THE GENERAL RADIO

EXPERIMENTER

VOLUME 37 Nos. 9 & 10 SEPTEMBER-OCTOBER, 1963

NEW PERFORMANCE, *NEW* CONVENIENCE WITH THE *NEW* SOUND AND VIBRATION ANALYZER

The TYPE 1564-A Sound and Vibration Analyzer is designed primarily for the frequency analysis of acoustic spectra having components in the frequency range between 2.5 cps and 25 kc. It incorporates many important improvements over its predecessor, the TYPE 1554-A,[1] which make it more useful and easier to operate.

Two bandwidths are provided, each a fixed percentage of the frequency to which the analyzer is tuned. The one-third-octave bandwidth is useful with moderately varying continuous spectra

[1] J. J. Faran, Jr., "A New Analyzer for Sound and Vibration," *General Radio Experimenter*, 33, 12, December, 1959.

Figure 1. Panel view of the Type 1564-A Sound and Vibration Analyzer in Flip-Tilt case, with cover removed. Also shown is the Type 1560-P4 PZT Microphone Assembly.

CONTENTS OF THIS ISSUE

(noise). The one-tenth-octave bandwidth can resolve sharply varying continuous spectra or discrete frequency components. The center frequency in each case is continuously tunable. In addition, a flat (ALL PASS) amplifier response permits measurement of the over-all level of the input signal. The analyzer can operate directly from a transducer (microphone or vibration pickup) or, for greater sensitivity, from the output of sound-level and vibration meters. With the TYPE 1521-A Graphic Level Recorder,[2] it forms a recording analyzer for automatic amplitude-frequency plotting.

Equally at home in the laboratory or in the field, the analyzer is available in the convenient Flip-Tilt case, weighing less than 15 pounds, or in a rack-mount adaptation. It can be powered by either a 115/230-volt line or by the internal, rechargeable nickel-cadmium battery.

It can also analyze electrical signals, and an accessory audio-frequency probe is available to facilitate connection to circuit elements.

CIRCUIT

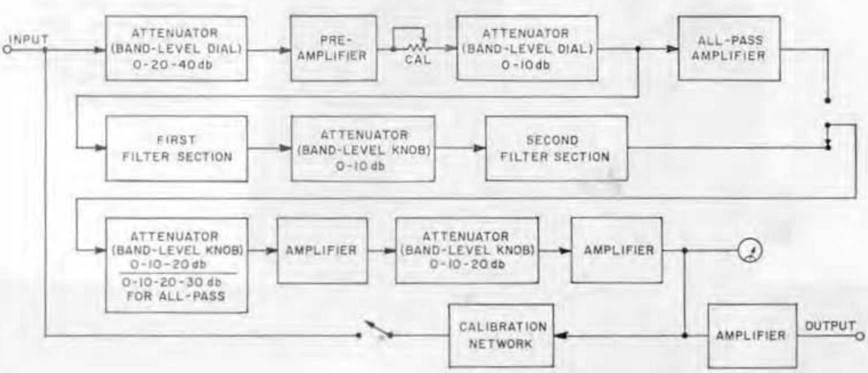
Figure 2 is a functional block diagram of the TYPE 1564-A Sound and Vibration Analyzer showing the three basic sections: preamplifier, filter, and output amplifier.

Preamplifier Section

The preamplifier section serves to adjust the amplitude of the input signal. The step attenuators are controlled by the knurled outer dial of the coaxial

[2] M. C. Holtje and M. J. Fitzmorris, "A Graphic Level Recorder with High Sensitivity and Wide Ranges," *General Radio Experimenter*, 33, 6, June, 1959.

Figure 2. Functional block diagram of the analyzer.



