel rather foolish talking to a sound-level meter," repeating this announcement daily and noting any variation in indicated level. Those who prefer a more reliable and less attention-getting approach will be interested in GR's new Type 1562-A Sound-Level Calibrator, a small, transistorized oscillator-speaker-coupler unit designed for the calibration of most commonly used sound-measuring microphones and systems.

Much is to be gained from accurate calibration of an acoustical measurement system. The better the calibration accuracy, the closer one can approach allowed performance specifications, the more consistent his comparison measurements will be, and the more confidence he can have in his measurements.

Acoustical measuring instruments can be calibrated in many ways. The simplest procedure is the amplifier self-check, provision for which is built into many General Radio sound-measuring instruments. At the other end of

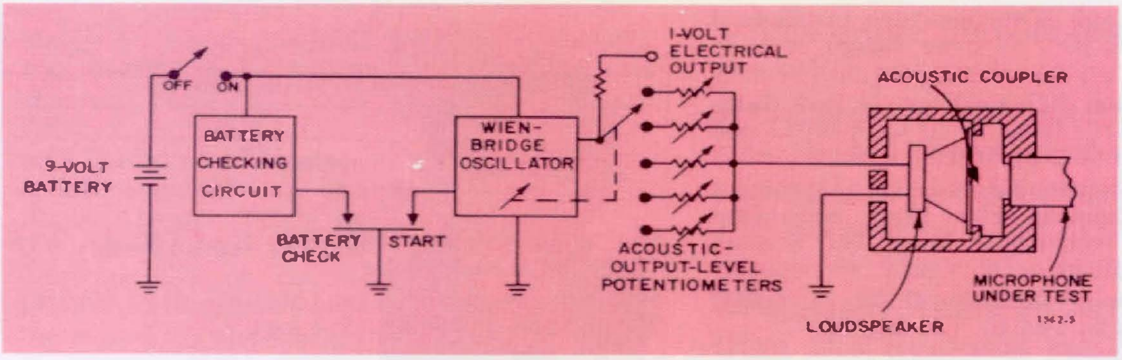



**Figure 2.** Diagram showing principal elements of the calibrator.

the scale is the precise calibration, from 20 to 8000 Hz, of a microphone or system by means of the TYPE 1559-B Reciprocity Calibrator.[1]

Probably the most commonly performed calibration has been a simple over-all system check at a specified frequency, for which General Radio has listed the combination of TYPE 1552 Sound-Level Calibrator and TYPE 1307 Transistor Oscillator.[2] This pair of instruments is now succeeded by the small cylinder shown in Figure 1, the TYPE 1562 Sound-Level Calibrator. The new calibrator offers, in addition to the obvious convenience of the new packaging, specifications far superior to those of its predecessor. (For example, the 1562 has five calibration frequencies vs the single frequency of the 1552.)

The new sound-level calibrator contains a solid-state oscillator, an electroacoustic transducer, and an acoustic coupler, all enclosed in a cylindrical housing only 2¼ inches in diameter and 5 inches long. In normal operation, it is placed over the microphone of the system to be calibrated, and the frequency selector switch is set to one or more of the five available test frequencies (125, 250, 500, 1000, and 2000 Hz). The calibrator is factory-adjusted to develop a sound-pressure level of 114 dB re 20 $\mu N/m^2$ (0.0002 $\mu$bar).

An important additional feature is the availability, at a phone jack, of the electrical output from the oscillator. Thus, for example, one can use the electrical output to measure the response of a system without its microphone, then connect the microphone and apply the calibrator's acoustic output to verify the microphone response.

Many types of sound-measuring systems can be checked by the new calibrator. With five test frequencies available, one can check frequency-selective instruments such as octave-band analyzers.

The calibrator is also a very useful accessory for the TYPE 1525 Data Recorder.[3] Not only can the acoustic output be used for system calibration, but the electrical output can be used to adjust recorder bias voltage and to produce electrical test signals on tape.

## DETAILED DESCRIPTION

The principal elements of the calibrator are shown in Figure 2. The oscillator drives a loudspeaker, which generates high-level acoustic signals in a coupler that fits over the microphone to be calibrated. The electrical output of the oscillator is available at a phone

[1] "A Reciprocity Calibration for the WE640AA and Other Microphones," *General Radio Experimenter*, December 1964.
[2] E. E. Gross, "An Improved Sound-Level Calibrator," *General Radio Experimenter*, June 1955.
[3] Arnold Peterson, "Magnetic Tape Recorder for Acoustical, Vibration, and Other Audio-Frequency Measurements," *General Radio Experimenter*, October 1966.

jack on the side of the calibrator housing. This jack is built into a tubular nut, which secures the outer shell of the instrument and which also keeps the calibrator from rolling off tables.

