the GENERAL RADIO Experimenter

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Photo Courtesy Interchemical Corporation

*In This Issue*

20-Amp, 400 ∾ Variac

Laboratory Amplifier

THE
# GENERAL RADIO EXPERIMENTER

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COVER

The electrical properties of resins are being used more and more as indicators of other physical properties. This photograph shows the General Radio Type 1610 Capacitance Measuring Assembly with the Type 1691-A Dielectric Sample Holder in use at the Interchemical Corporation for measurements of dielectric constant and power factor as functions of frequency. Photograph reprinted from the *Interchemical Review*, Volume 15, Number 1, Spring, 1956 (Copyright 1956 by Interchemical Corporation).

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# THE SOUND-LEVEL METER AS AN AUDIO-FREQUENCY VOLTMETER AND AMPLIFIER

**Figure 1. View of the Sound-Level Meter with microphone replaced by connector.**

The Type 1551-A Sound-Level Meter[1] is widely used as the basic instrument for sound measurements, but its capabilities as a general-purpose laboratory instrument are usually overlooked. The heart of the instrument is a stabilized, wide-range, high-gain amplifier which drives an indicating meter, and these are the essential elements for a high-sensitivity audio-frequency voltmeter. Thus, it can be used for gain or loss measurements, for hum and noise measurements, for monitoring, and as a bridge amplifier and null detector.

For these uses the microphone is removed as shown in Figure 1, and the voltage to be measured is applied to the microphone input connector.[2] The range of the instrument is from 5 microvolts to 3 volts. The actual indications are in decibels, which can be used directly for gain or loss. The corresponding voltages can be obtained through the use of decibel conversion tables. In fact, the gain of the instrument can be set so that full-scale meter readings follow the 1-3-10 series commonly found on audio frequency voltmeters.

The other important characteristics of the instrument are summarized in the following table:

*Input Impedance:* 7.3 MΩ shunted by 50 μμf

*Output Impedance:* 10 KΩ

*Attenuator:* 10 steps of 10 db (30 db to 130 db); overall transmission can be adjusted from 90 db gain to 10 db loss

*Meter:* Linear 16 db scale (−6 to +10 db)

*Range:* 116 db (24 to 140 db)
631,000:1 or 5 μv to 3.16 volts

| | *Open Circuit* | *20 KΩ Load* |
|---|---|---|
| *Full Scale Output Voltage:* | 1.4 volts | 1.0 volts |
| *Maximum Undistorted Output Voltage:* | 4.4 volts | 3.0 volts |
| *Maximum Gain:* | 97 db | 94 db |

[1] E. E. Gross, "The Type 1551-A Sound-Level Meter" *General Radio Experimenter*, March 1952, Vol. 26, No. 10, pps. 1-7.

[2] The proper mating connector is the Amphenol 91 MC3M male cable connector, which should have the orientation of the insert specified as position No. 2. (See Figure 2 for connection diagram.)

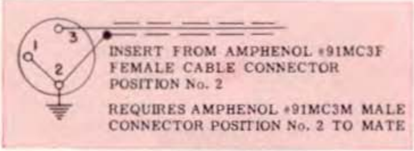



**Figure 2. Connection diagram for input connector.**

## USES

### Bridge Detector

The high sensitivity of this amplifier makes it a very satisfactory null detector. Either the panel meter or earphones can be used to indicate the bridge balance. Tuned filters can be inserted to discriminate against harmonics in the bridge source. The 1231-P2, P3, and P5 filters plug into the FILTER OUT jack[3] of the Sound-Level Meter. The Type 1951-A Filter, which gives greater harmonic rejection can be connected at the input to the amplifier.

Low-frequency hum, such as pickup from power lines, can be reduced by a factor of 10 if the weighting-network switch is set at A rather than at 20 kc. This setting reduces the response to low-frequency signals.

### Gain-Loss Measurements

This voltmeter is particularly useful for measuring the transmission characteristic of audio-frequency amplifiers, filters, and transformers. The decibel scale can be used directly, since it is usually the ratio of input to output voltage that is wanted and not the absolute value. The input impedance (7.32 MΩ) is high enough so that the meter will ordinarily not upset the circuit being tested.

At frequencies between 15 Kc and 20 Kc errors in the meter scale can approach +15% when the meter is used to measure changes in the order of 10 db. At these frequencies it is desirable to use the attenuator to keep changes in meter reading as small as possible.

[3] The plug should be inserted just far enough to contact the terminal of the jack but not far enough to cause the jack to open and disconnect the preceding stages in the amplifier.

