THE GENERAL RADIO

EXPERIMENTER

VOLUME 33 No. 12 DECEMBER, 1959

IN THIS ISSUE

THE GENERAL RADIO

EXPERIMENTER

Published Monthly by the General Radio Company

VOLUME 33 · NUMBER 12 DECEMBER, 1959

CONTENTS

The General Radio EXPERIMENTER is mailed without charge each month to engineers, scientists, technicians, and others interested in electronic techniques in measurement. When sending requests for subscriptions and address-change notices, please supply the following information: name, company address, type of business company is engaged in, and title or position of individual.

GENERAL RADIO COMPANY

West Concord, Massachusetts

Telephone: (Concord) EMerson 9-4400; (Boston) CLearwater 9-8900

NEW YORK: Broad Avenue at Linden, Ridgefield, New Jersey
Telephone — N. Y., WOrth 4-2722
N. J., WHitney 3-3140

CHICAGO: 6605 West North Avenue, Oak Park, Illinois
Telephone — VIllage 8-9400

PHILADELPHIA: 1150 York Road, Abington, Pennsylvania
Telephone — HAncock 4-7419

WASHINGTON: 8055 13th St., Silver Spring, Maryland
Telephone — JUniper 5-1088

LOS ANGELES: 1000 North Seward St., Los Angeles 38, Calif.
Telephone — HOllywood 9-6201

SAN FRANCISCO: 1186 Los Altos Ave., Los Altos, Calif.
Telephone — WHitecliff 8-8233

CANADA: 99 Floral Parkway, Toronto 15, Ontario
Telephone — CHerry 6-2171

REPAIR SERVICES

EAST COAST: General Radio Co., Service Dept., 22 Baker Avenue, West Concord, Mass.
Telephone — Concord, EMerson 9-4400
Boston, CLearwater 9-8900

NEW YORK: General Radio Co., Service Dept., Broad Ave. at Linden, Ridgefield, New Jersey
Telephone — N. Y., WOrth 4-2722
N. J., WHitney 3-3140

MIDWEST: General Radio Co., Service Dept., 6605 West North Ave., Oak Park, Illinois
Telephone — VIllage 8-9400

WEST COAST: Western Instrument Co., 826 North Victory Boulevard, Burbank, Calif.
Telephone — VIctoria 9-3013

CANADA: Bayly Engineering, Ltd., First St., Ajax, Ontario
Telephone — Toronto EMpire 2-3741

COVER

The Type 1554-A Sound and Vibration Analyzer with the Type 761-A Vibration Meter, as set up for the measurements on an air compressor (see Figure 4, page 5).

A NEW ANALYZER FOR SOUND AND VIBRATION

The Type 1554-A Sound and Vibration Analyzer (Figure 1) is a new instrument designed to supersede both the Type 760-B Sound Analyzer and the Type 762-B Vibration Analyzer. Its tuning range (2.5 to 25,000 cycles per second) is wider than those of the two earlier analyzers together. It provides for the first time a continuously tunable one-third-octave pass-band as well as a narrow band (8%). Among its other features are an "all-pass" mode of operation for measurement of the level of the entire input signal, greatly increased attenuation far from the center of the analysis band, and 10-to-1 span on the main frequency dial.

This new analyzer is battery powered and portable and is, therefore, convenient for analysis of sound and vibration "in the field." In the laboratory, in conjunction with the Type 1521-A Graphic Level Recorder, it provides continuous records of level versus frequency.

Several types of analyzers are used for the analysis of sound and vibration spectra. The constant-bandwidth heterodyne type, exemplified by the General Radio Type 736-A, is very useful where a high degree of selectivity is required, i.e., where the frequency separation of adjacent components is very small. The constant-percentage-bandwidth type, of which the General Radio Type 760 is an example, has a bandwidth which increases in proportion to its center frequency.

The analysis of sounds with broad-

Figure 1. Panel View of the Type 1554-A Sound and Vibration Analyzer.

band or continuous spectra requires the measurement of bands of noise, rather than of discrete components, and for this purpose octave-band analyzers, like the General Radio TYPE 1550-A, are used. This type of analysis provides data for the calculation of speech interference level and hearing-damage risk.