At the top of the calibrator is a rotary switch and dial combination with seven positions: the five operating frequencies, a battery-check position, and a power-off position.

### The Oscillator and Amplifier

The oscillator is a Wien-bridge circuit first described by Fulks.[4] The key to its stable operation is a thermistor in the negative feedback path, which automatically adjusts its resistance to the value needed to maintain oscillation. Its time constant is short enough to correct rapidly for amplitude variations, yet long enough to cause little distortion at low frequencies. It operates at a high temperature, in an evacuated bulb, to minimize the effects of ambient temperature.

The amplifier uses four transistors in a single, direct-coupled feedback loop. Enough negative feedback is used to achieve a transfer characteristic that is substantially independent of transistor characteristics.

### The Output System

The loudspeaker is a controlled-reluctance magnetic transducer with a very low temperature coefficient and long-term stability proven by years of successful operation in the TYPE 1552 Calibrator. Similarity with the older calibrator ends, however, with the output coupler, which is designed to accommodate the 1⅛-inch-diameter piezoelectric ceramic microphone now in use on thousands of sound-level meters. Two snap-in adaptors are provided, one for the new 15⁄16-inch-diameter sound-level meter microphone (see page 3, this issue) and type L laboratory standard microphones such as the WE 640AA, and the other for the ⅝-inch microphone used with the TYPE 1551-P1 Condenser Microphone System. Figure 3 is a cross-section drawing of the coupler in place on a 1⅛-inch microphone, and Figure 4 shows the coupler plus snap-in adaptor in place on a 15⁄16-inch microphone.

## PRINCIPLES OF CALIBRATION

The 1562 Calibrator develops a constant sound-pressure level of 114 dB

[4] Fulks, R. G. "Novel Feedback Loop Stabilizes Audio Oscillator," *Electronics*, Vol 36 No 5, Feb. 1963. Available from General Radio as Reprint A-107

