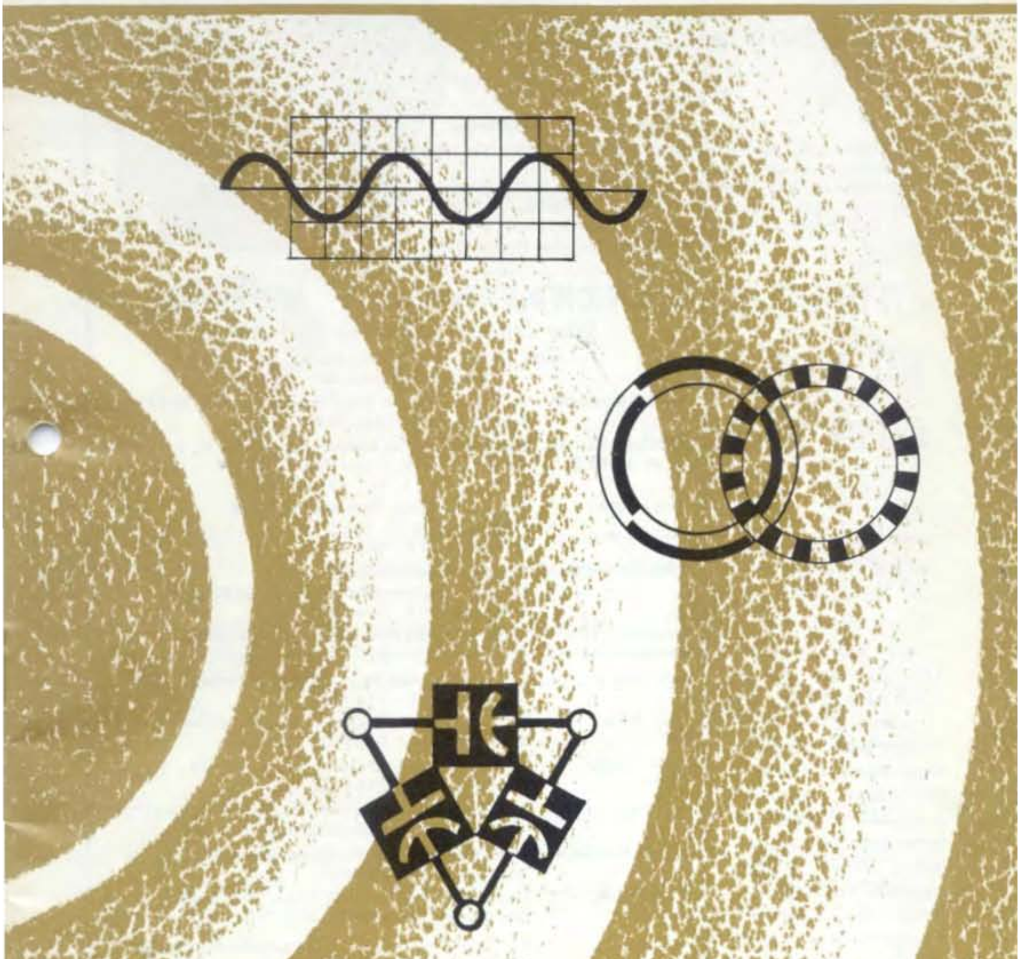
the GENERAL RADIO
experimenter

VOLUME 39 NO 7 JULY 1965



in this issue:

VIBRATION PICKUPS • 100 μF DECADE CAPACITOR • 900–2000 MHz OSCILLATOR • COAXIAL MICROWAVE NEWS

the GENERAL RADIO
experimenter

©1965—GENERAL RADIO COMPANY, WEST CONCORD, MASS., U.S.A.

Published Monthly by the General Radio Company

VOLUME 39 NO 7 JULY 1965

CONTENTS Page

GENERAL RADIO COMPANY

West Concord, Massachusetts*, 01781

Telephone (Concord) 369-4400; (Boston) 646-7400
Area Code Number 617

NEW ENGLAND:	22 Baker Avenue, West Concord, Mass., 01781 *Telephone—617 646-0550*
METROPOLITAN NEW YORK:*	Broad Avenue at Linden, Ridgefield, N. J., 07657 *Telephone—N. Y., 212 964-2722 N. J., 201 943-3140*
SYRACUSE:	Pickard Building, East Molloy Road, Syracuse, N. Y., 13211 *Telephone—315 454-9323*
PHILADELPHIA:	Fort Washington Industrial Park, Fort Washington, Pennsylvania 19034 *Telephone—215 646-8030*
WASHINGTON* and BALTIMORE:	11420 Rockville Pike, Rockville, Md., 20852 *Telephone—301 946-1600*
ORLANDO:	113 East Colonial Drive, Orlando, Florida, 32801 *Telephone—305 425-4671*
CHICAGO:*	6605 West North Avenue, Oak Park, Illinois, 60302 *Telephone—312 848-9400*
CLEVELAND:	5579 Pearl Road, Cleveland, Ohio, 44129 *Telephone—216 886-0150*
DALLAS:	2501-A West Mockingbird Lane, Dallas, Texas, 75235 *Telephone—214 Fleetwood 7-4031*
LOS ANGELES:*	1000 North Seward St., Los Angeles, Cal., 90038 *Telephone—213 469-6201*
SAN FRANCISCO:	1186 Los Altos Ave., Los Altos, Cal., 94022 *Telephone—415 948-8233*
TORONTO:*	99 Floral Parkway, Toronto 15, Ontario, Canada *Telephone—416 247-2171*
MONTREAL:	Office 395, 1255 Laird Blvd., Town of Mount Royal, Quebec, Canada *Telephone—514 737-3673*

*Repair services are available at these offices.

GENERAL RADIO COMPANY (Overseas), 8008 Zurich, Switzerland
GENERAL RADIO COMPANY (U.K.) LIMITED, Bourne End, Buckinghamshire, England
Representatives in Principal Overseas Countries

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.