A later development, and one of ever-increasing popularity, is measurement with a one-third-octave bandwidth, which gives more detailed spectrum data than the octave band, but which is still not as time-consuming as a very-narrow-band measurement. Many standard measurement procedures and some military specifications now call for one-third-octave analysis. It was to provide equipment for such measurements that the TYPE 1554-A Sound and Vibration Analyzer was designed. To achieve maximum usefulness, the frequency range was extended to include those low frequencies of interest in most vibration measurements, and the narrow filter characteristic was added for the identification and measurement of single-frequency spectrum components.

A WIDE VARIETY OF USES

The TYPE 1554-A Sound and Vibration Analyzer has been designed for analysis of the output voltages from the TYPE 1551-B Sound-Level Meter and the TYPE 761-A Vibration Meter, but also has many other uses in acoustical and electrical wave analysis.

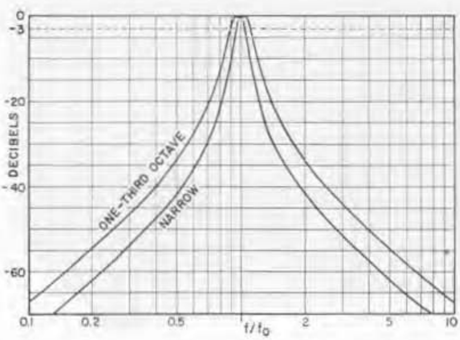


Figure 2. Response characteristics of the analyzer.

1. Measurement of Noise and Vibration.

Figures 3 and 4 show sound and vibration spectra as measured with the analyzer. These measurements were occasioned by the presence in a group of offices of an intense low-frequency noise, which was easily traced to an air compressor some distance away. The measured spectra were plotted on Codex No. 31.462 graph paper, which is especially arranged for one-third-octave frequency analysis. Dots on the main frequency dial of the TYPE 1554-A allow one to advance it easily from one preferred one-third-octave center frequency to the next. The strong 40-cycle peak shown in the noise spectrum of Figure 3 was evidently the annoying component. A simple calculation demonstrated a resonance in the offices at this frequency. The vibration measurements were made on the pump structure and indicated that no important vibration at the offending frequency was present. The pulsations of air at the compressor intake proved to be the source of the noise. Corrective measures were taken, and the resulting sound spectrum is shown in Figure 5.

Because the measurement extended to frequencies below 20 cycles, the TYPE 761-A Vibration Meter was used for both sound and vibration measurements. For sound measurements, the vibration pickup was replaced by a microphone of the type used on the TYPE 1551-B Sound-Level Meter, and the selector switch on the vibration meter was set to ACCELERATION.

2. Electric Wave Analysis.

Outside the field of purely acoustical measurements, the TYPE 1554-A Sound and Vibration Analyzer has considerable

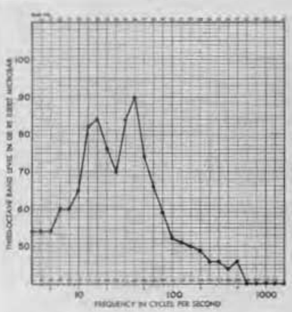


Figure 3. Sound spectrum of noise in office.

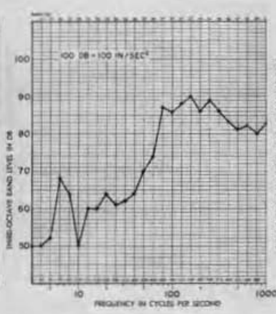


Figure 4. Vibration spectrum at pump.

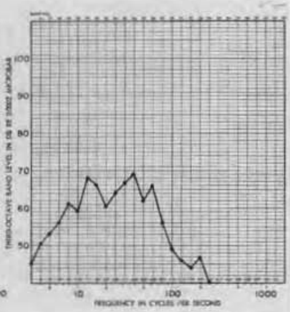


Figure 5. Sound spectrum of office noise after corrections.

usefulness as an electric wave analyzer, especially for the determination of the spectrum of electrical noise signals. A particularly difficult problem has been the accurate measurement of the low-frequency spectrum of the output of the General Radio Type 1390 Random Noise Generator. Previously, with a narrow-band analyzer, it has been necessary to use exceedingly long averaging times to produce reliable data. The measurement can be made more easily with the one-third-octave bandwidth, which permits a shorter averaging time, but is still sufficiently selective to yield reliable data. A graph of the one-third-octave spectrum level as a function of frequency for the Type 1390-B is shown in Figure 6. Note that, because the bandwidth of the analyzer is proportional to the frequency to which it is tuned, "white" noise appears to slope upwards with increasing frequency at 3 db per octave.