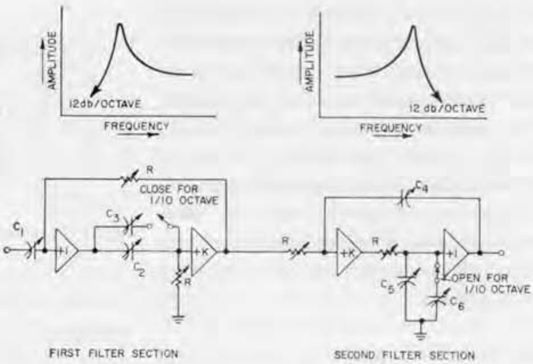


Figure 3. Elementary schematic of the filter sections.

BAND LEVEL control (see Figure 1). The panel CAL control adjusts the gain over a range of 12 db and is used to calibrate the instrument to read directly in volts, sound-pressure level, or other appropriate units. The amplifier at the input uses a field-effect transistor to provide the high input impedance and low noise needed for operation with piezoelectric transducers.

Filter Section

The filter is synthesized as an isolated cascade of two resonant (second order) sections. The resonant frequencies of the sections are staggered about the selected center frequency to produce a filter with a noise bandwidth of one-third octave. To obtain a one-tenth octave response, the sections are synchronously tuned. Figure 3 is a functional diagram.

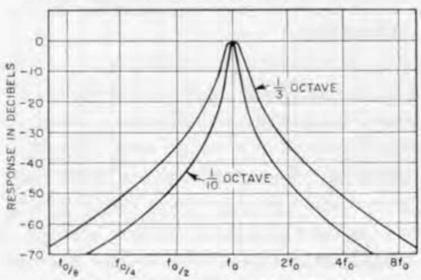


Figure 4. Filter response characteristics.

Capacitors C_1 through C_6, switched by the FREQUENCY MULTIPLIER control, determine the tuning range. The four resistors (R) are adjusted simultaneously by the FREQUENCY control to span the ten-to-one range selected. Frequency responses that are mirror images of each other result from interchanged placement of resistors and capacitors for the two sections. A symmetrical over-all filter response is thus obtained.

Filters similar to these have, in the past, required very close-tolerance, stable components to maintain a stable transmission. In a tunable filter, this necessitates close tracking between the tuning components, a requirement that is difficult and costly to achieve. For the circuit configurations given in Figure 3, there are an infinite number of solutions for component values that will yield the desired transmission. It can be shown, however, that when the instabilities (tracking errors, tolerances, and aging effects) of all circuit parameters are considered, there is only one solution that will yield both the desired transmission and minimum drift. The peak transmission of a filter section in the TYPE 1564-A Sound and Vibration Analyzer is about 3.5 times less sensitive to tracking errors than it would be if, for example, both the resistors and the capacitors had equal values. This design accounts in part for the small size and low weight of the analyzer, since it allows small, relatively simple potentiometers to be used for tuning. It has also made possible an improved tolerance on the uniformity of peak response (see Specifications). Figure 4 shows the filter response characteristics.

Output-Amplifier Section

The output amplifier consists of a cascade of amplifiers and attenuators, which ultimately drive the detector-meter circuit and provide a one-volt output signal, corresponding to a full-scale meter indication. The output signal is supplied from an isolating amplifier so that the load has no effect on analyzer operation. The detector-meter circuit is driven by a push-pull amplifier to ensure high linearity and low temperature drift. The detector characteristic[3] is essentially rms for all waveforms except low-duty-ratio pulses.

Three detector averaging times are available. They ensure that the user will not be burdened with either a slow-acting meter when analyzing at high frequencies or with a widely fluctuating meter when tuning noise signals at low frequencies. The two faster speeds satisfy the ASA specification for "General Purpose Sound Level Meters." The slowest speed gives the meter rise and fall characteristics analogous to those of simple resistance-capacitance networks. Rise and fall time constants for this speed are two and six seconds respectively. Detector speed is dependent

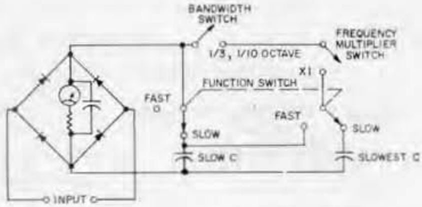


Figure 5. Switching arrangement for the meter circuit.

on the settings of the BANDWIDTH and FREQUENCY MULTIPLIER controls, as well as on the setting of the panel FAST-SLOW switch. Figure 5 shows the interconnection of these panel controls.