Figure 1. ***(Left)*** **Vibration pickup with control box installed on Type 1551-C Sound-Level Meter.** ***(Above)*** **The three vibration pickups with their connecting cable. Left to right: Type 1560-P52, Type 1560-P53, and Type 1560-P54.**

VIBRATION MEASUREMENTS WITH THE SOUND-LEVEL METER

The standard sound-level meter can be adapted for the measurement of solid-borne vibrations by the substitution of a vibration pickup, or accelerometer, in place of the microphone. For use with General Radio sound-level meters, three vibration pickups are now available, offering a wide choice of characteristics.

Each pickup is offered, either by itself or in combination with a control box, which by means of electrical integrating networks converts the acceleration response of the pickup into velocity and displacement responses. Each combination, called a Vibration Pickup System, consists of pickup, control box, low-noise connecting cable, and convenient probes or fastening devices.

The control boxes are basically alike, but each type requires unique input and output circuits determined by the vibration-pickup characteristics. A three-position switch, labeled ACC, VEL, DISP, selects the characteristic desired. At each switch position the signal level is automatically adjusted to the correct calibration value.

VIBRATION-PICKUP CHARACTERISTICS

Table I lists the characteristics of the three Vibration Pickups and of their corresponding Vibration Pickup Systems.

Type 1560-P52 Vibration Pickup

This pickup has a low output impedance and is especially suited for the detection of low-frequency vibrations.

TABLE I

VIBRATION PICKUPS

Type Number	Type 1560-P52	Type 1560-P53	Type 1560-P54
Catalog Number	1560-9652	1560-9653	1560-9654
Sensitivity (mV/g), nominal	75	72	580
Temp Coeff of Sens (dB/°C)	0.06	<0.02	0.01
Resonant Frequency (c/s)	3200	28,000	5000
Capacitance (pF)	10,000	350	700
Temperature Range (°C)	0 to 75	− 18 to 120	− 18 to 120
Relative Humidity Range (%)	0 to 100	0 to 100	0 to 100
Cable Length (ft)	5 (1.55 m)	8 (2.5 m)	8 (2.5 m)
Dimensions (in)	1⅝ by 1 7/16 by 9/16	⅝ hex by 0.7	1 3/16 dia by 1 1/16
(mm)	42 by 37 by 15	15.5 by 18	31 by 27
Net Weight (oz)	1.6 (45 grams)	1.1 (31 grams)	3.1 (90 grams)
Price	**$100.00**	**$220.00**	**$160.00**

VIBRATION PICKUP SYSTEMS

(Used with Type 1551-B or Type 1551-C Sound-Level Meter)

Type Number	Type 1560-P11B	Type 1560-P13	Type 1560-P14
Catalog Number	1560-9922	1560-9613	1560-9614
Ranges of Measurement Rms Acceleration (in/s²)	0.1 to 39,000	0.3 to 390,000	0.01 to 3900
(m/s²)	0.002 to 1000	0.006 to 10,000	0.0002 to 100
(g†)	0.0002 to 100	0.0006 to 1000	0.00002 to 10
Rms Velocity (in/s)	0.001 to *	0.001 to 1000	0.0001 to *
(m/s)	0.00002 to *	0.00002 to 20	0.000002 to *
Rms Displacement (mils)	0.03 to *	0.03 to 30,000	0.003 to *
(mm)	0.0006 to *	0.0006 to 600	0.00006 to *
Frequency Range (see Figure 2)			
Net Weight of System (lb)	1¾ (0.8 kg)	1¾ (0.8 kg)	2(1 kg)
Shipping Weight (lb)	5 (2.3 kg)	5 (2.3 kg)	5 (2.3 kg)
Price	**$160.00**	**$290.00**	**$220.00**

* Upper limit of displacement and velocity measurements depends upon frequency and is determined by the maximum acceleration possible before nonlinearity occurs (100 g for Type 1560-P11B, 10 g for Type 1560-P14).
† g = acceleration of gravity.

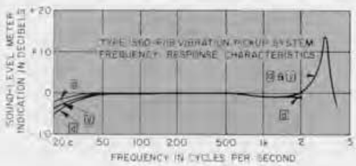
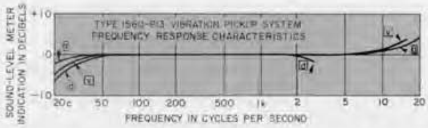
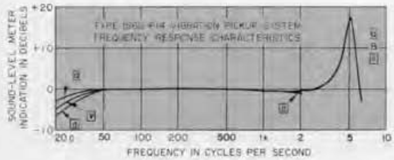


Figure 2. Response characteristics for constant applied (a) acceleration, (v) velocity, and (d) displacement.





It is supplied with the Type 1553 Vibration Meters for measurements down to 2 c/s. When the pickup is used on the Type 1560-P11B Vibration Pickup System, the 20-cycle low-frequency limit for acceleration measurements is set by the frequency response of the Type 1551-C Sound-Level Meter and for velocity and displacement by the integrating networks in the control box. Measurements of acceleration down to 2.5 c/s can be made if the Type 1564-A Sound and Vibration Analyzer is used in place of the sound-level meter. Velocity and displacement are easily calculated from the acceleration readings, when the frequency of the vibration is known.

Type 1560-P53 Vibration Pickup

From among the many excellent, small, lightweight accelerometers now available, this pickup has been chosen as best suited for vibration measurements over the complete audio range with GR instruments. It has (approximately) 10 times the resonant frequency, 20 times the output impedance, and the same output voltage as the Type 1560-P52. Owing to its high output impedance, this pickup requires the Type 1560-P40 Preamplifier for measurements down to 2 c/s with the Type 1553 Vibration Meter or to 2.5 c/s with the Type 1564-A Sound and Vibration Analyzer. Without the preamplifier, acceleration response will be down approximately 3 dB at 12 c/s.

The Type 1560-P13 Vibration Pickup System, in which this pickup is used, is capable of measurements down to 20 c/s with the Type 1551-C Sound-Level Meter. This combination is recommended for measurements to meet the requirements of Mil Std-740 (Ships).