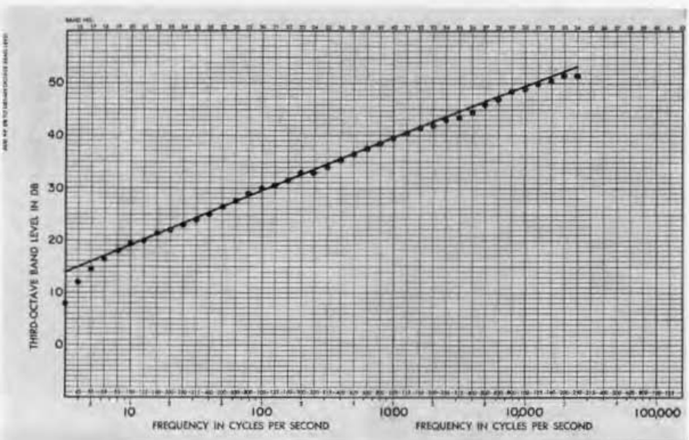


Figure 6. Spectrum level of the Type 1390-B Random-Noise Generator as measured with the one-third-octave bandwidth.

3. Use with Graphic Level Recorder.

There are many advantages to using the Type 1521-A Graphic Level Recorder to record automatically the output of the sound and vibration analyzer. Data are acquired with much less concentration and strain on the part of the operator; they are acquired more rapidly; and are in the form of continuous curves rather than as data taken at discrete points such as the one-third-octave band center frequencies. Figure 7 is a photograph of the Type 1554-A Sound and Vibration Analyzer coupled to the Type 1521-A Graphic Level Recorder.

Special chart paper, TYPE CTP-554, for the recorder has a frequency scale which matches the dial of the analyzer. Because the lower limit of the frequency range of the recorder is 20 cycles per second, this chart paper covers only the top three dial spans of the TYPE 1554-A, from 25 to 25,000 cycles per second. Within this frequency range, the combination of the analyzer and recorder can be used for the frequency analysis of sounds, vibration, or electrical signals.

An example of this use is the measurement of the response of a loudspeaker in a room inadequately treated for good listening properties. When such a measurement is made with a sine-wave signal, the response fluctuates over a wide range of level, depending strongly upon the position of the receiving microphone. The results of two such measurements made with the TYPE 1304-B Beat-Frequency Oscillator chain-driven by the recorder are shown in Figure 8. It would be difficult to average a number of such curves or to draw a relatively smooth average curve on either graph. It has been customary in acoustic measurements of such systems to use a warble tone (a sine-wave signal frequency-modulated over a relatively wide range at a low frequency) to average, in effect,

Figure 7. View of the analyzer with dial drive coupled to the Type 1521-A Graphic Level Recorder.

