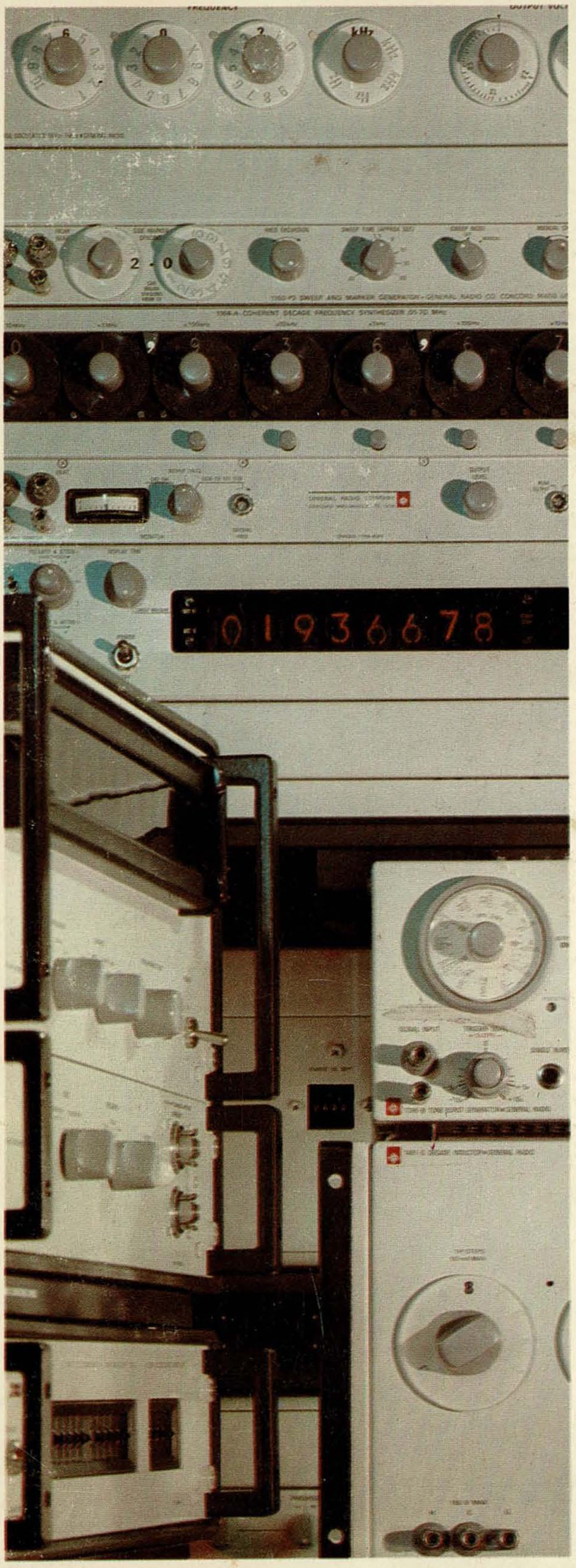

CATALOG T • GENERAL RADIO • WEST CONCORD, MASSACHUSETTS USA 01781

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GENERAL RADIO COMPANY

MAIN OFFICE AND PLANT: WEST CONCORD, MASSACHUSETTS 01781

FOR SALES DEPARTMENT:

See below for most convenient office

FOR GENERAL BUSINESS:

Telephone: (From Metropolitan Boston) 646-7400
(From all other locations) 617 369-4400

TWX NO. 710 347-1051
Cable Address: GENRADCO CONCORD (MASS)

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CATALOG T

FEBRUARY 1968

GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS, U S A

GENERAL RADIO COMPANY (OVERSEAS)
Zürich, Switzerland

GENERAL RADIO COMPANY (U.K.) LIMITED
Bourne End, Buckinghamshire, England

GENERAL RADIO GmbH
München, West Germany

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West Concord, Massachusetts

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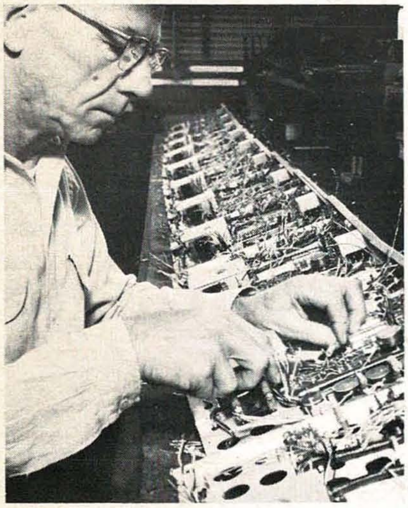
GENERAL RADIO is an employee-owned manufacturer of electrical and electronic measuring instruments for science and industry. Our administrative offices and plant are at West Concord, Massachusetts, and a second plant is located in Bolton, Massachusetts.



Because of the highly technical nature of our products, there is a high proportion of professional employees among the 1200-plus people who make up General Radio. We have been called "an engineer's company," and it is true that the engineering personality and discipline are present in most of the Company's operations.

Every employee is, directly or indirectly, a part owner of the Company and is jealous of his Company's reputation for quality. The extra reliability and years of life built into GR instruments are the result of both a deliberate corporate dedication to quality and an employee-by-employee commitment to the same principle.

General Radio sells standard, proprietary, off-the-shelf products, listed in this catalog. In addition, we also custom-assemble a variety of systems, notably in the automatic-measurement area, including non-GR as well as GR products. We have also developed many special-purpose instruments, and we are always happy to explore ways of tailoring our capabilities to your needs.

What We Offer Our Customers

A Soundly and Imaginatively Designed Instrument

GR instruments are designed by engineers who draw on a unique combination of resources. First, there is a stockpile of Company experience in each of our product areas. Second, the breadth of GR's product line is reflected in a wide range of engineering activity, with constant exchange of ideas both within the Company and within the profession. (Recently, for example, our engineers concerned with low-frequency measurements were able to advance the art of capacitance standardization by "borrowing" a precision coaxial connector designed by our microwave group.) By this environment and by education, the GR engineer is well equipped to make important technical contributions. The long list of early GR "firsts" is too well known to bear repeating. What GR engineers have done lately is no less impressive, including pioneering developments in the fields of automatic component-measuring systems and precision microwave devices.

A Well Manufactured Instrument

GR has earned an envied reputation for making quality instruments, and it is one of our most cherished — and best protected — possessions. It is protected chiefly by our highly skilled instrument assemblers, many of whom have 20 to 30 years on the job.

Quality, of course, begins long before instrument assembly. Components must meet rigid standards, and, for closest control of quality, we make many of them ourselves.

After we put an instrument together, we test it thoroughly. By the time it crosses our shipping platform, we are so confident of its quality that we place a two-year warranty on it. It's a liberal warranty, but odds are better than 30 to 1 that you'll never use it.

Prompt Delivery

Everything that is in our catalog is on our shelf. At least that's our policy, even if occasionally orders exceed our expectations and we are caught with an empty shelf or two. To minimize delays, we stock instruments at several locations throughout the U.S., and we send all transcontinental shipments by air freight.

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Solid Service

In the unlikely event that you do require service for your GR instrument, you'll get it fast, and it will be thorough and courteous.

GR service centers, staffed with factory-trained technicians, are on both coasts and in Chicago, Dallas, and Toronto. Even if an instrument needs only minor service, we give it a complete performance test and send it back to you with a one-year warranty that it will meet its original specifications.

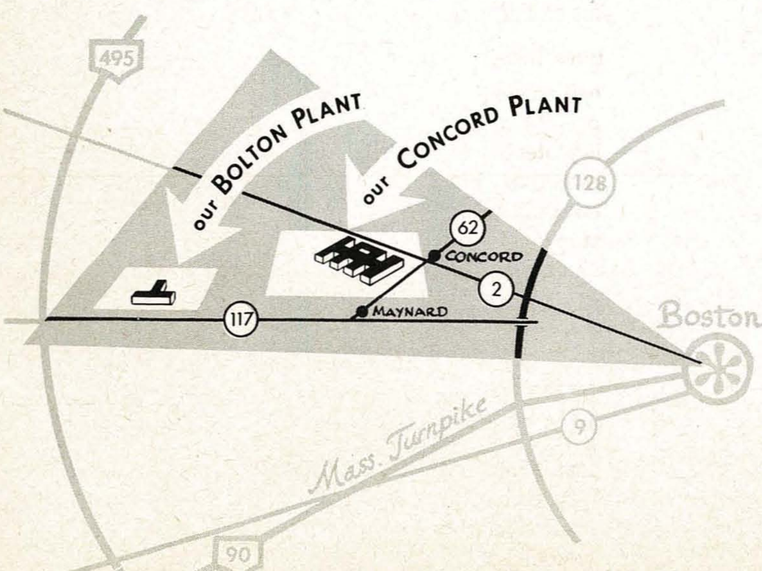
Expert Sales and Applications Engineering

Our sales engineers are salaried GR employees, all are graduate engineers, and all have completed a home-office training course in the commercial as well as the technical aspects of selling GR products. Selling an instrument line as broad as GR's, they are experts in instrumentation, well prepared to guide you in selecting the right instruments for your job.

GR sales engineers are located throughout the U.S. and Canada, from Seattle to Orlando, from San Diego to Boston. Where GR sales-engineering offices aren't, our traveling **Tourlabs** are. Abroad, the same expertise is available from our sales subsidiaries in London, Munich, and Zurich, and from representatives throughout the world.

To help you get the most out of your GR instruments, we publish a vast amount of technical literature, and we hope that you will take advantage of it. The long list includes **The Experimenter;** handbooks on noise and vibration measurement, stroboscopy, high-speed photography, textile applications for the stroboscope, voltage control, and coaxial microwave measurements; student laboratory experiments instrument notes; the periodicals **Noise Measurement** and **Strobotactics;** and many, many other bulletins and papers. Just drop us a line telling us what you want; we'll mail it out promptly.

If you have any questions on GR products, sales, or service, write us or phone your nearest GR sales engineer. Or, if you're in our neighborhood, stop by for a visit; you're always welcome.



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Ordering and Service Information

WHERE TO ORDER

USA and Canada

Please address orders and other communications to any of the District Offices listed on the inside front cover of this catalog. Areas regularly served by the offices are given; customers in other areas should phone or write the nearest District Office or communicate directly with the Sales Engineering Office at West Concord, Mass.

Export Orders

Customers outside the United States and Canada are served by General Radio, by its subsidiaries, General Radio (Overseas), General Radio (U. K.) Ltd., and General Radio GmbH, and by the export representatives listed on the inside back cover of this catalog. All communications should be directed to the appropriate export representative. For countries not listed, inquiries should be addressed to General Radio Company, West Concord, Massachusetts 01781, U. S. A., or, for customers in Europe, to General Radio Company (Overseas), Postfach 124, CH 8034 Zurich 34.

HOW TO ORDER

Always order by both catalog number and complete description. AC-operated instruments are supplied wired for operation from 115-volt power, unless otherwise specified. Most instruments can also be supplied for operation from other common voltages and frequencies as indicated in the specifications under Power Required. Be sure to specify operating voltage and frequency if other than nominal 115 volts, 60 Hz.

For example:

Catalog No. 1900-9801, Type 1900-A Wave Analyzer, 230 V, 50 Hz, Bench Model

Special features and modifications not listed in the specifications (such as extra calibrations) are available at extra cost. Please include in your order information regarding any nonstandard features desired.

CONDITIONS OF SALE

Determination of prices, terms, and conditions of sale and final acceptance of orders are made only at General Radio Company, West Concord, Massachusetts, USA, or General Radio Company (Overseas), Zurich, Switzerland.

Domestic Terms: Net 30 days if credit has been arranged; otherwise, unless payment is received before shipment, shipment will be made COD.

Outside USA and Canada: Terms of payment for orders placed on General Radio representatives and on General Radio sales offices are those that are mutually agreed upon. If there is no representative in your area, the terms for orders placed directly on General Radio Company or on General Radio Company (Overseas) are full payment in advance of shipment or sight draft against an irrevocable letter of credit, unless other terms have been previously arranged.

MINIMUM BILLING

The minimum billing per order is $10.00. This applies to all purchases except repair parts and cash-with-order transactions.

SOURCE-INSPECTION SURCHARGE

A surcharge of 1 percent ($2.50 minimum) applies on all orders requiring inspection at our plant. The inspection surcharge applies on each shipment inspected and covers only our costs.

SHIPPING INSTRUCTIONS

Unless specific instructions accompany the order, we shall use our judgment as to the best method of shipment. Shipments can be made by either air or surface transportation. For fast delivery, at a reasonable premium over other means, air shipment is generally recommended and will be employed on request.

The prices listed in this catalog apply only on transactions originating in the USA, include the cost of domestic packing, are FOB our plant, West Concord, Massachusetts, and are exclusive of all taxes now in effect or that may be imposed hereafter by Federal, State, or local governments. Prices given are subject to change without notice. Formal price quotations remain in effect for 30 days.

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Export prices including the cost of packing are available from the offices or representatives listed on the inside back cover of this catalog. Canadian customers may obtain prices FOB Toronto from our District Offices in Toronto or Montreal.

WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards, after examination by our factory, district office, or authorized repair agency personnel, will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

SPECIFICATION CHANGES

We reserve the right to discontinue any item without notice and to change specifications at any time without incurring any obligation to incorporate new features in instruments or parts previously sold.

SERVICE AND PARTS

The return of instruments for repair or recalibration and the ordering of repair parts should be arranged with the most convenient General Radio office or representative. When arranging a return, be sure to give the catalog and type number, description, serial number of the instrument, date of original purchase, and details concerning the difficulty or the service desired.

When ordering repair parts, please specify the part number and description of the item as well as the type number and serial number of the instrument in which it is used. Advice on repairs to General Radio instruments may be obtained from any GR office or representative.

An instrument returned for credit will be subject to a restocking charge. If more than 6 months has elapsed since original purchase, an instrument will not be accepted for credit.

POWER-SUPPLY CONSIDERATIONS

General Radio ac-operated instruments will meet the published specifications when operated from power lines whose voltages and frequencies are within the limits stated in the specifications under the heading Power Required.

Most instruments have input voltage ranges of 100 to 125 and 200 to 250 volts and will therefore operate on nominal power-line voltages of 115, 220, 230, and 240 volts. The voltage range for which an instrument is wired is marked at the power-input plug or cord. Proper fuses for this voltage range are fitted in the fuse holders.

When the power-line voltage on which the instrument is to be operated is specified on the order, the necessary changes in connections, fuses, and name plate are made at the factory. Instruments equipped with line-voltage-selector slide switches are set for 115 volts when shipped.

Certain instruments are available for use only on power lines of 220, 230, and 240 volts (nominal).

For most instruments, the normal operating frequency range is 50 to 60 hertz.

All ac-operated instruments are supplied with three-wire power cords, designed for USA standard three-wire receptacles.

Battery Operation

Portable, battery-operated instruments are shipped with dry-cell batteries in place but disabled to prevent drain and leakage during shipment. To render the instrument operative, the user need only remove the yellow insulating disks from the battery terminals.

DIMENSIONS

Over-all dimensions are given for instruments except that the depth dimension for rack-mount instruments is actually depth behind panel, i.e., clearance required. However, no allowance is made for additional clearance that may be required for cables and connectors at rear panel.

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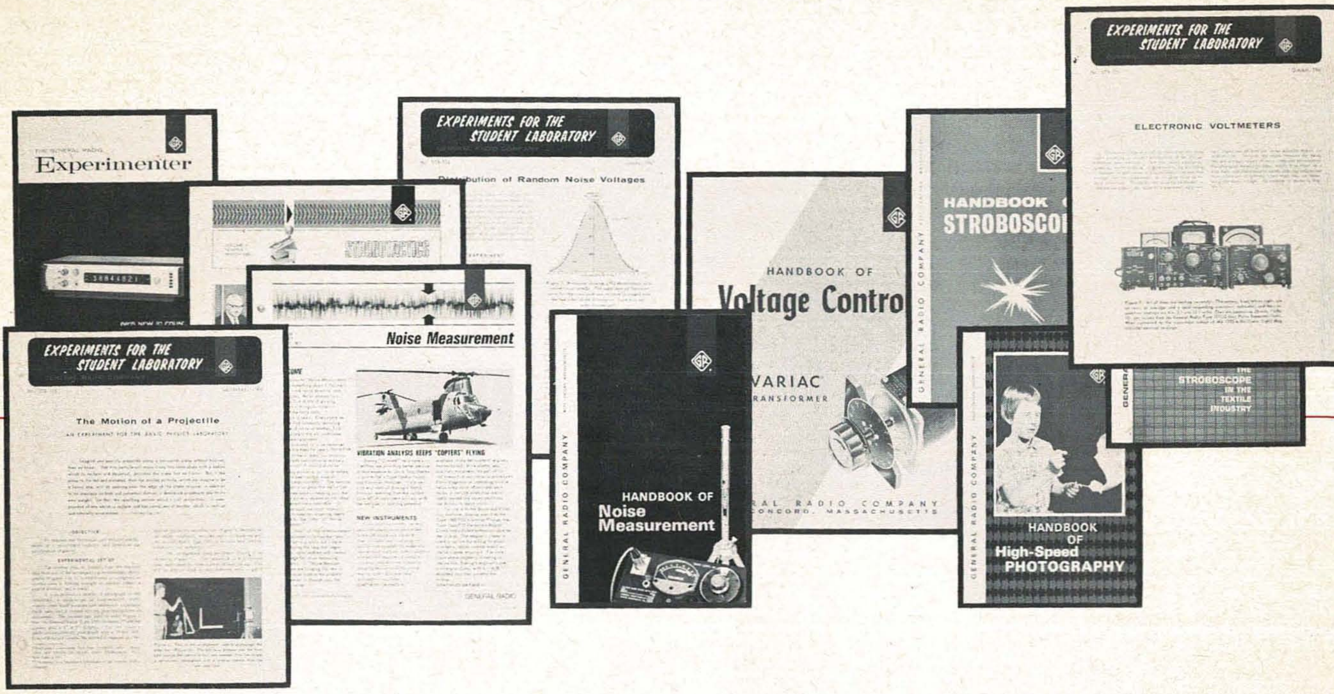
PUBLICATIONS



The **General Radio Experimenter,** issued monthly, discusses new products and applications as well as general technical subjects. Sent free on request, this periodical is mailed to over 100,000 readers throughout the world.

For those especially interested in stroboscopic techniques and in sound and vibration measurements, two specialized quarterlies, **Strobotactics** and **Noise Measurement** are now published by GR.

Other GR publications include **Experiments for the Student Laboratory** with suggested experimental procedures for the electrical or physics laboratory in college, university, and technical schools, and a variety of handbooks: the **Handbook of Noise Measurement,** the **Handbook of Voltage Control,** the **Handbook of Stroboscopy,** the **Handbook of High-Speed Photography,** and **The Stroboscope in the Textile Industry.** Also available are Instruments Notes, booklets, and many reprinted articles on a wide range of technical subjects.

PATENTS

Many of our products are manufactured and sold under United States Letters Patent owned by the General Radio Company or under license grants from other companies. To simplify the listing of these patents they are given here in a single list and referred to at each instrument only by appropriate reference number.

1. "Certain vacuum-tube amplifier devices, electric wave filters, vacuum-tube oscillators, and sound-level meters are licensed by Western Electric Company, Inc., under all United States Letters Patent owned or controlled by American Telephone and Telegraph Company, or Western Electric Company, Inc., and any or all other United States patents with respect to which Western Electric Company, Inc., has the right to grant a license, solely for utilization in research, investigation, measurement, testing, instruction and development work in pure and applied science, including engineering and industrial fields.
2. 2,578,429.
3. Patent 2,586,397.
4. Patent 2,548,457.
5. Patent 2,802,907.
6. Patent 2,977,508.
7. Patent 3,067,388.
8. Patent Applied For.
9. Patent Re 24,204.
10. Patent 3,050,685.
11. Patent 3,022,944.
12. Patent 3,012,197.
13. Patent 2,977,540.
14. Patent 2,763,733.
15. Patent D 187,740.
16. Patent 2,970,258.
18. Patent 2,581,133.
19. Patent 2,872,639.
20. Patent 2,943,277.
21. Patent 2,942,172.
22. Patent 2,966,257.
24. Patent 2,702,736.
25. Patent 2,715,718.
26. Patent 2,786,140.
27. Patent 3,156,870.
28. Patent 3,300,731.
29. Patent 3,286,199.
30. Patent 3,339,108.

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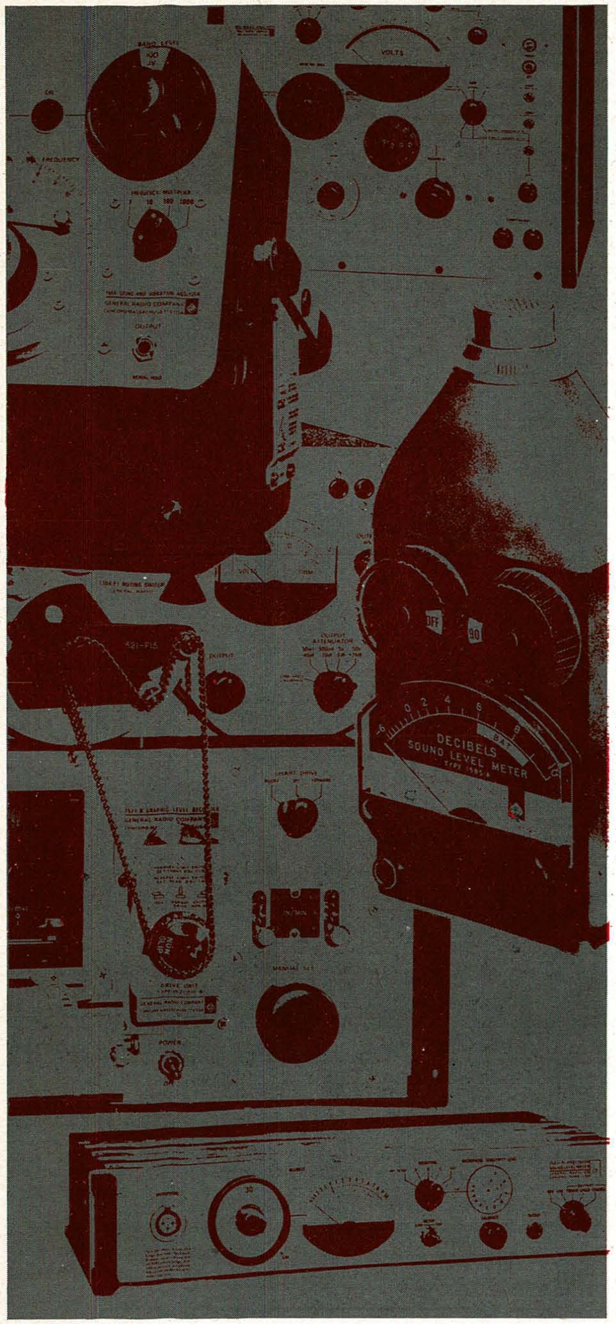

ACOUSTICS

ACOUSTICS
ANALYZERS and RECORDERS
ATTENUATORS

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ACOUSTICS

General Radio's comprehensive line of acoustical and audio-frequency instruments provides the essential elements for the efficient evaluation of noise and vibration and for the measurement of other acoustical phenomena. The basic instruments described in this section comprise sound-level meters, a vibration meter, and a variety of transducers, couplers, and calibrators, for the quantitative measurement of both air-borne and solid-borne vibrations.

These are supplemented by:

(1) A group of analyzers, which operate from the electrical output of the sound-level meter* to measure the amplitude and frequency of the components of the sound or vibration spectrum. These include narrow-band, ⅓-octave, and octave-band instruments, and a universal filter, as well as a peak-reading device for evaluating impact-type sounds. (See pages 28 to 46.)

(2) A preamplifier that operates directly from a microphone or vibration pickup to increase the sensitivity of any of the analyzers or to allow the use of long cables between the transducer and an instrument without loss in sensitivity. (See page 23.)

(3) Audio-frequency oscillators, frequency synthesizers, random-noise generators, a tone-burst generator, and pulse generators for exciting acoustical and electrical systems under test, and a level regulator for controlling the excitation. (See pages 198 to 232.)

(4) Graphic recorders for automatic spectrum analysis, reverberation-time measurements, and permanent records of measurements. (See pages 38 through 42.)

(5) Stroboscopes for visual analysis of vibration phenomena. (See page 241.)

(6) Impedance bridges for determining the characteristics of transducers and other acoustical devices. (See page 65.)

(7) Auxiliary equipment, such as frequency meters, counters, voltmeters, attenuators, adaptors, and cables.

With GR instruments, one can make the measurements necessary for rating and evaluating practically any industrial noise problem. They can be used by nontechnical personnel and are designed for long life and trouble-free operation. The use of these and other noise-measuring instruments is discussed thoroughly in the Handbook of Noise Measurement, published by General Radio Company, and available at one dollar a copy, postpaid.

SOUND-LEVEL MEASUREMENTS

The standard sound-level meter is the basic sound-measuring instrument and has been improved in each successive model in performance, in convenience, and in versatility, culminating in the Type 1561 Precision Sound-Level Meter. The Type 1565-A Sound-Level Meter is a simplified version, particularly designed for convenience in use, small size, and low cost. The 1551 Sound-Level Meter has gained wide acceptance over many years as a general-purpose meter combining wide range, flexibility, and economy. All GR sound-level meters conform fully to the appropriate USASI and IEC standards†.

The excellent, general-purpose piezoelectric ceramic microphones supplied as standard equipment are stable and rugged, have smooth frequency response, and are relatively unaffected by normal temperature changes. They can be mounted directly on the instruments or separately with connection by extension cable when it is necessary to avoid the effects of the observer and instrument on the acoustical measurement. For very wide band measurements the Type 1551-P1 Condenser Microphone System is available.

Any of these meters can be used to measure over-all level, the first important measure of a noise. A frequency analysis is also often desirable to estimate the effects of the noise, to track down the source, and to determine efficient control measures.

OCTAVE-BAND AND NARROWER-BAND MEASUREMENTS — SPECTRUM ANALYSIS

The Type 1558 Octave-Band Noise Analyzers and Type 1564-A Sound and Vibration Analyzer can be used directly with a ceramic microphone to measure octave-, ⅓-octave-, and 1/10-octave-band sound-pressure levels in the range from 44 to 150 dB, which yields adequate data for comparison with most hearing-damage criteria, test codes, and noise ordinances. For even lower band levels, the Type 1560-P40 Preamplifier can be used, or the electrical output of the 1551-C or 1561 Sound-Level Meters can be analyzed. This output is the amplified electrical replica of the acoustic signal at the microphone, and it has a wide dynamic range. Its frequency spectrum can be analyzed by the Octave-Band Noise Analyzers, the Sound and Vibration Analyzer, with both 1/10-octave and ⅓-octave bandwidths, the Type 1900-A Wave Analyzer with 3-, 10-, and 50-Hz bandwidths, and the 1568 1%-bandwidth wave analyzer. The latter 3 are also available as recording analyzers for automatic measurements producing permanent-record data.