### Noise and Hum Measurement

The high sensitivity of the sound-level meter makes it very useful for measuring directly the hum and noise level at the output of audio devices.

Although an a-c power supply is available, the instrument is normally battery operated, so it does not introduce hum into the system being measured. In the measurement of the noise level of magnetic tape recorders, the weighted (A or B) response of the sound-level meter is often used since this gives a better representation of audibility of the noise. If measurements are desired in terms of dbm, the gain can be set so that 0 dbm will be at a reading of 130 db and the total range will be from −106 to +10 dbm.

The upper limit of voltage measurement is increased by a factor of ten if the Type 1551-P11 20 db pad is inserted in the filter jacks. The voltage range then becomes 58 microvolts to 30 volts, and the dbm range −86 to +30 dbm.

### Monitoring and Recording

The low-distortion output circuit of the sound-level meter can be used to operate an oscillograph to monitor visually the signal being measured, or earphones can be used for aural monitoring. The output system can also be used to operate analyzers, or graphic level recorders. Since separate amplifier stages drive the meter circuit and the output circuit, the nature of the load placed across the output terminals will not affect the voltmeter readings. For best operation of the output amplifier, however, the load should be 20 kΩ or higher.

## Calibration Procedure for Voltage Measurements

When it is desirable to convert the decibel readings of the meter to the corresponding voltages, the following procedure is used to adjust the gain of the instrument for full scale readings of 1, 3, 10, etc.:

1. Calibrate the sound-level meter in the normal fashion using the 60-cycle internal calibration system.

2. From Table I below, determine Δdb, the correction factor dictated by the microphone sensitivity posted in the microphone well of the sound-level meter.

3. Adjust CAL control until meter reading with the weighting switch on 20 kc is different from the reading when the weighting switch is on CAL by the amount determined in 2 above.

4. Use the chart in Figure 3 to convert the decibel readings of the sound-level meter to the voltage appearing at its input terminals.

TABLE I

| Microphone Sensitivity db re 1 volt/μbar. From 1551-A Microphone Well | Δdb Value to Use in Setting CAL Control Step 3 Above |
|---|---|
| −60 | −4.2 |
| −59 | −3.2 |
| −58 | −2.2 |
| −57 | −1.2 |
| −56 | −0.2 |
| −55 | +0.8 |

*Example*

1. When the instrument is calibrated in the normal fashion, the meter reads +3.2 db when the DECIBELS switch (attenuator) is at CAL and the weighting switch is at 20 kc or CAL.

2. The microphone sensitivity is −57.5 db and Δdb from Table I is −1.7.

3. The CAL control is readjusted until the meter reads 3.2 −1.7 or +1.5 db with the weighting switch at 20 kc; the meter still reads +3.2 db when the weighting switch is rotated to CAL.

4. The voltage being measured causes the meter to read +2 db with the attenuator set at 60, i.e., 62 db. To convert db to volts, enter the horizontal scale of the chart (Figure 3) at the

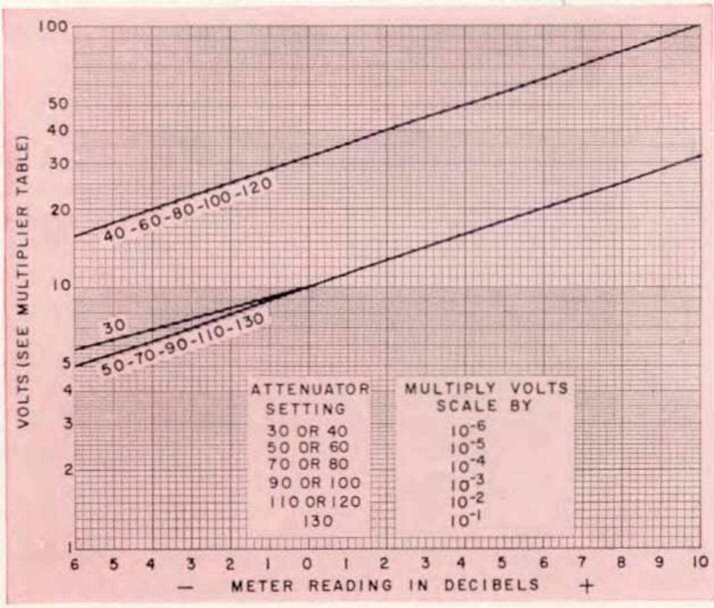



**Figure 3. Chart for converting db readings to volts, after instrument has been standardized for full-scale values of 1, 3, 10, etc.**

meter reading (+2 db) and then go up to curve for the attenuator setting (60 db); at this point read the voltage input to the instrument (400 microvolts) by going horizontally either to the left or right and multiplying by the factor indicated in the table.