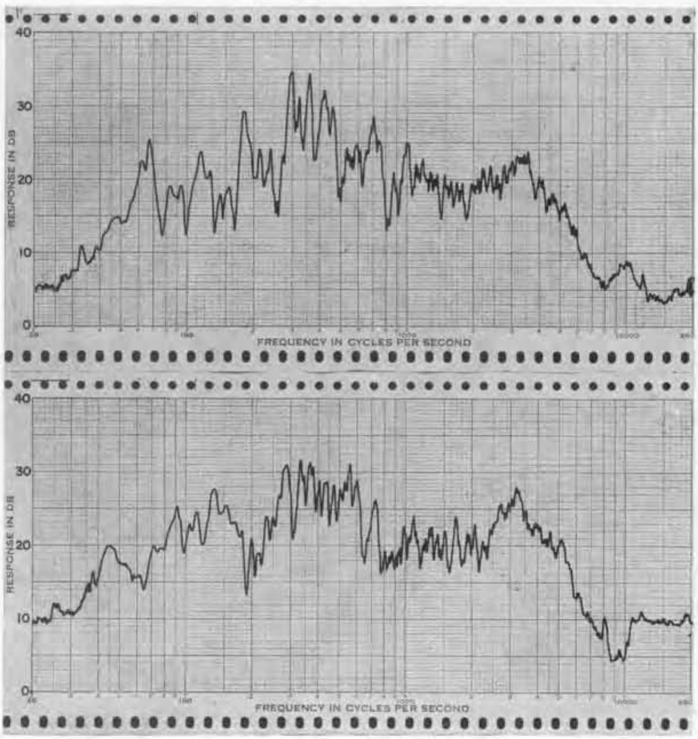


Figure 8. Two typical loudspeaker characteristics as measured with a sine-wave signal from the Type 1304-B Beat-Frequency Audio Generator and recorded automatically on the Type 1521-A Graphic Level Recorder.

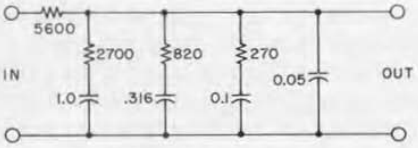


Figure 9. Schematic of pink noise filter.

over a range of frequencies and thereby produce a smoother response curve. From such a curve, gross tendencies away from ideal performance can be easily detected and corrective measures designed. A more modern technique uses random noise. It is convenient to correct first for the 3-db-per-octave slope of white noise as viewed through a constant-percentage-bandwidth filter. A filter having a slope of —3 db per octave from 20 to 20,000 cycles per second is shown in Figure 9. White noise which has been converted by such a filter from constant energy per cycle to constant energy per octave has been called "pink" noise.[1] The spectra of the white noise output of the TYPE 1390-A Random Noise Generator and the pink noise output of the filter as measured with the one-third-octave bandwidth are shown in Figure 10.

This pink noise was applied to the loudspeaker in the same location and the response was recorded after passing through the one-third-octave filter of the TYPE 1554-A. Figure 11 is a block

[1] C. G. Mayo and D. G. Beadle, "Equipment for Acoustic Measurements (Part 4)," *Electronic Engineering*, Vol. 23, pp. 462-465, December, 1951.

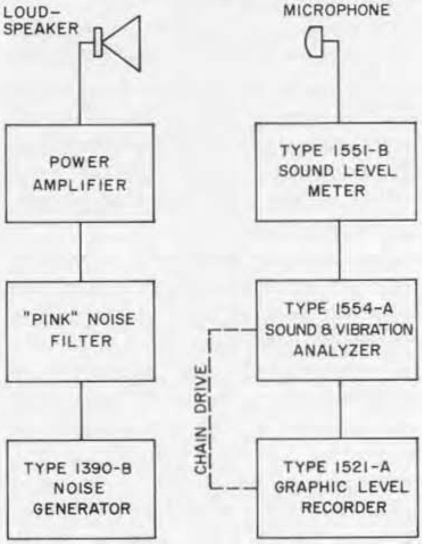


Figure 11. Block diagram of the system used for the loudspeaker measurements.

Figure 10. (*Upper curve*) White noise output of the Type 1390-B Random-Noise Generator as measured by the one-third-octave bandwidth and (*lower curve*) pink noise output of the filter. Curves were plotted automatically on the Type 1521-A Graphic-Level Recorder, coupled to the Type 1554-A Sound and Vibration Analyzer.