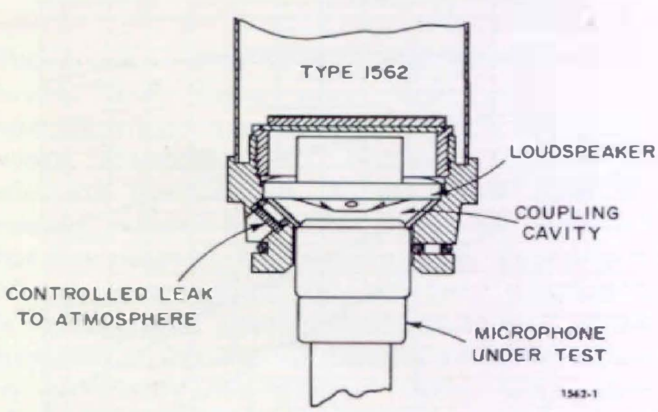



**Figure 3. Cross-section drawing of calibrator in place on 1⅛-inch-diameter microphone.**

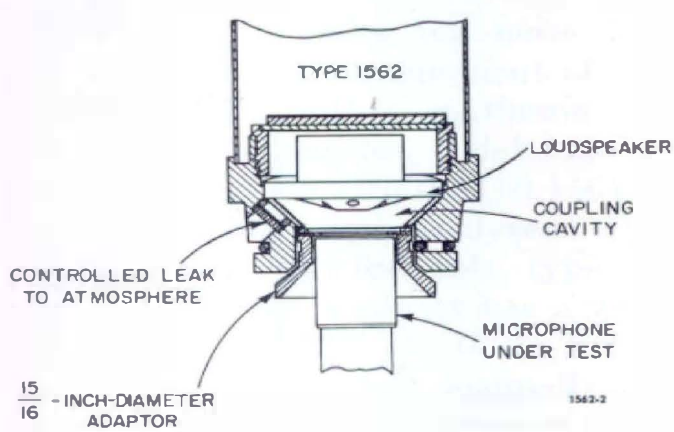



**Figure 4. Cross-section drawing of calibrator and adaptor in place on 15⁄16-inch-diameter microphone.**

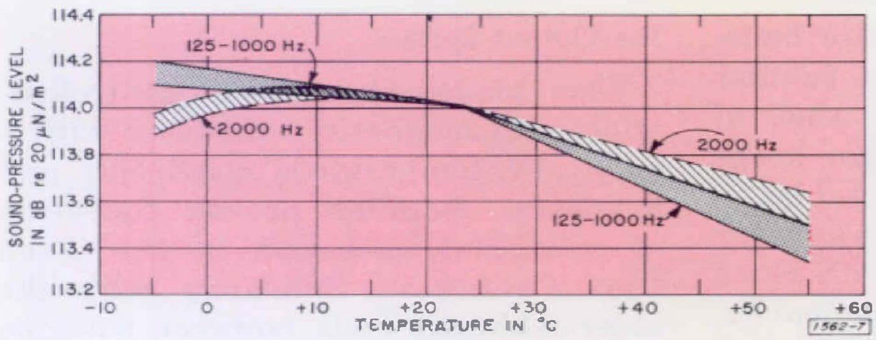



**Figure 5. Typical and specified variation in output vs ambient temperature.**

re 20 $\mu$N/m² at each of five frequencies (125, 250, 500, 1000, and 2000 Hz) when its acoustic coupler is placed over a high-acoustic-impedance sound-measuring microphone. This level is established at General Radio in terms of a carefully maintained laboratory standard microphone (WE 640AA) with a pressure calibration determined by reciprocity and traceable to the National Bureau of Standards.

The calibrator's constant output vs frequency is in contrast with the characteristic of a sound-level meter, which is designed with weighted frequency response in accordance with international standards. Furthermore, the microphones used on most sound-level meters are adjusted for a flat response to sounds of *random incidence* in a free field. Therefore, to determine exactly what a sound-level meter should indicate when the calibrator is coupled to its microphone, one must correct for the random-incidence characteristic of the microphone and for the weighted response of the sound-level-meter amplifier. These corrections are small for the new $1\frac{5}{16}$-inch microphones, but they should be taken into account where extreme accuracy is needed. Detailed correction tables are included in the instruction manual for the calibrator.

## ENVIRONMENTAL EFFECTS

The calibrator output level is established at a temperature of 23°C and an atmospheric pressure of 760 mm of mercury. As long as the battery voltage is at least 6 volts (a 9-V battery is used),

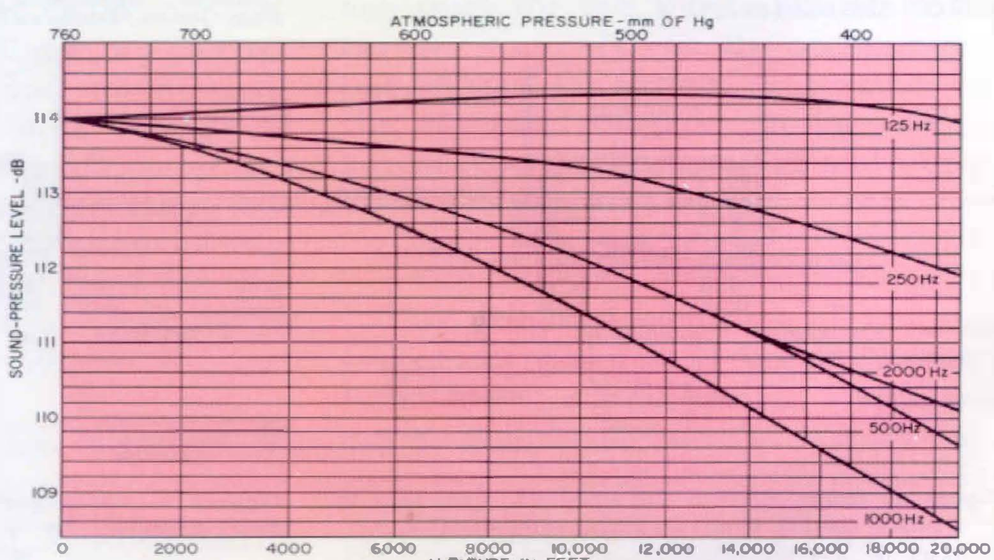



**Figure 6. Typical variation in output vs altitude and atmospheric pressure.**

normal variations in temperature and barometric pressure will have negligible effect on the sound-pressure level developed. Figure 5 shows the variation in output that may be expected as the ambient temperature departs from 23°C.

Large changes in barometric pressure due to altitude changes as one moves about the country do produce appreciable variations in output, but even these are generally smaller than the changes that occur in a closed coupler with high-acoustic-impedance transducers. For example, the sound-pressure reduction in a closed coupler at 15,000 feet altitude is about 6 dB. The corresponding loss for the 1562 is only about 3 dB (Figure 6).

— E. E. Gross

A brief biography of Mr. Gross appeared in the October 1966 *Experimenter*.

## SPECIFICATIONS

**ACOUSTIC OUTPUT**

**Frequencies:** 125, 250, 500, 1000, and 2000 Hz, ±3%.

**Sound-Pressure Level:** 114 dB re 20 μN/m².

**Accuracy (at 23°C and 760 mm Hg):**

| | *at 500 Hz* | *other frequencies* |
|---|---|---|
| WE 640AA or equivalent | ±0.3 dB | ±0.5 dB |
| Other microphones | ±0.5 dB | ±0.7 dB |

**Temperature Coefficient:** At 125, 250, 500, and 1000 Hz: −0.01 to −0.025 dB/°C from 23°C to 50°C, 0 to −0.01 dB/°C from 0 to 23°C. At 2000 Hz: −0.01 to −0.015 dB/°C from 23°C to 50°C, 0 to −0.01 dB/°C from 0 to 23°C.