The lowest full-scale reading is 31.6 microvolts when the attenuator is at 30. The maximum full-scale reading (with the attenuator at 130) is 3.16 volts.

## Frequency Response

The over-all frequency characteristic with the weighting switch in the 20-kc position is shown in Figure 4. The amplifier has a very flat response from 40 cps to 15 kc, with the half-power points (−3 db) occurring below 20 cps and above 20 kc, and the response is useful down to 10 cycles and up to 35 kc. Weighting networks are included in a sound-level meter to modify its response to approximate the response of the human ear to pure tones. The response of the ear is essentially uniform at high sound levels, but at very low sound levels the ear is much less sensitive to low frequency sounds than it is to high frequency sounds. The curves in Figure 5 show the frequency response characteristics chosen for the sound-level meter for low level sounds (A Network) moderate level sounds (B Network) and high level sounds (C Network). The C Network response differs from the 20 kc response because the amplifiers are adjusted to give the flattest response with the microphone that is used with the sound-level meter. As indicated above, the weighted response of the sound-level meter is useful when hum is present in the signal from a bridge or when the effective noise level in the output of an audio amplifier is being measured.

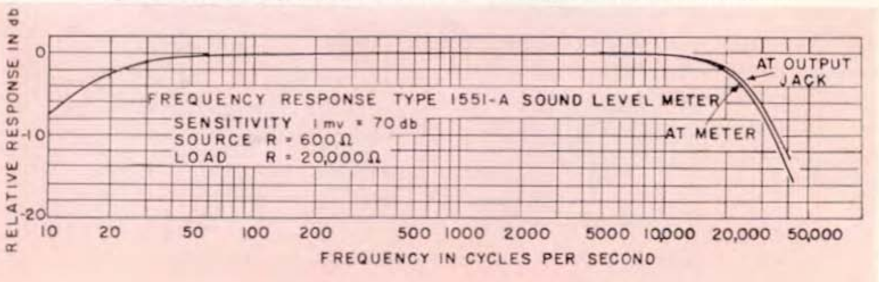
## Input Noise

The inherent electrical noise voltage in the source resistance and in the instrument can cause an error in the meter reading at the lowest levels. This effect has been taken into account, and the curve for the 30-db attenuator position in Figure 3 has been corrected for source resistances of 0 to 20,000 ohms. Hence, the minimum voltage measurement is 5.8 microvolts and not 5.0 microvolts as it would be without the noise voltage. With a 1-megohm source resistance, the noise voltage causes a meter reading of −2 db (8 microvolts) with the attenuator at 30 db. For practical purposes, the noise voltage of the source can be neglected if it remains 10 db (3.16 to 1) below the signal voltage being measured.

## Effects of Waveform

The indicator on the Sound-Level Meter is a copper-oxide-rectifier type, in which the rectifiers are operated at low current density. The meter is calibrated to read the r-m-s value of a sine wave and will pass the test for r-m-s addition specified in Appendix B of the

**Figure 4. Over-all frequency characteristic, with weighting switch in 20 kc position.**



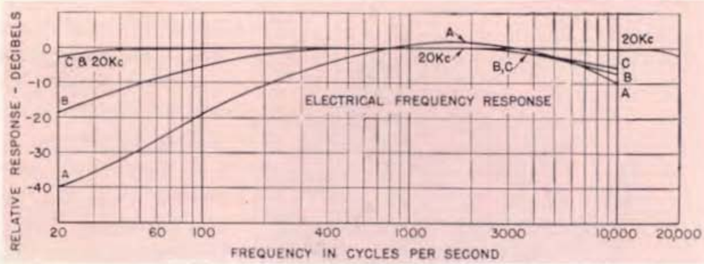



**Figure 5. Frequency response for all positions of the weighting switch.**

"American Standard for Sound-Level Meters for the Measurement of Noise and Other Sounds."[4] On complex waves the meter indication approaches the full-wave rectified average, rather than the r-m-s value. This type of indication closely approximates an r-m-s indication for many common waveforms. On square waves, where peak, r-m-s, and average values are identical, the meter reading is high by approximately 10% because it is calibrated for sine waves. On triangular waves its reading is below rms by about 3%, while on random noise the reading is low by approximately 10%.