ACOUSTIC-DATA RECORDER

A tape recorder, the Type 1525-A, has stability and calibration accuracy comparable to the other GR acoustic instruments, permitting it to be used in collecting noise and vibration data for later analysis and as permanent records.

IMPACT NOISE

The measurement of impact noise can be made simply with the sound-level meter and the Type 1556-B Impact-Noise Analyzer. This analyzer can also measure electrical noise peaks in communication circuits.

SOUND-MEASURING SYSTEM CALIBRATION

Although GR sound-measuring instruments are inherently reliable and stable, after long periods of use their performance may change. To ensure that important changes will be discovered and corrected, the 1562 Sound-Level Calibrator has been developed. It supplies a known acoustic signal, at 5 frequencies, to the microphone for over-all calibration of the system.

Greatest accuracy of calibration is achieved with the Type 1559-B Microphone Reciprocity Calibrator. This device, which uses the closed-coupler reciprocity method of calibration, will determine the sensitivity of GR microphones over a frequency range of 20 to 8000 Hz. It is also a precision acoustic source, as well as a sound-level calibrator.

* The Type 1564-A Sound and Vibration Analyzer and the Type 1558 Octave-Band Analyzers can also be operated directly from a microphone or vibration pickup.

† USASI S1.4-1961: IEC Publications 123, 1961 and 179, 1965.

File Courtesy of GRWiki.org

GR sound-measuring instruments, particularly the 1565-Z Audiometer Test Set, are useful in calibrating of audiometer output, frequency accuracy, and other characteristics.

VIBRATION MEASUREMENTS

GR vibration-measuring equipment includes the Type 1553 Vibration Meters to measure the acceleration, velocity, displacement, and jerk* of a vibrating element; the 1564-A Sound and Vibration Analyzer or the 1900-A or 1568-A Wave Analyzer to analyze the vibration; and the Type 1560 Vibration Pickup Systems to convert the sound-level meter to a vibration meter. The Octave-Band Noise Analyzers and the Sound and Vibration Analyzer can also be operated directly from the output of a vibration pickup. These instruments are easily calibrated with the Type 1557-A Vibration Calibrator, a self-contained electromagnetic shaker.

Stroboscopes comprise another important group of vibration measuring instruments. They permit vibrating objects to be viewed intermittently and produce the optical effect of slowing down or stopping a periodic vibration.

LEVEL RECORDERS

The Type 1521-B Graphic Level Recorder can record the level and spectral distribution of sound and vibration, operating from the output of the sound-level meter, the vibration meter, or one of the analyzers. The frequency dials of the 1564-A Sound and Vibration Analyzer and the 1568-A and 1900-A Wave Analyzers can be driven by the recorder for automatic plotting of the spectrum. Reverberation measurements can also be made with this recorder.

The Type 1520-A Sampling Recorder can record the instantaneous value of the wave from the output of a vibration meter or a sound-level meter. Its high speed makes it particularly useful for studying transient signals.

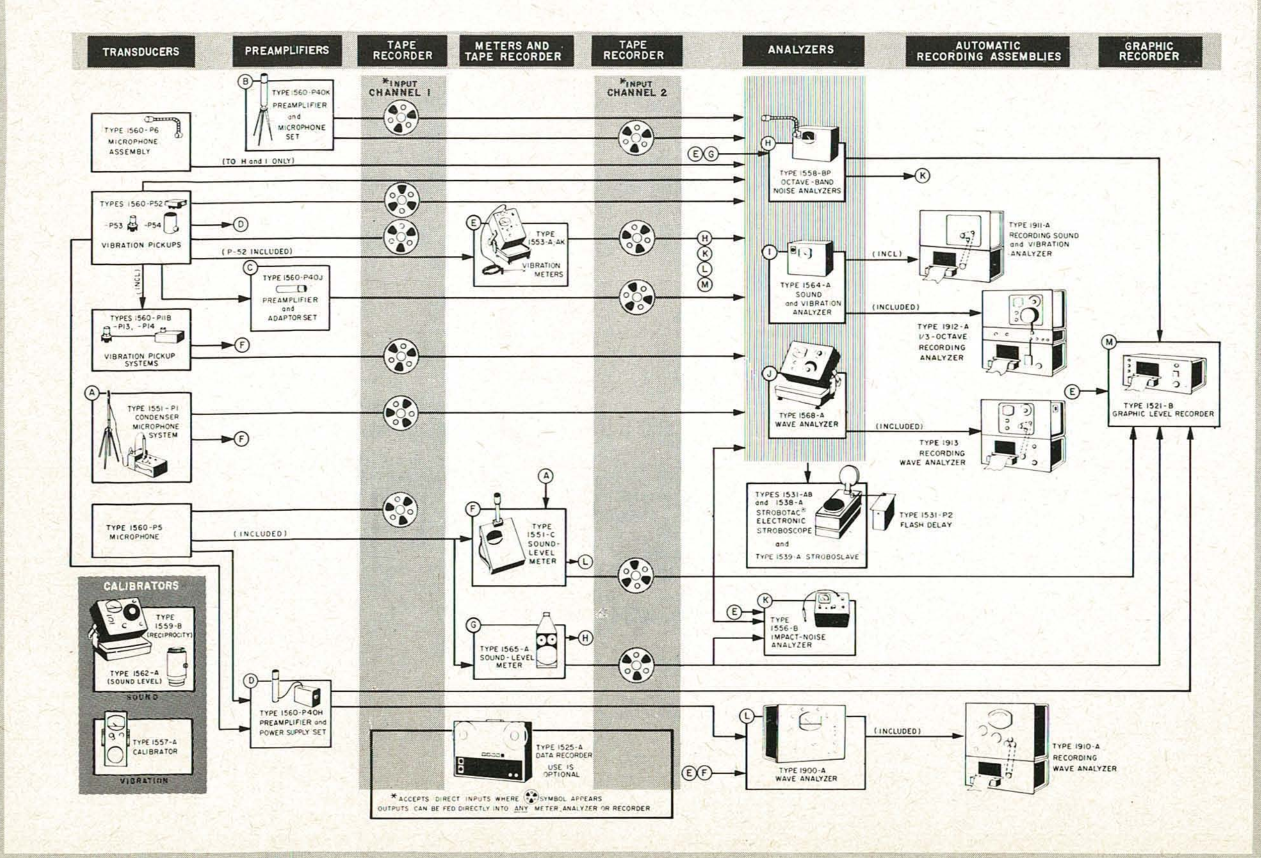
MEASUREMENT POWER SOURCES

The Type 1304-B Beat-Frequency Audio Generator can drive transducers with pure tones to excite vibratory and acoustical systems. If the response is recorded on the Type 1521-B Graphic Level Recorder, a plot of the transfer-response level in decibels versus frequency on a standard logarithmic scale is obtained. An output of the Type 1900-A Wave Analyzer can also be used to drive transducers or networks, and the response can be detected by the same analyzer and plotted automatically on the Type 1521-B Graphic Level Recorder. When higher power is needed, the Type 1308-A Audio Oscillator and Power Amplifier is recommended.

The Types 1381, 1382 and 1390-B Random-Noise Generators can supply a useful broad-band noise. When the output is fed to one of the General Radio analyzers or the 1952 Universal Filter, a narrower, tunable band of noise is available. Such a signal has many applications in acoustical testing, particularly in architectural acoustics and psychoacoustics. For transient-response measurements, square-wave and pulse generators can provide steep-wavefront signals, and the tone-burst generator provides a signal that is particularly useful in acoustical testing.

The accompanying diagram shows the functional relations among these various instruments, which collectively make up the General Radio Sound-Measuring System.

* Jerk = rate of change of acceleration.



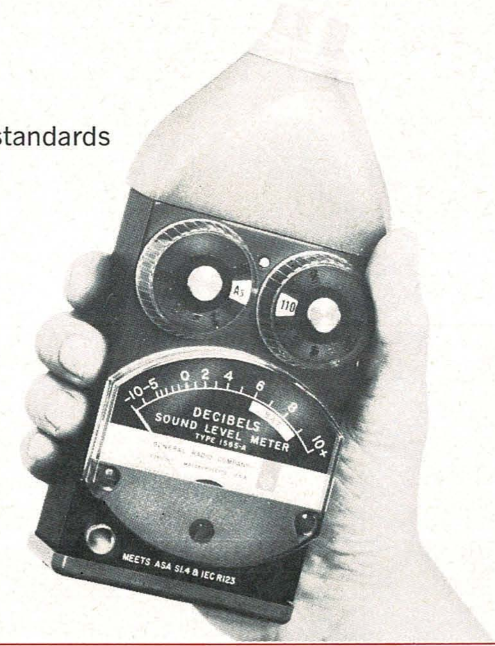
File Courtesy of GRWiki.org

acoustics

SOUND-LEVEL METER

Type 1565-A

- conforms to USA and international standards
- 44- to 140-dB measurement range
- ceramic microphone
- solid-state circuits



Sound-Level Meter in leather carrying case.

Although not so versatile in application as the Type 1551, this instrument is a standard sound-level meter capable of accurate noise measurements, in conformity with national and international standards. It is particularly useful for rapid surveys, for periodic checks on noisy environments, and for production testing of manufactured products.

The 1565-A Sound-Level Meter is a pocket-sized, lightweight instrument that can be held and operated with one hand. It includes most of the features usually found only in larger, more expensive instruments. With an adaptor in place of the microphone, the 1565 will accept a connector from a vibration pickup or other transducer or from a cable to a remotely placed microphone.

— See **GR Experimenter** for October-November 1964.

specifications

Sound-Level Range: 44 to 140 dB (re 20 μN/m^2).

Weighting: A, B, and C weighting in accordance with USA Standard S1.4-1961 and IEC Publication 123, 1961.

Microphone: Lead-zirconate-titanate ceramic unit.

Output: At least 1.5 V behind 20 kΩ when meter reads full scale. Output can be used to drive a 1556 Impact-Noise Analyzer, 1558 Octave-Band Noise Analyzer, 1521 Graphic Level Recorder, or headphones. Harmonic distortion, 1% or less for frequencies above 100 Hz and 2% or less for frequencies below 100 Hz (panel meter at full scale).

Calibrator page 21

Meter: Rms response, and fast and slow meter speeds, in accordance with USA S1.4-1961 and IEC Publication 123, 1961.

Auxiliary Input Provision: A 1560-P96 Adaptor is available to allow connection to any source fitted with a male 3-terminal microphone connector. Input impedance is approximately 13 MΩ in parallel with 25 pF. For correct weighting, source impedance must be 380 pF ±5%.

Calibration: Sound-level meter can be pressure calibrated at 125, 250, 500, 1000, and 2000 Hz with a 1562 Sound-Level Calibrator or at any frequency from 20 to 2000 Hz with a 1559-B Microphone Reciprocity Calibrator.

Operating Temperature Range: 0 to 50°C.

Storage Temperature Range: –20° to 70°C (battery removed).

Operating Humidity Range: 0 to 90% R.H.

Temperature Coefficient of Sensitivity: Approx +0.03 dB/°C.

Effect of Magnetic Field: Equivalent C-weighted sound level of a 1-oersted (80 A/m) 60-Hz field is about 47 dB when meter is oriented for maximum indication.

Power Supply: One 1½-V size C flashlight cell. Battery life approx 35 hours for 2 h/day service.

Accessories Available: 1565-P1 Leather Carrying Case, 1562-A Sound-Level Calibrator, 1560-P96 Adaptor to adapt input to mate with three-terminal male microphone connector necessary for connection to vibration pickup, 1560-P95 Adaptor Cable to connect output to 1521-B Graphic Level Recorder or other devices fitted with jack-top binding posts on ¾-in. centers.

Dimensions (width x height x depth): 3¹⁄₁₆ x 7⅜ x 2⅛ in. (78 x 190 x 54 mm).

Weight: Net, 1¾ lb (0.8 kg); shipping, 5 lb (2.3 kg).

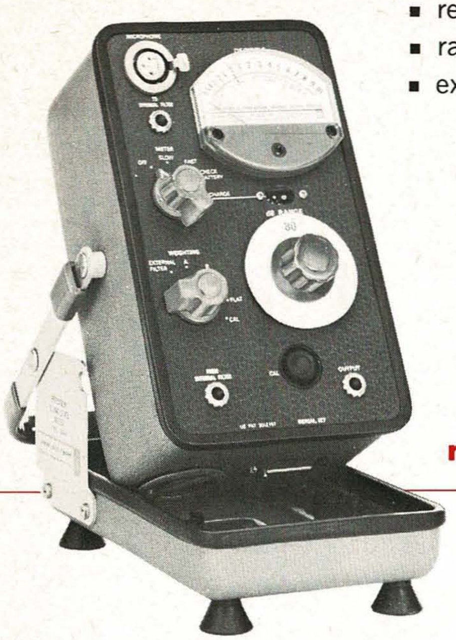
Catalog Number	Description	Price in USA
1565-9701	**1565-A Sound-Level Meter**	**$295.00**
1565-9601	**1565-P1 Leather Carrying Case**	**10.00**
8410-9899	**Replacement Battery**	**.20**

File Courtesy of GRWiki.org

PRECISION SOUND-LEVEL METER

Type 1561

- meets IEC 179 and USASI S1.4
- rechargeable-battery operation
- rack model available
- external-filter connections



new

Rack Model

Industry standards for acoustical measurements are becoming more stringent. IEC Publication 179, 1965 requires greater accuracy of sound-level meters, particularly at frequencies above 1 kHz. The 1561 was designed to meet this requirement and the tighter low-frequency requirements of USA Standard S1.4-1961. It has the weighting characteristics, wide sound-level range, internal calibration facility, high-level output, and other capabilities of proven value in all the GR sound-level meters.

SPECIAL FILTERING

For special needs, the 1561 has provisions for the connection of an external filter to shape the frequency response as required. The new GR 1952 Universal Filter is designed for such service.

CHOICE OF MOUNTING

For many applications, a rack-mounted sound-level meter is more appropriate than a portable instrument, e.g., in complete measuring systems. The 1561 is offered in both versions.

RECHARGEABLE BATTERY OPERATION

Either model of the 1561 can be powered by nickel-cadmium batteries; the portable model is available with two sets and separate battery charger or with dry cells; the rack model will operate from an ac line or from rechargeable batteries for which a charging circuit is built in.

specifications

Sound-Level Range (rms, dB re 20 μN/m²):

Frequency Characteristic	With 1560-P7 Microphone and 10-ft cable	With 1560-P7 Microphone and 1560-P40 Preamplifier*
Flat	35 to 150 dB	31 to 130 dB
C Weighting	32 to 150 dB	27 to 130 dB
B Weighting	31 to 150 dB	26 to 130 dB
A Weighting	31 to 150 dB	27 to 130 dB

*Min obtained with ×10 preamp gain, max with ×1.

Max peak levels about 11 dB higher; at least 5-dB signal-to-noise ratio for lower values given above.

Frequency Characteristics: A, B, and C weighting in accordance with USA Standard S1.4-1961, IEC Publication 123, 1961 and IEC Publication 179, 1965 for precision sound-level meters. Also provided is a flat response from 20 Hz to 20 kHz to permit measurement of sound-pressure level. Jacks are provided for insertion of an external filter.

Microphones: The GR 1560-P7 Precision Microphone is supplied with portable models with a 10-ft cable to permit microphone to be located away from instrument and observer to minimize diffraction effects (1561 gain is set to compensate for cable loss).

Sound-Level Indication: Reading is sum of meter and attenuator setting. Meter calibrated −6 to +10 dB; attenuator calibrated 30 to 140 dB in 10-dB steps.

Output (full-scale meter reading): 1.25 V behind 5500 Ω; harmonic distortion <0.5%.

Input Impedance: >100 MΩ, across 40 pF in portable model, across 90 pF in rack model.

Meter: Rms response; fast and slow meter speeds in accordance with above USASI and IEC standards.

Calibration: Absolute calibration of the 1561 is set acoustically at 500 Hz and a level of 114 dB re 20 μN/m². Microphone response and sensitivity are measured in a free field 20 Hz to 15 kHz by comparison with a WE 640AA Laboratory Standard microphone with calibration traceable to the National Bureau of Standards. Complete electrical frequency-response measurements are made on each instrument. Panel adjustment provided for standardizing gain with internal calibration circuit, which has adjustment to permit calibration in terms of microphone sensitivity (control is internal and accessible through case of portable models, on front panel of rack models). The 1562 Sound-Level Calibrator or 1559 Microphone Reciprocity Calibrator can be used for making periodic over-all acoustic checks.

Calibrators pages 20, 21

Temperature and Humidity Effects: The instrument will operate within specifications, for meter indications above 0 dB, over a range of 10 to 50°C and 0 to 90% relative humidity, when standardized by its internal calibration circuit or an external calibrator. No damage to microphone from −30 to +60°C and 0 to 100% relative humidity.

Magnetic-Field Effects: In a 60-Hz, 1-oersted (80 A/m) magnetic field and oriented for max reading, the rack model will indicate about 42 dB, the portable model about 53 dB (C weighting).

Accessories Supplied: Portable models include Precision Microphone Type 1560-P7, 10-ft microphone cable, and either one set of dry-cell batteries or two sets of rechargeable batteries and Battery Charger Type 1560-P60. Rack model includes power cord and spare fuses.

Accessories Available: 1952 Universal Filter and 1560-P40 Preamplifier (power supplied by 1561).

File Courtesy of GRWiki.org

Power Required: The rack-mount 1561-R contains ac power supplies for operating the instrument and for recharging the batteries (not supplied) that can be used to power the instrument. This model operates from 100 to 125 or 200 to 250 V, 50 to 60 Hz, 2.5 W max.

The portable 1561 is supplied with either 3 Burgess type PM6 dry-cell batteries (or equivalent), which give about 15-h average operation, or with 2 sets of rechargeable nickel-cadmium batteries and the 1560-P60 Battery Charger. This unit will simultaneously recharge two sets of batteries (one set in the 1561, the other in the charger) from a power line of 105 to 125 or 210 to 250 V, 50 to 60 Hz, 5 W.

The nickel-cadmium batteries will provide about 20-h of operation and recharge in about 15-h; dry-cells about 15 h.

Mounting: The 1561-R is in a rack-mount cabinet, the portable model in a Flip-Tilt case; the charger in an aluminum case.

Dimensions (width x height x depth): Portable, 10¾ x 6⅛ x 5¾ in. (275 x 160 x 150 mm); rack, 19 x 3½ x 15 in. (485 x 89 x 385 mm); Battery Charger, 4¼ x 3¾ x 8 in. (110 x 96 x 205 mm).

Net Weight: Portable, 5½ lb (2.5 kg); rack, 15 lb (7.0 kg).

Shipping Weight (est): Portable, 20 lb (4.6 kg); rack, 23 lb (10.5 kg).

Catalog Number	Description	Price in USA
	1561 Precision Sound-Level Meter Portable Models, incl precision microphone and 10-ft cable	
1561-9700	with dry-cell batteries	**$675.00**
	with 2 sets rechargeable batteries and recharger	
1561-9701	for 115 volts	**775.00**
1561-9702	for 230 volts	**on request**
1561-9703	**1561-R Precision Sound-Level Meter** Rack Model (no battery or microphone)	**725.00**
8410-3000	**Replacement Dry Cell,** 3 req'd	**1.20**
8410-1040	**Rechargeable Battery,** 2 req'd	**12.00**

SOUND-LEVEL METER

Type 1551-C

- 24- to 150-dB measurement range
- meets common standards:
  USA Standards S1.4-1961
  IEC Publication 123, 1961
- 20-Hz to 20-kHz amplifier response
- internal calibration system

The 1551-C is not only a convenient, highly accurate sound-level meter but is also the key instrument in a wide variety of sound and vibration measuring systems. In use as a sound-level meter alone, the 1551 is compact and easy to handle, rugged enough for severe environments, and simple to use.

A highly versatile instrument, it will, for example, serve as a calibrated preamplifier in combination with other, related instruments such as spectrum analyzers, special-purpose microphones, calibrators, and vibration pickups. Many other accessories, such as graphic level recorders and tape recorders, can be operated from the sound-level-meter output.

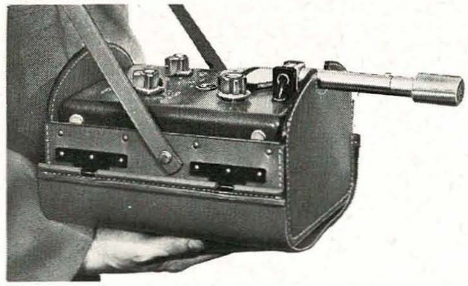
This sound-level meter can also be used as a portable amplifier, attenuator, and voltmeter for laboratory measurements in the audio-frequency range.

Many of its applications are described in detail in the Handbook of Noise Measurement, a copy of which is available to each user.

Description

The 1551-C consists of an omnidirectional microphone, a calibrated attenuator, an amplifier, standard weighting networks, and an indicating meter. The complete instrument, including batteries, is mounted in an aluminum case. The microphone can be used in several positions and, when not in use, folds down into a storage position, automatically disconnecting batteries. An ac power-supply unit is available.

File Courtesy of GRWiki.org



(Left) Microphone in the storage position (batteries automatically disconnected). (Center) The sound-level meter operated in its leather carrying case, microphone in the horizontal operating position. (Right) The sound-level meter ac-operated with the Type 1262-B Power Supply, which plugs directly into the base of the sound-level meter.

specifications

Sound-Level Range: From 24 to 150 dB (re 20 μN/m²).

Frequency Characteristics: Four response characteristics, A, B, C, or 20 kHz, as selected by panel switch. The A-, B-, and C-weighting positions are in accordance with USA Standard S1.4-1961 and IEC Publication 123, 1961. Frequency response for the 20-kHz position is flat from 20 Hz to 20 kHz, so that complete use can be made of very wide-band microphones such as the 1551-P1 Condenser Microphone Systems.

Microphone: GR Type 1560-P5. Accessory condenser microphone is available.

Sound-Level Indication: Sound level is indicated by the sum of the meter and attenuator readings. The clearly marked, open-scale meter covers a span of 16 dB with calibration from −6 to +10 dB. The attenuator is calibrated in 10-dB steps from 30 to 140 dB above 20 μN/m².

Calibration Accuracy: When amplifier sensitivity has been standardized, the absolute accuracy of sound-level measurements at 500 Hz is within ± 1 dB and at all frequencies is in accordance with the USA Standard.

Panel adjustment is provided for standardizing amplifier gain with internal calibration circuit.

Absolute acoustic sensitivity is factory calibrated at 500 Hz. Microphone response and sensitivity are measured in a free field from 20 Hz to 15 kHz by comparison with a WE 640AA laboratory-standard microphone with calibration traceable to the National Bureau of Standards. Complete electrical frequency-response measurements are made on each instrument.

The 1562-A Sound-Level Calibrator or the 1559-B Microphone Reciprocity Calibrator can be used for making periodic over-all acoustic checks.

Output: 1.4 V behind 7000 Ω (panel meter at full scale). The output can be used to drive analyzers, recorders, oscilloscopes, and headphones. Harmonic distortion (panel meter at full scale) <1%.

Input Impedance: 25 MΩ in parallel with 50 pF.

Meter: Rms response, and fast and slow meter speeds in accordance with USA S1.4-1961 and IEC 123, 1961.

Environmental Effects

Temperature and Humidity: Microphone is not damaged at temperatures from −30 to +95°C and relative humidities from 0 to 100%. When standardized by its internal calibration system or a 1562 Sound-Level Calibrator, the instrument will operate within catalog specifications (for panel-meter indications above 0 dB) over the temperature range of 0 to 60°C and the relative humidity range of 0 to 90%.

Magnetic Fields: When exposed to a 60-Hz, 1-oersted (80 A/m) field, the sound-level meter will indicate 60 dB (C weighting) when oriented for maximum sensitivity to the magnetic field.

Electrostatic Fields: Aluminum case provides sufficient shielding, so that normally encountered electrostatic fields have no effect.

Vibration: Case is fitted with soft rubber feet and amplifier is resiliently mounted for vibration isolation. When the instrument is set on its feet on a shake table and vibrated at 10 mils pk-pk displacement over the frequency range of 10 to 55 Hz, the unwanted signals generated do not exceed an equivalent C-weighted sound-pressure level of 45 dB when motion is vertical, 60 dB when motion is lengthwise, or 40 dB when motion is sidewise.

GENERAL

Power Supply: Two 1½-V size D flashlight cells and one 67½-V battery (Burgess XX45 or equivalent) are supplied. An ac power supply, the Type 1262-B, is available.

Accessories Supplied: Telephone plug.

Accessories Available: 1551-P2 Leather Case (permits operation of instrument without removal from case), 1562 Sound-Level Calibrator, 1560-P95 Adaptor Cable for connecting output to 1521-B Graphic Level Recorder.

Calibrator page 20, 21

Mounting: Aluminum cabinet.

Dimensions (width x height x depth): 7¼ x 9¼ x 6⅛ in. (185 x 235 x 160 mm).

Weight, Net, 7¾ lb (3.6 kg); shipping, 16 lb (7.5 kg), batteries incl. Add 2 lb for leather case.

1262-B POWER SUPPLY

Attaches to the 1551-C Sound-Level Meter for ac-line operation.

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 2 W.

Dimensions (width x height x depth): 5 x 7¼ x 3⅛ in. (130 x 185 x 80 mm).

Weight: Net, 2½ lb (1.2 kg); shipping, 8 lb (3.7 kg).

Catalog Number	Description	Price in USA
1551-9703	**1551-C Sound-Level Meter**	**$565.00**
8410-9499	**Set of Replacement Batteries**	**4.25**
1551-9602	**1551-P2 Leather Carrying Case**	**25.00**
1262-9702	**1262-B Power Supply**	**115.00**

PATENT NOTICE. See Note 12.

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VIBRATION METER

Type 1553

- direct reading in acceleration, velocity, displacement, and jerk
- 2 to 2000 Hz (120 to 120,000 rpm) to 20,000 Hz with suitable pickup
- portable, battery operated, simple to use

Analyzers page 29 ff

Vibration Pickups page 25

Vibration in a machine can cause faulty production, premature wear, structural fatigue, and human discomfort and fatigue.

The 1553, portable and simple to use and to read, is well suited to making rapid, repetitive measurements against vibration criteria, such as required in quality control product testing and preventive maintenance programs. With the 1553, periodic measurements of over-all vibration in a machine will quickly show any deteriorating performance trends and lead to early preventive maintenance.