Type 1560-P54 Vibration Pickup

This high-sensitivity pickup is a newly developed high-output, high-performance piezoelectric ceramic transducer. It has (approximately) 1.5 times the resonant frequency, 10 times the output, and 10 times the output impedance of the Type 1560-P52 Pickup. With its associated control box in the Type 1560-P14 Vibration Pickup System, it is intended for use with the Type 1551-C Sound-Level Meter. It is equally useful with the Type 1553 Vibration Meters and the Type 1564-A Sound and Vibration Analyzer. With these two instruments, the low-frequency response will be down about

3 dB at 6 c/s. With the Type 1560-P40 Preamplifier, the full range of the vibration meter and analyzer can be covered.

VIBRATION PICKUP SYSTEM CHARACTERISTICS

The curves of Figure 2 show the frequency-response characteristics of the three systems. In each case the response shown is the combined response of the pickup, its connecting cable, the associated control box, and the Type 1551-C Sound-Level Meter on 20-kc weighting switch position. Table II lists the characteristics of the three Vibration Pickup Systems so they can be readily compared.

DECIBELS OR VIBRATION QUANTITIES?

When a Vibration Pickup System is used in place of the microphone, the decibel readings of the sound-level meter can be converted to the corresponding vibration quantities, as above, or alternatively, the decibel scale can be assigned new reference levels. A data plate, see Figure 3, on the panel of the control box for each Vibration Pickup System lists the conversion factors to convert the dB reading to magnitudes of the vibration parameters. In addition, dB conversion charts are supplied in the operating instruction booklet, which relate any decibel reading of the sound-level meter to the vibration quantity being measured.

Some of the recent vibration specifications require answers in acceleration level, L_a (sometimes called adB), for acceleration measurements and velocity level, L_v (sometimes called vdB), for velocity measurements. There have been no standardized reference levels for these quantities, but some Navy specifications have commonly used 10^{-5} m/s² (10^{-3} cm/s²) for the L_a reference and 10^{-8} m/s (10^{-6} cm/s) for the L_v reference.

A new ASA Standard for Reference Quantities for Acoustical Measurements is now in process. It includes the two reference quantities above plus the

Figure 3. Two views of the control box, which attaches to the Type 1551-C Sound-Level Meter.

reference quantity of 10^{-10} m (10^{-8} cm) for displacement level, L_d.

When the Sound-Level Meter is used with any of the Vibration Pickup Systems, decibel readings can be easily translated to the proper vibration level in dB by adjustment of the internal calibration of the Sound-Level Meter for a −58.1 dB (re 1 volt/μbar) microphone and addition of the dB corrections listed in Table II.

TABLE II

Vibration Pickup System Type Number		*dB to be added to SLM* reading when control box switch is*		
	set at	ACC	VEL	DISP
	to get	L_a	L_v	L_d
	re	$10^{-5} m/s^2$	$10^{-8} m/s$	$10^{-10} m$
1560-P11B		20	40	50
1560-P13		30	40	50
1560-P14		0	20	30

*Internal calibration set for −58.1 dB microphone (re 1 volt/μbar).

USE WITH TYPE 1565-A SOUND-LEVEL METER

All three pickups can be used with the Type 1565-A Sound-Level Meter. Since the sensitivity of the Type 1565-A is lower by 10:1 than that of the Type 1551-C Sound-Level Meter, it may be desirable to avoid the loss introduced by the control box. With the pickup connected directly to the sound-level-meter input, acceleration measurements can be made to 10 c/s, 25 c/s, and 20 c/s with the Types 1560-P52, -P53, and -P54 Vibration Pickups, respectively. The upper frequency limits of 1200 c/s and 1500 c/s are safely below the resonant frequencies of the Types 1560-P52 and -P54. Above 3000 c/s the response of the Type 1560-P53 will be modified by the C-weighting characteristic (the Type 1565-A does not have a flat-response position). The operating instructions for the Type 1565-A Sound-Level Meter include a table of meter readings (level in dB) versus acceleration in g for the Type 1560-P52 Vibration Pickup. The same table applies to the Type 1560-P53 Vibration Pickup. For the Type 1560-P54, the table can be used if 20 dB is added to the "Level in dB" column. Use of the control box will permit measurement of velocity and displacement as well as acceleration, but, owing to the lower sensitivity of the Type 1565-A Sound-Level Meter, minimum readings will be 10:1 (20 dB) higher than those possible with the Type 1551-C.

PICKUP FASTENING OR ATTACHMENT

Specifications for the three vibration measuring systems described apply when the pickup is fastened to the device to be measured in a rigid manner, so that it cannot move with respect to the surface to which it is attached. Probes or other simple mounting devices are supplied as conveniences to be used when survey-type measurements are required or the preferred stud mounting cannot be readily ac-

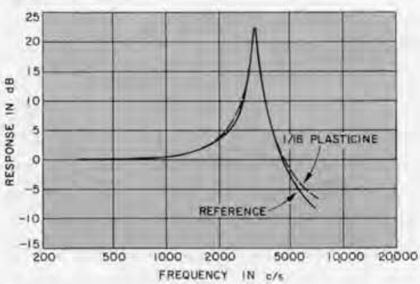


Figure 4. Frequency response of Type 1560-P52 Vibration Pickup attached by means of 1/16-inch-thick layer of Plasticine. Reference line shows response of pickup mounted directly on shaker.

Figure 5. Vibration Pickup with Type 1560-P35 Permanent-Magnet Clamp.

complished. When vibration measurements are made to meet specifications that require that the pickup be mounted by a stud or bolt, that is the way one must make the measurement.

Pickups can be fastened by many different methods but for greatest accuracy the fastening should be as direct and rigid as possible. If the pickup is to be fastened only temporarily, and if the acceleration is less than gravity and only low frequencies are present, simple methods of fastening are adequate. Plasticine or double-faced tape can be placed between the base of the pickup and a flat surface, at the desired point. If the surface is horizontal, flat, and smooth, the pickup may be wrung to the surface with a thin film of petroleum jelly or light silicone grease. Figure 4 shows the responses of a Type 1560-P52 Pickup fastened securely and by means of Plasticine.

On magnetic materials, the pickup may be fastened to a magnet and the magnet then attached to a flat surface on the device that is to be measured.