The step attenuators in the output-amplifier section, and also the one between the filter sections, are operated by the BAND LEVEL knob (inner control) and are used to set the level of the frequency component to which the filter is tuned.

Power Supply

The power supply permits either battery or line operation. The battery is a rechargeable nickel-cadmium unit, which also serves as a ripple filter for line operation. When the line voltage is interrupted, the battery automatically takes over. A fully charged battery permits the analyzer to be operated for about 25 hours; fourteen hours are required for charging.

Calibration

A feedback-type calibration circuit similar to those used in other GR sound-measuring equipment is used in the TYPE 1564-A Sound and Vibration Analyzer. To amplitude-calibrate the instrument, the output is connected to the input through a limiter and calibrated attenuator. When the gain is adjusted to equal the *known* loss in the

[3] E. E. Gross, "Improved Performance Plus a New Look for the Sound-Level Meter," *General Radio Experimenter*, 32, 17, October, 1958.

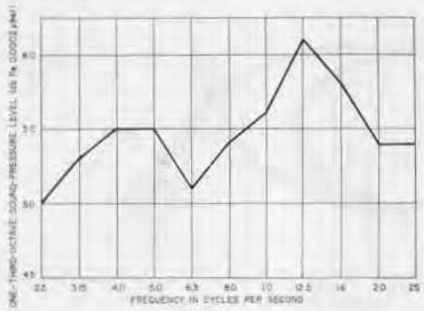


Figure 6. Subaudio sound spectrum measured in a quiet office.

feedback path, the system oscillates. The frequency of oscillation is determined by the filter. The analyzer can be calibrated when the BANDWIDTH is set to 1/10 OCTAVE, 1/3 OCTAVE, or ALL PASS. For ALL PASS calibration, a 1-kc filter is included in the calibration network and determines the frequency of oscillation. The loss in the feedback network is adjustable by means of an internal control calibrated in terms of microphone sensitivity. An additional reference point provides for a calibration direct reading in volts.

APPLICATIONS

The TYPE 1564-A Sound and Vibration Analyzer fills the gap between the simple octave-band noise analyzer and narrow-band analyzers that supply more detailed information but whose operation is more time consuming. Although the octave-band analyzer yields ample data for many purposes, a closer look at the spectrum is often necessary. This is especially true when the analysis may lead to expensive modifications of the object under test. Here, the sound and vibration analyzer helps to identify the various sources of the noise so that effective corrective measures can be taken.

Use with Microphone

The 25-megohm input impedance of the new analyzer, coupled with its high sensitivity, allows piezoelectric transducers to be connected directly to the INPUT.

For analysis of sound spectra where band-pressure levels exceed 44 db, a TYPE 1560-P3 or -P4 PZT Microphone[4] is recommended. These microphones have identical response characteristics. The TYPE 1560-P4 includes a short, flexible conduit for mounting the microphone on the instrument. The -P3 model can be plugged directly into the analyzer or used with the TYPE 1560-P34 Tripod and Extension Cable. When connected to the analyzer, the microphone has a response that is essentially flat from 20 cps to 8 kc; the low-frequency end is limited only by the input time constant (product of microphone capacitance and analyzer input resistance) for frequencies above 2.5 cps. For the measurement of subaudio sound spectra, sometimes of interest in connection with jet aircraft and missile tests, a capacitor can be connected across the microphone terminals to extend the low-frequency range as desired. When levels are not sufficiently high, the microphone-capacitor combination can be used to drive the TYPE 1553-A Vibration Meter,[5] which in turn drives the analyzer.* Figure 6 shows a subaudio spectrum measured in a quiet office.