[4] Z24.3 — 1944, American Standards Association.

## Summary

The Type 1551-A Sound-Level Meter has many characteristics that make it a useful general-purpose laboratory instrument. It is essentially a battery-operated, high-sensitivity, audio-frequency voltmeter, specifically designed to meter the output of a microphone. The characteristics needed to make the instrument satisfactory for its intended purpose are those required in a number of other laboratory measurements. High sensitivity and high gain are useful for bridge amplifiers and null detectors as well as for hum and noise measurements. The decibel scale is useful when measuring transmission characteristics of audio circuits while the decibel reading can readily be converted to corresponding voltage.

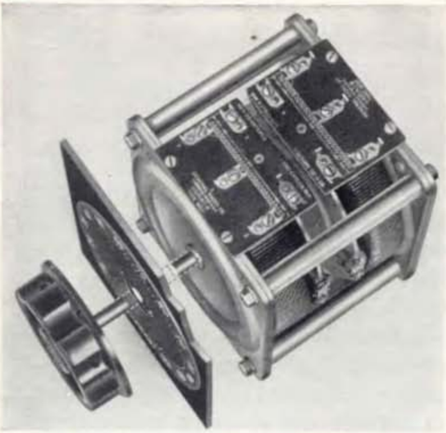
— E. E. Gross

# A 400-CYCLE VARIAC® WITH 20-AMPERE RATING

The new General Radio 20-ampere, militarized, high-frequency Variac follows the pattern established in the smaller ratings previously announced.[1] The Type M20 Variac, like its companion types, the M2, M5 and M10, is ruggedized, tropicalized, and designed to withstand successfully the usual environmental, operational shock and vibration tests normally required for military operation. It can be operated at any supply frequency between 350

**View of the Type M20 Variac.**

[1] "New Variac® Autotransformers for 350-to-1200 cycles Service," *General Radio Experimenter*, 29, 2; July, 1954, pp. 6–8.
"The Type M10, a 10-ampere Variac® Autotransformer for 350-to-1200 cycle Service," *General Radio Experimenter*, 29, 6; November, 1954, pp. 6–7.



View of 2-gang unit, Type M20G2.

and 1200 cycles. Other features of the "M" line Variacs include stamped base and radiator for improved shock resistance and protection; improved heat transfer between coil and base for cooler operation; finishes, materials, and lubrication to meet rigorous military requirements.

A new brush assembly, removable radially instead of axially, for greater service accessibility, is here introduced for the first time. The new brushes preserve the valuable attributes of the former GR unit brushes, low unsprung weight, coil springing, limited travel; but offer improved heat transfer to the radiator and greater convenience in examination or replacement.

The M20 Variac extends the range of controllable 400 cycle power into the multi-kva region required by today's aircraft, missiles, vessels and vehicles.

## SPECIFICATIONS

**Input Voltage:** 115 volts, 380–1200 cycles per second
**Output Volts:** 0–115 or 0–135.
**KVA Load Rating:** 3.0
**Rated Current:** 20.0 amperes
**Maximum Current:** 26.0 amperes
**No Load Loss at 400 Cycles:** 27 watts
**Dial Calibration:** 0–115, 0–135
**Angle of Rotation:** 319 degrees
**No. of Turns on Winding:** 169
**D-C Resistance, 20° C:** 0.153 ohms
**Driving Torque:** 30–60 oz. inches
**Replacement Brushes:** Type VBT-8, $2.00 per set
**Dimensions:** Base, 7½ x 7½ inches (add ⅛ inch for adequate clearance); four mounting holes, 0.390 inches, in corners of base, 6¼ inches on centers; three alternate mounting holes, spaced 120° on 3-inch radius, tapped ¼-28; depth behind panel, 3 9/16 inches. Maximum panel thickness, ½ inch.
**Net Weight (with knob and dial):** 12 pounds, 13 ounces

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| M20 | Variac | CAVIL | $48.00 |
| M20BB | Variac (with ball bearings) | CAVILBALLY | 56.00 |

## GANGED UNITS

| | 2-gang Type No. M20G2 (uncased) | 3-gang Type No. M20G3 (uncased) |
|---|---|---|
| Dial Calibration | 0–10 | 0–10 |
| Driving Torque, inch-ounces | 60–120 | 90–180 |
| Code Word | CAVILGANDU | CAVILGANTY |
| Price | $107.00 | $155.00 |
| Price with Ball Bearings* | 117.00 | 167.00 |

* Add suffix BB to type number

General Radio Company