A small magnet clamp is supplied with the Type 1560-P13 System. A slightly larger clamp, Type 1560-P35 (see Figure 5), is available as an accessory for the Types 1560-P11B and 1560-P14 Systems. If the Type 1560-P53 Vibration Pickup is fastened to the magnet and the magnet attached to a smooth, flat surface with petroleum jelly or light silicone grease used to ensure close contact between all mating surfaces, the response of the Type 1560-P13 System is not significantly altered for frequencies up to 10 kc/s and accelerations up to 5 g. Figure 6 shows the response of a small shaker system measured with the Type 1560-P53 Pickup with and without the magnet clamp. Unless the mass of the pickup is many times smaller than the mass of the device being measured, the addition of the pickup will modify the response of the system. By the same token, adding the magnet will modify the response of the system still further. For the responses shown in Figure 6, the mass of the system, including shaker plus pickup and shaker plus pickup on magnet, was maintained constant.

At high accelerations simple fastenings are inadequate; a stud must be used to hold the pickup directly against the surface being measured. Even with the stud, petroleum jelly or silicone grease should be used to ensure close contact, without applying undue strain to the pickup.

To install the pickup permanently, where tapped holes for studs are not available, an adhesive such as dental cement, Eastman 910, or an epoxy ce-

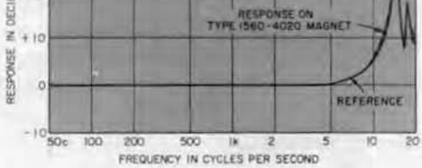
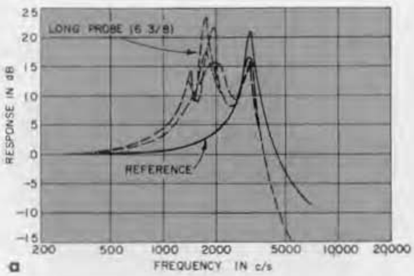


Figure 6. Response of Type 1560-P53 Vibration Pickup with and without magnetic clamp.



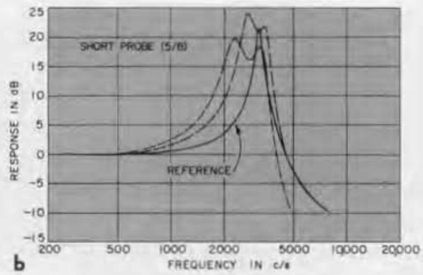


Figure 7. (a) Frequency response of Type 1560-P52 Vibration Pickup mounted on hand-held (6⅜-inch) probe. Several sample responses are shown. Reference line shows response of pickup mounted directly on shaker. (b) Frequency response of the Vibration Pickup mounted on hand-held short (⅝-inch) probe. Several sample responses are shown. Reference line shows response of pickup mounted directly on shaker.

ment should be used. For best results, use only a thin layer so that the elastic characteristics of the cement will not affect the behavior of the pickup.

Use of Probes

Probes and probe tips are supplied with the Types 1560-P11B and 1560-P14 Systems. These are supplied as a convenience to help in cases where flat smooth surfaces may not be available for proper mounting of the vibration pickup. A long probe will modify the pickup response appreciably. The primary resonance of the measuring system will be determined by the probe dimensions. For example, Figure 7 shows the response of the Type 1560-P52 Pickup mounted directly on a flat, smooth surface and hand held in contact with the surface through (a) a 6⅜-inch long and (b) a ⅝-inch long probe. Figure 8 shows the response obtained with a Type 1560-P53 Vibration Pickup mounted on a flat, smooth surface and then held in contact through a 6-inch long × ¼-inch diameter probe.

Unless the device being measured is massive, a hand-held probe may seriously alter the motion. Also, some vibration is transferred to the pickup by tremor of the hand. This vibration is made up mostly of components below 20 c/s so it is attenuated somewhat by the 20-cycle, low-frequency cutoff of these measuring systems. The observed peak-to-peak displacement from this source is in the order of 0.2 mil so that, even with care, low-level measurements are limited by this factor.

The hand-held probe is useful at frequencies below 1000 c/s if the vibrating object is large and has relatively large motion.

— Ervin E. Gross

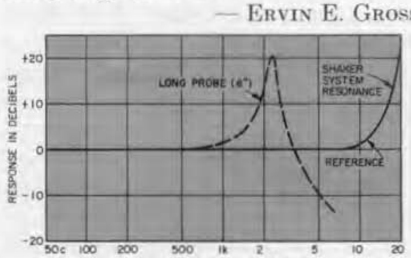


Figure 8. Frequency response of the Type 1560-P53 Vibration Pickup mounted on hand-held 6-inch long by ¼-inch diameter probe. Curve is smoothed average of several responses. Reference line shows response of Pickup mounted directly on shaker.

A 100-μF DECADE CAPACITOR

Performance and acceptance tests on high-capacitance electrolytic capacitors have created a need for high-capacitance standards against which the accuracy of the test equipment can be monitored. Following the introduction of the Type 1424-A Standard Polystyrene Decade Capacitor (10 μF) a few years ago, customer interest in a 100-μF decade developed, and a special unit was designed and built. Having thus proved the practicability of the basic design, we are now able to offer a 100-μF decade as a standard catalog item.

Design Factors

The effects of residual impedances become more serious as capacitance increases, creating design problems in a 100-μF decade that are not significant in a 10-μF unit. Some of these problems are:

Control of series loss outside the dielectric, that is, the resistance of the leads, switching means, and binding posts. One can reduce the resistance of leads and binding posts by making them of larger cross section, but reduction of the switching resistance requires more drastic treatment. In the 10-μF decade, the switch contacts were duplicated and paralleled to make the resistance loss negligible in comparison with the dielectric loss inherent in well made polystyrene capacitors. For the 100-μF decade the tapered-plug technique long used in accurate dc bridges and resistance boxes was adopted. The resistance of a connection made by the tapered plug wrung into its mating tapered socket (approximately 5.5° included angle) by its actuating T-handled knob is quite acceptably low, of the order of 50$\mu\Omega$. All other joints in the internal electrical circuit are soft-soldered. The resistance of the external connections at the binding posts is minimized by the large contact areas and the use of large knobs so that high contact pressures can be obtained.