This instrument gives readings in quantities that are physically meaningful: displacement (for clearance problems), velocity (for a criterion in preventive maintenance of machines), acceleration (a measure of the possibility of mechanical failure), and jerk (related to vehicular riding comfort).

Its excellent low-frequency response permits the study of the operation of belt drives and of the effectiveness of mountings designed to reduce vibrations in adjacent structures.

Frequency analysis of vibrations aids in identifying their mechanical sources, diagnosing causes, and measuring the effect of remedies. The GR 1564-A Sound and Vibration Analyzer or the 1568-A or 1900-A Wave Analyzer is of great value in making such frequency analyses.

The 1553 Vibration Meter consists of an inertia-operated, lead-zirconate-titanate ceramic pickup, which delivers a voltage proportional to the acceleration of the vibratory motion; an adjustable attenuator; an amplifier; and an indicating meter. Networks can be switched to convert the output of the vibration pickup to a voltage proportional to displacement, velocity, or jerk (time rate of change of acceleration).

The 1553-A indicates directly in inches, in./s, in./s^2, or in./s^3. The 1553-AK indication is in metric units: mm, m/s, m/s^2, and m/s^3.

Filter jacks on the panel allow the use of external high-

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pass filters where it is desired to eliminate the frequency components below 30 or 70 Hz.

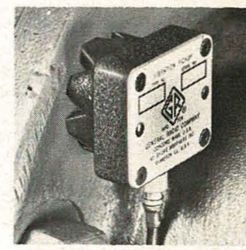
The vibration meter is portable and is mounted in a Flip-Tilt cabinet, which serves as protective cover and case in transit, and as a base on which the instrument can be operated in almost any position from vertical to horizontal.

Accessories include various tips and a metal probe for the pickup to facilitate measurements in normally inaccessible places. Available at additional cost is the 1560-P35 Permanent-Magnet Clamp, which replaces the probe or tip when measurements are made under conditions where hand-held operation would not be satisfactory.

specifications

Ranges of Measurement:

Type No.	Quantity	Peak to Peak Min	Peak to Peak Max	Average Min	Average Max	Units	Frequency Range (Hz)
1533-A	Acceleration	0.3	300,000	0.03	30,000	in./s²	2-2000
	Velocity	0.03	30,000	0.003	3,000	in./s	2-2000
	Displacement	3	300,000	0.3	30,000	mils	2-2000
	Displacement	0.03	30,000	0.003	3,000	mils	20-2000
	Jerk	30	300,000	3	30,000	in./s³	2-20
1553-AK	Acceleration	0.01	10,000	0.001	1,000	m/s²	2-2000
	Velocity	0.001	1,000	0.0001	100	m/s	2-2000
	Displacement	0.1	10,000	0.01	1,000	mm	2-2000
	Displacement	0.001	1,000	0.0001	100	mm	20-2000
	Jerk	1	10,000	0.1	1,000	m/s³	2-20



Vibration pickup with permanent-magnet clamp

Accuracy: ±10% of full scale.

Input Impedance: 25 MΩ.

Voltage at Output Jack: 5 V rms, behind 75 kΩ for full-scale deflection.

Attenuators: A 10-step attenuator changes the meter-scale range by a factor of 100,000 to 1. Window readout indicates full-scale values and units (10 times full-scale for AVERAGE readings).

Calibration: Internal.

Allowable Pickup Sensitivity for Direct Reading: 30 to 150 mV/g.

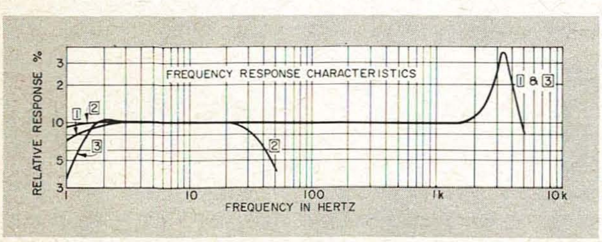
Terminals: A panel jack is provided for plugging in earphones, 1564-A Sound and Vibration Analyzer, 1556-B Impact-Noise Analyzer, 1538 or 1531 Strobotac® electronic stroboscope, 1568-A or 1900-A Wave Analyzer, or an oscilloscope.

Power Supply: Portable model, 3 size-D cells and one 67½-V battery (Burgess Type XX45 or equivalent) supplied. Typical battery life, 7 days at 8 h per day. For ac operation, use Type 1262-C Power Supply (listed below). Rack model, Type 1262-C Power Supply is included.

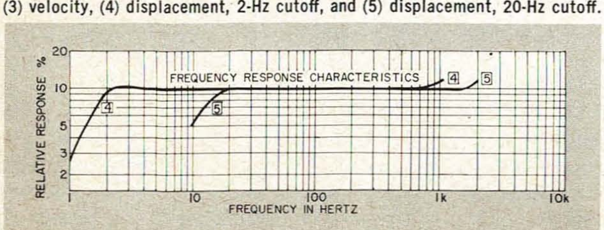
Accessory Supplied: 1560-P52 Vibration Pickup.

Accessories Available: 1560-P35 Permanent-Magnet Clamp; 1557-A Vibration Calibrator, high-frequency pickup 1560-P53, and high-sensitivity pickup 1560-P54.

Mounting: Flip-Tilt Case. Rack-mount versions also available.



Response characteristics for constant applied (1) acceleration, (2) jerk, (3) velocity, (4) displacement, 2-Hz cutoff, and (5) displacement, 20-Hz cutoff.

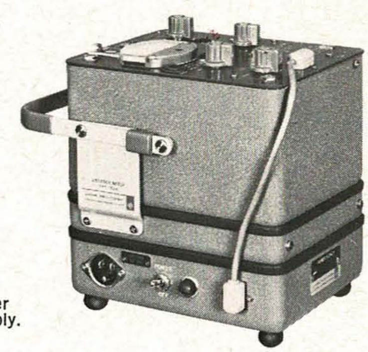


Dimensions (width x height x depth): Portable model, 8 x 9¼ x 7½ in. (205 x 235 x 190 mm); rack model, 19 x 10½ x 5 in. (485 x 270 x 130 mm).

Net Weight: Portable model, 10½ lb (4.8 kg); rack model, 14 lb (6.5 kg).

Shipping Weight: Portable model, 14 lb (6.5 kg); rack model, 31 lb (14.5 kg).

Type 1262-C Power Supply



Vibration meter with power supply.

Attaches to 1553 for ac operation. Included with rack model.

specifications

Power Required: 105 to 125 V, 50 to 400 Hz, 3 W, or 195 to 250 V, 50 Hz, 6 W.

Dimensions (width x height x depth): 7¼ x 9¼ x 3¼ in. (185 x 235 x 83 mm).

Weight: Net, 2¼ lb (1.1 kg); shipping, 8 lb (3.7 kg).

Catalog Number	Description	Price in USA
	Vibration Meter	
1553-9701	**1553-A (English Units)** Portable model	$ 880.00
1553-9550	**1553-A (English Units)** Rack model (with ac supply)	1040.00
1553-9819	**1553-AK (Metric Units)** Portable model	880.00
1553-9560	**1553-AK (Metric Units)** Rack model (with ac supply)	1040.00
1262-9703	**1262-C Power Supply**	150.00
8410-9799	**Set of Replacement Batteries**	4.45
1560-9652	**1560-P52 Replacement Vibration Pickup**	75.00
1560-9635	**1560-P35 Permanent-Magnet Clamp**	6.50

PATENT NOTICE. See Note 12.

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acoustics

DATA RECORDER

Type 1525-A

- 15 Hz to 16 kHz
- built-in sound-level meter
- 2 channels, 2 speeds
- wide dynamic range

new

Tailored by GR specifically for acoustic-noise measurements, this instrument is both a sound-level meter and audio tape recorder. With it you can make on-location measurements and calibrated recordings for unhurried and detailed laboratory analysis later or make a permanent record of once-only events. The 1525-A permits recording with a flat frequency-response characteristic, recommended for recording noise and not available with speech and music recorders. Dual channels, simultaneous playback and recording, two-speed drive, and accessory tape-loop guides add versatility.

MAIN CHANNEL

The main-channel recording amplifier doubles as the sound-level-meter amplifier and, for its dual role, contains an accurate step attenuator and several weighting networks: those prescribed by USASI for a sound-level meter, NAB equalization, and constant-current (flat) response. The high input impedance of this amplifier will accommodate a variety of high-impedance transducers. The GR 1560-P5 Microphone is recommended; with it, sound-level-meter performance conforms to American Standard S1.4-1961 and IEC 123-1961. The 1562 Sound-Level Calibrator is recommended as a source of standard sound level for the calibration of recording levels.

The GR 1560-P40 Preamplifier can be used to drive either channel; power for its operation is supplied at both input connectors.

SECOND CHANNEL

The second channel lets you record timing signals or a narration of test program and conditions. Or you can play back a prerecorded test signal (e.g., swept tone, tone bursts, or filtered noise) into a system whose output is being recorded on the main channel. This method simplifies many measurements, room reverberation for one. Acoustical noise, too, can be recorded on channel 2 with the aid of an external sound-level meter or preamplifier.

PLAYBACK AND MONITORING

Identical playback amplifiers monitor both channels and provide outputs that are always available, even during recording. In addition, the monitor amplifier that drives the panel meter and supplies an additional output can be switched to monitor the output of any of the recording or playback amplifiers. A peak-responding monitor light,

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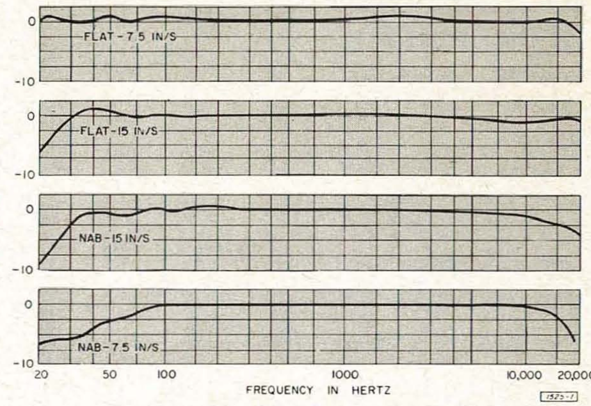
sensing recording levels in the main channel after equalization, warns you against saturating the tape, with resultant distortion.

VERSATILE OPERATION

In addition to recording and storing data for later use, the 1525-A can serve many other purposes. Short-duration, varying, or once-only sounds can be made continuous or repetitive by playback of the recording as a tape loop, guides for which are supplied. Frequency of a noise may be doubled or halved by playback at a tape speed that is twice or half that used for recording, thus similarly scaling the effective bandwidth of an analyzer and of the recorder itself. Time can also be scaled or reversed, a convenience in graphic recording of transients.

— See **GR Experimenter** for October 1966.



Typical over-all frequency response characteristics.

specifications

Frequency Response (over-all):

At 15 in./s (38.1 cm/s)

Constant Current: ±2 dB, 50 to 15,000 Hz.
+2, −4 dB, 30 to 18,000 Hz.

NAB equalization: ±2 dB, 50 to 15,000 Hz.

At 7½ in./s (19.05 cm/s)

Constant Current: ±2 dB, 20 to 10,000 Hz.
+2, −4 dB, 15 to 16.000 Hz.

NAB equalization: +2, −4 dB, 50 to 15,000 Hz.

Signal-to-Noise Ratio:
NAB equalization: Over 54 dB below 2% distortion point as measured according to NAB standard (A weighting).
Constant Current: Over 45 db below 2% distortion point for noise band from 20 to 15,000 Hz (over 65 dB for octave band at 1 kHz) with input channel #1 more than 10 mV.

INPUT

Channels: 2 channels with separate record and playback amplifiers and separate channel erase.

Measurement Range (Input Level): 10 µV to 1 V on channel #1 (40 to 140 dB sound-pressure level for microphone sensitivity of −66 dB re 1 V/µbar). About 0.7 V on channel #2 for full-scale meter indication. (For high sensitivity, channel #2 can be driven by the output of a separate sound-level meter.)

Impedance: Channel #1: approx 20 pF shunted by 400 MΩ.
Channel #2: > 100 kΩ.

Weighting Characteristics: NAB, constant current, A, B, and C weighting (standard sound-level-meter characteristic) and D weighting (decreasing response with increasing frequency above 1 kHz of 20 dB per decade of frequency) for record channel #1. Constant current for record channel #2.

RECORDING

Flutter and Wow: Below 0.2%, rms.

Bias and Erase Frequency: 95 kHz nominal; separate erase for each channel; cleans tape greater than 60 dB.

Tape Speeds: 15 in./s (38.1 cm/s).
7½ in./s (19.05 cm/s).

OUTPUT

Weighting Characteristics: NAB and constant current for both playback amplifiers.

Monitoring: Electronic voltmeter with 16-dB range and sound-level-meter ballistic characteristics, switchable to monitor record or playback level on either channel. Peak monitor on record channel #1.

Levels: When meter reads +10 dB, monitor output is approx 1.5 V, open circuit, and playback outputs are approx 0.5 V, open circuit.

Impedance: Source impedance for monitor output is 330 Ω; for playback outputs it is 10,000 Ω. Any load can be connected to the output.

GENERAL

Tapes: ¼-inch, professional quality, 7-inch reel (max).

Power Required: 105 to 125 V, 60 Hz, 135 W.

Accessories Supplied: Guides for tape loop: 1560-P99 Adaptor Cable; line power cord; transport power cord; roll of tape; take-up reel; 2 reel-lock knobs; maintenance kit; rack-mount accessories.

Accessories Available: 1562-A Sound-Level Calibrator, 1560-P5 Microphone and 1560-P34 Tripod and Extension Cable for sound measurements and recording. 1560-P40K Preamplifier and Microphone Set for sound measurements and recording at levels below 50 dB where the best signal-to-noise ratio must be maintained (the recorder supplies the necessary power to operate a 1560-P40 Preamplifier). For sound and noise analysis, 1900-A Wave Analyzer, 1564-A Sound and Vibration Analyzer, 1568-A Wave Analyzer, 1558 Octave-Band Noise Analyzers.

Microphones, Preamplifier pages 22, 23

Analyzers page 28 ff

Mounting: Luggage carrying case or rack.

Dimensions (width x height x depth): Portable, 21 x 16 x 9 in. (540 x 410 x 230 mm); rack, 19 x 14 x 7 in. (485 x 355 x 180 mm).

Net Weight: Portable, 53 lb (25 kg); rack, 50 lb (23 kg).

Shipping Weight: 60 lb (28 kg).

Catalog Number	Description	Price in USA
1525-9701	**1525-A Data Recorder**	**$2350.00**

The Type 1560-P40K Preamplifier and Microphone Set, with an additional Type 1560-P5 Microphone, is a convenient accessory for two-channel operation of the recorder.

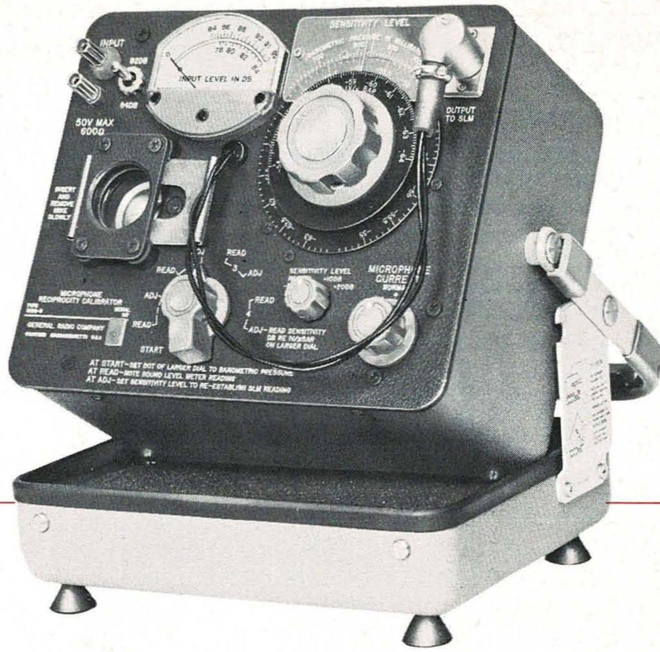
File Courtesy of GRWiki.org

acoustics

MICROPHONE RECIPROCITY CALIBRATOR

Type 1559-B

- accuracy ±0.3 dB
- NBS traceable via WE 640AA microphone
- direct readout without calculations



This unique instrument employs the recognized method of performing the absolute calibration of laboratory standard microphones*: the closed-coupler (cylindrical cavity) reciprocity-calibration procedure. It will also serve as a sound-level calibrator or precision acoustical source for making rapid checks on microphones and sound-level meters or setting reference levels in analyzing systems.

The 1559-B contains the acoustic cavity and two transducers used in reciprocity calibration, interconnecting circuits and switching that obviate the need for physically moving the microphones during calibration, and an analog calculator that directly reads out microphone sensitivity after a simple 4-step voltage-matching procedure. A sound-level meter and nearly any general-purpose audio oscillator will serve as the required external detector and signal source.

* General Radio Types 1560-P3, 1560-P4, 1560-P5, 1560-P6, Western Electric 640AA or equivalent, and (with special adaptor) GR Type 1551-P1L.

BASIC PRINCIPLES

The analog calculator solves for the sensitivity of the unknown microphone from two quantities that the 1559-B measures by voltage matching: the ratio and the product of the sensitivities of the unknown and the internal reciprocal microphone.

— See **GR Experimenter** for December 1964.

specifications

AS MICROPHONE CALIBRATOR

Range: For microphone sensitivities between —35 dB and —75 dB re 1 V/μbar.

Accuracy:

Microphone Type	Accuracy	Frequency Range
GR 1560-P5,-P6 and WE 640AA	$\pm(0.2 + 0.1\ f_{kHz})$ dB	20 Hz to 2.5 kHz
	±0.7 dB	2.5 to 6 kHz*
GR 1560-P3, -P4	$\pm(0.2 + 0.1\ f_{kHz})$ dB	20 Hz to 2.5 kHz
	±0.7 dB	2.5 to 7 kHz*
GR 1551-P1L†	$\pm(0.2 + 0.1\ f_{kHz})$ dB	20 Hz to 2.5 kHz
	±0.7 dB	2.5 to 5 kHz

* To 8 kHz with corrections. † Requires special adaptor.

Oscillators page 198 ff

AS PRECISION ACOUSTICAL SOURCE

Frequency Range: 20 Hz to 7 kHz.

Output: 92 dB re 20 μN/m² for excitation of 50 V.

Accuracy: At 92 dB, ±0.2 dB + error in determining microphone sensitivity.

AS SOUND-LEVEL CALIBRATOR

Frequency Range: 20 Hz to 2.5 kHz.

Output: 92 dB re 20 μN/m² when the input level in dB meter reads 92 dB.

Accuracy: ±0.7 dB at standard atmospheric pressure.

Note: The above specifications apply when the cavity is properly sealed. It may be necessary to apply a sealing compound (grease, etc) to the rim of the unknown microphone.

GENERAL

Accessories Required: Generator and detector. Generator to supply 5 V or more into a 2000-pF load, and 2.5 V or more into a 600-Ω load. The 1304-B Beat-Frequency Audio Generator, the 1210-C Unit R-C Oscillator, and the 1310-A Audio Oscillator are recommended. The 1551 or 1561 Sound-Level Meter, 1558 Octave-Band Analyzer, or 1564 Sound and Vibration Analyzer is recommended for the detector.

Accessories Supplied: 274-NP Patch Cord and an extension cable for connection to generator and detector; and adaptors for reciprocity and comparison calibration of the 1560-P5, 1560-P6, and Western Electric 640AA or equivalent microphones.

Mounting: Flip-Tilt Case. Also available in rack-mount version.

Dimensions (width x height x depth): Portable model, 10 x 8 x 7½ in. (255 x 205 x 190 mm); rack model, 19 x 10½ x 5 in. (485 x 270 x 130 mm).

Net Weight: Portable model, 13 lb (6 kg); rack model, 14 lb (6.5 kg).

Shipping Weight: Portable model, 16 lb (7.5 kg); rack model, 25 lb (11.5 kg).

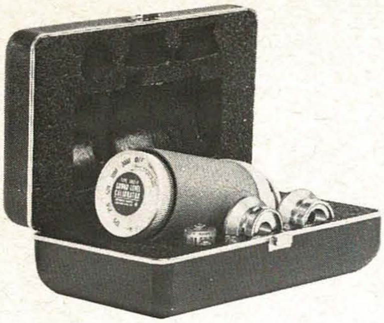
Catalog Number	Description	Price in USA
	1559-B Microphone Reciprocity Calibrator	
1559-9702	Portable Model	**$650.00**
1559-9842	Rack Model	**650.00**

PATENT NOTICE. See Notes 15 and 22.

File Courtesy of GRWiki.org

SOUND-LEVEL CALIBRATOR

Type 1562-A



- 125 to 2000 Hz
- ±0.3-dB accuracy
- fits many microphones

new

The 1562 is a self-contained unit for making accurate field calibrations on microphones and sound-measuring instruments. It generates a precisely known sound-pressure level at five USASI-preferred frequencies. With its several frequencies, improved accuracy, and built-in oscillator, the 1562 supersedes the 1552-1307 two-instrument combination.

The 1562 will calibrate the Western Electric 640AA and the GR 1560-P5, -P6, and -P7 microphones used with current instruments, the GR 1551-P1 Condenser Microphone System, and the older Types 1560-P3 and 1560-P4. Thus sensitivity and response tests can be made at several frequencies on a variety of instruments with microphones, including Types 1551, 1561, and 1565-A Sound-Level Meters, 1558 Octave-Band Analyzers, 1564-A Sound and Vibration Analyzer, 1555-A Sound-Survey Meter, and 1525-A Data Recorder.

An electrical signal output is provided for tests on instruments without microphones. An indicator lamp is provided to check for adequate battery voltage.

For even greater accuracy and NBS traceability, use the 1559-B Microphone Reciprocity Calibrator.

— See **GR Experimenter** for May-June 1967.

specifications

ACOUSTIC OUTPUT

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

Sound-Pressure Level: 114 dB re 20 μN/m^2.

Accuracy (at 23°C and 760 mm Hg):

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

Temperature Coefficient: Between 0 and −0.012 dB/°C.
Pressure Correction: Chart supplied.

ELECTRICAL OUTPUT

Voltage: 1.0 V ±20% behind 6000 Ω.

Frequency Characteristic: Output is flat ±2%.

Distortion: <0.5%.

Connector: Standard telephone jack.

GENERAL

Operating Environment: 0 to 50°C, 0 to 95% relative humidity.

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

Battery: One 9 V Burgess PM6 or equal. 120 hours use.

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

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

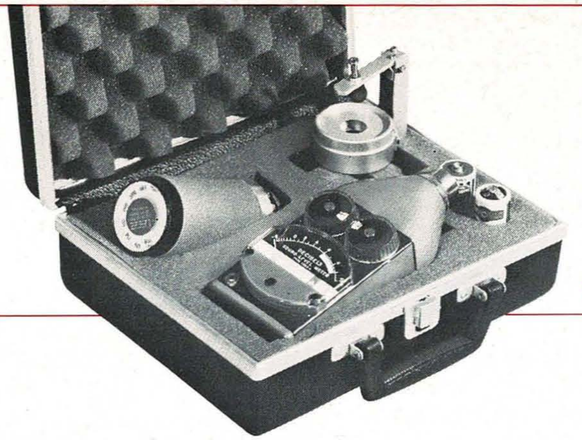
Catalog Number	Description	Price in USA
1562-9701	**1562-A Sound-Level Calibrator**	**$225.00**

File Courtesy of GRWiki.org

acoustics

AUDIOMETER CALIBRATION SET

Type 1565-Z



new

A set of three GR acoustical-measuring instruments comprises an accurate, portable, and inexpensive system for the field calibration of audiometers. The importance of periodic calibration to ensure accurate, defensible audiometric data is being increasingly emphasized. Many of the recent articles on the subject are referred to in the October 1966 **GR Experimenter.**

The 1565-Z calibration set contains the GR 1565-A Sound-Level Meter to measure the response of the audiometer, the 1560-P82, a Type 1 earphone coupler that fits the 1565's microphone, the 1562-A Sound-Level Calibrator to ensure accurate reading from the sound-level meter, and a calibration chart, all in a convenient carrying case.

1311-AU Audiometric Oscillator page 204

EARPHONE COUPLERS

GR offers two couplers that will meet the requirements of a Type 1 coupler in the American Standard Method Z24.9-1949 on "Coupler Calibration of Earphones."

The 1560-P82 coupler fits 15⁄16-in. diameter microphones, including the GR 1560-P5 and -P6 and the Type L laboratory standard microphones like the Western Electric 640AA. The 1560-P81 coupler fits 1⅛-in. microphones such as the older GR 1560-P3 and -P4 Microphones.

— See **GR Experimenter** for October 1966.

specifications — couplers only

Type Coupler: USASI Type 1.

Volume: 6 cm³ including equivalent volume of microphone (Type 1560-P5 Microphone for Type 1560-P82 Coupler; Type 1560-P3 Microphone for the Type 1560-P81 Coupler).

Axial Holding Force: 500 grams.

Frequency Range: 100 Hz to 8000 Hz; ±1 dB from 100 Hz to 6000 Hz, increasing to ±3 dB at 8000 Hz (with corrections for pressure response of microphone).

Dimensions: Coupler (diameter x height), 2¼ x 1 1⁄16 in. (57 x 26 mm); over-all (width x height x depth), 2¼ x 3 x 3 in. (57 x 76 x 76 mm).

Weight: Net, 8 oz (230 g); shipping, 2 lb (1 kg).

specifications — 1565-Z

Comprises: 1565-A Sound-Level Meter, 1560-P82 Earphone Coupler, 1562-A Sound-Level Calibrator, storage case.

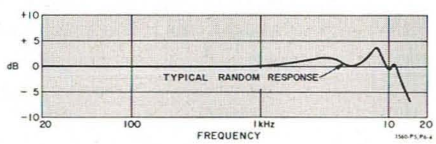
Dimensions (width x height x depth): 11¼ x 4¼ x 10 in. (290 x 110 x 255 mm).

Weight: Net, 5 lb (2.3 kg); shipping (est), 12 lb (5.5 kg).

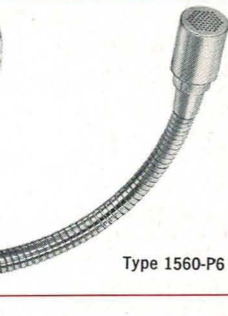
Catalog Number	Description	Price in USA
1565-9900	**1565-Z Audiometer Calibration Set**	**$565.00**
1560-9682	**1560-P82 Earphone Coupler**	**35.00**
1560-9681	**1560-P81 Earphone Coupler**	**35.00**

MICROPHONES

Type 1560-P5
Type 1560-P6



Type 1560-P5



Type 1560-P6

These GR-manufactured microphones are piezoelectric ceramic units, whose characteristics closely approach those of condenser microphones used as laboratory standards. They require no polarizing voltage and their impedance is lower by an order of magnitude. Thus, leakage due to high humidity is less of a problem than with the condenser type. Its stable capacitance makes the cable correction relatively independent of temperature. The 1560-P5 and the 1560-P6 Microphones use the same cartridge, which is the same diameter as the Western Electric 640AA laboratory standard microphone.