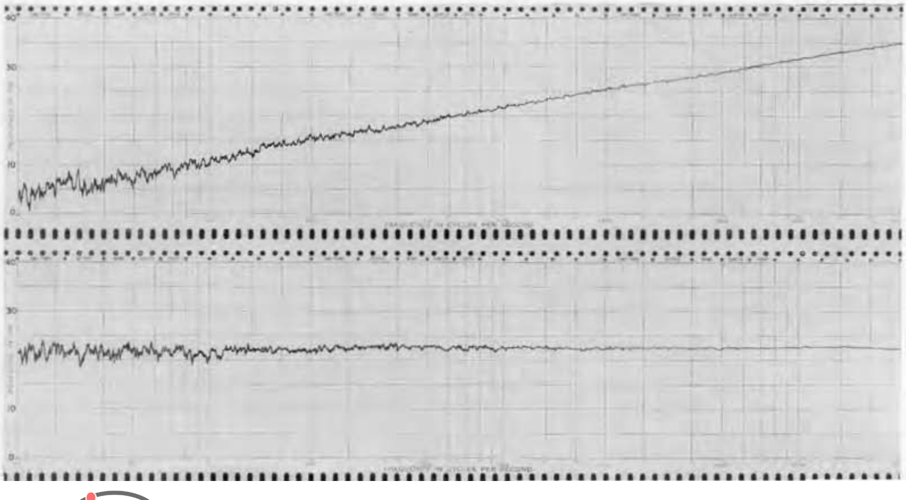


diagram of the measurement system. The response is shown in Figure 12, and the improvement over the curves of Figure 8 is evident. The response measured with the narrow filter of the Type 1554-A is shown at the bottom. Here a little more of the fine structure of the curve is apparent.

On these curves the fluctuation steadily decreases as the center frequency increases because the pass band of the filter is steadily increasing. This will be a characteristic of all such recordings of noise signals made with the Type 1554-A or any other constant-percentage-bandwidth analyzer.

The analyzer used with a random noise generator constitutes a generator of one-third-octave bands of noise, which are desirable for many types of acoustical measurements. The superiority of one-third-octave bands of noise over warble tones for measurements of sound decay time has been pointed out in a recent article.[2] An example of this use of the Type 1554-A Sound and Vibration Analyzer was the measurement of the reverberation time of a large auditorium reported in a recent issue of the *Experimenter*.[3] The block diagram and the recorder chart (Figures 7 and 8 of that article, respectively) show the measurement setup and the resulting decay curve.

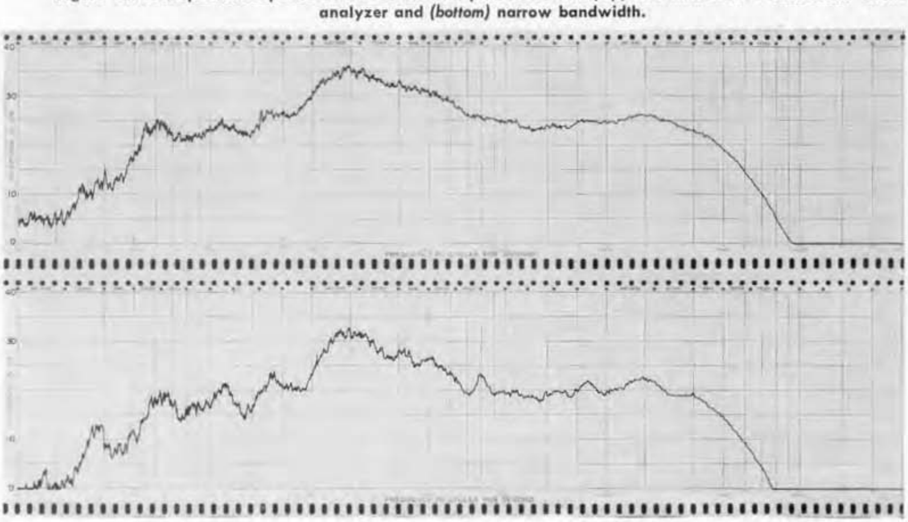
DESCRIPTION OF THE TYPE 1554-A SOUND AND VIBRATION ANALYZER

Figure 13 is a block diagram of the Type 1554-A Sound and Vibration Analyzer. The four main blocks are the preamplifier, the two tuning units, and the meter-and-output amplifier. There are two attenuators operated by coaxial controls. The large outer dial controls the input attenuator, which is used to adjust the gain of the preamplifier to suit the input signal; the knob controls the main attenuator, which is used during the analysis of a signal. The main attenuator is in three separate sections, located at the inputs of the tuning units and of the meter-and-output circuit. Consecutive 10-db steps of attenuation are inserted in the different sections in such a way as to yield the greatest possible dynamic range and protection against overloading.

[2] C. G. Balachandran, "Random Sound Field in Reverberation Chambers," *The Journal of the Acoustical Society of America*, Vol. 31, pp. 1319-1321, October, 1959.

[3] M. C. Holtje and M. J. Fitzmorris, "A Graphic Level Recorder With High Sensitivity and Wide Ranges," *General Radio Experimenter*, June, 1959.

Figure 12. Loudspeaker response as measured with pink noise and *(top)* one-third-octave bandwidth on the analyzer and *(bottom)* narrow bandwidth.