Control of residual series inductance. The geometrical locations and the dimensions of binding posts, bus, islands, studs and current-sheet connectors were chosen to minimize the inductance. The binding posts are located as near one edge of the instrument as practical. They are staggered with respect to one another so that wide low-inductance ribbons or strips can be run directly when connections are made to associated equipment. Although the instrument is considerably larger than the 10-μF decade, the total residual inductance is less than twice as large.

Maintenance of manageable size and weight. The 10-μF Type 1424-A weighs 16½ pounds. The thought of a decade weighing ten times as much is a little shattering. The only ready way to reduce size and weight is to use lower-voltage capacitors, and, therefore, the peak voltage rating has been reduced to 25 volts. This is not a serious limitation in use, since large standard capacitors are almost never required for use with high voltages applied, either ac or dc. The capacitor volume is only twice that of the 10-μF box.

Protection and dc energy storage. The reduction in voltage rating minimizes the danger from dc energy stored in the capacitor. The lower stored energy and the low voltage greatly reduce the shock hazard. If the metal components of the switching means were exposed, dropping metal pieces would be a hazard. A plexiglas cover plate protects against this contingency as well as serving as an insertion guide for the tapered plugs. Built-in current-limiting resistors are provided for limiting the charging and discharging current to a safe value when the capacitor is used on dc.

A Standard of D as well as of C

A major application for the Type 1425-A Standard Polystyrene Decade Capacitor is the calibration of bridges used for measuring capacitance and dissipation factor of electrolytic capacitors. A characteristic that makes polystyrene such a desirable dielectric is that its D is very low and is quite constant as a function of frequency. Electrolytic capacitors, on the other hand, have characteristically high D's. When the decade is to be used as a reference standard to check the calibration of electrolytic-capacitor-measuring bridges, it should be possible to increase its D to any desired degree, in order to check the dissipation factor accuracy of the bridge.

This can be accomplished by the addition of a known external resistor. Ideally, the resistor should be in *series* with the capacitor, since electrolytic capacitors are specified and usually measured in terms of series components.

A massive binding post is provided for the series connection. Unfortunately when low values of D are desired, the required series resistance may be very low, and suitable adjustable resistors may not be available. Even if they are, the problem of connecting a resistor of, say, one milliohm into a simple series circuit is formidable when lead-and-contact resistance is considered.

If the required series resistance is unmanageably low, the desired D value can be produced by a much larger, more practical value of resistance connected in parallel. A pair of conventional instrument binding posts (Type 938) is provided for such parallel connection.

When using the parallel connections, one must remember that the equivalent series capacitance of the combination is the parallel capacitance multiplied by $1 + D^2$. Thus, the series connection should be used whenever practical.

A few numerical examples will serve to illustrate the situation. Suppose, at 1000 cycles, one wishes to establish a D of 0.01 for 100 μF. The required series resistance is 0.0016 ohms, which is rather awkward. The parallel value on the other hand is 16 ohms, conveniently realized with a decade resistance box. For a D of 0.01 the difference between series and parallel capacitance is only 0.01%, and the use of the parallel resistor is clearly indicated. As another example, a D of 0.5 at 120 cycles, 50 μF requires about 26 ohms in series, again a practical value, and in this case the series connection is indicated.

The new Type 1425-A Standard Capacitor extends by one more decade the calibration capabilities of GR capacitance standards, which now cover the range from 10^{-3} picofarad to 100 microfarads, a formidable 10^{11} range.

— P. K. McElroy

SPECIFICATIONS

Total Capacitance: 100 μF.
Capacitance per Step: 10 μF.
Dielectric: Polystyrene.
Adjustment Accuracy at 1 kc/s: ±0.25%.
Certificate: A certificate is supplied giving measured values obtained by comparison, to a precision better than ±0.01%, with working standards whose absolute values are known to an accuracy better than ±0.05%, determined and maintained in terms of reference standards periodically measured by the National Bureau of Standards.
Stability: ±0.05%/year.

Dissipation Factor at 1 kc/s: <0.0004.
Insulation Resistance: $>10^6$ ΩF.
Voltage Recovery*: <0.1%.
Temperature Coefficient of Capacitance (typical) ppm/°C: −140.
Max Operating Temperature °C: 65.
Max Safe Voltage: 25 V, peak, below 10 kc/s.
Dimensions: Width 9⅜, height 19⅛, depth 8⅛ inches (240 by 195 by 205 mm), over-all.
Net Weight: 46½ lb (21.5 kg).
Shipping Weight: 67 lb (31 kg).

* Dielectric absorption.

Catalog Number	*Description*	*Price in USA*
1425-9701	**Type 1425-A Standard Polystyrene-Decade Dielectric Capacitor**	**$1400.00**

Hz or c/s?

In describing the new Type 1218-B Unit Oscillator we have used the abbreviation MHz for the unit of frequency, rather than Mc/s. The explanation is simple: the frequency dial is engraved in megahertz.

The International Electrotechnical Commission has recently recommended that hertz be the international unit of frequency, and the National Bureau of Standards has adopted it. The new standard on abbreviations of the Institute of Electrical and Electronic Engineers prefers Hz but allows the alternative of c/s.

At General Radio we shall use Hz on all new designs. Existing designs will continue to use c/s (or cps, kc, and Mc) until they are redesigned or otherwise superseded.

In the *Experimenter* and other General Radio publications, we shall use hertz except when discussing instruments on whose dials or panels the older units appear.

IMPROVED UHF OSCILLATOR

900 to 2000 MHz

A low-priced, high-powered, stable signal source covering better than an octave of uhf or "L band" has been a unique and popular member of the Unit rf oscillator family for some 10 years.[1] Additional convenience in use and greater stability of output are now offered in the completely redesigned Type 1218-B Unit Oscillator.

Compatible with the other oscillators in the family it heads, the new oscillator has a much lower profile than its predecessor. Seven inches high and 12 inches wide, it can be attached semi-permanently to any GR power supply of that height. If the power supply is a Type 1267 or 1269, both of which are 4 inches wide, the combination can be rack-mounted side by side. On the other hand, the Types 1263 and 1264 Power Supplies, which are 8 inches wide, mount above or below the oscillator for a total height of 14 inches in a 19-inch rack.[2]

[1] E. Karplus, "A 900–2000 Mc Unit Oscillator," *General Radio Experimenter*, February 1955.
[2] "Oscillator-Power-Supply Combinations for Frequencies from 0.5 Mc/s to 2 Gc/s," *General Radio Experimenter*, June 1965.