— See **GR Experimenter** for May-June 1967.

specifications

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

Sensitivity: −60 dB re 1 V/μbar nominal.

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

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

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

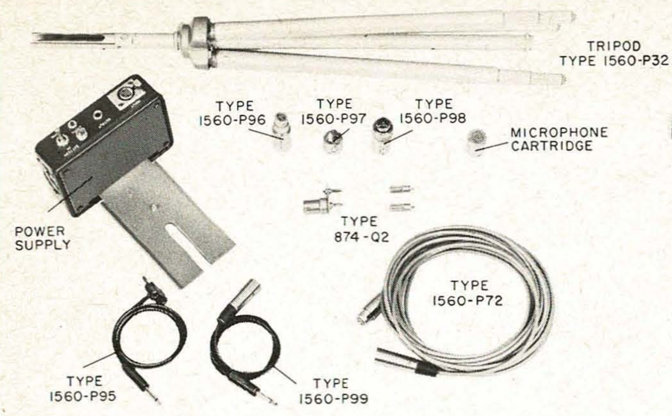
Terminals: Microphones fit 3-terminal microphone cable connector. For hum reduction both microphone terminals may be floated with respect to ground.

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

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

Catalog Number	Description	Price in USA
1560-9605	**1560-P5 Microphone**	**$ 80.00**
1560-9606	**1560-P6 Microphone Assembly**	**110.00**

File Courtesy of GRWiki.org




1560-P40
Preamplifier

PREAMPLIFIER

Type 1560-P40

- High input impedance; low output impedance
- Low electrical noise level
- Voltage gain of 1 or 10

The 1560-P40 Preamplifier is a high-input impedance, low-noise preamplifier. It is particularly well suited for amplifying the output of piezoelectric transducers, such as microphones and vibration pickups, and for use with GR sound-level meters and analyzers when a long cable (up to 1 mile) must be used between microphone and instrument. It is also a useful probe amplifier for other electrical signals where its high input impedance and low noise are necessary. For example, it can increase the sensitivity and input impedance of analyzers, recorders, amplifiers and null detectors, counters and frequency meters, voltmeters, and low-frequency oscilloscopes.

DESCRIPTION

The 1560-P40 is a three-stage negative-feedback amplifier that makes full use of the low-noise and high-input-impedance characteristics of a unipolar transistor (FET). The feedback can be switched by the user to obtain a voltage gain of either 1:1 or 10:1. A 1560-P5 or P7 microphone cartridge plugs directly onto the input end of the case. Adaptors are available for connecting the preamplifier to the cartridge of the GR 1560-P3 Microphone, to GR874 connectors, and to 3-terminal microphone connectors. Output from the preamplifier is through a 3-terminal shielded connector. The required dc supply voltage is applied from one of these terminals to ground. This voltage can be obtained directly from the 1558, 1568, or 1564 Analyzers, the 1525 Recorder, 1561 Precision Sound-Level Meters, or from the rechargeable-battery power supply listed below.

THREE SETS

The 1560-P40H Preamplifier and Power Supply Set is self-powered and independent of any external supply so that it can be used with the 1900-A Wave Analyzer as well as with all the other instruments mentioned above.

The 1560-P40J Preamplifier and Adaptor Set is dependent for its power on the instrument to which it is connected, so that it should be used with the analyzers, recorder, and sound-level meters mentioned above. If the connector from the source is not one of those for which an adaptor is supplied, GR874 adaptors can be used with almost all standard coaxial connectors.

The 1560-P40K Preamplifier and Microphone Set is for use with the sound-level meters, analyzers, or recorder when an acoustical measurement is needed at low levels and the microphone must be mounted at the end of a cable.

— See **GR Experimenter** for June 1965.

specifications

Gain: 1:1 or 10:1 (20 dB) ±0.3 dB at 25°C; <±0.3 dB gain change −50°C to +55°C.
Input Capacitance: 6 pF.
Input Resistance: >500 MΩ at low audio frequencies.
Output Resistance: 1:1 gain — approx 10 Ω in series with 3.3 μF. 10:1 gain — approx 100 Ω in series with 3.3 μF.
Noise: ≤2.5 μV equivalent input voltage (400-pF source impedance, C-weighted, 10-kHz effective bandwidth).
Frequency Response (at 0.5 V pk-pk open-circuit output):

1:1 gain		
0°C to 55°C	±1.5 dB ±0.25 dB	1 Hz to 500 kHz 3 Hz to 500 kHz
−30°C to 55°C	±1 dB ±0.25 dB	5 Hz to 500 kHz 20 Hz to 500 kHz
10:1 gain		
−30°C to 55°C	±3 dB ±1.5 dB ±0.25 dB	3 Hz to 500 kHz 5 Hz to 500 kHz 20 Hz to 250 kHz

Harmonic Distortion at Audio Frequencies:
Open circuit, at 1 V pk-pk: <0.25%.
Capacitor load of 0.01 μF (equivalent to a cable over 200 ft long): Max output (pk-pk) at 1% distortion is 5 V for 1 kHz, 2 V for 10 kHz.

Accessories Available (supplied in combinations listed below): Power supply, includes two 9.6-V nickel-cadmium rechargeable batteries, a charging circuit, a battery-check light, and a power cord.
Types 1560-P96, 1560-P97, and 1560-P98 Adaptors for converting the input pin connections to 3-terminal shielded microphone connectors, to the pin sockets necessary for the cartridge of a 1560-P3 Microphone, and to a GR874 connector, respectively.
Types 1560-P72 (25-ft), 1560-P72B (100-ft), and 1560-P72C (4-ft) cables for supplying power to and transferring the signal from the preamplifier.
Type 1560-P95 Adaptor Cable for connecting the signal from the power supply through a cable to a double plug.
Type 1560-P99 Adaptor Cable for connection from phone plug to microphone plug.

Power Required: 15 to 25 V, 1 to 2 mA, dc; available from power supply listed below, or from 1558, 1568, and 1564 analyzers, 1525 Recorder, and 1561 Sound-Level Meter.
Dimensions: Length 6⅞, diameter 1.155 by 1 in. (175 x 30 x 26 mm).
Weight: Net, 9 oz (0.3 kg); shipping, 3 lb (1.4 kg), preamplifier only.

	1560-P40H	1560-P40J	1560 P40K
1560-P40 Preamplifier	X	X	X
Power Supply	X		
Microphone Cartridge			X
1560-P32 Tripod			X
1560-P72 Cable (25 ft)			X
1560-P72C Cable (4 ft)	X	X	X
1560-P95 Adaptor Cable	X		
1560-P96 Adaptor	X	X	
1560-P97 Adaptor		X	
1560-P98 Adaptor	X	X	
1560-P99 Adaptor Cable	X		
874-Q2 Adaptor	X		
Shipping Weight:	10 lb (4.6 kg)	4 lb (1.9 kg)	14 lb (6.5 kg)

Catalog Number	Description	Price in USA
1560-9640	**1560-P40 Preamplifier**	**$125.00**
1560-9500	**1560-P40H Preamplifier and Power Supply Set**	**315.00**
1560-9510	**1560-P40J Preamplifier and Adaptor Set**	**190.00**
1560-9520	**1560-P40K Preamplifier and Microphone Set**	**251.00**

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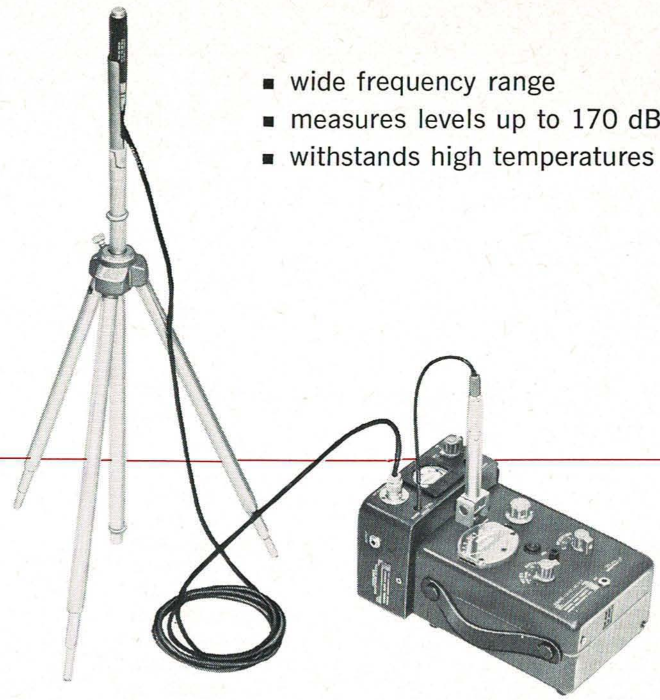
CONDENSER MICROPHONE SYSTEM

Type 1551-P1

- wide frequency range
- measures levels up to 170 dB
- withstands high temperatures



1551-P1 with 1551-C Sound-Level Meter.

Applications include:

Measurement of high-frequency and high-level noises produced by such noise sources as air streams, woodworking and metalworking machinery, turbines, and jet engines.

General-purpose sound-level measurements where ambient temperature and sound level are high.

Measurements on high-fidelity sound systems over the full audio spectrum.

DESCRIPTION

The 1551-P1L Condenser Microphone System uses an Altec 21-BR-150 microphone and measures sound-pressure levels up to 155 dB; the 1551-P1H, which uses a 21-BR-180 microphone, measures levels up to 170 dB.

The microphone base houses a subminiature pre-amplifier tube. A battery-operated power supply provides power and polarizing voltage. An extension cable, a tripod, and a leather carrying case are supplied.

specifications

Frequency Response: 20 Hz to 18 kHz with either microphone. Typical response curves are shown.

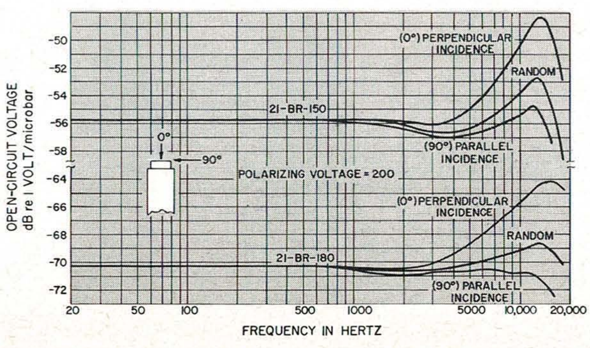
Calibration: Output level vs frequency is measured in our laboratory by comparison with a standard microphone. The measured level at 500 Hz and a calibration curve are supplied.

Output Impedance: 6500 Ω (typical).

Direct Use with Analyzers: These assemblies can supply a signal directly to the 1558 Octave-Band Noise Analyzer or the 1564-A Sound and Vibration Analyzer, provided that the levels of the measured components are above the following indicated values:

	1551-P1H	1551-P1L
1558-A, -BP	65 dB	50 dB
1564-A	65 dB	50 dB

A 1562 Sound-Level Calibrator is necessary for absolute level calibration.



Typical response vs frequency.

Max Sound-Pressure Level:

Frequency	Up to 1.5 kHz		At 15 kHz	
Distortion	<1%	<10%	<10%	<1%
1551-P1L	135 dB	155 dB	125 dB	135 dB
1551-P1H	150 dB	170 dB	140 dB	150 dB

Minimum Measurable Sound-Pressure Level:
1551-P1L—50 dB (re 20 μN/m^2) } with 10-dB
1551-P1H—65 dB (re 20 μN/m^2) } signal-to-noise ratio

Temperature and Humidity: Max recommended operating temperature of the microphone in its probe is 100°C. Microphone is not damaged by exposure to high humidity, but prolonged exposure may render it temporarily inoperative.

Batteries: One 1½-V size D flashlight cell and one 300-V B battery (Eveready 493, Burgess V-200 or equivalent) are supplied. Batteries should last at least 150 hours under normal use.

Mounting: The microphone on its base plugs into one end of a 10-ft cable and will slip into a receptacle on the tripod. The other end of the cable is connected to the power-supply unit, which fastens to one end of the sound-level meter.

Components and Accessories Supplied: Microphone base assembly, cable assembly, power supply, microphone, microphone cap, carrying case, and tripod.

Dimensions: In carrying case, 7 x 5½ x 8½ in. (180 x 140 x 220 mm).

Weight: Net, in carrying case, 7¼ lb (3.3 kg); shipping, 15 lb (7 kg).

Catalog Number	Description	Price in USA
	Condenser Microphone System	
1551-9866	**1551-P1L** (Normal Level)	**$550.00**
1551-9865	**1551-P1H** (High Level)	**550.00**
8410-9599	**Set of Replacement Batteries**	**12.15**

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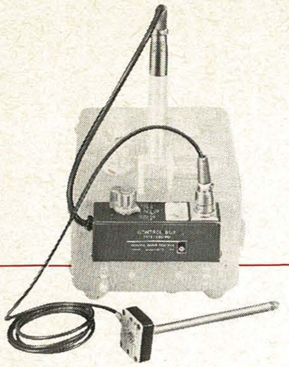
VIBRATION PICKUPS AND SYSTEMS

- accessories for sound-level meters
- select for:
  high-frequency performance
  high sensitivity
  general application, economy



The 1560-P11B Vibration Pickup System with the 1551-C Sound-Level Meter.

For the measurement of solid-borne vibrations with the sound-level meter a vibration pickup is used in place of the microphone.

Each of these Vibration Pickup Systems consists of a vibration pickup, a control box, and a connection cable. The vibration pickup is an inertia-operated, ceramic device, which generates a voltage proportional to the acceleration of the vibrating body. By means of integrating networks in the control box, voltages proportional to velocity and displacement can also be delivered to the sound-level meter. The desired response is selected by means of a three-position switch on the control box. Conversion data are supplied for translating the decibel indications of the sound-level meter into the vibration parameters of displacement, velocity, and acceleration.

Three models are offered, differing in frequency range, sensitivity, and price.

TYPE 1560-P11B

This system uses a lead-zirconate-titanate pickup, identical with that used on the 1553-A Vibration Meter. Probe and probe tips are provided. A permanent-magnet mount is also available.

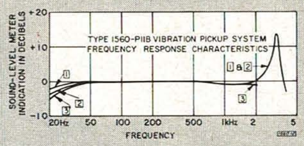
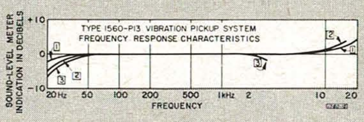
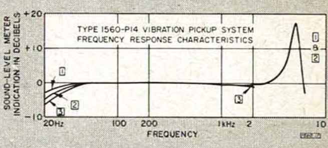
TYPE 1560-P13

For measurements at higher frequencies than the -P11B system affords, the -P13 combination is recommended, consisting of the 1560-P53 Vibration Pickup and the 1560-P23 Control Box. A small holding magnet is included.

This system with the Type 1551-C or -B Sound-Level Meter provides the flat frequency response and low-noise operation required by MIL-STD-740 (SHIPS) for vibration measurement. (The holding magnet is not used for measurements according to that standard.)

TYPE 1560-P14

The vibration pickup used in this system has approximately 10 times the sensitivity and 10 times the impedance of the 1560-P52.

Pickup Systems	General Purpose 1560-P11B Vibration Pickup System	High Frequency 1560-P13 Vibration Pickup System	High Sensitivity 1560-P14 Vibration Pickup System
Ranges of Measurement Rms Acceleration (in./s²)	0.1 to 39,000 (100 g)†	0.3 to 390,000 (1000 g)†	0.01 to 3900 (10 g)†
Rms Velocity (in./s)	0.001 to *	0.001 to 1000	0.0001 to *
Rms Displacement (in.)	0.00003 to *	0.00003 to 30	0.000003 to *
Frequency Range Response characteristics for constant applied (1) acceleration, (2) velocity, and (3) displacement.			
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)
Catalog Number	1560-9922	1560-9613	1560-9614
Price: Vibration Pickup System	**$140.00** in USA	**$330.00** in USA	**$200.00** in USA

Pickup Characteristics

Pickup Type Number	1560-P52	1560-P53	1560-P54
Sensitivity (mV/g), nominal	70	70	700
Temp Coeff of Sens (dB/°C)	<−0.01	<0.02	0.01
Resonant Frequency (Hz)	3200	27,000	5000
Capacitance (pF)	10,000	350	700
Temperature Range (°C)	−18 to 100	−54 to 177	−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 × 1⁷⁄₁₆ × ⁵⁄₁₆	⅝ (hex) × 0.7	1³⁄₁₆ (dia) × 1¹⁄₁₆
(mm)	42 × 37 × 15	15.5 × 18	31 × 27
Net Weight (oz)	1.6 (45 grams)	1.1 (31 grams)	3.1 (90 grams)
Catalog Number	1560-9652	1560-9653	1560-9654
Price: Pickup Only	**$75.00** in USA	**$260.00** in USA	**$140.00** in USA

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

File Courtesy of GRWiki.org

acoustics

VIBRATION CALIBRATOR

Type 1557-A

- calibrates vibration pickups, meters
- generates 1 g at 100 Hz
- portable, battery-operated

The calibrator provides a single-frequency (100 Hz), single-level (1 g) check on the GR Vibration Pickups, the 1553 Vibration Meter, or any pickup whose total mass is 300 grams or less. It can provide on-the-spot calibration of vibration-measuring systems immediately before and after important measurements and can also be used to compare transducers or to calibrate working transducers against a standard transducer.

Operation of the calibrator is simple. A pickup of known mass is attached to the shaker, either in place of one of the removable 50-gram disks or to one of the disks by double-faced, pressure-sensitive tape. The user adjusts the LEVEL control until the panel meter, calibrated in grams, indicates the mass of the pickup. The pickup will then be automatically subjected to an acceleration of 1 g at 100 Hz.

The 1557-A is a small, battery-operated unit consisting of a transistorized electromechanical oscillator and a cylindrical shaker. The acceleration output of the calibrator appears at two pillbox-shaped, 50-gram disks mounted on an internal cylinder that projects through the sides of the instrument.

View of the calibrator with Type 1560-P52 Vibration Pickup attached.

specifications

OUTPUT

Acceleration: 1 g rms ±10%. 1 g = 386 in./s^2 (9.81 m/s^2).

Velocity: 0.614 in./s (15.6 mm/s) rms.

Displacement: 0.000978 in. (0.0248 mm) rms; 0.00277 in. (0.0704 mm) pk-pk.

Frequency: 100 Hz ±1% for 50-gram load; 100 Hz +0, −2% for 300-gram load.

GENERAL

Batteries: Four RM-4 (or equivalent) mercury cells. Battery life is 100 hours of continuous operation. (Dry cells optional; please specify.)

Accessory Supplied: Leather carrying case.

Mounting: Aluminum case.

Dimensions (width x height x depth): 4 x 8 x 4 in. (105 x 205 x 105 mm).

Weight: Net, 3¼ lb (1.5 kg); shipping, 5¼ lb (2.4 kg).

Catalog Number	Description	Price in USA
1557-9701	**1557-A Vibration Calibrator**	**$325.00**

File Courtesy of GRWiki.org

ACCESSORIES FOR ACOUSTIC INSTRUMENTS

CONNECTORS

Many acoustic instruments are equipped with 3-terminal, shielded input connectors (female) that match or mate with connectors of the Switchcraft A3 type, Cannon XLR-3, or equivalent. GR microphones and vibration pickups are, of course, similarly equipped. Most instrument inputs also have a dc-supply voltage on the third connector pin to power the 1560-P40 Preamplifier when it is connected directly or through appropriate 3-conductor cable. Standard ¼-inch-shank 2-conductor phone jacks are used for most outputs and some inputs, so several cables are fitted with mating "phone plugs."

		Catalog Number	Price in USA
CABLES			
Extension cable, 25 ft, with microphone plug and jack; for use between microphone or pickup and instrument input.	**1560-P73 Extension Cable**	1560-9673	**$15.00**
Tripod and 25-ft extension cable same as 1560-P73, above.	**1560-P34 Tripod and Extension Cable**	1560-9634	**50.00**
Extension cable, 100 ft, same cable, connectors, and uses as 1560-P73, above.	**1560-P73B Extension Cable**	1560-9982	**23.00**
Extension cable, 100 ft, with microphone jack and plug; for use between output of 1560-P40 Preamplifier and instrument input; has extra conductor to carry dc power to preamplifier.	**1560-P72B Extension Cable**	1560-9977	**29.00**
Patch cord, 3 ft; shielded cable with phone plug on each end; general use.	**1560-P76 Patch Cord**	1560-2101	**3.00**
Adaptor cable, 3 ft; shielded cable with phone plug and double banana plug; for use from instrument outputs to binding-post inputs, general use.	**1560-P95 Adaptor Cable**	1560-9695	**3.00**
ADAPTORS			
Converts inputs of 1560-P40 Preamplifier and 1565 Sound-Level Meter (without microphones) to female microphone connector (jack).	**1560-P96 Adaptor**	1560-9696	**20.00**
Adaptor cable, phone plug to double banana plug; see 1560-P95, above.			
MISCELLANEOUS			
Tripod and 25-ft extension cable; see 1560-P34, above.			
Magnet clamp for firm, temporary holding of vibration pickups on metal surfaces.	**1560-P35 Permanent-Magnet Clamp**	1560-9635	**6.50**
Battery charger, recharges nickel-cadmium batteries used with 1561 Precision Sound-Level Meter and 1952 Universal Filter.	**1560-P60 Charger,** 115 V 230 V	1560-9660 1560-9661	**95.00** **on request**
Earphone couplers, for audiometric calibration, acoustically couple earphones to GR microphones.			page 22
Preamplifier, enhances measurement of low-level sound and vibration, permits use of microphones and pickups with long cables and direct connection to low-impedance and low-sensitivity inputs.			page 23
Microphones, GR-made, ceramic element; supplied with many GR instruments. Exceptional stability, frequency response, and ruggedness.			page 22
Vibration pickup systems; high-frequency, high-sensitivity, or general-purpose accelerometers, with or without integrating networks for velocity and displacement.			page 25

See also pages 267, 268.

File Courtesy of GRWiki.org

ANALYZERS AND RECORDERS

The instruments described in this section are used to determine the frequency components and the wave shape of complex electrical signals, acoustic noise, or mechanical vibrations. The choice of an instrument for evaluating the individual components of such a signal depends upon the character of the signal, the information that is needed, and how the results are to be used.

WAVE ANALYZER — FIXED BANDWIDTH

If, for example, the signal is a periodic one that is reasonably stable in frequency, each spectrum component is readily measured with the 1900-A Wave Analyzer. The very high selectivity of this analyzer, with its bandwidths of 3, 10, and 50 Hz, is independent of the frequency to which the analyzer is tuned. These selectivity characteristics make the 1900-A particularly useful in measuring intermodulation distortion, as a tuned electronic voltmeter or as a null detector when it is necessary to avoid interference from hum, noise, and distortion products. Frequently convenient in these uses is the sine-wave output of the analyzer at the frequency to which it is tuned. The 1900 is also well suited for spectrum-level measurements of noise.

WAVE ANALYZER — 1% BANDWIDTH

The GR 1568 Wave Analyzer makes available for many applications the best features of both fixed-bandwidth and constant-percentage-bandwidth analyzers, in a portable, battery-operated instrument.

SOUND AND VIBRATION ANALYZER — 1/3 AND 1/10 OCTAVE

The 1564-A Sound and Vibration Analyzer finds its greatest use in the measurement of the components of noise, either electrical or acoustic, when the bandwidth of a wave analyzer is too narrow for rapid analysis, and in the measurement of noises and complex waveforms whose frequency components fluctuate. It provides two bandwidths, which are constant percentages of the center frequency: 1/3 octave (23%), and 1/10 octave (7%).

OCTAVE-BAND ANALYZER

For many noise measurements a simpler division of the spectrum is desired than that provided by either the 1564-A Sound and Vibration Analyzer or the wave analyzers. Much time can be saved in the evaluation of the general spectral distribution of a noise through the use of a wide-band device such as the 1558 Octave-Band Analyzers. These divide the audio spectrum into ten bands. Like the more selective analyzers, the octave-band analyzer can be used as a selective voltmeter when it is desired to exclude certain bands of frequencies or individual frequencies from a signal.

RECORDING ANALYZERS

The 1564-A Sound and Vibration Analyzer and the two wave analyzers can each be combined with the GR 1521-B Graphic Level Recorder to form recording analyzers. With these assemblies, listed in the following pages, complex spectra can be plotted automatically. One recording analyzer containing the 1564 can make stepped third-octave analyses as well as continuous plots.

RECORDERS

The 1521-B Graphic Level Recorder is a servo-type device, producing an ink record on moving paper. It plots linearly in decibels the rms level of ac voltage up to 200 kHz. Interchangeable potentiometers give full-scale values of 20, 40, and 80 dB, as well as a linear dc range. This recorder can plot the output level of electrical and electroacoustic devices as a function of time. It is available in combination with wave analyzers for automatic plotting of frequency spectra and with the beat-frequency audio-generator for automatic frequency-response plotting.

The 1520-A Sampling Recorder uses 117 fixed pens, spaced along the vertical scale of a moving chart paper, each of which prints a dot whenever the voltage level of the input function, which is scanned at a 3-kHz rate, equals the level of an internally generated linear ramp voltage. Such a system has no frequency response limitation for the recording of transients except that which is imposed by the sampling rate.

UNIVERSAL FILTER

A band-pass or band-reject filter, with variable bandwidth, and a tunable low-pass or high-pass filter are valuable in applications calling for control of system bandwidth, a noise spectrum of controlled bandwidth, or the rejection of unwanted frequencies. The GR 1952 Universal Filter will meet all these needs and more.

AUTOMATIC LEVEL REGULATOR

Frequency analyses, particularly those using sweep methods, require that the level of an electrical signal, a noise, or vibration be held constant at some point in the system for convenience in interpreting the results. The 1569 regulator will monitor and hold constant the signal from a microphone or other sensor by varying the gain of its amplifier through which the test signal is passing.

STEEP WAVEFRONTS

With impact-type acoustic noise and electrical noise, which have extremely steep wavefronts, a frequency analysis is usually of little value. The important characteristics of such signals are the peak amplitude and the duration or decay time. To evaluate these quantities, the 1556-B Impact-Noise Analyzer is used.