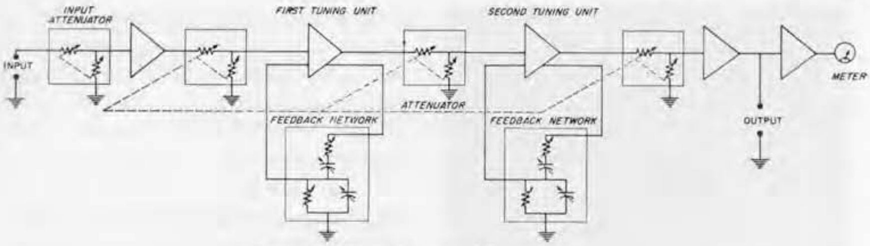


Figure 13. Block diagram of the analyzer.

A simplified schematic diagram of one of the tuning units is shown in Figure 14. The circuit is basically a two-stage tube-and-transistor amplifier. There is negative feedback from the collector circuit of Q-1 to the filament of V-1, which stabilizes the gain of the amplifier and the operating points of V-1 and Q-2. There are two possible paths for positive feedback. One of these is the so-called Wien bridge network, which produces a maximum feedback at one frequency and gives the tuning unit its selective characteristic. The other is a resistive voltage divider, which gives the tuning unit its flat frequency or all-pass characteristic. When either positive feedback network is used, there is always an excess of negative feedback for stability of gain.

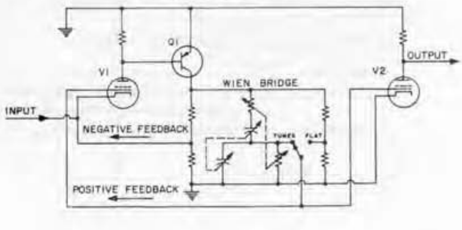
The one-third-octave response was synthesized by choice of the Q and the frequency separation of two tuning units in cascade. The resultant response is flat topped, as shown in Figure 2. When the BANDWIDTH switch is in the NARROW position, the two circuits are tuned to the same frequency, producing the narrow peak shown also in Figure 2. The resulting bandwidth is 8%, approximately one-tenth octave.

CALIBRATION

For measurements made in conjunction with the TYPE 1551-B Sound-Level Meter, the sound and vibration analyzer can be calibrated to be direct reading in sound-pressure level. The method for doing so can best be explained by reference to Figure 15, a photograph of the attenuator controls. The large outer dial marked INPUT ATTENUATOR is set according to the amplitude of the input signal so that the appropriate number is adjacent to the INPUT VOLTS SHOULD NOT EXCEED marker. The main attenuator knob is usually turned fully clockwise (as it is in Figure 15) during calibration. The signal from the sound-level meter is connected to the input of the analyzer and, with the analyzer BANDWIDTH switch set at ALL-PASS, the reading of the analyzer meter can be made the same (in decibels) by adjustment of the CAL thumb control, while at the same time the movable DECIBELS dial under the attenuator knob can be moved so that the same number is below the pointer of the knob as is shown at the window of the attenuator on the sound-level meter.

Both the sound-level meter and the analyzer then read the same over-all level, and the analyzer is thenceforth direct reading in one-third-octave sound-

Figure 14. Elementary schematics of the tuning unit used in the analyzer.



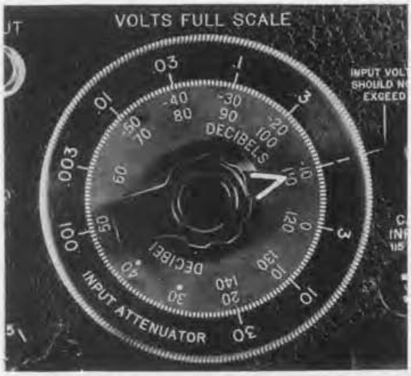


Figure 15. View of the attenuator dial.

pressure level (the sum of the meter reading on the decibel scale and the indication of the attenuator knob against the DECIBELS dial).

A similar system can be used with the TYPE 761-A Vibration Meter to make the analyzer's meter scale direct reading in amplitude. The analyzer also can be operated directly from a microphone, if the component levels are sufficiently high (see specifications), and the TYPE 1552-B Sound-Level Calibrator can be used for calibration.