For convenience, particularly in rack assemblies, all three controls are on the front panel. Frequency is set by a vernier-drive knob, which makes 8 complete turns, and is indicated on a custom-calibrated dial to better than ±1%. The scale length of 10.5 inches was unchanged in the redesign. A logging scale has been added for precise interpolation or resetting of frequencies. The ΔF control operates an incremental tuning capacitor, which is considerably more effective and stable

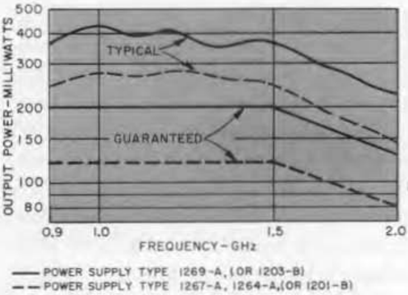


Figure 1.
Output power vs frequency.

Figure 2. Panel view of the Type 1218-B7R, for rack mount.

than the variable grid resistor that it replaces. This control can be used to make adjustments as fine as 1 part per million, over a range of about 0.1%. The third control sets the output level between zero and maximum by rotation of the pickup loop. The redesign brought this control to the front and also "geared it down" so that settings as low as 30 dB below full output are easily made.

A pencil triode is used in a tuned-plate-tuned-cathode circuit (although plate, not grid, runs at dc ground potential). The plate resonator is a high-Q, quarter-wavelength, coaxial line with a contacting plunger. The output loop is mounted on the plunger and therefore maintains a position in the zone of highest magnetic-field intensity. The cathode is tuned by a curled three-quarter-wavelength line of unusual design. The rotary motion of the cathode tuner and the linear motion of the plate tuner are coupled to the main dial by an improved mechanism having negligible backlash.

The shielding has been improved by about 40 dB. All control shafts are nonconducting and act through waveguide-below-cutoff sleeves. Circuit connections are brought through the main casting wall through filters. Cathode and grid-voltage test points have been brought out so that monitoring or special-purpose modulation can be accomplished without disturbance to the shielded compartments.

The rear location of the locking GR874 output connector is convenient in many applications. In addition, the adaptor-panel set used for rack installation provides front mounting space for a similar connector to which the output is brought by a short coaxial cable. The guaranteed output power (shown in Figure 1) is now specified more precisely than before. The power available from a typical Type 1218-B compared to its predecessor is the same at most frequencies except where the older instrument had weak spots. These have been alleviated by improvements in the tuned circuits.

A substantial improvement in spectral purity of the output signal results from two measures. First, the cathode circuit has been isolated from the heater so that alternating current there does not modulate the oscillator appreciably. Second, the entire tuning assembly has been so mounted as to reduce the transmission of acoustic energy from the main casting to the tube, where modulation can result. The electrodes in the tube resonate mechanically at nearly 3 kHz, but the resultant frequency modulation at resonance is less than a very few parts per million at sound levels found in most laboratories.

In cw applications requiring the highest stability of frequency and amplitude, it is important to regulate both heater and plate supplies. Because the frequency is more sensitive to heater voltage changes than to proportional changes in the plate (or B+) circuit, the TYPE 1267-A Power Supply, which is fully regulated, is recommended for critical applications.

Modulation is facilitated by duplication of the usual plate-modulation jack on the front and behind the panel. A connector is also provided for direct connection of the TYPE 1264-A Modulating Power Supply (formerly possible only with adaptor cables). With that modulator, typical delay, rise, and fall times of square-wave or pulse modulation are about 1 microsecond. To obtain very constant output, cw or square wave, the TYPE 1263-B Amplitude-Regulating Power Supply should be used.

Applications for the TYPE 1218-B Unit Oscillator are widespread in laboratories and production facilities where uhf signals are handled. For example, it is an excellent, low-cost pump for a parametric amplifier. It may be the "local oscillator" in a heterodyne receiving or measuring system. It is recommended as a generator for the TYPE 900-LB Slotted Line in the 900-to-2000 MHz frequency range.

— R. W. HARLEY

SPECIFICATIONS

Frequency Range: 900 to 2000 MHz (0.9 to 2.0 GHz).

Frequency Calibration Accuracy: ±1%.

Warmup Frequency Drift: 0.1% approximate total warmup drift.

Frequency Control: A 4-inch dial with calibration in MHz over 290° (10½-inch scale length), with a slow-motion drive of about 8 turns. Supplemented by a logging scale of 800 divisions.

ΔF Control: 1.8 turns for approximately 0.1% total range.

Output Power (Into 50 Ω): 200 mW (0.9 to 1.5 GHz) guaranteed minimum, dropping linearly to 130 mW at 2.0 GHz, with TYPE 1269-A or 1203-B Power supply.

120 mW (0.9 to 1.5 GHz) guaranteed minimum, dropping linearly to 80 mW at 2.0 GHz, with TYPE 1267-A, 1264-A, or 1201-C Power Supply.

Output Connector: Locking type GR874, located at rear. Adaptors available for other connector systems.

Level Control: Full output to about 30-dB attenuation easily set by 200° rotation, uncalibrated.

Modulation: An external audio-frequency voltage for plate modulation can be introduced at the front-panel MODULATION jack. The impedance there is about 6,000 Ω; approximately 30 V, rms, is required for 30% amplitude modulation. For 400- and 1000-Hz modulation, the TYPE 1214-A Unit Oscillator is recommended.

Power Supply: Four types of power supplies are recommended; the choice depends on the intended application.

The TYPE 1267-A is fully regulated, for cw operation.

The TYPE 1269-A is unregulated, for maximum power, cw.

The TYPE 1263-B automatically controls the output level up to 2 V behind 50 Ω, cw or 1-kHz square-wave modulated.

The TYPE 1264-A provides full-power cw or modulated operation: 1-kHz square wave or pulse at externally determined duty ratio and frequency up to 100 kHz.