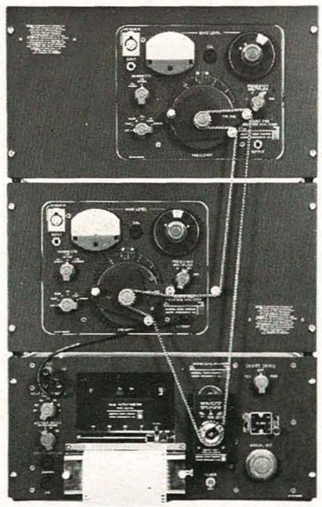
File Courtesy of GRWiki.org

ACOUSTICAL MEASURING SYSTEMS

General Radio's wide line of audio and acoustical measuring instruments provides the building blocks for complete measuring systems, enabling you to specify and receive total measurement capability in a single assembly from one reputable source.

General Radio has delivered many specialized acoustical measuring systems and offers, as well, a growing selection of standard off-the-shelf systems from which to choose. Some typical custom systems that have been assembled are shown below. Any GR sales engineer or representative will be glad to help in assessing your system needs.

Standard Systems
pages 38, 208



2990-9110

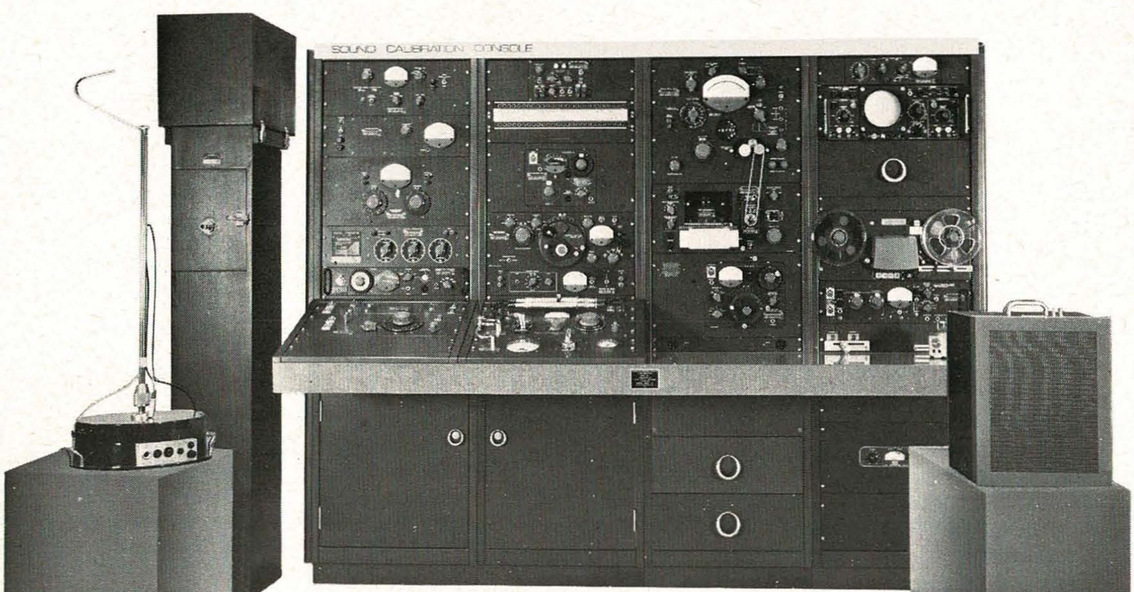
Acoustical Analysis and Recording System

Used to shape and analyze bands of noise for acoustical attenuation measurements.

Includes:

⅓-Octave Analyzer
Special Analyzer
Graphic Level Recorder

Typical price: **$4000**



2990-9104

Acoustical Measurement System

(For more information, request GR Reprint No. A138.)

Includes instruments for the following measurements:

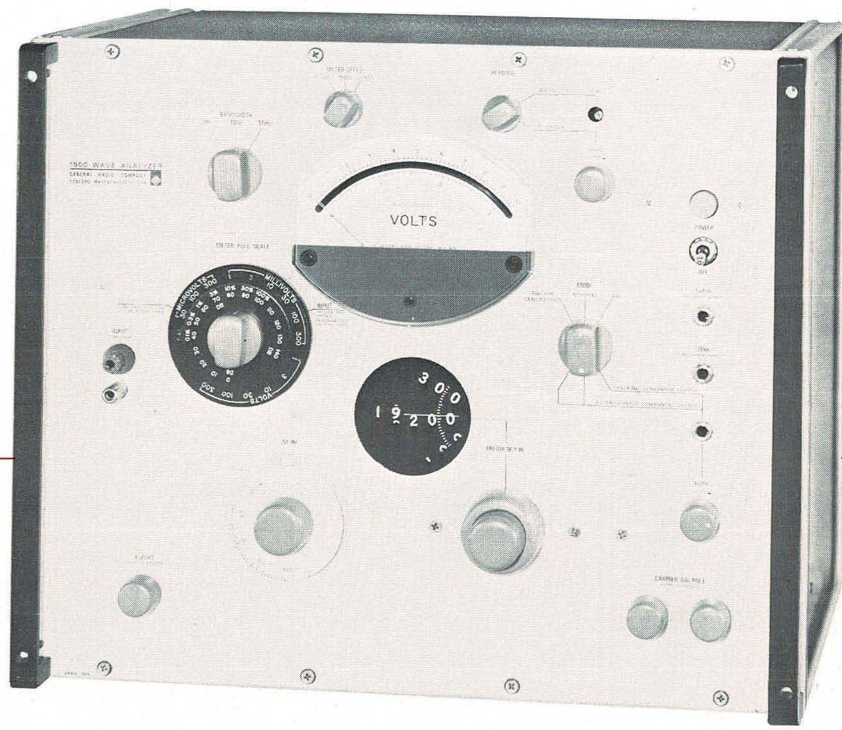
- microphone calibration (2 methods)
- directional calibration of microphones
- frequency response of microphones, amplifiers, recorders
- anechoic-chamber characteristics
- reverberation (noise bands and warble tones)
- frequency analysis
  - narrow band
  - octave band
  - ⅓-octave band

File Courtesy of GRWiki.org

WAVE ANALYZER

Type 1900-A

- 20 to 54,000 Hz, linear frequency scale
- 3-, 10-, and 50-Hz bandwidths
- 30 μV to 300 V, full scale — 3 μV with preamp
- 80-dB recording analyzer with 1521 recorder
- outputs: filtered or BFO, 100 kHz and dc recorder
- 1-megohm input impedance on all ranges



The wave analyzer is used for measuring the components of, or analyzing the spectra of, complex electrical signals, acoustic noise, or mechanical vibrations

Individual components of periodic complex waveforms such as harmonic or intermodulation distortion are readily separated and measured, owing to the excellent selectivity.

Automatic frequency control enables the 1900-A to remain tuned to a slowly varying component that might otherwise drift out of the 50-Hz bandwidth.

This analyzer is particularly suited for analyzing noise, because its bandwidth in hertz is independent of the center frequency. The required averaging time is, therefore, constant, and the calculation of spectrum level is simple. Furthermore, when the 50-Hz bandwidth is used, the averaging time required is reasonably short.

For automatic analysis, outputs are provided for driving the 1521 Graphic Level Recorder as well as dc recorders.

Preamplifier
page 23

The 1560-P40H Preamplifier and Power Supply Set is available to extend the full-scale sensitivity to 3 microvolts and to increase the input impedance.

TUNABLE FILTER USE

The analyzer can also be used as a tunable filter, so that the individual components of a complex input signal can be used to drive other instruments, such as frequency counters, when a highly accurate measure of the component frequencies is desired, or to drive earphones. When a wide-band noise generator drives the analyzer, the output is a tunable narrow band of noise. Such a signal is useful in a number of psychological and architectural-acoustics tests.

AS A TRACKING GENERATOR

In the "tracking generator" mode of operation the output is a sine-wave signal tunable over the 54-kHz range and always in tune with the analyzer. When this signal is used to drive a bridge or other network, the output can be measured by the analyzer, whose selectivity reduces the interference from extraneous noise, hum, and distortion.

DESCRIPTION

The 1900-A is a heterodyne type of voltmeter. The intermediate-frequency amplifier at 100 kHz includes a

File Courtesy of GRWiki.org

highly selective quartz-crystal filter whose bandwidth can be switched to 3, 10, and 50 Hz. The use of a heterodyne system makes it possible to vary the response frequency although the filter frequency is fixed. The 100-kHz output of the filter is indicated on a meter and is also available at the panel. In one mode of operation the output is also heterodyned back to the original frequency. In another mode the local oscillator beats with a 100-kHz quartz-crystal oscillator to function as a beat-frequency oscillator. These two outputs are also available at panel terminals as FILTERED INPUT COMPONENT and INDICATED FREQUENCY, respectively.

— See **GR Experimenter** for April 1964.

specifications

FREQUENCY

Range: 20 to 54,000 Hz. The frequency is indicated on a counter and a dial with a linear graduation, 10 Hz per division.

Accuracy of Calibration: ±(½% + 5 Hz) up to 50 kHz; ±1% beyond 50 kHz.

Incremental-Frequency Dial (ΔF): ±100 Hz. Accuracy is ±2 Hz below 2 kHz, ±5 Hz up to 54 kHz.

Automatic Frequency Control: At frequencies below 10 kHz, total range of frequency lock is 400 Hz for the 50-Hz band and 150 Hz for the 10-Hz band, as defined by 3-dB drop in response from full-scale deflection. At 50 kHz, the lock ranges decrease to one-half of these values.

SELECTIVITY Three bandwidths (3, 10, and 50 Hz).

Effective bandwidth for noise equal to nominal bandwidth within ±10% for 10- and 50-Hz bands and ±20% for 3-Hz band.

3-Hertz Band: At least 30 dB down at ±6 Hz from center frequency, at least 60 dB down at ±15 Hz, at least 80 dB down at ±25 Hz and beyond.

10-Hertz Band: At least 30 dB down at ±20 Hz, at least 60 dB down at ±45 Hz, at least 80 dB down at ±80 Hz and beyond.

50-Hertz Band: At least 30 dB down at ±100 Hz, at least 60 dB down at ±250 Hz, at least 80 dB down at ±500 Hz and beyond.

INPUT

Impedance: 1 MΩ shunted by 30 pF on all ranges.

Voltage Range: 30 μV to 300 V, full scale, in 3, 10 series. A decibel scale is also provided.

Voltage Accuracy: After calibration by internal source, the accuracy up to 50 kHz is ±(3% of indicated value + 2% of full scale) except for the effects of internal noise when the attenuator knob is in the maximum-sensitivity position. From 50 to 54 kHz, the above 3% error becomes 6%.

Residual Modulation Products and Hum: At least 75 dB down.

OUTPUT

100-kHz Output: Amplitude is proportional to amplitude of selected component in analyzer input signal. With the 1521 Graphic Level Recorder connected, full-scale output is at least 3 V. Dynamic range from overload point to internal noise is >80 dB with attenuator knob fully clockwise.

Recording Analyzer: See the 1910-A Recording Analyzer and 1521-B Graphic Level Recorder.

1521 Recorder page 40

DC Output: 1 mA in 1500 Ω, full scale, one side grounded.

Filtered Input Component: Output at least 1 V across 600-Ω load for full-scale meter deflection with output control at max.

Tracking Analyzer (Indicated Frequency): 20 Hz to 54 kHz; output is at least 2 V across 600-Ω load with output control at max.

GENERAL

Terminals: Input, binding posts; output, telephone jacks.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz, 40 W.

Accessories Supplied: 1560-P95 Adaptor Cable, phone plug, power cord, spare fuses.

Accessories Available: 1900-P1 and 1900-P3 Link Units for coupling to 1521 Graphic Level Recorder, 1560-P40H Preamplifier and Power Supply Set.

Mounting: Rack-Bench Cabinet.

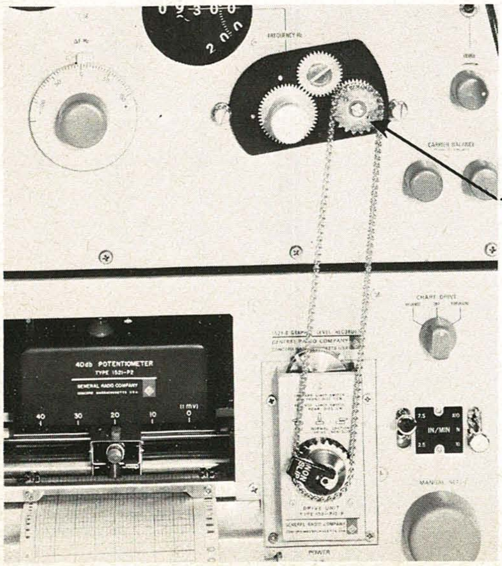
Dimensions (width x height x depth): Bench model, 19 x 16¼ x 15¼ in. (485 x 415 x 390 mm); rack model, 19 x 15¾ x 13¼ in. (485 x 400 x 340 mm).

Weight: Net, 56 lb (26 kg); shipping, 140 lb (64 kg).

Catalog Number	Description	Price in USA
1900-9801	**1900-A Wave Analyzer,** Bench Model	**$2650.00**
1900-9811	**1900-A Wave Analyzer,** Rack Model	**2650.00**

PATENT NOTICE. See Notes 1, 15, and 18.

AUTOMATIC WAVE ANALYSIS



1900-P1

The 1900-A Wave Analyzer can be used in conjunction with the GR 1521 Graphic Level Recorder to produce, automatically, permanent graphic records of high-resolution spectrum analyses. The necessary coupling mechanisms and chart papers are available for frequency scales of 50, 500, or 5000 Hz per inch. A choice of 3 recorder potentiometers permits selection of 20, 10, or 5 dB per inch, so that virtually any combination of horizontal and vertical scale resolution is possible.

The 1900-P1 and 1900-P3 Link Units mount on the wave analyzer in place of the manual frequency-tuning dial providing mechanical coupling to the recorder. The 1900-P3 permits selection of 500 or 50 Hz per inch scale factors with a lever; the 1900-P1 provides 5000 or 500 Hz per inch by the interchanging of sprocket wheels.

An assembly of the 1900-A Wave Analyzer, 1900-P1, and 1521-B Graphic Level Recorder is available as the 1910-A Recording Wave Analyzer.

1910 Assembly page 38

Catalog Number	Description	Chart Paper	Price in USA
1900-9601	**1900-P1 Link Unit**	1521-9464, 500 Hz/in. 1521-9465, 5000 Hz/in.	**$40.00**
1900-9603	**1900-P3 Link Unit**	1521-9464	**75.00**

File Courtesy of GRWiki.org

analyzers

WAVE ANALYZER

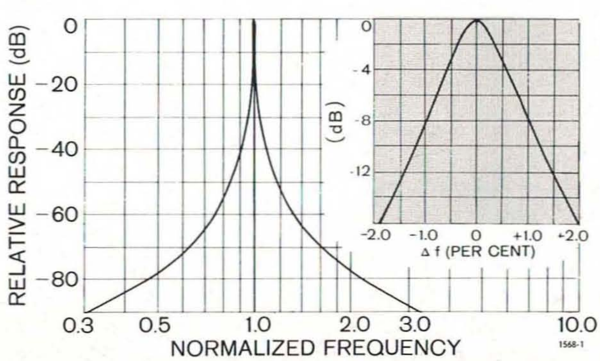
Type 1568-A

- 20 Hz to 20 kHz
- 1% constant-percentage bandwidth
- portable, battery-operated
- 85-db rejection

new

The 1568-A is an important new instrument for high-resolution frequency analyses, whether for measuring vibration and noise components or the spectrum of a complex electrical signal. Recent design advances combine the excellent filter shape of a wave analyzer with the convenient, simple operation of constant-percentage-bandwidth analyzers in a portable, low-cost instrument.

The voltage sensitivity and input impedance, adequate for most uses, can be improved to 10 microvolts full-scale and > 500 megohms, respectively, by the use of a 1560-P40 Preamplifier. Power for it is supplied at the input connector.



Attenuation characteristics of the filter.

HIGH RESOLUTION

Narrow bandwidth permits separation of closely spaced frequencies; wide dynamic range, high stop-band attenuation, and low distortion allow measurement of small components in the presence of components up to 80 dB larger. These capabilities are vital to the identification of unwanted vibration and noise components and to the measuring of discrete frequencies in complex electrical waveforms. At low frequencies bandwidth is narrower, stability better, and calibration more accurate than those of fixed-bandwidth heterodyne wave analyzers.

The 1568 will excell in such applications as

- harmonic distortion measurements at low frequencies
- harmonic analysis — 1% bw yields 50 components
- detailed analysis of machinery noise and vibration
- separation of close, discrete, low frequencies

AUTOMATIC ANALYSIS

In combination, the 1568-A and 1521-B Graphic Level Recorder produce spectrum plots with as much as a 70-dB recording range. Automatic range switching is included for ease and speed in making spectrum analyses. The analyzer and recorder are available mounted in a cabinet, interconnected, and mechanically coupled as a complete system, the 1913 Recording Wave Analyzer.

— See **GR Experimenter** for September 1966.

File Courtesy of GRWiki.org

specifications

FREQUENCY

Range: 20 Hz to 20 kHz in six half-decade bands.

Dial Calibration: Logarithmic.

Accuracy of Frequency Calibration: 1%.

Filter Characteristics: Bandwidth between 3-dB points on selectivity curve is one percent of selected frequency.

Attenuation at 20% above and at 20% below selected frequency is greater than 50 dB referred to the level at the selected frequency. Attenuation at twice and at one-half the selected frequency is at least 75 dB referred to the level at the selected frequency. Ultimate attenuation is greater than 85 dB.

Uniformity of filter peak response with tuning is ±1 dB from 20 Hz to 6.3 kHz and ±2 dB from 20 Hz to 20 kHz.

INPUT

Impedance: 100 kΩ.

Voltage Range: 100 μV to 300 V, full scale, in 3-10 series steps. Power is supplied at input socket for the 1560-P40 Preamplifier, which extends the sensitivity to 10 μV, full scale, and increases the input impedance to more than 500 MΩ.

Distortion: Input-circuit distortion is lower than −80 dB relative to input-signal level.

OUTPUT

Impedance: 6000 Ω. Any load can be connected.

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

Crest-Factor Capacity: Greater than 13 dB.

Output Meter: In addition to normal-speed mode, meter has slow-speed mode for manual measurements of noise.

GENERAL

Analyzing Range: 80 dB. Components of an input signal that differ in amplitude by as much as 80 dB can be measured.

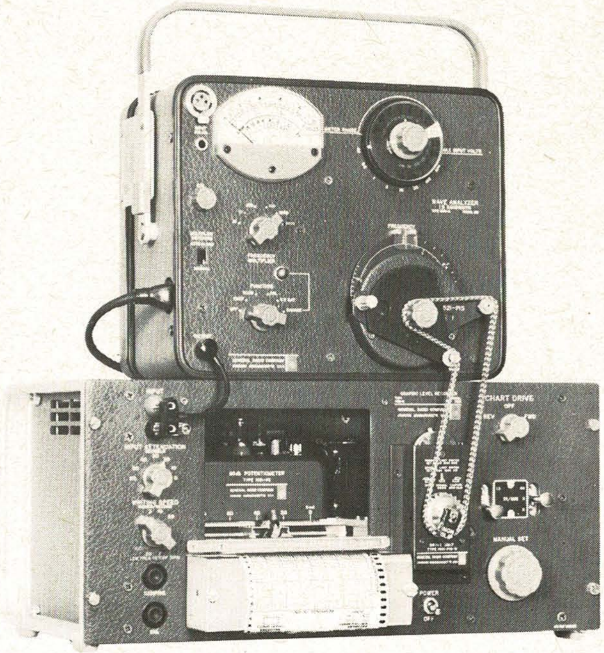
Automatic Recording: Automatic range switching is provided to allow convenient, continuous spectrum plotting when the 1521 Graphic Level Recorder is used. Medium-speed motor is recommended. Chart paper is Catalog No. 1521-9475. Frequency scale is logarithmic, 10 inches per decade; vertical scale is 4 inches for 20, 40, or 80 dB, depending on the potentiometer used in the recorder.

Amplitude Calibrator: A built-in, feedback-type calibration system permits amplitude calibration at any frequency.

Accessories Supplied: Power cord; 1568-2090 Detented Knob and Dial Assembly, used to facilitate measuring the components of an input signal as a percentage or in decibels with an arbitrary voltage reference.

Accessories Available: Preamplifier and Adaptor Set 1560-P40J; Link Unit 1521-P15, with Sprocket Kit 1521-P16 for mechanical coupling to 1521-B Graphic Level Recorder equipped with Drive Unit 1521-P10B; Chart Paper 1521-9475.

Power Supply: 100 to 125 or 200 to 250 V, 50 to 60 Hz. 2 W for normal operation, 3.5 W for battery charging. A rechargeable nickel-cadmium battery is supplied. Battery provides about 20 hours of operation when fully charged and requires 16 hours for charging. Internal charger operates from the power line.



The analyzer coupled to the Type 1521-B Graphic Level Recorder for the automatic plotting of frequency spectra. The chart paper has a logarithmic frequency scale, and frequency ranges on the analyzer are changed automatically.

Recording Analyzers page 39 ff

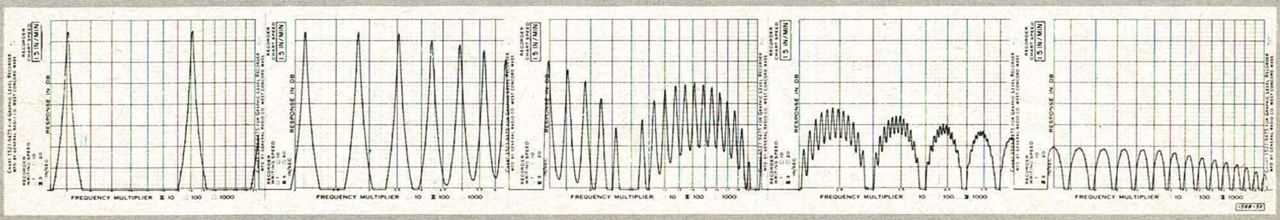
Mounting: Flip-Tilt case, rack model available.

Dimensions (width x height x depth): Portable, with case closed, 13¼ x 13 x 8¼ in. (340 x 330 x 210 mm); rack, 19 x 12¼ x 5 in. (485 x 310 x 130 mm).

Weight: Net, 21½ lb (10.0 kg); shipping, 27 lb (12.5 kg).

Catalog Number	Description	Price in USA
1568-9701	**1568-A Wave Analyzer,** Portable Model	**$1400.00**
1568-9820	**1568-A Wave Analyzer,** Rack Model	**1400.00**
1560-9510	**1560-P40J Preamplifier and Adaptor Set**	**190.00**
1521-9615	**1521-P15 Link Unit**	**30.00**
1521-9616	**1521-P16 Sprocket Kit**	**20.00**
1521-9475	**Chart Paper**	**2.75**

Preamplifier page 23



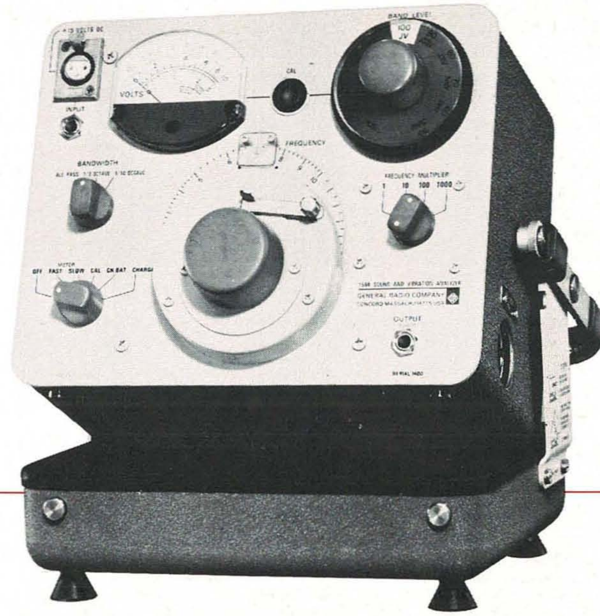
Frequency spectrum analysis of a 1.0-ms pulse at a 70-Hz repetition rate. The 1% bandwidth yields high resolution at low frequencies, shows the envelope at high frequencies.

File Courtesy of GRWiki.org

SOUND AND VIBRATION ANALYZER

Type 1564-A

- 2.5 Hz to 25 kHz
- 2 bandwidths: 1/3- and 1/10-octave
- use direct from microphone or vibration pickup
- ac or portable battery operation
- automatic spectrum plots with 1521 recorder



The 1564-A Sound and Vibration Analyzer is designed primarily for measuring the amplitude and frequency of the components of complex sound and vibration spectra. Its 1/3-octave (23%) and 1/10-octave (7%) noise bandwidths provide the flexibility needed for analysis of both the noise and its causes.

INPUT SOURCES

The high input impedance of the analyzer permits direct connection of piezoelectric transducers for measuring sound pressures from 44 to 150 dB re 20μN/m^2 and acceleration from 0.0007 g to 100 g.

The 1560-P40 preamplifier is available to extend the full scale sensitivity of the analyzer by 20 dB (10:1) and to allow use of the transducer at the end of a long extension cable. Alternatively, for higher sensitivity, the analyzer can be driven from a sound-level meter or vibration meter.

AUTOMATIC ANALYSIS

1521 Recorder page 40

Automatic range switching is provided so that the 1521-B Graphic Level Recorder can record automatically the spectrum of a signal under analysis. The combination of analyzer and recorder is available as the 1911-A Recording Sound and Vibration Analyzer for continuous spectrum plots. For both stepped and continuous 1/3-octave analysis, the recorder and analyzer are coupled by the 1564-P1 Dial Drive; this system is available as the 1912 Third-Octave Recording Analyzer.

NOISE FILTER

The analyzer can be used in conjunction with the 1390-B, 1381, or 1382 random-noise generators for transfer and reverberation measurements using 1/3- or 1/10-octave bands of random noise.

DESCRIPTION

The 1564-A consists of a high impedance amplifier, a continuously tunable filter having a noise bandwidth of either 1/3 or 1/10 octave, an output amplifier, and a meter. The center frequency of the filter is continuously adjustable. An all-pass, or flat, characteristic permits measurement of the over-all signal amplitude.

— See **GR Experimenter** for September-October 1963.

specifications

FREQUENCY

Range: 2.5 Hz to 25 kHz in four decade ranges.

Dial Calibration: Logarithmic.

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

Filter Characteristics: Noise bandwidth is either ⅓ octave or 1/10 octave. One-third-octave characteristic has at least 30-dB attenuation at one-half and twice the selected frequency. One-tenth-octave characteristic has at least 40-dB attenuation at one-half and twice the selected frequency. Ultimate attenuation is 70 dB or greater for both characteristics. For both bandwidths, peak response is uniform ±1 dB from 5 Hz to 10 kHz and ±1.5 dB from 2.5 Hz to 25 kHz. An ALL-PASS, or flat, characteristic is also included.