**Pressure Correction:** Chart supplied.

**ELECTRICAL OUTPUT**

**Voltage:** 1.0 V ±20% behind 6000 Ω.

**Frequency Characteristic:** Output is flat ±2%.

**Distortion:** <0.5%.

**Connector:** Jack to accept standard phone plug.

**GENERAL**

**Operating Environment:** 0 to 50°C, 0 to 100% relative humidity.

**Accessories Supplied:** Carrying case, adaptors for 15/16-in.- and 5/8-in.-diameter microphones (fits 1 1/8-in. microphones without adaptor). Battery included.

**Battery:** One 9-V Burgess PM6 or equivalent. 120 hours use.

**Dimensions:** Length 5 in. (130 mm); diameter 2 1/4 in. (55 mm).

**weight:** Net, 1 lb (0.5 kg); shipping 4 lb (1.9 kg).

| *Catalog Number* | *Description* | *Price in USA* |
|---|---|---|
| 1562-9701 | 1562-A Sound-Level Calibrator | $195.00 |

# A DIAL DRIVE FOR STEPPED OR SWEPT ANALYSIS

Those who must specify acceptable noise levels and those who must follow such specifications are understandably happiest when dealing with discrete values at discrete frequencies. At the same time, of course, enough information must be included for the noise to be meaningfully described. Many people think that the best approach is a stepped third-octave analysis, which presents a significant amount of information in an easily interpreted form. GR's new dial drive automates the procedure and also permits no-hands analysis by the traditional swept technique.

Modern test codes for noise frequently involve a measurement of the noise spectrum, either continuous or at specified frequencies, which can be conveniently made with the GR 1564-A Sound and Vibration Analyzer.[1] Designed specifically for this type of measurement, the analyzer has a wide frequency range (2.5 Hz to 25 kHz), can be operated either manually or automatically, and has both one-tenth-

[1] W. R. Kundert, "New Performance, New Convenience With the New Sound and Vibration Analyzer," *General Radio Experimenter*, Sept–Oct 1963.

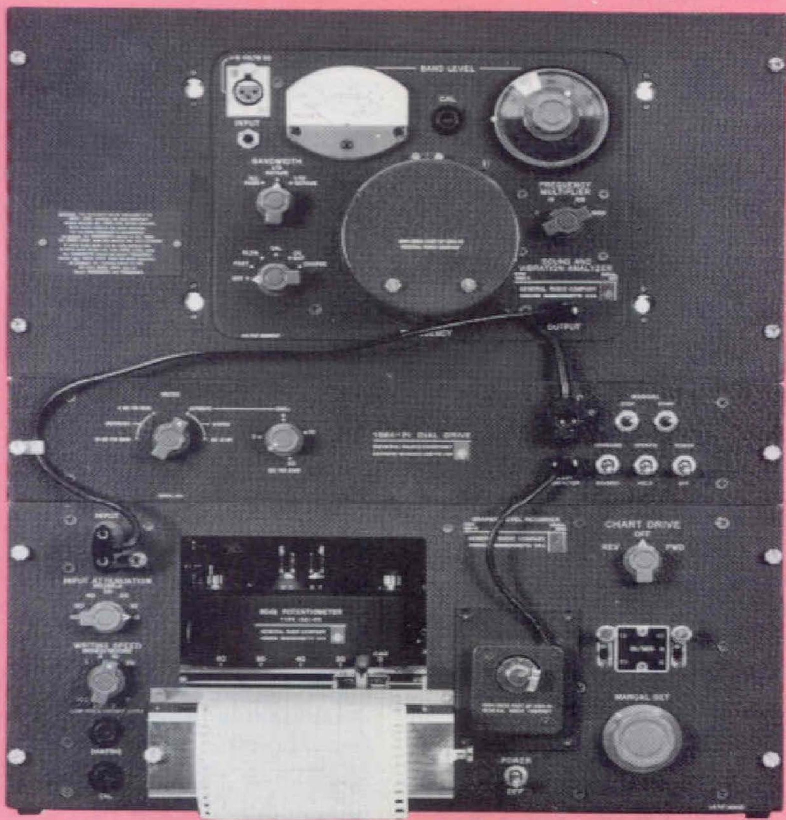


Figure 1. Type 1564-P1 Dial Drive mounted on 1564-A Sound and Vibration Analyzer and synchronized with 1521-B Graphic Level Recorder.

octave and one-third-octave bands. For automatic operation, it is used with the Type 1521-B Graphic Level Recorder, and the combination of analyzer and recorder is available, completely assembled, as the Type 1911-A Recording Sound and Vibration Analyzer.