Vibration

For analysis of acceleration spectra in the frequency range from 2.5 cps to 1

[4] W. R. Kundert, "New, Compact, Octave-Band Analyzer," *General Radio Experimenter*, 36, 10, October, 1962.

[5] E. E. Gross, Jr., "The TYPE 1553-A Vibration Meter," *General Radio Experimenter*, 35, 11, November, 1961.

* The vibration meter, rather than the sound-level meter, is used because of its better low-frequency response.

kc, the Type 1560-P52 Vibration Pickup[6] is recommended for use with the analyzer. This combination measures band levels from 0.0007 to 100 g, rms. For lower-level measurements, the vibration meter is recommended as a preamplifier. High-frequency vibration pickups can be used to extend the upper frequency limit to 25 kc.

Electrical Noise

The Type 1564-A is useful for analyzing the noise voltage produced by amplifiers, tape recorders, semiconductors, and other electronic devices.

Bands of noise can be generated for transfer and reverberation studies when the analyzer is driven by a Type 1390-B Random-Noise Generator.[7]

Wave Analysis

The Type 1564-A Sound and Vibration Analyzer can also be used as an analyzer for periodic electrical signals. A Type 1560-P41 Audio-Frequency Voltage Probe (Figure 7) is available for convenient connection to high-impedance sources. The probe, at the end of a 40-inch length of cable, presents to the source under test an impedance of 25 megohms in parallel with 20 pf. It inserts a 20-db loss ahead of the analyzer so that the range of full-scale sensitivity becomes 3 millivolts to 300 volts.

Figure 7. The Audio-Frequency Voltage Probe is supplied with a variety of probe tips.

Automatic Recording

Continuous, unattended, amplitude-*vs*-frequency recording in conjunction

[6] E. E. Gross, Jr., "New PZT Ceramic Vibration Pickup and Control Box for Vibration Measurements," *General Radio Experimenter*, 36, 11, November, 1962.

[7] A. P. G. Peterson, "A New Generator of Random Noise," *General Radio Experimenter*, 34, 1, January, 1960.

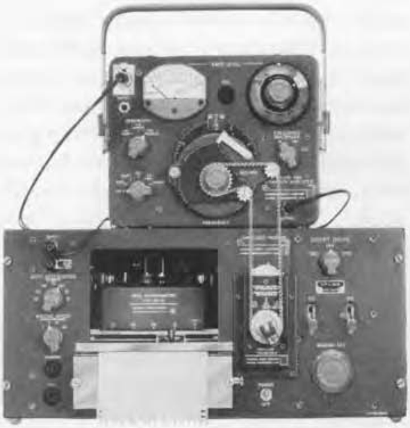


Figure 8. Either model of the Analyzer, rack or portable, can be combined with the Graphic Level Recorder.

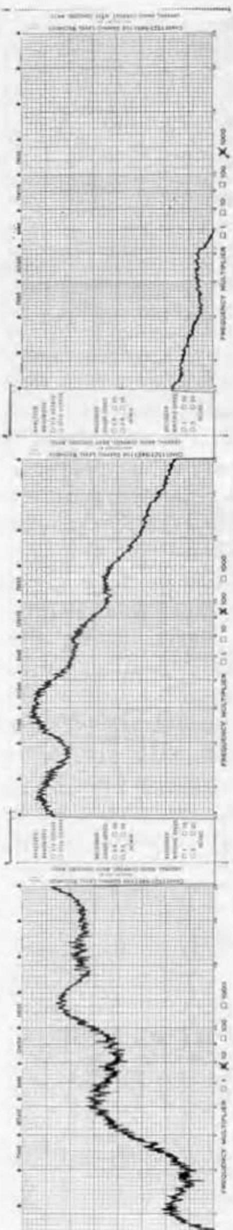


Figure 9a. Chart record of a vibration acceleration spectrum measured on the chassis of a calculating machine. For this measurement a high-frequency vibration pickup is used.