INPUT

Impedance: 25 MΩ in parallel with 80 pF (independent of attenuator setting).

File Courtesy of GRWiki.org

Voltage Range: 0.3 mV to 30 V full scale in 10-dB steps.

Microphone: 1560-P6 Microphone Assembly or the 1560-P40K Preamplifier and Microphone Set is recommended.

OUTPUT

Voltage: At least 1.0 V open circuit, when meter reads full scale.

Impedance: 6000 Ω. Any load can be connected.

Meter: Three scales, 0 to 3 V; 0 to 10 V; −6 to +10 dB.

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

GENERAL

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

Detector: Rms with three averaging times. Faster two speeds conform with USA standard for sound-level meters.

Power Required: Operates from 105 to 125 or 210 to 230 V, 50-60 Hz, or from nickel-cadmium battery supplied. Battery provides 25 h of operation when fully charged and requires 14 h for charging.

Accessories Supplied: Power cord, shielded cable, and detented knob and dial assembly.

Accessories Available: 1560-P6 Microphone Assembly, 1560-P52, -P53, -P54 Vibration Pickups, 1560-P40 Preamplifier (power for preamp available at input connector), 1564-P1 Dial Drive for coupling to 1521 recorder for stepped third-octave analysis.

Mounting: Flip-Tilt Case. Rack-mount version also available.

Preamplifier page 23

Dimensions (width x height x depth): Portable model, 10¼ x 8⅛ x 8 in. (260 x 210 x 205 mm); rack model, 19 x 10½ x 6 in. (485 x 270 x 155 mm).

Net Weight: Portable model, 14½ lb (7 kg); rack model, 15½ lb (7.5 kg).

Shipping Weight: Portable model, 17 lb (8 kg); rack model, 28 lb (13 kg).

Catalog Number	Description	Price in USA
	1564-A Sound and Vibration Analyzer	
1564-9701	Portable Model	**$1485.00**
1564-9820	Rack Model	**1485.00**

PATENT NOTICE. See Notes 12, 15, and 22.

new DIAL DRIVE

Type 1564-P1

Noise and vibration measurement criteria often call for "stepped" frequency analysis in which the analyzer, rather than sweeping continuously through its frequency range, dwells briefly at each specified frequency. Stepped one-third-octave analysis is widely used for noise measurements to check compliance with various criteria such as Military Standard-740B(SHIPS), ASHRAE 36A-63, and others.

The 1564-P1 synchronizes the 1564 analyzer and the 1521-B Graphic Level Recorder for producing automatic third-octave-analysis plots. This complete system is available as the 1912 Third-Octave Recording Analyzer, or the 1564-P1 can be added to existing units.

The dial drive automatically sets the analyzer to the one-third-octave center frequencies designated by USASI as Preferred Frequencies for Acoustical Measurements in Standard S1.6-1960 and in S1.11-1966.

The dwell time in each band is adjustable to permit averaging the noise level over a desired time interval and is controlled by an internal timer (set by front-panel control) or by a synchronizing signal. This signal is normally generated by the contactor attached to the graphic level recorder. Alternately, a tape loop containing a recorded signal for analysis could trigger a sensing device to generate the synchronizing signal, thus making the dwell time equal to the time for one "pass" of the tape loop.

Recording Analyzer page 39

The 1564-P1 also permits the analyzer frequency to be continuously swept for more detailed analysis of a noise.

— See **GR Experimenter** for May-June 1967.

specifications

STEPPING CHARACTERISTICS

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

Stepping Time: Stepped positions, approx 0.35 s/30°; continuous positions, 6 s/30° or 20 s/30°, both synchronized to 60-Hz line.

Dwell Time (per ⅓-octave band): Dwell time plus stepping time is 1, 3, 10 or 30 s, when controlled by 1521-B Graphic Level Recorder with medium-speed motor installed. These times can be increased by a factor of 2 or 4 with cam adjustment. Dwell time can also be controlled by front-panel knob over a range of about 1 to 60 s.

GENERAL

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

Humidity Range: 0 to 95% relative humidity.

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

Recording System: Output from 1564-A Sound and Vibration Analyzer can be connected to any recording system with an input impedance of 10 kΩ or more and a sensitivity of at least 10 mV.

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

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

Accessories Available: Chart paper for use with 1521 Graphic Level Recorders: 1521-9460 for stepped analysis and 1521-9469 for continuous analysis.

Dimensions (width x height x depth): Relay-rack section, 19 x 3½ x 12½ in. (485 x 89 x 320 mm); stepper motor, 4¼ (dia) x 5⅛ in. (110 x 135 mm); contactor assembly, 3 x 4¹⁄₁₆ x 2⅛ in. (77 x 105 x 54 mm).

Weight: Total shipping, 36 lb (16.5 kg); net, relay-rack section, 14½ lb (7 kg); stepper motor, 1½ lb (0.7 kg); contactor assembly, 8 oz (230 g).

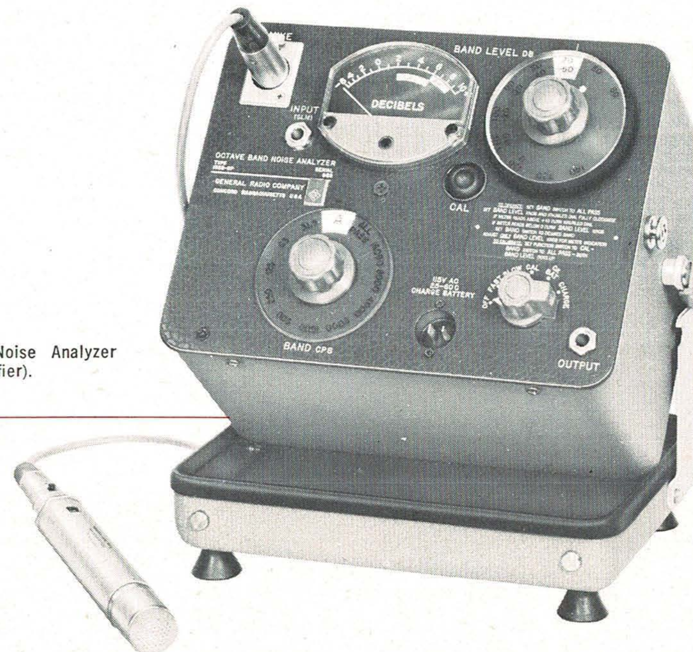
Catalog Number	Description	Price in USA
1564-9771	**1564-P1 Dial Drive,** Bench Model	**$540.00**
1564-9772	**1564-P1 Dial Drive,** Rack Model	**540.00**
1521-9460	**Chart Paper** (for stepped mode)	**2.75**
1521-9469	**Chart Paper** (for continuous mode)	**2.75**

File Courtesy of GRWiki.org

OCTAVE-BAND NOISE ANALYZER

Type 1558

- 44 to 150 dB direct from microphone to 24 dB with preamplifier
- meets USASI Standards
- A-weighting available in 1558-BP
- portable, battery-operated
- internal calibration circuit



The 1558-BP Octave-Band Noise Analyzer (with the 1560-P40K preamplifier).

The 1558 is used for the rapid analysis of broadband noises, where a knowledge of individual frequency components is not required. For the measurement of octave-band sound-pressure levels above 44 dB re 20 μN/m² the analyzer can be used directly with a piezoelectric microphone. For lower levels, it can be operated from the output of the 1560-P40 Preamplifier or a sound-level meter.

It is particularly useful for:

- Studies of environmental noise as related to hearing damage.
- Measurement of environmental noise, as in offices and factories, where speech-interference level is important.
- Measurement of aircraft, vehicle, and machinery noise.
- Production testing and noise-level acceptance tests.
- Loudness determinations.
- Acoustical studies of rooms and materials.

Two models of the octave-band noise analyzer are available. The 1558-BP has octave bands centered at USASI Preferred Frequencies (USA Standard S1.6-1960*) and includes an A-weighted filter characteristic that eliminates the need for a separate sound-level meter in some applications. It also conforms to the current American Standard Specification for Octave, Half-Octave, and Third-Octave-Band Filter Sets S1.11-1966 for Type E, Class II octave-band filters. The 1558-A has octave bands as specified by the older USASI Standard for Octave-Band Filters Z24.10-1953, as well as bandpass filters that extend the range at both ends beyond that specified in the standard.

* Also specified by ISO Recommendation 266 and German Standard DIN45-401.

Essentially, the analyzer consists of a high-impedance preamplifier, a filter, an output amplifier, and a meter. The preamplifier frequency response can be internally set to be either "flat" or C-weighted. A built-in reference allows calibration for microphones ranging in sensitivity from −52 to −62 dB re 1 volt/μbar. RC active filters are used, resulting in small size, light weight, and lack of interference from stray magnetic fields. The high input impedance and preamplification permit the use of piezoelectric microphones and vibration pickups. The analyzer is portable and powered by rechargeable nickel-cadmium batteries.

— See **GR Experimenter** for October 1962.

Accessory Microphone and Preamplifier

The 1560-P6 Microphone Assembly, recommended for use with the 1558, consists of a ceramic microphone unit attached to a short length of flexible conduit, which in turn mounts on a swivel base. The microphone assembly plugs into the MIKE input connector on the panel of the octave-band analyzer.

It has a flat response to sounds of random incidence from 20 Hz to 8 kHz. It will withstand temperatures from −40 to +60°C and relative humidity from 0 to 100%. It shows little change in sensitivity and internal impedance with temperature.

Another microphone assembly that also extends the sensitivity of the 1558 to 24 dB is the 1560-P40K Preamplifier and Microphone Set. The preamplifier also allows the microphone to be used at the end of a long extension cable without loss in sensitivity.

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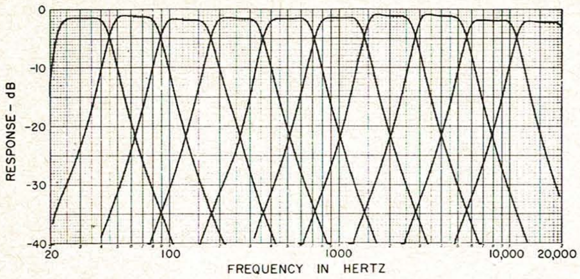
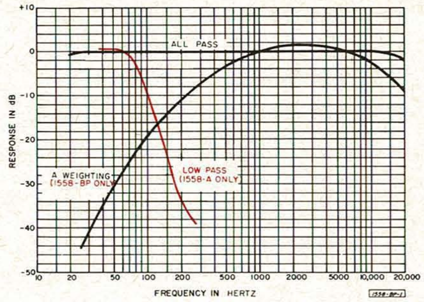


(Left) Filter characteristics of the 1558-BP. The 1558-A characteristics are similar, except that the center frequencies are different as specified in the data below. (Right) Lowpass and allpass characteristics of the 1558.



specifications for 1558-BP (1558-A similar)

Filter Characteristics (measured with signal applied at INPUT (SLM) terminals): Level at center frequency in bands from 63 to 8000 Hz is uniform ±1 dB. Max deviation from ALL PASS level at center frequency in any band is 1 dB. For bands from 63 to 8000 response at nominal cutoff frequency is (3.5 ±1) dB below response at center frequency. Attenuation is at least 30 dB at one-half the lower nominal cutoff frequency and twice the upper nominal cutoff frequency for all octave bands. Attenuation is at least 50 dB at one-fourth the lower nominal cutoff frequency and four times the upper nominal cutoff frequency for all octave bands. The 75-Hz low-pass filter in 1558-A has at least 35-dB attenuation at 200 Hz and at least 50-dB attenuation at 400 Hz.

Bands: 1558-BP, center frequencies of bands are 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000, and 16,000 Hz; also ALL PASS, and A-weighting characteristic conforming to USASI specification S1.4-1961 for sound-level meters.

1558-A, filter bands conform to USASI specification Z24.10-1953 for octave-band filters and are 18.75 to 37.5, 37.5 to 75, 75 to 150, 150 to 300, 300 to 600, 600 to 1200, 1200 to 2400, 2400 to 4800, 4800 to 9600, and 9600 to 19200 Hz; also ALL PASS, and low-pass with 75-Hz upper cutoff frequency.

Sound-Pressure-Level Range: 44 to 150 dB re 20 $\mu N/m^2$ in any band when 1560-P6 Microphone is used, 24 to 130 dB with 1560-P40K Preamplifier and Microphone Set.

Input: Impedance at MIKE terminals is approx 50 pF in parallel with 50 MΩ. It is intended for use with high-impedance transducers such as the 1560-P6 Microphone Assembly.

Impedance at INPUT (SLM) terminals, intended for connection to output of a sound-level meter, is approx 100 kΩ. Max input is 3 V.

Amplifier Frequency Characteristic: Can be set to be either C-weighting, which is specified by USASI (S1.4-1961, Sound-Level Meters), or 20 kHz, an essentially flat response.

Output: Output is at least 1 V behind 6000 Ω (panel meter at full scale). Any load can be connected across the output terminals.

Meter: Rms response and FAST and SLOW meter speeds in accordance with USASI S1.4-1961.

Internal Calibration: A built-in reference allows the gain of the analyzer to be calibrated for use with piezoelectric microphones having sensitivities from −52 to −62 dB re 1 V/μbar. The absolute accuracy for ALL PASS is then within 1 dB over a wide range of atmospheric conditions.

Batteries: An 19.2-V rechargeable nickel-cadmium battery gives 30-h operation. It is recharged from a 25- to 60-Hz power line. Full charge takes about 14 h.

Accessories Supplied: Carrying strap, power cord for charging battery, shielded cable for connection to sound-level meter.

Accessories Available: 1560-P6 Microphone Assembly. 1560-P40K Preamplifier and Microphone Set. Power is available for the 1560-P40 Preamplifier at the MIKE connector.

Preamplifier page 23

Sound-Level Meters page 12 ff

Mounting: Flip-Tilt Case. Rack-version also available.

Dimensions (width x height x depth): Portable model, 10¼ x 9¼ x 7¼ in. (260 x 235 x 185 mm); rack model, 19 x 8¾ x 5 in. (485 x 225 x 130 mm).

Net Weight: Portable model, 8¾ lb (4 kg); rack model, 9 lb (4.1 kg).

Shipping Weight: Portable model, 12 lb (5.5 kg); rack model, 22 lb (10 kg).

Catalog Number	Description	Price in USA
	Octave-Band Noise Analyzer 1558-BP, Current Standard Frequencies	
1558-9890	Portable Model	**$950.00**
1558-9848	Rack Model	**950.00**
	1558-A, Old Standard Frequencies	
1558-9701	Portable Model	**950.00**
1558-9820	Rack Model	**950.00**
1560-9606	**1560-P6 Microphone Assembly**	**110.00**
1560-9520	**1560-P40K Preamplifier and Microphone Set**	**251.00**

PATENT NOTICE. See Notes 15 and 22.

Relay-rack model is adapted from portable model.

File Courtesy of GRWiki.org

FREQUENCY-RESPONSE & SPECTRUM RECORDER ASSEMBLIES

Several GR instruments can be used with the 1521-B Graphic Level Recorder for automatic plotting of the frequency response of devices or the frequency spectrum of acoustic or electrical noise or of a complex electrical waveform. Automatic plotting with these instruments replaces tedious point-by-point manual methods and provides much more information in the form of finer-resolution curves. Listed below are several such assemblies that can be ordered under a single catalog number and include all accessories normally needed. Or the component items can be ordered individually to convert existing equipment into fully automatic recording assemblies.

Custom assemblies of GR analysis equipment and sound and vibration instruments can be built to order to meet a variety of special requirements.

— See **GR Experimenter** for Sept 1964 and Nov-Dec 1967.

RECORDING ANALYZERS

1910-A RECORDING WAVE ANALYZER

The 1910-A is particularly useful in analyzing and recording the frequency components present in mechanical vibrations, acoustic signals, and in complex electrical signals including random noise. Its linear frequency scale, 20-Hz to 54-kHz range, three bandwidths (3, 10, and 50 Hz), and 80-dB dynamic range permit higher-order, closely spaced and weak components to be found with ease.

The complete assembly includes the following:

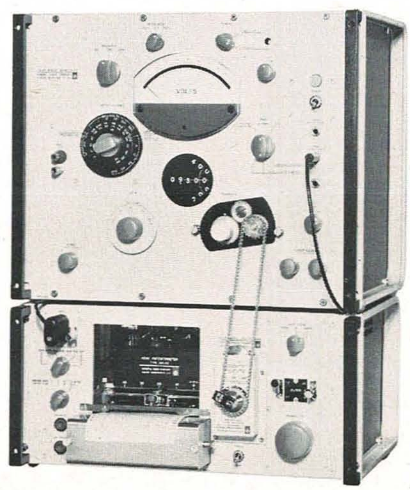
1900-A Wave Analyzer, including **1560-P95 Adaptor** cable and other accessories
1521-B (or -BQ1 for 50-Hz supply) **Graphic Level Recorder** with **40-dB Potentiometer** (1521-9602) and medium-speed motor
1521-P3 80-dB Potentiometer (1521-9603)
1521-P10B Drive Unit (1521-9467) (installed)
1900-P1 Link Unit (1900-9601) (installed)
1900-P3 Link Unit (1900-9603)
Chart Paper, 10 rolls (1521-9464), scale 0-10 kHz
Chart Paper, 10 rolls (1521-9465), scale 0-50 kHz

Accessories Available: 1560-P40H Preamplifier and Power Supply Set; choice of vibration pickups or microphones.

Mounting: Rack-Bench Cabinets; includes end frames for bench use and supports for rack mounting.

Dimensions (width x height x depth): Bench, 19 x 25¼ x 15¼ in. (485 x 645 x 390 mm); rack, 19 x 24½ x 13¼ in. (485 x 625 x 340 mm).

Weight: Net, 116 lb (53 kg); shipping, 227 lb (104 kg).



	Catalog Number	Price in USA
1910-A Recording Wave Analyzer, (for 60-Hz supply)	1910-9701	**$4345.00**
1910-AQ1 Recording Wave Analyzer, (for 50-Hz supply)	1910-9494	**on request**

PATENT NOTICE. See Notes 1, 15, and 18.

1911-A RECORDING SOUND AND VIBRATION ANALYZER

This assembly will generate continuous frequency plots of the 1/3- or 1/10-octave spectrum of sound and vibration signals over the range of 4.5 Hz to 25 kHz. Thus 1/3-octave measurements can be made in accordance with several common military and industrial noise-control specifications. While the third-octave bandwidth is convenient for testing compliance to a specification for maximum allowable noise or vibration level, the 1/10-octave bandwidth permits identification of individual frequency components, leading to their reduction or elimination. The analyzer will accept signals from a sound-level meter, vibration meter, or other stable amplifier, or directly from a microphone or vibration pickup.

The 1911-A consists of the following:

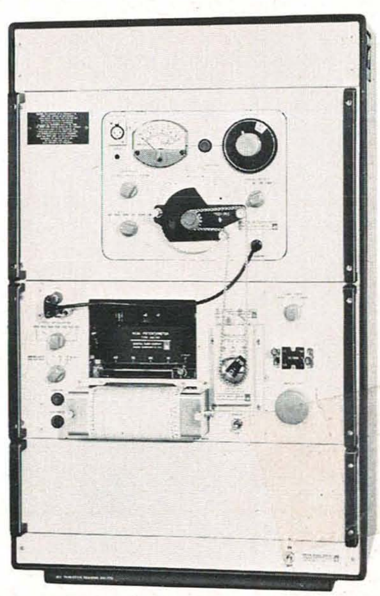
1564-A Sound and Vibration Analyzer, rack model
1521-B (or -BQ1 for 50-Hz supply) **Graphic Level Recorder** with **40-dB Potentiometer** (1521-9602) and medium-speed motor
1521-P10B Drive Unit (1521-9467)
1521-P15 Link Unit (1521-9615), with 16-tooth sprocket installed (standard 24-tooth sprocket also included)
Chart Paper, 10 rolls (1521-9469), calibrated 2.5-25 normalized, logarithmic
Adaptor Cable, double plug to offset phone plug.

Accessories Available: 1560-P40K Preamplifier and Microphone Set; 80-dB potentiometer; choice of vibration pickups.

Mounting: Completely assembled with end frames for bench use. Hardware for rack mounting is supplied.

Dimensions (width x height x depth): 19¾ x 31¼ x 15¾ in. (500 x 800 x 400 mm).

Weight: Net, 76 lb (35 kg); shipping, 155 lb (71 kg).



	Catalog Number	Price in USA
1911-A Recording Sound and Vibration Analyzer (for 60-Hz supply)	1911-9701	**$3075.00**
1911-AQ1 Recording Sound and Vibration Analyzer (for 50-Hz supply)	1911-9494	**on request**

PATENT NOTICE. See Notes 12, 15, and 22.

File Courtesy of GRWiki.org

RECORDING ANALYZERS
(cont'd)

	Catalog Number	Price in USA

1912 THIRD-OCTAVE RECORDING ANALYZER

new

The 1912 will make chart records of stepped third-octave analyses of sound and vibration as called for in such standards as Military Standard-740B(SHIPS), ASHRAE 36A-63, and others. In stepped analysis, the analyzer steps from frequency to frequency and dwells a specified time at each while the recorder chart paper feeds continuously. The result is a synchronized, calibrated plot of time-averaged levels in each third-octave band for ease of analysis.

Frequency can also be swept continuously, giving more detailed information than when stepped. See individual descriptions of 1564-A, 1564-P1, and 1521-B.

The 1912 is supplied completely assembled in a cabinet and includes a storage drawer and a system power control, which switches the analyzer battery supply as well as the ac line.

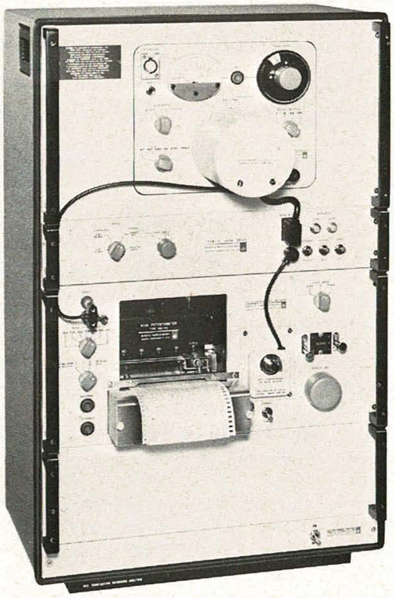
The 1912 includes the following:
- **1564-A Sound and Vibration Analyzer,** rack model
- **1564-P1 Dial Drive**
- **1521-B Graphic Level Recorder** with **40-dB Potentiometer** (1521-9602) and medium-speed motor
- **Chart Paper,** 10 rolls (1521-9460), for stepped analysis

Accessories Available: 1560-P40K Preamplifier and Microphone Set, Chart Paper 1521-9469 for continuous-mode analysis, 80-dB potentiometer, choice of GR microphones and vibration pickups for direct vibration or acoustic analysis.

Mounting: Assembled in cabinet.

Dimensions (width x height x depth): 19¾ x 31¼ x 18½ in. (500 x 800 x 470 mm).

Weight: Net, 115 lb (53 kg); shipping (est), 215 lb (100 kg).



	Catalog Number	Price in USA
1912 Third-Octave Recording Analyzer (for 115-V, 60-Hz supply)	1912-9700	**$3510.00**

1913 RECORDING WAVE ANALYZER — 1% Bandwidth

new

This constant-percentage-bandwidth recording analyzer will make high-resolution spectrum plots from 20 Hz to 20 kHz. It is easy to use, having automatic range switching and few controls. Wide dynamic range and the 80-dB potentiometer reduce the need to change sensitivity manually to accommodate widely varying amplitudes. Narrow bandwidth permits separation of closely spaced low frequencies without forfeiting high-frequency resolution; typically, the fiftieth harmonic can be identified. See description of 1568-A Wave Analyzer for more details.

The 1913 is supplied assembled and includes a storage drawer and system power control, which switches the analyzer battery supply as well as the ac line.

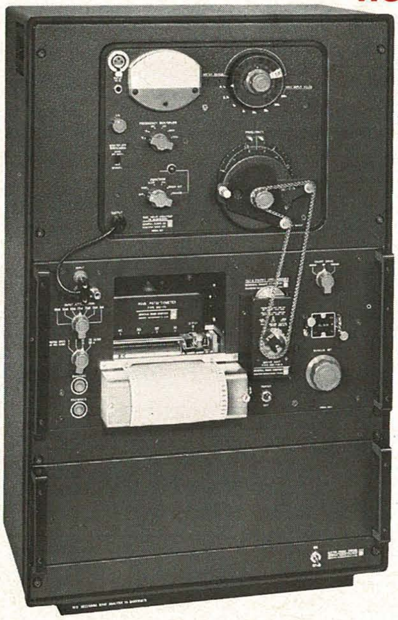
The 1913 includes the following:
- **1568-A Wave Analyzer,** rack model, and accessories
- **1521-B** (or -BQ1 for 50-Hz supply) **Graphic Level Recorder** with **40-dB Potentiometer** (1521-9602) and medium-speed motor
- **1521-P3 80-dB Potentiometer** (1521-9603)
- **1521-P10B Drive Unit** (1521-9467)
- **1521-P15 Link Unit** (1521-9615), with 16-tooth sprocket installed (standard 24-tooth sprocket also included)
- **Chart Paper,** 10 rolls (1521-9475), scale 2-20 log, normalized

Accessories Available: 1560-P40J Preamplifier and Adaptor Set.

Mounting: Assembled in cabinet.

Dimensions (width x height x depth): 19¾ x 31¼ x 15¾ in. (500 x 800 x 400 mm).

Weight: Net, 100 lb (46 kg); shipping (est), 200 lb (92 kg).



1913 Recording Wave Analyzer, 1% Bandwidth	Catalog Number	Price in USA
for 115-V, 60-Hz supply	1913-9700	**$3180.00**
for 230-V, 50-Hz supply	1913-9701	**on request**

File Courtesy of GRWiki.org

analyzers

GRAPHIC LEVEL RECORDER

Type 1521-B

- 4.5 Hz to 200 kHz
- 1-mV ac sensitivity
- linear dB plot of rms ac-voltage level
- 20-, 40-, or 80-dB range
- convenient, disposable pens

The 1521-B is a completely transistorized, single-channel, servo-type recorder. It produces a permanent, reproducible strip-chart record of ac-voltage level as a function of time or some other quantity.

Most often these are records of the frequency response of a device or the frequency spectrum of noise or of a complex electrical signal. The Graphic Level Recorder can be mechanically or electrically coupled to various GR analyzers and oscillators to synchronize the frequency scale of the chart record with the instrument's calibrated tuning-control dial. Such combinations of instruments are available factory assembled or as individual components to add to existing equipment. (See preceding pages.)