Recently a growing interest in stepped ⅓-octave analysis has placed new demands on many acoustical laboratories. To adapt the 1564 for automatic stepped as well as continuous analysis, we now offer the Type 1564-P1 Dial Drive.

The dial drive is essentially a device for automatically moving the frequency dial of the Type 1564 Sound and Vibration Analyzer from one third-octave center frequency to the next, with adjustable dwell time at each step. As a matter of convenience, the dial drive also provides for continuous rotation of the analyzer frequency control. Thus the combination of 1564-A Analyzer and 1564-P1 Dial Drive presents three possibilities: stepped ⅓-octave, continuous ⅓-octave, and continuous 1/10-octave analysis. The complete analysis setup will often also include a GR 1521-B Graphic Level Recorder, and here the dial drive also contributes to convenience by replacing the usual chain linkage between recorder and analyzer with electrical synchronization.

## CONTINUOUS VS STEPPED ANALYSIS

A continuous plot of the spectrum is very helpful in the evaluation of a noise if the noise limits are specified as continuous functions of frequency, which can be entered on the spectrum chart to check compliance. Some test codes (e.g., MIL-STD 740 and ASHRAE 36A-63) have tried to simplify the analysis procedure by specifying acceptance levels in discrete third-octave bands. The selected center frequencies of these bands are those of the preferred frequency series (S1.6-1960, American Standard Preferred Frequencies for Acoustical Measurements, and ISO-R266-1962). These frequencies include 1000 Hz and the frequencies spaced above and below 1000 Hz in third-octave steps.

With stepped analysis, the presentation for each third octave is a single reading that can be quickly compared with the requirements of a code or with a similar reading taken at another time. This simplification is achieved at the expense of some information; where one is *not* bound by specification he can choose either the single-valued approach of stepped analysis or the detail that only a continuous analysis can provide.

Figures 2, 3, and 4 describe, better than can words, the difference between

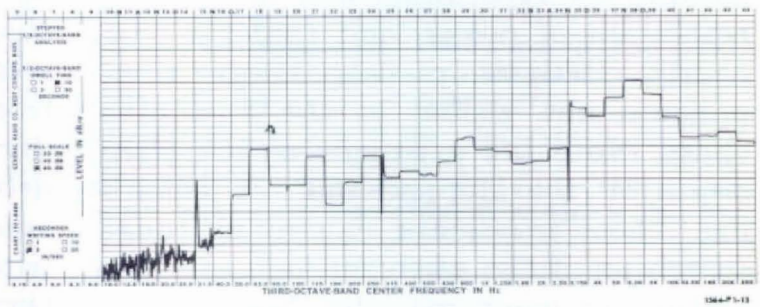



**Figure 2. A stepped ⅓-octave analysis of vibration of defective motor. Dwell time was set at 10 seconds, full-scale level was 80 dB, and recorder writing speed was 3 in./s. Chart paper is GR 1521-9460, specially designed for stepped ⅓-octave analysis.**

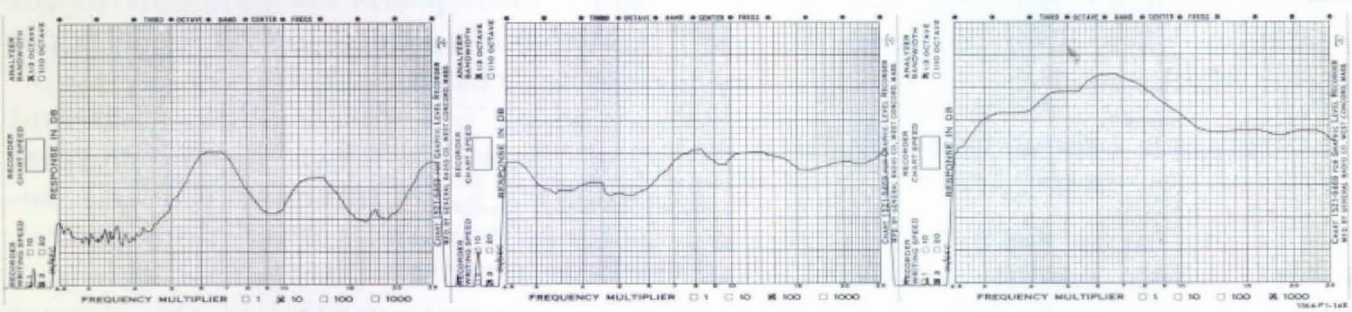



**Figure 3. Continuous ⅓-octave analysis of the same vibration analyzed in Figure 2. Detail is greater, but ⅓-octave levels are harder to read.**