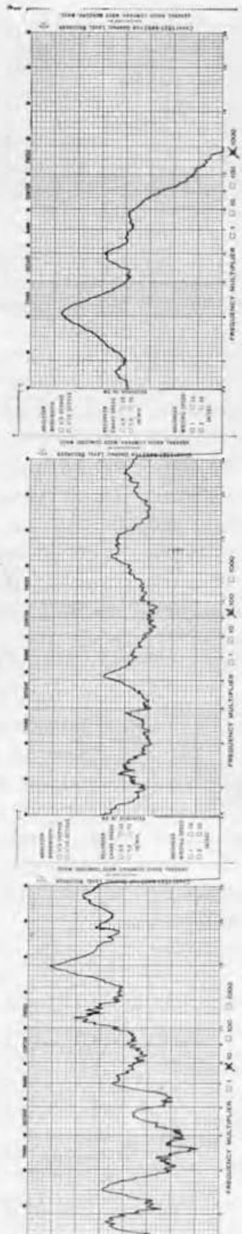


Figure 9b. Sound-pressure spectrum in the vicinity of an air compressor, measured with the recording analyzer and the Type 1560-P4 PZT Microphone Assembly.

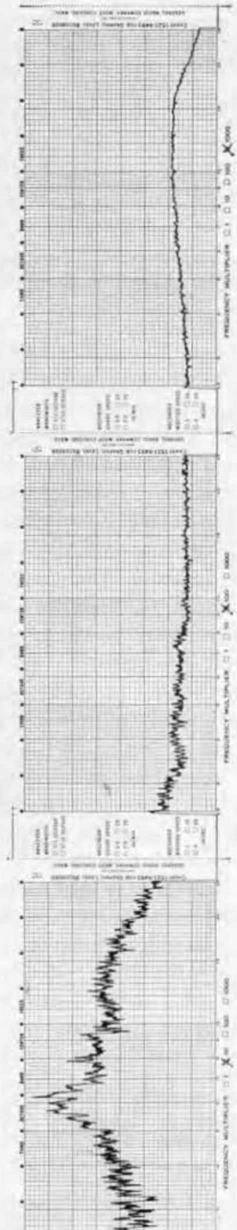


Figure 9c. Electrical noise spectrum of a tape recorder.

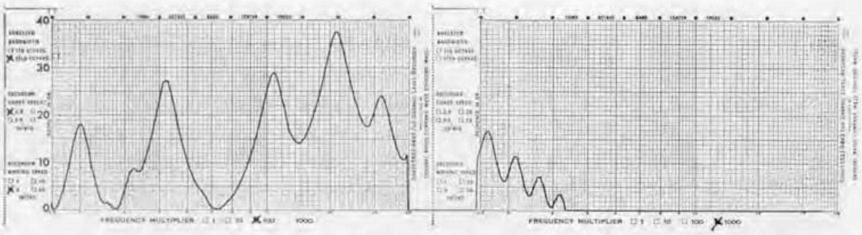


Figure 9d. Voltage spectrum generated by the oboe stop of an electric organ at C_5 (523 cps). Note the presence of the fifth, sixth, and seventh harmonics of the 60-cycle power-line frequency and the pronounced 1500-cycle formant frequency.

with the TYPE 1521-A Graphic Level Recorder is made possible by an automatic range-changing device. After each revolution of the main FREQUENCY dial (a frequency span of ten to one) the FREQUENCY MULTIPLIER control (see Figure 1) advances one position. When the tuning control is driven continuously by the recorder, the analyzer sweeps repeatedly through its entire frequency range. Both the FREQUENCY dial and the chart produced by the recorder have logarithmic frequency scales. Manual operation is simplified by a detent device which can be engaged by a panel control to locate the dial at the ASA-preferred one-third-octave frequencies or, optionally, at any series of frequencies related by one-third octave.