Owing to the high stability of its reference voltage and amplifier gain, the 1521 can be calibrated and used as a recorder of absolute level.

With a sound-level meter, the recorder can plot sound levels over a wide dynamic range as a function of time. The writing speed is sufficiently high for the measurement of reverberation time and other transient phenomena.

The wide range of paper speed facilitates long-period studies of the noise produced by traffic and machinery, as well as of short-duration transients.

The frequency response can be extended downward to 4.5 Hz at the slower writing speeds. Writing speeds and low-frequency cutoff are selected by a single switch.

Changes of range are easily accomplished by use of a 20-dB or an 80-dB potentiometer in place of the standard 40-dB unit. With the 80-dB unit, the maximum writing speed is 300 dB/second. The slow writing speeds filter out abrupt level variations, yielding a smoothed plot without loss of accuracy.

A linear potentiometer is available, which can be used for dc recording and is easily substituted for the logarithmic ac potentiometers.

— See **GR Experimenter** for September 1964.

specifications

Recording Range: As supplied, 40 dB full-scale; 20-dB and 80-dB ranges are also available. For dc recording, 0.8 to 1 V (0.8 to 1.0 mA) full-scale, with zero position adjustable over full scale.

Frequency Response and Writing Speed

Level Recording: High-frequency response ±2 dB to 200 kHz. Low-frequency sine-wave response depends on writing speed, as shown in following table:

Writing Speed (approx) in./s with 0.1-inch overshoot	Low-Frequency Cutoff Hz (less than 1 dB down)
20	100
10	20
3	7 (3 dB down at 4.5 Hz)
1	7 (3 dB down at 4.5 Hz)

Dc Recording: 3 dB down at 8 Hz (pk-pk amplitude less than 25% of full scale).

Potentiometer Linearity

20-, 40-, 80-dB Potentiometers: ±1% of full-scale dB value plus a frequency error of 0.5 dB at 100 kHz and 1.5 dB at 200 kHz.

Linear Potentiometer: ±1% of full scale.

Resolution ±0.25% of full scale.

Max Input Voltage: 100 V ac.

Input Attenuator: 60 dB in 10-dB steps.

Input Impedance: 10,000 Ω for ac level recording; 1000 Ω for dc recording.

Max Sensitivity: 1 mV at 0 dB for level recording; 0.8 or 1 V full-scale for dc recording.

Paper Speeds

High-speed motor (normally supplied): Paper speeds of 2.5, 7.5, 25, 75 in./min. Used for high-speed-transient measurements and with Type 1304 Beat-Frequency Audio Generator.

Medium-speed motor (supplied on request): Paper speeds of 0.5, 1.5, 5, 15 in./min. Used with analyzers and in level-vs-time plots.

Low-speed motor (supplied on request): Paper speeds of 2.5, 7.5, 25, 75 in./h. Used for level-vs-time measurements from 1 to 24 h.

External Dc Reference: An external dc reference voltage of from 0.5 to 1.5 V can be applied internally to correct for variations of up to 3 to 1 in the signal source of the system under test.

Detector Response: Rms within 0.25 dB for multiple sine waves, square waves, or noise. Detector operating level is 1 V.

Chart Paper: 4-inch recording width on 5-inch paper. All rolls are 100 feet long. See full list of charts below.

Accessories Supplied: 40-dB potentiometer, 12 disposable pens with assorted ink colors, 1 roll of 1521-9428 chart paper, power cord, spare fuses, 1560-P95 Adaptor Cable (phone to double plug).

Accessories Available: Potentiometers, chart paper, pens, high-, medium-, and low-speed motors, drive and link units.

Power Required: 105 to 125 or 210 to 250 V, 50 or 60 Hz, 35 W.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench model, 19 x 9 x 13½ in. (485 x 230 x 345 mm); rack model, 19 x 8¾ x 11¼ in. (485 x 225 x 290 mm).

Weight: Net, 50 lb (23 kg); shipping, 62 lb (29 kg).

Catalog Number	Description	Price in USA
	Graphic Level Recorder	
1521-9812	**1521-B**, Rack Model (for 60-Hz supply)	**$1250.00**
1521-9802	**1521-B**, Bench Model (for 60-Hz supply)	**1250.00**
1521-9507	**1521-BQ1**, Rack Model (for 50-Hz supply)	**on request**
1521-9506	**1521-BQ1**, Bench Model (for 50-Hz supply)	**on request**

PATENT NOTICE. See Notes 1 and 18.

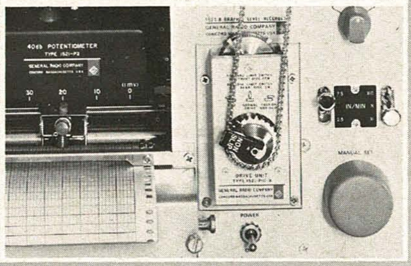
File Courtesy of GRWiki.org

Graphic Level Recorder Accessories

DRIVE AND LINK UNITS FOR COUPLING TO GENERATOR AND ANALYZERS

1521-P10B Drive Unit

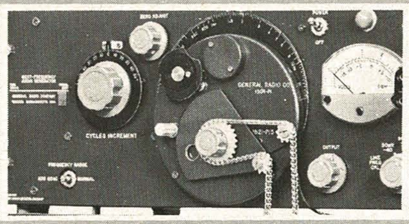
Provides mechanical-drive output from 1521-B to operate any link unit.



Catalog Number	Price in USA
1521-9467	$80.00

1521-P15 Link Unit

For mechanical coupling to 1304-B oscillator or to 1564 or 1568 analyzers. Fitted with 24-tooth sprocket. Includes chain.



Catalog Number	Price in USA
1521-9615	30.00

1521-P16 Sprocket Kit,

contains 5 sizes of interchangeable sprockets for 1521-P15: 40, 36, 32, 20, and 16 teeth. Provides choice of scale factor in proportion to that with normal 24-tooth sprocket. Includes chain.

INDUSTRY SCALE FACTORS

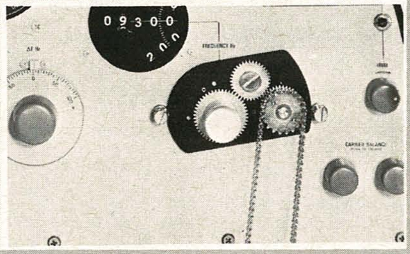
Industry Standard	Scale Factor (dB/decade)	Decade Length (inches) for Type 1304 Generator	Sprocket (teeth)	Pot (dB)
Institute of High Fidelity Manufacturers	20	2.0	16	40
Proposed International Standard	25	2.5	20	40
Electronic Industries Association	30	3.0*	24	40
Institute of High Fidelity Manufacturers	20	4.0	32	20
Hearing Aid Industry	45	4.5	36	40
Proposed International Standard	50	5.0	40	40
Proposed International Standard	50	5.0**	16	40

* Chart paper available for Type 1304-B Beat-Frequency Audio Generator.
** Decade length applies to Type 1564-A Sound and Vibration Analyzer; chart paper available.

Catalog Number	Price in USA
1521-9616	20.00

1900-P1 Link Unit

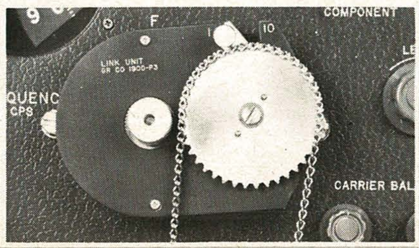
For coupling to 1900-A Wave Analyzer. Use with chart paper 1521-9464 for scale of 10 kHz per 20 in. and with 1521-9465 for scale of 50 kHz per 10 in. Chain included.



Catalog Number	Price in USA
1900-9601	40.00

1900-P3 Link Unit

For coupling to 1900-A Wave Analyzer. Use with chart paper 1521-9464 for scale factors of 10 kHz per 20 in. or expanded 1 kHz per 20 in.



new

Catalog Number	Price in USA
1900-9603	75.00

File Courtesy of GRWiki.org

Graphic Level Recorder Accessories (cont'd)

		Catalog Number	Price in USA
1564-P1 Dial Drive Electromechanical coupler between 1521-B recorder and 1564-A Sound and Vibration Analyzer. Generates chart records of "stepped" one-third octave analysis. Keeps synchronism between continuous chart-paper feed and stepped analyzer motion, i.e., where 1564 dwells for selected interval at each third-octave center frequency. Also provides for continuous swept-frequency analysis. Uses chart paper 1521-9460 for stepped mode, 1521-9469 for continuous analysis. See page 35 for full details on 1564-P1.	Bench Model	1564-9771	**$540.00**
	Rack Model	1564-9772	**540.00**

CHART PAPERS

Associated Instrument	Calibration: Horizontal	Calibration: Vertical (Div)	Chart Length (in.): Cal.	Chart Length (in.): Blank	Catalog Number	Price in USA
1304-B Generator with **1521-P15 Link Unit**	20 Hz-20 kHz, log	80	9	4½	1521-9427	**2.75**
1900-A Analyzer with **1900-P1** or **1900-P3 Link Units**	0-1 or 0-10 kHz, linear	40	20	0	1521-9464	**2.75**
1900-A Analyzer with **1900-P1 Link Unit**	0-50 kHz, linear	40	16	0	1521-9465	**2.75**
1564-A Analyzer with **1521-P15 Link Unit** and 24-tooth sprocket	2.5-25 normalized, log	40	7½	1½	1521-9493	**2.75**
1564-A Analyzer with **1521-P15 Link Unit** and 16-tooth sprocket or with **1564-P1 Dial Drive** (continuous mode)	2.5-25 normalized, log	40	5	1	1521-9469	**2.75**
1564-A Analyzer with **1564-P1 Dial Drive** (stepped mode)	Third-octave bands 3.15 Hz-25 kHz	40	10	0	1521-9460	**2.75**
1568-A Analyzer with **1521-P15 Link Unit**	2-20 normalized, log	40	10	2	1521-9475	**2.75**
1554-A Analyzer	2.5 Hz-25 kHz, log	40	18	3	1521-9463	**2.75**
760-B Analyzer	25-7500 Hz, log	40	12½	1	1521-9429	**2.75**
General use	Continuous ¼-in. div	40	Continuous		1521-9428	**2.75**
1136-A D/A Converter	Continuous ⅝-in. div	50	Continuous		1521-9466	**3.25**

POTENTIOMETERS

*Normally supplied with the recorder

	Catalog Number	Price in USA
1521-P1 20-dB Potentiometer	1521-9601	**60.00**
1521-P2 40-dB Potentiometer*	1521-9602	**85.00**
1521-P3 80-dB Potentiometer	1521-9603	**155.00**
1521-P4 Linear Potentiometer (for dc)	1521-9604	**60.00**

OPTIONAL MOTORS **

			Chart Speeds	Catalog Number	Price in USA
High-Speed Motors	Used for high-speed-transient measurements and with **1304 Beat-Frequency Audio Generator.** Not for use with 1900-A, 1564-A, and 1568 analyzers, 1564-A, and 1568 analyzers.	**1521-P19** (for 60-Hz supply) normally supplied in recorder**)	2.5-75 in./min	1521-9619	**65.00**
		1521-P21B (for 50-Hz supply)	2.5-75 in./min	1521-9921	**on request**
Medium-Speed Motors	Used with analyzers and in level-vs-time plots.	**1521-P23** (for 60-Hz supply)	0.5-15 in./min	1521-9623	**65.00**
		1521-P24 (for 50-Hz supply)	0.5-15 in./min	1521-9624	**on request**
Low-Speed Motors	Used for level-vs-time measurements 1-24 hours.	**1521-P20B** (for 60-Hz supply)	2.5-75 in./h	1521-9513	**72.00**
		1521-P22 (for 50-Hz supply)	2.5-75 in./h	1521-9622	**on request**

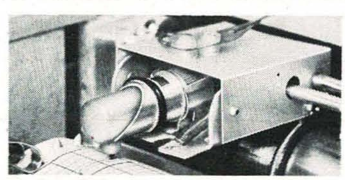
** Recorder can be supplied with low- or medium-speed motor installed, at same price as with standard motor.

fastrak PEN SETS AND CONVERSION KIT

The pen used in the 1521-B recorder combines ink reservoir and writing point in a single disposable unit, eliminates refilling. Each cartridge has about twice the life of one old-style pen refill and can outlast three rolls of chart paper. The pen consists of a sealed plastic cartridge with a fiber plastic point that requires only about 2 grams of force to operate properly.

The pens are available with red, green, and blue ink and are supplied in sets of twelve pens. A set of assorted colors is included with the recorder and with the conversion kit.

For converting older 1521-A and 1521-B recorders to use the improved pen, a kit is available that contains a pen holder, set of 12 assorted-color pens, and conversion instructions.



new

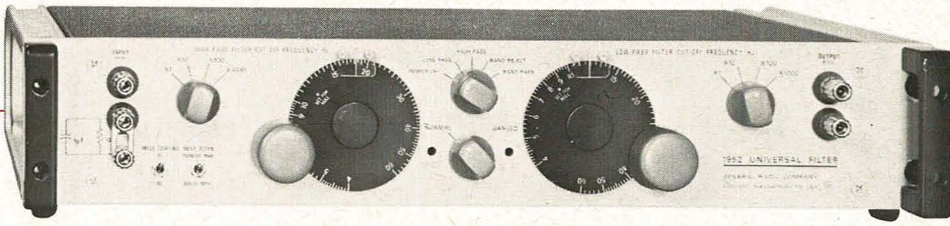
	Catalog Number	Price in USA
fastrak Marker Set, Red	1521-9446	**15.00**
fastrak Marker Set, Green	1521-9447	**15.00**
fastrak Marker Set, Blue	1521-9448	**15.00**
fastrak Marker Set, Assorted Colors	1521-9449	**15.00**
fastrak Recorder Marker Conversion Kit	1521-9439	**25.00**

File Courtesy of GRWiki.org

UNIVERSAL FILTER

Type 1952

- 4-Hz to 60-kHz tuning
- low-pass or high-pass, band-pass or band-reject, ganged for easy tuning
- high attenuation rate — 30 db/octave
- line or battery operation



new

The 1952 Universal Filter will perform as a low-pass, high-pass, band-pass, or band-reject filter at the turn of a panel switch. It consists of a low-pass and a high-pass filter that can be employed singly, in cascade, or in parallel, to provide the assortment of over-all characteristics. The cut-off frequencies of the two filters can be controlled independently or ganged together to provide constant-percentage bandwidth for band-pass or band-reject tuning.

This filter is of value in many signal-conditioning applications. For example, it can be used to control system bandwidth for reduction of extraneous signals or to evaluate the effect of limited bandwidth upon signal intelligibility and data-transmission accuracy. As a high-pass filter it can reduce power-line-related components, as a low-pass filter control high-frequency noise, or as a notch filter eliminate single-frequency components. The 1952 can also act as part of a spectrum analyzer or distortion meter and, with a random-noise generator, produce controlled bands of noise as test signals. It is recommended as an accessory for the GR 1142 Frequency Meter and Discriminator and the 1561-R Precision Sound-Level Meter.

Noise Generators page 229

specifications

FREQUENCY RANGE

Cut-off Frequencies: Adjustable 4 Hz to 60 kHz in four ranges.

Pass-Band Limits: Low-frequency response to dc (approx 0.7 Hz with ac input coupling) in LOW PASS and BAND REJECT modes. High-frequency response uniform ±0.2 dB to 300 kHz in HIGH PASS and BAND REJECT modes.

Controls: Log frequency-dial calibration; accuracy ±2% of cut-off frequency (at 3-dB points).

FILTERS

Filter Characteristics: Filters are fourth-order (four-pole) Chebyshev approximations to ideal magnitude response. The nominal pass-band ripple is ±0.1 dB (±0.2 dB max); nominal attenuation at the calibrated cut-off frequency is 3 dB; initial attenuation rate is 30 dB per octave. Attenuation at twice or at one-half the selected frequency, as applicable, is at least 30 dB.

Tuning Modes: Switch selected, LOW PASS, HIGH PASS, BAND PASS, and BAND REJECT.

Ganged Tuning: The two frequency controls can be ganged in BAND PASS and BAND REJECT modes so the ratio of upper to lower cut-off frequencies remains constant as controls are adjusted. Range overlap is sufficient to permit tuning through successive ranges without the need to reset frequency controls if ratio of upper to lower cut-off frequencies is 1.5 or less.

Minimum Bandwidth: 25% (approx ⅓ octave) in BAND PASS mode.

Null Tuning: In BAND REJECT mode, setting the frequency controls for a critical ratio of upper to lower cut-off frequency (indicated on dials) gives a null characteristic (point of infinite attenuation) that can be tuned from 5 Hz to 50 kHz.

INPUT

Gain: 0 or −20 dB, switch selected. Accuracy of gain is ±1 dB, of 20-dB attenuator is ±0.2 dB.

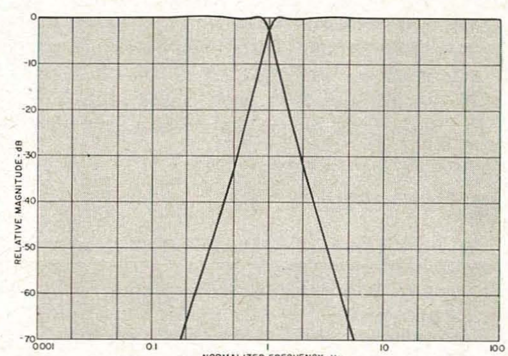
Impedance: 100 kΩ.

Coupling: Ac or dc, switch selected. Lower cut-off frequency (3 dB down) for ac coupling is about 0.7 Hz.

Max Voltage: Max sine-wave input is 3 V rms (8.4 V pk-pk) or 30 V rms with input attenuator at 20 dB. Max peak input voltage for dc coupling is ±4.2 V. For ac coupling max peak level of ac component must not exceed ±4.2 V and dc component must not exceed 100 V. Input can tolerate peak voltages of ±100 V without damage. An LC filter at input limits bandwidth to 300 kHz, thus reducing danger of overloading active circuits at frequencies above normal operating range.

GENERAL

Output: 600-Ω impedance. Any load can be connected without affecting linear operation of output circuit. Temperature coefficient of output offset voltage is between 0 and +4 mV/°C.



Low-pass and high-pass filter characteristics.

Noise: <100 µV in an effective bandwidth of 50 kHz.

Distortion: Max harmonic distortion, with all components in the pass band, for a linear load, is less than 0.25% for open-circuit voltages up to 3 V and frequencies up to 50 kHz.

Power Required: 100 to 125 or 200 to 250 V (switch selected), 50 to 60 Hz, 2.5 W. Or 19.2 V, approx 20 mA from rechargeable nickel-cadmium batteries (not supplied), about 10-h operation. Connections for external battery.

Accessories Supplied: Power cord, spare fuses, bench- or rack-mount hardware.

Accessories Available: Rechargeable batteries (two required) and 1560-P60 Battery Charger.

Dimensions (width x height x depth): Bench, 19 x 3⅞ x 15 in. (485 x 99 x 385 mm); rack, 19 x 3½ x 11¾ in. (485 x 89 x 300 mm); charger, 4¼ x 3¾ x 8 in. (110 x 96 x 205 mm).

Weight: Net, 20½ lb (9.5 kg); shipping, 25 lb (11.5 kg).

Catalog Number	Description	Price in USA
	1952 Universal Filter	
1952-9801	Bench Model	**$950.00**
1952-9811	Rack Model	**950.00**
8410-1040	**Rechargeable Battery** (2 req'd)	**12.00**
	1560-P60 Battery Charger	
1560-9660	115 volts	**95.00**
1560-9661	230 volts	**on request**

File Courtesy of GRWiki.org

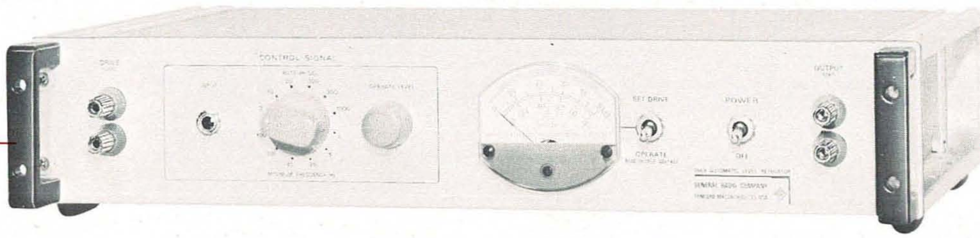
analyzers

AUTOMATIC LEVEL REGULATOR

Type 1569

- 2 Hz to 100 kHz
- 50-dB control range
- acoustic-system accessory

new



The 1569 Automatic Level Regulator is intended as an accessory for an oscillator or for a source of narrow-band noise. Its primary function is to control the signal level in swept-frequency sound and vibration tests.

The regulator senses a control voltage from a microphone, accelerometer, or other transducer monitoring the sound or vibration to be controlled and adjusts its output to maintain constant level (see diagram). Output level is indicated by a panel meter with a linear-dB scale, showing the operator where in its 50-dB control range the regulator is operating. Regulation is such that a level variation (without the regulator) of 25 dB, for instance, is compressed to a variation of 1 dB. The control rate is adjustable by means of a panel control to suit the

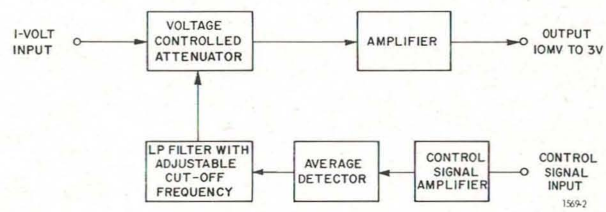


Diagram of 1569 Automatic Level Regulator

operating frequency and magnitude-phase conditions in the control loop.

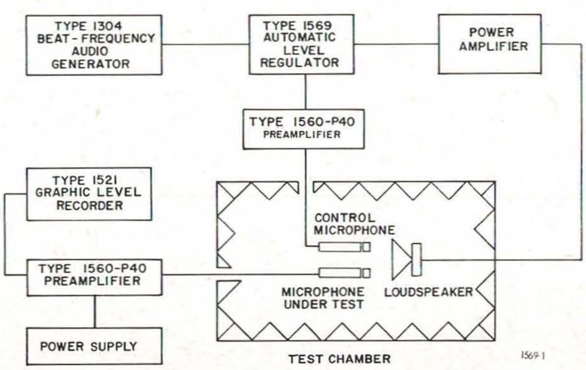
The 1569 can also be used to regulate voltage from an oscillator or other signal source. In this mode, the control range is limited to 15 dB.

specifications

Frequency Range: 2 Hz to 100 kHz.
Control Range: 50 dB.
Compression Ratio: 25 (0.04 dB per dB).

DRIVE (INPUT)
Voltage Required (for normal operation): 1 V.
Impedance: 100 kΩ.

OUTPUT
Voltage: 3 V max to 10 mV min.
Impedance: 600 Ω. Any load impedance can be connected without affecting linear operation of output circuit.



Typical Measurement System Using 1569

Preamplifier
page 23

Noise: Typically better than 65 dB below 3 V in 100-kHz band.
Harmonic Distortion: <1% total for <1-V output level.
Automatic "Shut-Down": A loss of drive (input) voltage from signal source causes the output voltage to drop to zero to protect equipment connected to output.

CONTROL-SIGNAL INPUT
Voltage: 5 mV to 4 V required.
Impedance: 25 MΩ.

Control Rates and Corresponding Min Operating Frequencies:

1000 dB/s	300 dB/s	100 dB/s	30 dB/s	10 dB/s	3 dB/s
600 Hz	200 Hz	60 Hz	20 Hz	6 Hz	2 Hz

Power Required: 100 to 125 or 200 to 250 V (switch selected), 50 to 60 Hz, 4 W.
Accessories Supplied: Power cord, spare fuses, bench- or rack-mount hardware.
Accessories Available: GR 1560-P40 Preamplifier (power for preamplifier available at rear-panel input connector); 1304 Beat-Frequency Audio Generator, 1521 Graphic Level Recorder; microphones and vibration pickups.
Mounting: Rack-Bench Cabinet.
Dimensions (width x height x depth): Bench model, 19 x 3⅞ x 13 in. (485 x 99 x 330 mm); rack model, 19 x 3½ x 10½ in. (485 x 89 x 275 mm).
Weight: Net, 13 lb (6 kg); shipping, 30 lb (14 kg).

Catalog Number	Description	Price in USA
	1569 Automatic Level Regulator	
1569-9700	Bench Model	**$485.00**
1569-9701	Rack Model	**485.00**

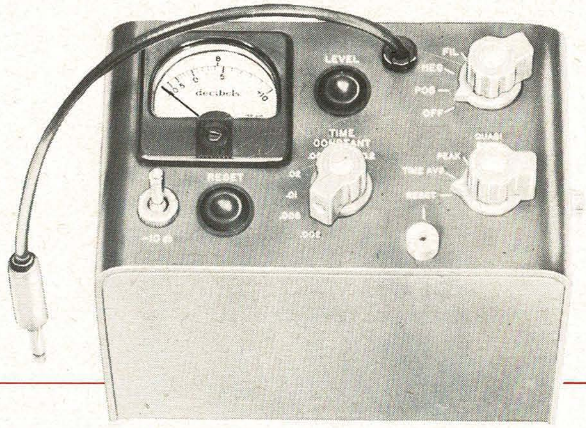
File Courtesy of GRWiki.org

IMPACT-NOISE ANALYZER

Type 1556-B

- measures electrical and acoustical noise peaks
- stores transient peak and time-average values
- 50-μs rise-time response

The 1556-B Impact-Noise Analyzer attaches to the 1551-C Sound-Level Meter as shown here.



This device evaluates the characteristics of impact-type sounds and electrical noise impulses, which cannot be satisfactorily measured with conventional noise-meters.

Impact Noises include those produced by punch presses, forging hammers, fire alarms, pile drivers, office machinery, and similar equipment. From the standpoint of hearing damage, some of these sounds constitute a serious problem for industry. They have hitherto been measurable only by complicated methods employing oscilloscopes.

The two characteristics of impact sounds that seem most significant are the peak amplitude and the duration, or decay time. This analyzer measures the:

- **peak value,** the maximum level reached by the noise,
- **"quasi-peak",** a continuously indicating measure of the high levels reached just before the time of indication, and
- **time-average,** a measure of the average level over a predetermined period of time, which, when subtracted from peak level, is a measure of the duration of the impact.

For these applications, the 1556-B operates from the output of a 1551, 1561, or 1565-A Sound-Level Meter or 1558 Octave-Band Noise Analyzer and, when a vibration pickup is used in place of the microphone, will measure vibration impacts. It will also operate from tape recorders, and vibration meters.