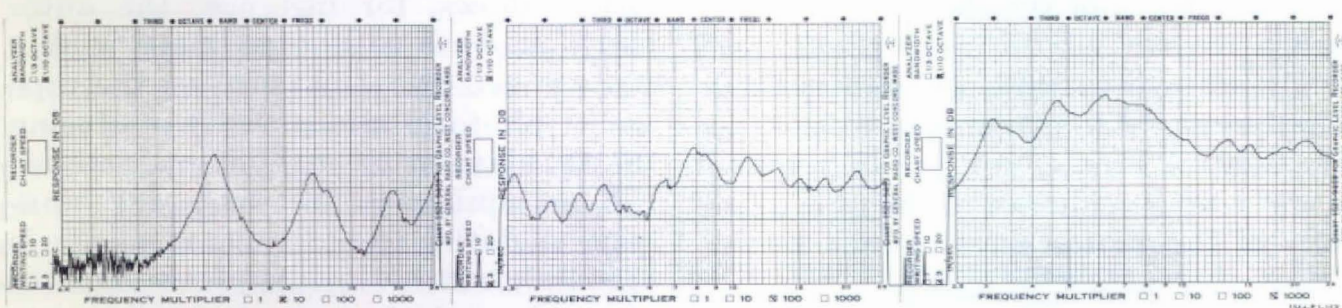



**Figure 4. Continuous 1/10-octave analysis of the same vibration analyzed in Figures 2 and 3. Note presence of components not visible on broader-band analyses.**

stepped and continuous analysis. These are chart recordings of the vibration of a motor with a damaged sleeve bearing. Figure 2 shows a stepped ⅓-octave analysis; Figures 3 and 4 are continuous ⅓- and ⅒-octave analyses, respectively. All were made with the combination of 1564 Sound and Vibration Analyzer, 1564-P1 Dial Drive, and 1521-B Graphic Level Recorder. In all cases, the recorder was set for a writing speed of 3 inches per second and was equipped with an 80-dB potentiometer.

It is immediately apparent that the stepped-analysis recording (Figure 2) is the easiest to interpret, that the continuous recordings give far better resolution of peaks, and that the ⅒-octave analysis reveals many components not visible in the ⅓-octave chart. Note the existence of the transients on the stepped-analysis recording. These transients, caused by range switching of the analyzer, can serve as useful frequency markers, because the ⅓-octave switching frequencies are accurately known.

## DETAILED DESCRIPTION OF THE DIAL DRIVE

The dial drive consists of a stepper motor, which mounts on and drives the analyzer; a contactor, which mounts on and provides synchronization with the recorder; and the electronic control unit.

The stepper motor is driven by pulses from a ring-of-four counting decade in the control unit. Four pulses applied in the proper sequence to the four drive coils of the motor advance the motor 7½ degrees per pulse. The 10-to-1 gear ratio between motor and analyzer frequency control divides these steps into ¾-degree increments.

The ring-of-four counting decade provides the necessary logic to sequence pulses for either forward or reverse operation and also to ensure that the motor never stops with one of its coils energized. The rate at which the motor, and thus the analyzer frequency dial, rotates is a function of the pulse train that is applied to the ring-of-four counting decade. For stepped operation, these pulses come from a free-running multivibrator, at a rate that moves the analyzer dial 30 degrees, or from one ⅓-octave-band center to the next, in about 0.35 second. For continuous operation, they are derived from the power-line frequency through dividers. (Since the 1521-B Recorder is driven by a synchronous motor, the analyzer is automatically synchronized with the recorder in continuous operation.) Two speeds are available in the continuous mode: 6 or 20 seconds per ⅓-octave band.

The control unit includes start and stop buttons, forward and reverse switches, a continuous-automatic selector switch, and a dwell-time control. A connector at the rear of the unit permits remote control of the stepper motor by electrical signal. This provision allows, for instance, the automatic analysis of a tape loop, with a piece of reflective material on the tape and a photoelectric pickoff[2] producing the signals to advance the stepper motor.

Synchronization between the analyzer and the recorder chart paper is accomplished by means of a contactor assembly, which mounts on the recorder. This is a cam-actuated switch,

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[2] G. Partridge, "A Simple Way to Synchronize Magnetic Tape With Oscilloscope Trace," *General Radio Experimenter*, October 1966.

which causes the dial drive to move the analyzer to the next ⅓-octave band at each ¼-inch travel of the chart paper. Chart paper 1521-9460 is specially calibrated for this application.

## SUMMARY

The TYPE 1564-P1 Dial Drive greatly simplifies stepped ⅓-octave analysis and permits changeover to continuous ⅓- or 1/10-octave continuous analysis at the turn of a switch. Those who are called upon to make such analyses should find appreciable savings in time and convenience through the use of this accessory.