If the analyzer is to be used for electrical signal analysis, it can be internally calibrated by use of a 115-volt ac line to be direct reading in voltage at the input jack.

ACKNOWLEDGMENT

As is often the case, the author has received much assistance in the development of this instrument from many colleagues. It is a particular pleasure, however, to single out A. P. G. Peterson for his helpful and inspiring direction and H. C. Jensen for aid in the mechanical design.

— J. J. FARAN

SPECIFICATIONS

Frequency Range: From 2.5 to 25,000 cycles in four ranges. The FREQUENCY dial is calibrated from 2.5 to 25 cycles; the FREQUENCY MULTIPLIER switch has four positions, 1, 10, 100, and 1000.

Frequency Calibration Accuracy: ±2% of the frequency dial settings.

Input Voltage Range: 100 microvolts to 30 volts for useful indication. Most sensitive range is 1 millivolt full scale.

Frequency Response: "NARROW": Maximum response is flat ±2 db over the entire tuning range. "ONE-THIRD OCTAVE": Maximum response is flat ±4 db over the entire tuning range. With respect to the "ALL-PASS" response, the effective bandwidth for noise is one-third octave ±2 db. "ALL-PASS": Flat from 2.5 cycles to 25 kilocycles ±2 db.

Bandwidth: "NARROW": (See plot) Response is down 3 db at ±4% of selected frequency. At one-half and twice selected frequency, response is down more than 40 db. "ONE-THIRD OCTAVE": (See plot) Bandwidth is 1.26:1 at the 3 db points. At one-half and twice the selected frequency, the response is down more than 30 db.

Input Impedance: 100 kilohms, unbalanced. Low input terminal grounded to case.

Meter: Three ranges, −10 to +10 decibels, 0 to 3 volts, and 0 to 10 volts.

Attenuator: Adjustable in 10-db steps.

Direct Use with Microphone:

Microphone Type	Component Levels Must Exceed
759-P25*	50 db re 0.0002 microbar
1551-P1L	50 db re 0.0002 microbar
1551-P1H	65 db re 0.0002 microbar

Output: Jack on front panel provides approximately 1 volt, open circuit, when meter indicates full scale. Output impedance, 5 kilohms.

Tubes: Four CK512AX and two CK526AX.

Transistors: Six 2N169A, two 2N521A, and seven 2N324.

Batteries: Four 1.5 volt (Eveready No. 935 Size C or equivalent) and two 67.5-volt (Eveready No. 467 or equivalent). Batteries are supplied with instrument. Life of batteries approximately 100 hours. A BATTERY CHECK position on the OFF-ON switch connects the panel meter to indicate when the batteries are satisfactory or need to be replaced.

Accessories Supplied: Shielded cable-and-plug assembly for connection to sound-level meter. Plugs to fit input and output jacks. Cable-and-plug assembly for calibration using 115-volt line. Pouch for accessories. Airplane-luggage-type carrying case.

Dimensions: $10\frac{5}{8} + 15\frac{3}{8} + 11\frac{1}{2}$ inches, over-all.

Weight: $31\frac{1}{2}$ pounds without accessories or carrying case; $39\frac{3}{4}$ pounds with accessories and carrying case.

*TYPE 1550-P1 Adaptor Plug required (see below).

Type		*Code Word*	*Price*
1554-A	Sound and Vibration Analyzer	DRAMA	$1060.00
	Set of Replacement Batteries	DRAMAADBAT	7.80
1550-P1	Adaptor Plug	MATOR	4.00

INCREASED BIAS CURRENT RATING ON TYPE 1607-A TRANSFER-FUNCTION AND IMMITTANCE BRIDGE

The maximum permissible continuous d-c bias current rating of the TYPE 1607-A Transfer-Function and Immittance Bridge has been increased from 100 ma to 250 ma. The new rating applies to both old and new instruments, since no change has been made in the instruments, but a re-examination of the temperature rises involved has shown the original rating to be too conservative.

In measurements on transistors with this instrument, in some cases difficulty has been encountered as a result of low-frequency oscillations arising in the circuit consisting of the external power supply and bias filters in combination with the transistor. This difficulty shows up as an inability to balance the instrument to a complete null. (The omission of the TYPE 1607-P500 Damper Unit may also produce a similar effect, but the resulting oscillation is then at a high frequency.) The presence of this low-frequency oscillation can be detected by means of an oscilloscope and cured by a rearrangement of the power supplies or by the addition of appropriate by-pass capacitors and loading resistors.