The oscillator is available in combination with each of these power supplies, for either bench or rack mount, as listed on page 16.

Tube: One 5675 pencil triode.

Mounting: The oscillator is housed in an aluminum casting with gray-wrinkle-finished shield covers on right and left ends and a front panel similarly finished.

Accessories Supplied: TYPE 874-R22LA Patch Cord, phone plug.

Other Accessories Available: GR874 coaxial elements.

Dimensions: Width 12, height 7⅝, depth 9 inches (320 by 205 by 240 mm), over-all.

Net Weight: 14 lb (6.5 kg).

Shipping Weight: 25 lb (11.5 kg).

Catalog Number	*Description*	*Price in USA*
1218-9702	**Type 1218-B Unit Oscillator**, only, Bench Mount	$465.00
0481-9642	**Type 481-P412 Rack-Adaptor Set**, for oscillator only	20.00

U.S. Patent Number 2,548,457.

OSCILLATOR – POWER-SUPPLY COMBINATIONS

These combinations include oscillator, power supply as listed, and accessory hardware for rack or bench mount, as specified.

Performance (Power Supply Type)		*Maximum power; lowest cost* (1269-A)	*Ultimate cw stability; very low residual fm* (1267-A)	(1267-AQ18)	*Stable cw; 100% square-wave & pulse modulation; internal 1-kc square-wave* (1264-A)	*Amplitude-leveled output behind 50-Ω source impedance; metered output level; 1-kc square-wave modulation, or cw* (1263-B)
Input Line Voltage		105 to 125 V or 195 to 250 V	105 to 125 V	195 to 250 V	105 to 125 V or 210 to 250 V	105 to 125 V or 210 to 250 V
Bench Mount	*Catalog No.*	1218-9429	1218-9427	1218-9428	1218-9424	1218-9423
	Type	1218-B9	1218-B7	1218-B7Q18	1218-B4	1218-B3
	Price	**$540.00**	**$635.00**	**on request**	**$750.00**	**$890.00**
Rack Mount	*Catalog No.*	1218-9549	1218-9547	1218-9548	1218-9544	1218-9543
	Type	1218-B9R	1218-B7R	1218-B7RQ18	1218-B4R	1218-B3R
	Price	**$561.00**	**$656.00**	**on request**	**$774.00**	**$914.00**

A TUNABLE, ADJUSTABLE PROBE FOR SLOTTED-LINE MEASUREMENTS

Users of the Type 874-LBA Slotted Line who need a calibrated and more precise probe penetration adjustment and more precise tuning than is provided by a simple stub will find the Type 900-DP Probe Tuner a useful accessory. This is the same probe assembly that is supplied with the precision slotted line, Type 900-LB.

The probe penetration is adjusted by a micrometer drive and its position is indicated on an engraved knob. Tuning is performed by rotation of the probe-tuner barrel, which imparts

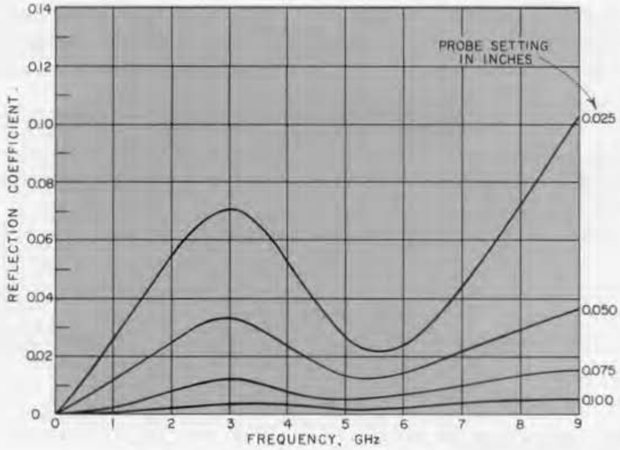


Figure 1. Typical probe reflections at four penetrations.

linear motion to the stub without rotation, and, in this case, the length of the stub in centimeters is shown on an engraved scale. Tuning is possible from 300 MHz to 9GHz, which encompasses the complete frequency range of the slotted line. A screw-on plastic cover is provided with each tuner to protect the probe tip when the probe tuner is not in use.

Since both the TYPE 874-LBA and the TYPE 900-LB Slotted Lines have their own diode- or bolometer-mount assemblies, the probe tuner does not contain a diode holder.

Probe penetration is an important factor in slotted-line measurements. A probe coupled too tightly into the slotted line can cause measurement errors when the source driving the slotted line is not matched. In this case, the probe reflects the incident wave back to the source; a second reflection occurs at the source and adds or subtracts to the incident wave as the slotted-line carriage is moved. The result is that minima and maxima are affected in both position and magnitude, and the VSWR measurement is in error. With the probe penetration clearly visible and directly readable, the chances for maladjustment of probe penetration are greatly reduced. It is usually much easier to decouple the probe than to match the source impedance.

Excessive probe penetration can also cause errors at the higher VSWR values, say above 10, because the loading effects are greater at the voltage maximum than at a minimum. The loading effects increase more and more as the VSWR is increased. Therefore, here again the easy readability feature removes any guesswork about probe penetration.

The probe reflection, as a function of frequency and distance to the slotted-line inner conductor (probe penetration), is shown in Figure 1.

A detailed instruction sheet is furnished with each probe tuner. It contains all the necessary installation instructions. A tuning graph is included, which indicates the correct setting for any frequency in the tuning range. A small 7/8-inch open-end wrench is provided for installation of the probe tuner on the slotted line, and a No. 2 Bristol wrench for scale adjustments.

SPECIFICATIONS

Frequency Range: 0.3 to 9 GHz.
Probe Depth Scale: Calibrated from 0.010 to 0.150 in., in intervals of 0.001 inch. One revolution of the knob moves the probe 0.025 inch.
Stub Tuner: Calibrated at intervals of 0.1 cm from 0 to 17 cm.
Dimensions: Length 11 in (280 mm), dia 7/8 in (23 mm), over-all, closed.
Net Weight: 8½ oz (245 g).
Shipping Weight: 3 lb (1.4 kg)

Catalog Number	*Description*	*Price in USA*
0900-9654	**Type 900-DP Probe Tuner**	**$75.00**

PANEL MOUNTING KIT FOR GR900 PRECISION COAXIAL CONNECTORS

The TYPE 900-PKM Panel Mounting Kit is a simple conversion kit for adapting a GR900 connector, or any component equipped with a GR900 connector, to panel mounting. This application includes adaptation of GR-900 connector devices as panel feed-through or "bulkhead" connectors.