Automatic plotting of one-third-octave and narrow-band data has become almost standard practice. The reasons for this are obvious. Data can be accumulated in a small fraction of the time required for manual analysis and with much less chance of error. Figure 8 shows analyzer-recorder combinations. Chart paper, TYPE 1521-9493, permits a continuous amplitude-frequency plot from 25 cps to 25 kc. The automatic range-changing device in the analyzer operates when the tuning potentiometer is in its "dead" region. During this period the signal path is shorted, so that generated transients will not reach the output terminals and the recorder pen returns to low scale. The chart produced has an active length of 7.5 inches per decade and a total length of 9 inches per decade. Figure 9 shows several charts made with a recorder-analyzer combination.

—W. R. KUNDERT

SPECIFICATIONS

FREQUENCY

Range: From 2.5 cps to 25 kc in four decade ranges.

Dial Calibration: Logarithmic.

Accuracy of Calibration: ±2% of frequency-dial setting.

Filter Characteristics: Noise bandwidth is either 1/3 octave or 1/10 octave.

One-third-octave characteristic has at least 30-db attenuation at one-half and twice the selected frequency (see plot). One-tenth-octave characteristic has at least 40-db attenuation at one-half and twice the selected frequency. Ultimate attenuation is greater than 70 db for both characteristics.

For both bandwidths peak response is uniform ± 1 db from 5 cps to 10 kc and ±1.5 db from 2.5 cps to 25 kc.

INPUT

Impedance: 25 megohms in parallel with 80 pf (independent of attenuator setting).

Voltage Range: 0.3 millivolt to 30 volts full scale in 10-db steps.

OUTPUT

Voltage: At least 1 volt open circuit when meter reads full scale.

SPECIFICATIONS (Cont.)

Impedance: 6000 ohms. Any load can be connected.

Meter: Three scales, 0 – 3 volts; 0 – 10 volts; −6 to +10 db.

Recording Analyzer: Automatic range switching at the end of each frequency decade allows convenient continuous recording of spectra with the TYPE 1521-A Graphic Level Recorder.

GENERAL

Amplitude Calibration: Built-in, feedback-type calibration system permits amplitude calibration at any frequency.

Detector: Quasi-rms with three averaging times. Faster two speeds conform with ASA standard for sound-level meters.

Power Requirements: Operates from 115 (or 230) volts, 50-60 cps, or from nickel-cadmium battery supplied. Battery provides 25 hours of operation when fully charged and requires 14 hours for charging.

Accessories Supplied: TYPE CAP-22 Power Cord, shielded cable, and TYPE 1564-2020 Detented Knob and Dial Assembly.

Accessories Available: TYPE 1560-P4 PZT Microphone Assembly or TYPE 1560-P3 PZT Microphone for direct acoustic pickup; TYPE 1560-P52 Vibration Pickup for solid-borne vibrations; TYPE 1560-P41 Audio-Frequency Voltage Probe for voltage measurements.

Cabinet: Flip-Tilt; relay-rack model also is available.

Dimensions: Portable model, case closed — width 10¼, height 8⅛, depth 8 inches (260 by 210 by 205 mm), over-all; rack model — panel 19 by 10½ inches (485 by 270 mm), depth behind panel 6 inches (155 mm).

Net Weight: Portable model, 14½ pounds (7 kg); rack model, 15½ pounds (7.5 kg). TYPE 1560-P41, ¼ pound (115 grams).

Shipping Weight: Portable model, 23 pounds (10.5 kg); rack model, 30 pounds (14 kg).

Type		*Code Number*	*Price*
1564-A	Sound and Vibration Analyzer, Portable Model . . .	1564-9701	$1150.00
1564-9820	Sound and Vibration Analyzer, Rack Model	1564-9820	1150.00
1560-P41	Audio-Frequency Voltage Probe	1560-9641	45.00

U. S. Patent Nos. 3,012,197; D187,740; and 2,966,257.

IMPROVED COAXIAL TERMINATION

New 50-ohm terminations, the TYPES 874-W50 and -W50L, replace the TYPE 874-WM. These new terminations, identical except for the type of connector used, are more accurate than their predecessors, and they have a lower standing-wave ratio and a higher power rating. Figure 2 is a plot of standing-wave ratio.