— B. A. BONK

## SPECIFICATIONS

**STEPPING CHARACTERISTICS**

**Stepping Motion:** 0.75°/step; 40 steps (30°) per ⅓ octave; controlled to step in sequence of 4 pulses = 3°.

**Stepping Time:** In stepped mode, approx 0.35s/30°; in continuous mode, 6s/30° or 20s/30°, both synchronized to 60-Hz line.

**Dwell Time (⅓-octave band):** Dwell time + stepping time is 1, 3, 10, or 30 s, when controlled by 1521-B Graphic Level Recorder with 60-rpm motor. These times can be increased 2 × or 4 × with cam adjustment. Dwell time can also be set by front-panel control from approx 1 to 60 s.

**GENERAL**

**Temperature Range:** Operating, 0 to 50°C; storage, −40 to +70°C.

**Humidity Range:** 0 to 95% RH.

**Synchronization:** To 1521 Graphic Level Recorder in both stepped and continuous modes.

**Recording System:** Output from 1564 analyzer can be connected to any recorder with input impedance of 10 kΩ or more and sensitivity of at least 10 mV (1521-B Recorder recommended).

**Power Required:** 100 to 125 or 200 to 250 V, 60 Hz.

**Accessories Supplied:** Adaptor-cable assembly, power cord, spare fuses, end frame set (bench model) or rack-support set (rack model).

**Accessories Available:** Chart paper for 1521 Recorders: 1521-9460 for stepped analysis, 1521-9469 for continuous analysis.

**Dimensions (w × h × d):** Relay-rack section, 19 × 3½ × 12½ in. (485 × 89 × 320 mm); stepper motor, 4¼ (dia) × 5⅛ in. (110 × 135 mm); contactor assembly, 3 × 4 1/16 × 2⅛ in. (77 × 105 × 54 mm).

**Weight:** Net 16½ lb (7.5 kg); shipping, 36 lb (16.5 kg).

| *Catalog Number* | *Description* | *Price in USA* |
|---|---|---|
| 1564-9771 | 1564-P1 Dial Drive, Bench Model | $720.00 |
| 1564-9772 | 1564-P1 Dial Drive, Rack Model | 720.00 |
| 1521-9460 | Chart Paper (stepped mode) | 2.75 |
| 1521-9469 | Chart Paper (continuous mode) | 2.75 |

# OSCILLATOR FOR AUDIOMETER CALIBRATION

With the introduction of a standard earphone coupler[1], General Radio greatly simplified the use of its sound-level meters and analyzers in the calibration of audiometric equipment. To round out the calibration system, we are now offering a low-distortion audio oscillator with switch selection of 12 frequencies commonly used in audiometry. Among these frequencies is the octave series based on 125 Hz, which is incorporated in specifications of the USA Standards Institute.[2]

[1] E. E. Gross, "A Standard Earphone Coupler for Field Calibration of Audiometers," *General Radio Experimenter*, October 1966.
[2] *American Standard Specification for General Diagnostic Purposes, Z24.5 — 1951*, USA Standards Institute, 70 E. 45th St., New York, N. Y.


Type 1311-A

The 1311-AU is an all-solid-state, Wien-bridge oscillator, which uses extensive negative feedback to attain very low distortion (typically under 0.1%) and high degrees of amplitude and frequency stability. Except for its output frequencies, it is identical to the Type 1311-A Audio Oscillator, described in the August-September 1962 isssue of the *Experimenter*.

## SPECIFICATIONS

### FREQUENCY

**Range:** 12 fixed frequencies, 125, 250, 400, 500, 750, 1000, 2000, 3000, 4000, 6000, and 8000 Hz. ΔF control provides ±2% adjustment.

**Accuracy:** ±1% when ΔF control is at zero.

**Frequency Stability:** 0.1% typical, long-term, after warmup.

**Synchronization:** Telephone jack provided for external synchronizing signal. Locking range is about ±3% for 1-V rms reference signal. ΔF control can be used for phase adjustment.

### OUTPUT

**Power:** 1 W into matched load (taps provide at least 0.5 W into any resistive load between 80 mΩ and 8 kΩ).

**Voltage:** Continuously adjustable from 0 to 1, 3, 10, 30, or 100 V, open circuit.

**Current:** Continuously adjustable from 0 to 40, 130, 400, 1300, 4000 mA, short circuit (approximately).

**Impedance:** Between one and two times matched load, depending on control setting. Output circuit is isolated from ground.

**Amplitude Stability:** Better than 1% long term, 0.01% short term, typical after warmup.

**Synchronization:** High-impedance, constant-amplitude, 1-V rms output for use with oscilloscope, counter, or other oscillator.

**Distortion:** Less than 0.5% under any linear load condition. Typically less than 0.1% over much of range. Oscillator will drive a short circuit without waveform clipping.