A 50-OHM TERMINATION FOR THE TYPE 805-C STANDARD-SIGNAL GENERATOR

To facilitate measurements on 50-ohm devices, a new 50-ohm termination, TYPE 805-P2, is now available for use with the TYPE 805-C Standard-Signal Generator. This generator has an open-circuit output impedance of 75 ohms, and the termination unit normally supplied with the generator gives output impedances of 37.5, 7.5, and 0.75 ohms. The output voltmeter reads output

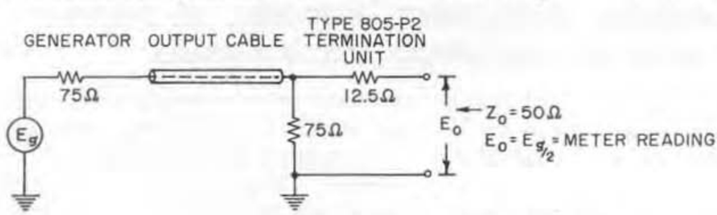


Figure 1

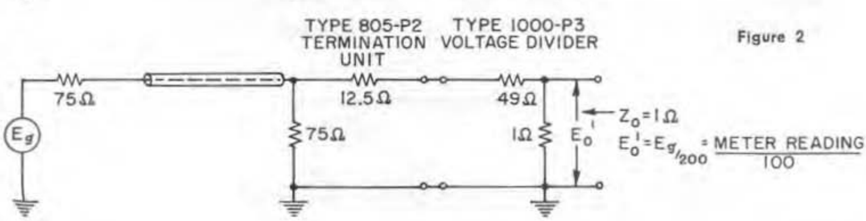
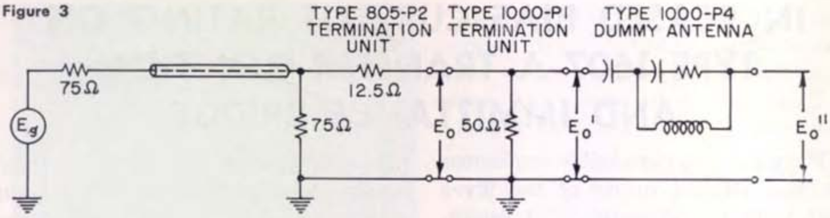


Figure 2

Figure 3



voltage directly for the 37.5-ohm termination; for the two lower impedances, the voltmeter reading is divided by 10 and 100, respectively. The Type 805-P1 Termination Unit supplied with the generator also includes a dummy antenna.

The Type 805-P2 50-ohm Termination Unit is shown schematically in Figure 1. It will be seen that the no-load voltage is still indicated correctly by the panel meter. With a 50-ohm load, the load voltage is one-half the meter reading.

Figures 2 and 3, respectively, show the 50-ohm termination unit as used with the standard Type 1000-P Signal Generator accessories, the Type 1000-P3 Voltage Divider, and the Type 1000-P4 Dummy Antenna.

The maximum output voltage with either termination is 2 volts. With the termination removed, the maximum open-circuit output voltage is 4 volts.

Type		*Code Word*	*Price*
805-P2	**50-ohm Termination Unit**	ALTER	**$25.00**
1000-P3	**100:1 Voltage Divider**	ARMOR	**17.50**
1000-P1	**50-ohm Termination**	ALOUD	**25.00**
1000-P4	**Dummy Antenna**	ARROW	**15.00**

SALON INTERNATIONAL DE PIÈCES DÉTACHÉS, TUBES, ÉLECTRONIQUES, ACCESSORIES, APPAREILS DE MESURES POUR LES INDUSTRIES ÉLECTRONIQUES

This international exhibit will be held at the Parc des Expositions, Porte de Versailles, Paris, February 19th through 23rd, 1960.

General Radio will participate again as in 1958 and will show a group of modern electronic instruments for laboratory and production. Engineers from our representatives in France, ETS. RADIOPHON, will be in attendance to greet our overseas friends and to discuss their measurement problems.

General Radio Company

PRINTED IN U.S.A.