Figure 1.

Both are equipped with TYPE 874 Coaxial Connectors, TYPE 874-W50 with the non-locking version, TYPE 874-W50L with the locking type.

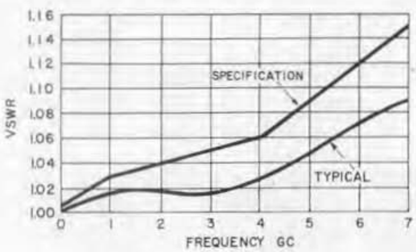


Figure 2.
VSWR of Type 874-W50.

DC Resistance: 50 ohms ± 0.5%.

Maximum Power: 2 watts continuous.

VSWR: Less than 1.06 at 4 Gc; see curve.

Net Weight: TYPE 874-W50, 2½ ounces; TYPE 874-W50L, 3 ounces.

Type		*Code Number*	*Price*
874-W50	50-ohm Termination	0874-9952	$18.50
874-W50L	50-ohm Termination (Locking Connector)	0874-9953	19.50

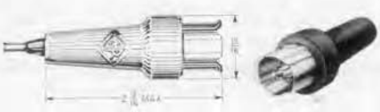
U. S. Patent No. 2,548,457

NEW CONNECTORS, NEW ADAPTORS FOR THE 874 LINE

CONNECTORS

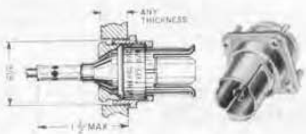
A set of connectors to fit RG-174/U 1/10-inch cable, a panel feedthrough connector, and a set of adaptors to Microdot connectors are the latest additions to the TYPE 874 line of coaxial equipment.

The 174-connector series consists of cable and panel connectors in both locking and non-locking versions. These will fit RG-174/U, -188/U, and -316/U 50-ohm cables; also RG-161/U and -179/U cables. The panel feedthrough connector mates any pair of TYPE 874 Connectors directly through a panel or bulkhead.

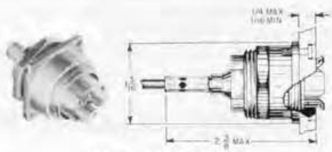


TYPE 874-C174A

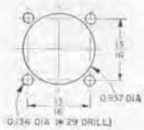
TYPE 874-CL174A

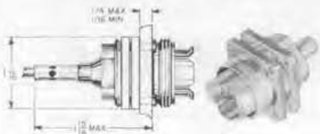


TYPE 874-PB174A

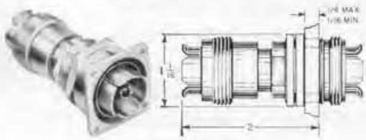


TYPE 874-PRL174A



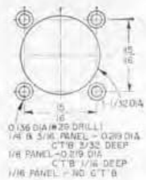


TYPE 874-PL174A



TYPE 874-PFL

Mounting dimensions for flanges; (above) non-recessed type, (below) recessed type.



Type		*Code Number*	*Price*
874-C174A	**Cable Connector**	0874-9418	**$4.50**
874-CL174A	**Cable Connector, locking**	0874-9419	**5.50**
874-PB174A	**Panel Connector, flanged**	0874-9448	**5.00**
874-PL174A	**Panel Connector, locking**	0874-9449	**5.00**
874-PRL174A	**Panel Connector, locking, recessed**	0874-9469	**5.00**
874-PFL	**Panel Connector, locking, feedthrough**	0874-9451	**9.50**

U. S. Patent No. 2,548,457.

ADAPTORS

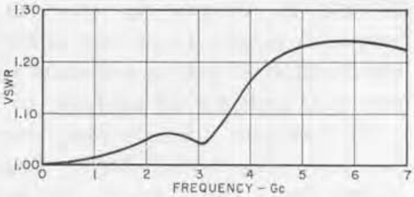
Adaptors to Microdot connectors include both locking and non-locking types. In addition to their use in connecting between Microdot and 874 structures, they can be combined with other GR adaptors to join Microdot connectors to other UG types. This is easily accomplished by the plugging together of the TYPE 874 ends of two adaptors.