**Ac Hum:** Typically less than 0.003% of output voltage.

### GENERAL

**Terminals:** Type 938 Binding Posts. Separate ground terminal holds shorting link, which can be used to ground adjacent OUTPUT binding post.

**Power Required:** 105 to 125 or 210 to 250 V, 50 to 400 Hz. 22 W.

**Accessories Supplied:** Type CAP-22 Power Cord, spare fuses.

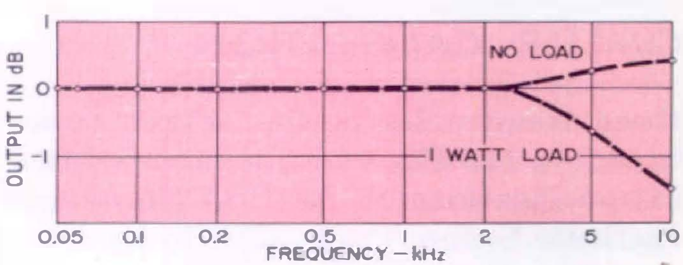
**Accessories Available:** Rack-mounting set (panel 5¼ in. high).

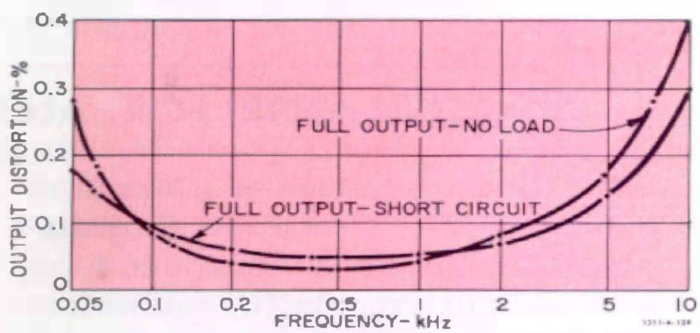
**Mechanical Data:** Convertible-bench cabinet.

**Dimensions** (width × height × depth): 8 × 6 × 7¾ in. (205 × 155 × 200 mm).

**Weight:** Net, 6 lb (2.8 kg); shipping, 9 lb (4.1 kg).

**Output characteristics.**




| *Catalog Number* | *Description* | *Price in USA* |
|---|---|---|
| 1311-9703 | **1311-AU Audiometric Oscillator, 115 volts** | $230.00 |
| 1311-9704 | **1311-AU Audiometric Oscillator, 230 volts** | 230.00 |
| 0480-9638 | **480-P308 Relay-Rack Adaptor Set** | 7.00 |

# GR Product Notes

## DECADE RESISTORS

Two six-dial decade resistors have been added to the 1434 series. The 1434-B (Catalog No. 1434-9702) has a total resistance of 1,111,110 ohms and a minimum per-step resistance of 1.0 ohm. The 1434-X (Catalog No. 1434-9724) has a total resistance of 111,111 ohms, a minimum per-step resistance of 0.1 ohm. Prices in USA are $135 and $116, respectively.

## SOUND—VIBRATION

A 100-foot extension cable (1560-P72B) is now available for use between the 1560-P40 Preamplifier and a microphone or analyzer. Catalog No. is 1560-9977. Price in USA, $29.00.

## STROBOSCOPES

The inexpensive 1539-A Stroboslave, when coupled with the 1531-P2 Flash Delay and the 1536-A Photoelectric Pickoff, is enough stroboscope for most people who want only to look at or to photograph objects moving at high speed and who do not have to measure speed. For easy ordering, we now offer the combination of all three items as the 1539-Z Motion Analysis and Photography Set. Catalog No. is 1539-9900 for 115-V systems, 1539-9901 for 230 V. Price in USA is $435.00.

## COAXIAL

An adaptor is now available between our two coaxial connector series, GR900 and GR874. The 874-Q900L Adaptor contains a 900-AB connector and a locking GR874. VSWR is typically under 1.04 to 9 GHz. Catalog Number is 0874-9709. Price in USA is $15.

**Erratum**

In Figure 3, page 9, of the April *Experimenter*, the case of the 1493 decade transformer should not have been shown connected to the −0.1 tap. In this setup the −0.1 tap is not used.

the Experimenter

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WEST CONCORD, MASSACHUSETTS 01781

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## WHEELS OF PROGRESS

General Radio's fleet of traveling exhibits has a new flagship, a spacious, air-conditioned Cortez outfitted with operating displays of GR instruments. The new van will roam the western and southwestern regions of the U.S.

Other GR "road shows" travel by specially equipped station wagons and are set up on invitation in or near industrial plants and laboratories.

Our line of acoustical instruments has its own vehicle, called GRAIL (General Radio Acoustical Instrument Laboratory). In Europe, two Mercedes vans cruise the autobahns for General Radio (Overseas).

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