The kit comprises one gear-ring assembly; four 4-40 screws, ½ inch long; four nuts and lockwashers; and a detailed instruction sheet.

A centering (gear) ring is modified to include a flange, as shown in Figure 1. It is installed directly on any GR900 connector after removal of the existing centering ring and locking nut.

The resulting panel connector does not contain a locking nut, since the locking nut on the mating connector is usually all that is needed. When two panel connectors are to be mated, a TYPE 900-L Air Line can be used.

Examples of applications of this kit are shown in Figures 1 to 4. Note that the flange mounted on the front face of the panel (Figure 2) provides the greatest accessibility and ease of connection. If necessary, the flange can be mounted behind the panel at the expense of accessibility and possibly appearance. Accessibility, in this case, is a matter of how much of the locking nut of the mated connector can be grasped during tightening. This recessed mounting configuration is shown in Figure 4.

Specific applications include: panel connector for frequency- or time-domain reflectometers or similar test sets, equipment modules, and rack-mounted assemblies where a feed-through from the rear to the front of the rack is required.

Over-all panel space required by the flange of the unit is 1$\frac{3}{16}$ inches on each side.

Weights: Net, 1 oz (30 g); Shipping, 8 oz (230 g).

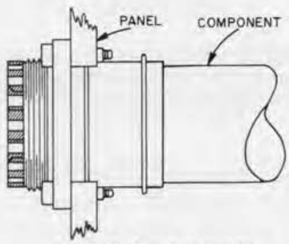


Figure 1. Panel connector mounted with air line.

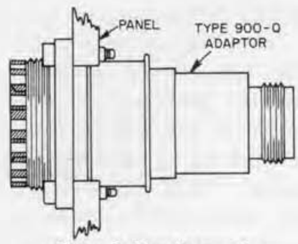


Figure 3. Panel connector mounted with a Type 900-Q Adaptor.

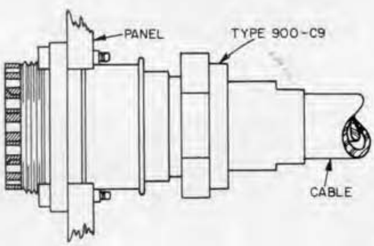


Figure 2. Panel connector mounted with coaxial cable.

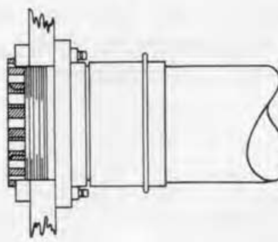


Figure 4. Panel connector mounted with flange behind panel.

Catalog Number	*Description*	*Price in USA*
0900-9498	**Type 900-PKM Panel Mounting Kit**	**$7.00**

GR874 COAXIAL CABLE CONNECTION

A very slight modification in the usual assembly procedure can improve the VSWR performance of ten GR874 coaxial connector types. Developed recently in General Radio's continual product-improvement program, this new technique can be applied to both panel-mount and patch-cord connectors, in two groupings, for use with RG-8 size cable. The connectors affected are listed in the table on page 20.

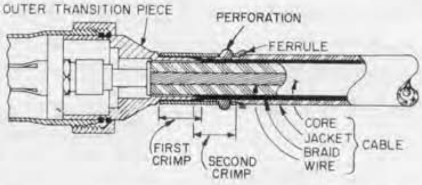
The new technique is of particular interest to those now using General Radio TYPE 874-TO8 and -TO58 Crimping Tools to fasten the connectors to the cable with a cylindrical metal ferrule.

Present practice calls for a slightly overlapping double crimp, utilizing the same diameter opening in the hex-shaped jaws of the crimping tool. The first crimp locks the cable braid between the ferrule and the knurled surface of the outer-transition piece of the connector. The second crimp holds the cable jacket firmly in place. (See figure at right.)

This second crimp is applied around the circular perforations on the ferrule. Jacket retention is accomplished by the cold flow of the jacket material through the perforations, which are distributed evenly around the ferrule.

The resulting squeeze on the cable can reduce braid diameter, thereby altering characteristic impedance at that point sufficiently to raise overall VSWR performance.

The new approach calls for use here of a larger crimp diameter, which avoids the discontinuity problem yet causes only a small reduction in jacket-retention capability. The result is a low-VSWR connector assembly with good jacket retention, unless subjected to severe pulling, twisting, or bending.



Section view of a GR874 connector attached to a coaxial cable. The larger-diameter second crimp still grips the jacket securely, without reducing the diameter of the braid.

The crimping tools offer an adequate selection of openings in their crimp dies to permit the diameter change.

— J. Zorzy

Connector Type No.	*Cable Type No.*	*Ferrule Part No.*	*First Crimp (over braid)*		*Second Crimp (over jacket)*	
			Tool	*Die Size (inch)*	*Tool*	*Die Size (inch)*
874-CA, -CLA, -PBA, -PLA, -PRLA	874-A2	5240-4026	TO-58	0.375	TO-8	0.389
874-C8A, -CL8A, -PB8A, -PL8A, -PRL8A	RG-8, RG-213, etc (single-braid only)	5240-4028	TO-8	0.389	TO-8	0.411

TYPE 1806-P MULTIPLIER

Omitted from the announcement in the *Experimenter* last month of the 10:1 Range Multiplier for the Type 1806-A Electronic Voltmeter was mention of the frequency characteristic Low-frequency roll-off of the Multiplier is less than 3% at 10 kc/s. It is useful, therefore, at frequencies from the top of the audio range up to where the inductance of connecting leads might begin to cause errors — at frequencies in the vicinity of 200 Mc/s. The addition of the multiplier has no appreciable effect upon the resonant frequency of the probe.

— J. J. Faran

General Radio Company

PRINTED IN U.S.A.