All GR coaxial adaptors are designed for low reflections and have low standing-wave ratios up to several gigacycles.

TYPE
874-QMDJ

TYPE
874-QMDP

Adaptors are now available to types BNC, C, HN, LC, LT, Microdot, N, SC, TNC, and UHF connectors, as well as to 50-ohm rigid line of ⅞-, 1⅝-, and 3⅛-inch sizes.



VSWR of a pair of adaptors (Types 874-QMDP and QMDJL) plugged together.

Type	*Contains 874 and*	*Connects to*	*Code Number*	*Price*
874-QMDJ	Microdot Jack	Microdot Plug	0874-9720	$ 9.50
874-QMDJL*	Microdot Jack	Microdot Plug	0874-9721	10.50
874-QMDP	Microdot Plug	Microdot Jack	0874-9820	9.50

* Locking Type 874.
U. S. Patent No. 2,548,457.

SALES-ENGINEERING OFFICES

NEW CLEVELAND OFFICE

September 1 marks the official opening of our 12th Sales-Engineering Office, in Cleveland. Manager of the new office will be L. C. (Tom) Fricke (BSEE, U. of Illinois, '57), who for the past few years has been at our Chicago Office. He will be assisted by Danny Woodward (BSEE, U. of Illinois, '62), who goes to Cleveland after an intensive training course at Concord. Customers in Ohio, Kentucky, and western Pennsylvania will find this new office a convenient source of technical and commercial information about General Radio products.

The address:

General Radio Company
5579 Pearl Road
Cleveland, Ohio, 44129

Telephone:
(area code 216) 886-0510
TWX:
(area code 216) 888-0716

DALLAS

Eric L. Mudama will join the staff of GR's Dallas Office in September. He received his SB in EE degree from MIT in February, 1963, and has been in our sales-engineering training course at Concord since October, 1962.

TORONTO

Walter F. Oetlinger was recently appointed Service Supervisor at General Radio's Service Laboratory in Toronto. Located adjacent to the General Radio Canadian Office at 99 Floral Parkway,

Tom Fricke

Danny Woodward

Eric Mudama

Thomas Mujica

Walter Oetlinger

Toronto 15, Ontario, the laboratory provides complete repair and calibration facilities, as well as a stock of replacement parts, for GR products.

Mr. Oetlinger, formerly Supervisor, Electronic Laboratory, Bayly Engineering Ltd., Ajax, Ontario, has had over ten years' experience in this field, and is well known to many of our Canadian customers.

NEW YORK

Thomas H. Mujica, a BEE from Brooklyn Polytechnic Institute in 1960, goes to the New York area office (Ridgefield, N. J.) after three years in sales engineering at Concord.

CANADIAN ELECTRONICS CONFERENCE

Exhibition Park Toronto *September 30-October 2, 1963*

NATIONAL ELECTRONICS CONFERENCE

McCormick Place Chicago *October 28-30, 1963*

We look forward to welcoming our many friends at these two important meetings. At the General Radio booth you will see many of the new instruments recently described in the *Experimenter*, plus others not yet announced.

Engineers from our local offices and from our main plant in Concord will be on hand to demonstrate the equipment and to answer your questions.

GENERAL RADIO COMPANY (OVERSEAS)

announces the appointment,

as exclusive GR representative for Austria, of

Dipl.-Ing. Peter Marchetti

Wien VII
Lindengasse 55

Telephones: 440453
5769053