Sound-Level Meters page 12 ff

1558 Analyzer page 36

Electrical Noise Peaks in a wire communication circuit can be measured with this instrument as one of the tests to determine the adequacy of the circuit for transmitting data pulses. In such measurements, many peaks may be measured in a short time, and, after each peak, the stored signal must be erased before the next pulse occurs. To facilitate this a RESET pushbutton is provided, which can also be operated by an ordinary camera cable release.

Circuit. A battery-operated, degenerative, transistor amplifier simultaneously drives three ac voltmeter circuits, which comprise rectifiers, storage capacitors, and a dc electronic voltmeter. The electrical storage system (a capacitor charged by a rectifier) makes it possible to measure three characteristics of an impulse — peak, quasi-peak, and time-average — with a single meter.

specifications

Input: Any voltage from 1 to 10 V for normal range. Inputs below 1 V reduce the range of reading.

Input Impedance: Between 25,000 and 100,000 Ω, depending on the setting of the LEVEL control.

Frequency Range: 5 Hz to 20 kHz.

Level Indication: Meter calibrated in dB from −10 to +10. Attenuator switch increases range by 10 dB.

Peak Reading: Rise time is less than 50 μs for a value within 1 dB of peak value (for rectangular pulses). Storage time at normal room temperature is greater than 10 s for a 1-dB change in value.

Quasi-Peak Reading: Rise time of less than ¼ ms and decay time of 600 ±120 ms for rectifier circuit.

Time-Average Reading: Charge time of rectifier circuit selected by seven-position switch, having times of 0.002, 0.005, 0.01, 0.02, 0.05, 0.1, and 0.2 s for the resistance-capacitance time constant. Storage time at normal room temperature is greater than 1 min for a 1-dB change in value.

Input Terminals: Cord with phone plug at one end.

Accessory Required: A sound-level meter, analyzer, or other calibrated amplifier to supply 1556 input.

Batteries: One 1½-V size-D flashlight cell and one 45-V battery are supplied. Typical battery life is 100 hours.

Mounting: Aluminum cabinet; leather carrying case supplied. Cabinet can be fastened directly to one end of a 1551 Sound-Level Meter.

Dimensions (width x height x depth): 7½ x 6½ x 4½ in. (190 x 170 x 110 mm).

Weight: Net, 4½ lb (2.1 kg); shipping, 12 lb (5.5 kg).

Catalog Number	Description	Price in USA
1556-9702	**1556-B Impact-Noise Analyzer**	**$285.00**

File Courtesy of GRWiki.org

SAMPLING RECORDER

Type 1520-A

- fast transient response — no waveform distortion
- quantized record — 3-kHz sampling rate
- no moving pen — 101 fixed styli
- prints coordinates, voltage range, time scale
- resolution 1% of full scale
- two calibrated input channels, each with nine linear and two log ranges
- uses inexpensive electro-sensitive paper

This unique recorder can be used for most of the purposes for which a moving-pen or moving-mirror recorder is used. For the recording of transients, it is usually superior to those types. There is no amplitude or phase distortion of high-speed transients. The practical response limitation is imposed, not by frequency, but by the sampling rate and the paper speed. An input waveform can be satisfactorily reproduced if 3000 samples per second will yield sufficient information and if a chart speed of 10 inches per second will yield sufficient horizontal resolution.

DESCRIPTION

The sampling recorder operates on principles entirely different from those of the well-known moving-coil or moving-mirror devices. Instead of a moving pen, it has 101 fixed styli, spaced at equal intervals along the vertical scale of the chart paper.

The input voltage is measured 3000 times per second. The stylus corresponding to the level of each measured voltage is energized, and a point is plotted. There are 100 discrete levels, each corresponding to one stylus position. The quantization is accomplished by means of an amplitude comparator and a voltage ramp — a linear ramp for linear scales, an exponential ramp for logarithmic scales. A complete scan-print cycle takes about 150 μs for each channel, or about 300 μs for both. The sampling time is thus about 300 μs, corresponding to a 3-kHz sampling rate for each channel, with the two channels sampled alternately. With the same input applied to both channels in parallel, the sampling rate is doubled.

Since the voltage-level information in the input signal is converted into the timing of a pulse, the only frequency limitations are those set by paper speed and sampling rate.

For the recording of sine waves and other simple periodic waveforms, paper speed is the limiting factor, since it determines the horizontal resolution. At maximum speed (10 inches/second), one cycle of a 50-Hz sine wave occupies 1/5 inch on the horizontal scale. On the other hand, a single step function or fast-rising pulse, which, in conventional recorders, is modified by the frequency response of the recorder, is accurately reproduced by the 1520 with no alteration of the waveshape. As can be seen from the sample charts shown here, the record consists of a series of dots. It is the spacing of individual

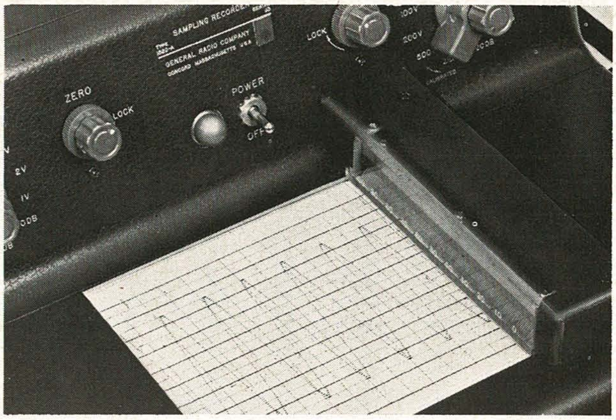
File Courtesy of GRWiki.org

dots that determines the vertical resolution. A vertical rise time as short as 300 μs can be accurately determined from the chart, since at least two dots will be printed during the rise. There can be no amplitude or phase distortion of high-speed transients — no lagging response, overshoot, ringing, or other common distortions introduced by a moving-coil system. There is no amplitude "shrinkage" with increasing frequency ("velocity saturation") or roll off, and the full width of the chart paper can always be used, if desired.

The charts illustrate the differences in response between the sampling recorder and the moving-pen type on a composite pulse.

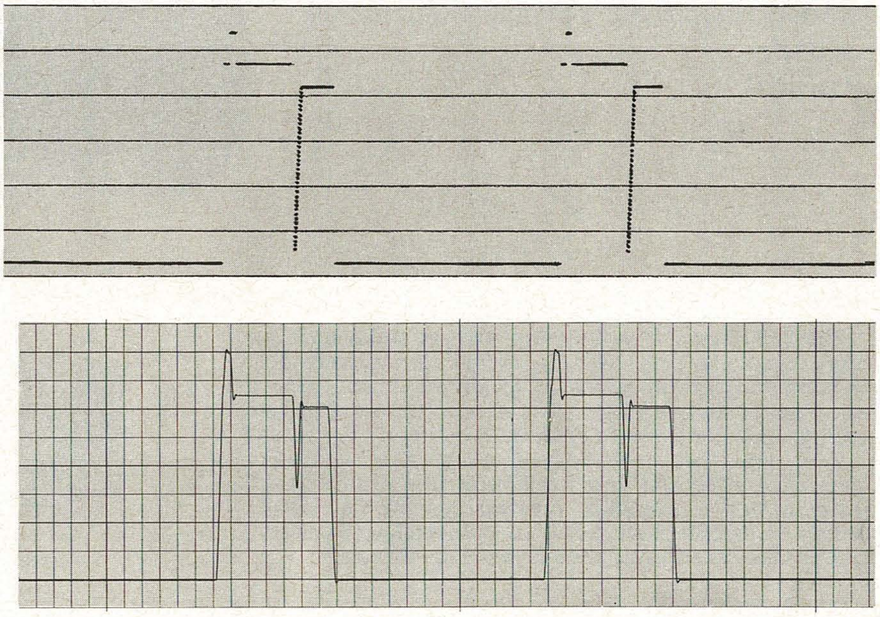
The recorder prints its own coordinates simultaneously with the recording of the input signals. These consist of 11 dark and 10 lighter horizontal lines marking intervals of 10% and 5% of full scale, which can easily be read to the nearest percent of full scale. Vertical lines are printed every half inch or every centimeter of paper motion, depending upon the setting of the paper drive clutch. This system for printing graph paper during recording gives the following advantages:

a) Only one type of paper must be stocked for all recording uses — a plain, inexpensive paper.



Close-up view of the 101-styli enclosed in a transparent plastic housing.

b) Any dimensional changes of the paper with age or humidity have no effect whatever on accuracy of recording, since the graph paper is printed by the same styli that print the recorded variable.



Recording of a composite pulse as plotted on (above, right) the Type 1520-A Sampling Recorder and (below, right) a fast pen-type recorder. Note that the pen recorder cannot follow the rapid step changes and shows overshoot, while the sampling recorder shows neither of these defects. The composite pulse consists of a 0.1-second pulse, with a 10-millisecond pulse superposed 10 milliseconds after the leading edge (pulses have 20-nanosecond rise and fall times), followed immediately by a 0.05-second pulse with a 20-millisecond linear rise and 20-nanosecond fall time.

specifications

Number of Input Channels: 2.

Number of Styli: 101 over 5-in. recording, 117 total.

Calibrated Voltage Ranges: 1 V to 500 V full scale, in 1, 2, 5 steps for each channel.

Uncalibrated Voltage Ranges: Any value from 0.3 V to 350 V full scale, for each channel.

Event Marking: External contact closure or dc voltage actuates one stylus along the lower chart-paper margin to mark the chart in accordance with an external event or condition related to the other signals being recorded.

Logarithmic Ranges: 20 dB and 50 dB full scale, for each channel.

Resolution: 1% of full scale.

Over-all Accuracy: ±1%.

Sampling Rate: Approx 3 kHz for each channel; 6 kHz if both channels are in parallel.

Time Scales: 10 min, 1 min, 10 s, 1 s, or 0.1 s per centimeter or per inch.

Scale Factors: Full-scale voltage setting and values of time scale are automatically printed along the upper and lower margins of the paper.

Chart Width: 5-in. recording on 6-in. paper.

Paper Type: Electric-writing paper.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 or 60 Hz, 300 W.

Accessories Supplied: Power cord, spare fuses, one roll chart paper, and hardware for rack mount.

Dimensions (width x height x depth): Bench, 21 x 9⅛ x 22 in. (540 x 235 x 560 mm); rack, 19 x 8¾ x 11 in. (behind panel), (485 x 225 x 280 mm), 11-in. (280-mm) projection in front of panel.

Weight: Net, 45 lb (20.5 kg) approx.

Catalog Number	Description	Price in USA
1520-9701	**1520-A Sampling Recorder,** for 60-Hz supply	**$3650.00**
1520-9494	**1520-AQ1 Sampling Recorder,** for 50-Hz supply	**on request**
1520-9301	**Chart Paper,** 200-foot roll	**6.00**

File Courtesy of GRWiki.org

ATTENUATORS

Calibrated attenuators and voltage dividers are basic instruments for the measurement of voltage ratios, linearity, circuit gain or loss, transmission efficiency, and for the calibration of meters, adjustable attenuators, and other devices.

Described in this section are resistive decade attenuators calibrated in decibels, precise voltage dividers, and a precision decade transformer with exceptional linearity that can be calibrated by the National Bureau of Standards and used as the standard in calibrating other attenuators and dividers.

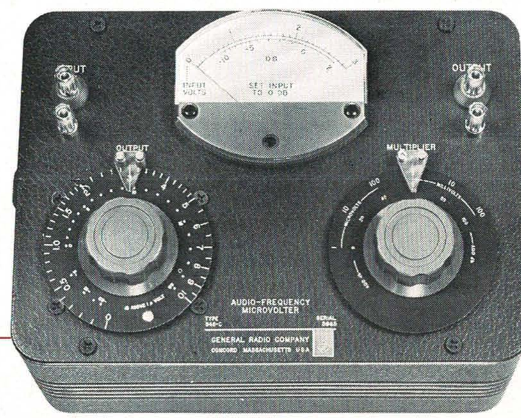
The audio-frequency Microvolter* is a metered, calibrated attenuator that can be used with an audio oscillator to standardize low output voltages.

*Trademark registered in USA.

AUDIO-FREQUENCY MICROVOLTER*

Type 546-C

- use with audio oscillator to calibrate output voltage
- dc to 100 kHz
- 0.5 μV to 1.0 V



The 546-C used in conjunction with an oscillator is a useful source of small, known, audio-frequency voltages for response measurements of amplifiers, transformers, and other audio equipment. The Microvolter can also be used to measure small voltages by substitution methods.

This instrument essentially consists of a constant-impedance attenuator and a voltmeter that standardizes the input to the attenuator. A switch controls the output voltage in decade steps, while an individually calibrated dial provides continuous control over each decade.

Oscillators page 198 ff

The Microvolter with the Type 1310-A Oscillator.

specifications

Output-Voltage Range: From 0.5 μV to 1.0 V open circuit, when the input voltage is set to the reference value (2.2 V).

Accuracy: Open-circuit output voltage, ±(3% + 0.5 μV) for output settings above 1 μV and for frequencies between 20 and 20,000 Hz. For frequencies up to 100 kHz, ±5% for output settings above 100 μV. These specifications apply only where waveform and temperature errors are negligible and when lowest possible multiplier is used.

Ratios of output voltage at a given frequency, ±(2% + 0.5 μV) up to 100 kHz. Above 20 kHz this accuracy applies only at levels above 100 μV.

The Microvolter can be used on dc with an external dc meter. Internal meter can be calibrated for dc.

Output Impedance: Approx 600 Ω, constant with setting within ±5%. No correction of the output voltage is necessary for load impedances of the order of 100,000 Ω and greater.

Input Impedance: Approx 600 Ω, substantially independent of output setting on all but the highest multiplier position.

Waveform Error: When this instrument is used as a calibrated attenuator or voltage divider, accuracy is independent of waveform. Absolute accuracy of output-voltage calibration depends on the characteristics of the input copper-oxide rectifier voltmeter, which has a small waveform error that can usually be neglected when the Microvolter is used with ordinary laboratory oscillators. The rectifier-type voltmeter introduces some distortion unless source impedance is very low. With a 600-Ω source, distortion introduced is about 0.2%.

Temperature Error: Ratios are independent of temperature. Absolute accuracy is affected slightly by temperature because of change in the voltmeter characteristics. Correction for temperatures from 65 to 95°F is furnished. The effects of humidity are negligible.

Input Requirements: 2.2 V across 600 Ω, or 8 mW.

Mounting: Lab-Bench Cabinet.

Dimensions (width x height x depth): 10 x 7¼ x 6¼ in. (255 x 185 x 160 mm).

Weight: Net, 6½ lb (3 kg); shipping, 13 lb (6 kg).

Catalog Number	Description	Price in USA
0546-9703	**546-C Audio-Frequency Microvolter***	**$250.00**

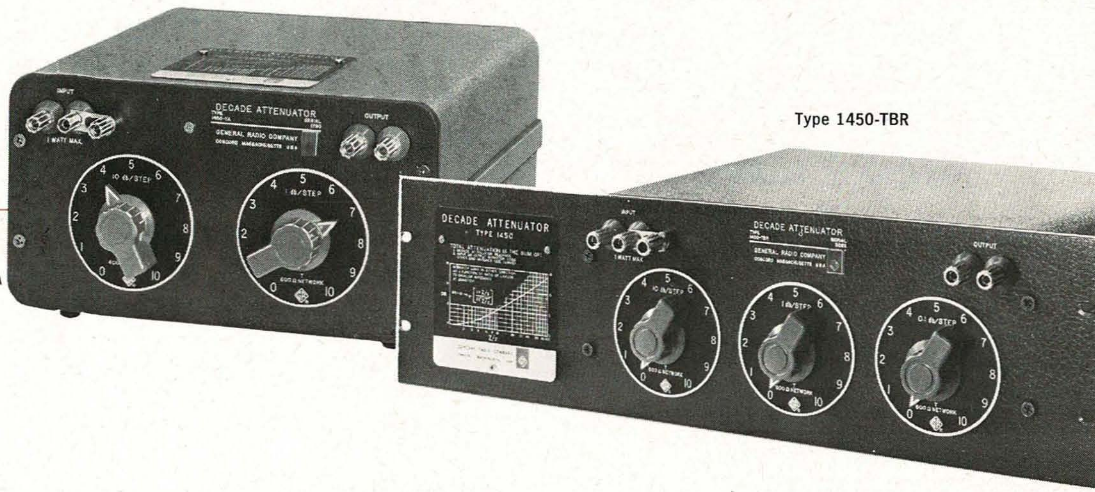
PATENT NOTICE. See Note 15. *Trademark registered in USA.

File Courtesy of GRWiki.org

DECADE ATTENUATOR

Type 1450

- 0-110 dB in 1.0- or 0.1-dB steps
- 600-ohm input and output impedance
- accuracy: ±0.02 dB ±0.25%
- usable to 1 MHz



Type 1450-TA

Type 1450-TBR

The 1450 Decade Attenuator provides accurate steps of attenuation for power-level measurements, transmission-efficiency tests, and gain or loss measurements on transistors, filters, amplifiers, and similar equipment. It can also be used as a power-level control in circuits not equipped with other volume controls.

Each decade consists of four individually shielded, series-connected, T-pads. The switches have eleven positions, 0 to 10 inclusive, so the decades overlap. There are no stops on the 0.1- and 1-dB-per-step decades, so that quick return from full to zero attenuation is facilitated.

specifications

Attenuation Range: 110 or 111 dB in steps of 1 or 0.1 dB, respectively.

Terminal Impedance: 600 Ω in either direction. An etched plate indicates the mismatch loss for other than 600-Ω circuits.

Accuracy: Each individual resistor is adjusted within ±0.25% of its correct value. The low-frequency error in attenuation is less than ±0.02 dB ±0.25% of indicated dB setting plus a switch-resistance error of 0.003 dB (for -TA) or 0.005 dB (for -TB), when attenuator is terminated at both ends in a pure resistance of 600 Ω. For differences in attenuation between any two settings, switch-resistance error virtually disappears. To maintain accuracy at high attenuations, special wiring methods are employed to the "low" INPUT post.

Frequency Discrimination (with low terminal at panel potential): Less than 0.1 dB ±1% of the indicated value at frequencies below 200 kHz. For increments in attenuation, the 1% tolerance extends to approximately 1 MHz.

Maximum Input Power: 1 W.

Switches: Cam-type switches are used with twelve positions covering 360°. Dials are numbered from 0 to 10 inclusive, and the twelfth point is also connected to 0. Stops are provided in the switch mechanism for the 100-dB decade. No stops are provided to prevent complete rotation of the 10- and 1-dB decades, but spacers, which are provided, can be used under the mounting screws to act as stops for the knob, if desired.

Characteristic Impedance: 600 Ω both directions. One end must be terminated in 600 Ω.

Terminals: Low-thermal-emf jack-top binding posts with ¾-inch spacing; common terminal insulated from chassis; ground terminal provided.

Shielding: Each decade is individually shielded, and all shields are connected to the panel, to which the "G" post is also connected. Terminals are insulated from the panel, the "low" ones being connected together. The user is thus given free choice of grounding point for the "low" side, including connection to the panel post by the link provided.

Mounting: Lab-Bench Cabinet. Available for rack mounting.

Dimensions (width x height x depth): Bench models, 2-dial 1450-TA, 10 x 5¾ x 12¼ in. (255 x 150 x 315 mm); 3-dial 1450-TB, 12 x 5¾ x 12¼ in. (305 x 150 x 315 mm). Rack models 19 in. (485 mm) wide, same height and depth as bench models.

Net Weight: 1450-TA, 10¾ lb (4.9 kg); -TB, 14½ lb (7 kg); -TAR, 12 lb (5.5 kg); -TBR, 15½ lb (7.5 kg).

Shipping Weight: 1450-TA, 17 lb (8 kg); -TB, 20 lb (9.5 kg); -TAR, 22½ lb (10.5 kg); -TBR, 26 lb (12 kg).

Catalog Number	Description	Attenuation Total	Attenuation Steps	Mount	Price in USA
	Decade Attenuator				
1450-9891	**1450-TA**	110 dB	1 dB	Bench	**$395.00**
1450-9894	**1450-TAR**	110 dB	1 dB	Rack	**405.00**
1450-9893	**1450-TB**	111 dB	0.1 dB	Bench	**560.00**
1450-9895	**1450-TBR**	111 dB	0.1 dB	Rack	**570.00**

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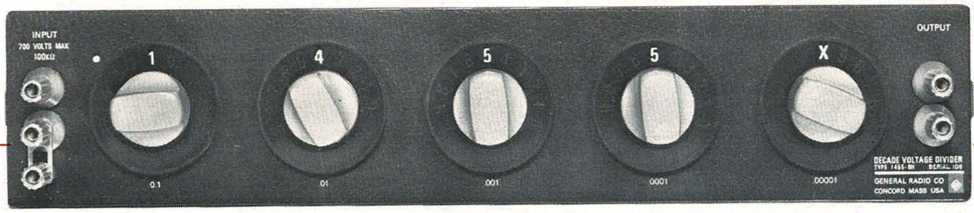
attenuators

DECADE VOLTAGE DIVIDER

Type 1455

- linearity better than 20 ppm (5-dial model)
- input impedance: 1, 10, or 100 kΩ
- high-frequency model, down 3 dB at 7.5 MHz

new



The GR 1455 Decade Voltage Dividers provide accurately known voltage ratios from 0.00001 to 1.00000 for use in many common measurements:

- voltage gain or attenuation,
- linearity of potentiometers and other controls,
- frequency response of audio and rf networks,
- transformer turns ratio,
- voltmeter calibration.

A resistive divider of the Kelvin-Varley type, the 1455 has precision resistors throughout rather than in selected positions only for over-all high accuracy. Linearity is as low as 0.02 ppm of input.

Match your needs exactly. Select input impedance, voltage rating, frequency range, 4- or 5-dial resolution, bench or rack mounting.

specifications

Type	1455-AH	-A	-AL	-BH	-B
Dials:	4	4	4	5	5
Input Resistance (accuracy given below):	100 kΩ	10 kΩ	1 kΩ	100 kΩ	10 kΩ
Input Voltage Rating (may be 20 ppm linearity change at full rating, see below):	700 V	230 V	70 V	700 V	230 V
Frequency Response (unloaded, at max output resistance setting), frequency at 3 dB down:	85 kHz	850 kHz	7.5 MHz	69 kHz	690 kHz
Resolution (in ppm of input):	100	100	100	10	10
LINEARITY					
Absolute Linearity (in ppm of input). Output taken with respect to output zero-setting at low audio frequencies with input voltage <½ rating:					
Ratio					
0.00001 to 0.00010	—	—	—	±0.02	±0.03
0.00010 to 0.00100	±0.2	±0.3	±0.7	±0.2	±0.3
0.00100 to 0.01000	±2	±2	±3	±2	±3
0.01000 to 0.10000	±15	±15	±20	±10	±10
0.10000 to 1.00000	±30	±30	±50	±20	±20
Terminal Linearity (in ppm of input). Add to absolute linearity.					
Four-Terminal (output with respect to low input terminal):	±0.004	±0.04	±0.4	±0.004	±0.04
Three-Terminal (low terminals common or output with respect to low input terminal):	±0.02	±0.2	±2	±0.02	±0.2
Max Output Resistance (input shorted):	27.9 kΩ	2.79 kΩ	333 Ω	28.8 kΩ	2.88 kΩ
Effective Output Capacitance (typical, unloaded):	67 pF	67 pF	67 pF	80 pF	80 pF

Frequency Characteristic: Acts like simple RC circuit below f_o so that

$$\frac{E_o}{E_{in}} \approx \frac{\text{reading}}{\sqrt{1+\left(\frac{f}{f_o}\right)^2}}$$

Tabulated value of f_o is at setting that gives max output resistance so that f_o at all other settings is higher. At $0.044f_o$, response is down <0.1%.

Accuracy of Input Resistance: +0.015%, except for 1455-AL, which is +0.025%.

Temperature Coefficient: <20 ppm for each resistor. Since voltage ratios are determined by resistors of similar construction, net ambient temperature effects are very small.

Dimensions (width x height x depth): Rack models, 19 x 3½ x 4⅝ in. (485 x 89 x 120 mm); 4-dial bench models, 14¾ x 3½ x 6 in. (375 x 89 x 155 mm); 5-dial bench models, 17$\frac{5}{16}$ x 3½ x 6 in. (455 x 89 x 155 mm).

Net Weight: Bench models, 4-dial, 6¾ lb (3.1 kg); 5-dial, 7¾ lb (3.6 kg).

Shipping Weight (est): Bench models, 4-dial, 7½ lb (3.5 kg); 5-dial, 8½ lb (3.9 kg). Add approx 1 lb (0.5 kg) to net and shipping weights for rack models.

Catalog Number	Description	Price in USA
	1455 Decade Voltage Divider	
	Bench Models	
1455-9700	1455-A, 4-dial, 10-kΩ	**$240.00**
1455-9702	1455-AH, 4-dial, 100-kΩ	**240.00**
1455-9704	1455-AL, 4-dial, 1-kΩ	**240.00**
1455-9706	1455-B, 5-dial, 10-kΩ	**280.00**
1455-9708	1455-BH, 5-dial, 100-kΩ	**280.00**
	Rack Models	
1455-9701	1455-A, 4-dial, 10-kΩ	**248.00**
1455-9703	1455-AH, 4-dial, 100-kΩ	**248.00**
1455-9705	1455-AL, 4-dial, 1-kΩ	**248.00**
1455-9707	1455-B, 5-dial, 10-kΩ	**288.00**
1455-9709	1455-BH, 5-dial, 100-kΩ	**288.00**

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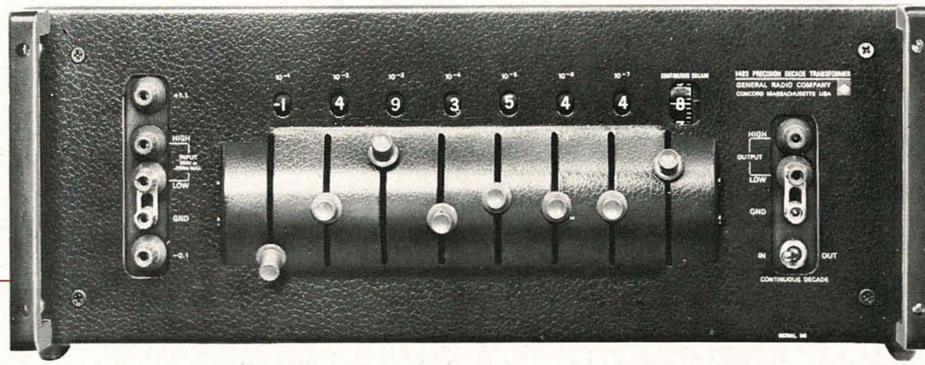
PRECISION DECADE TRANSFORMER

Type 1493

- 9-figure resolution
- linearity: ± 2 digits in 10^{-7} decade
- continuous 10^{-8} decade

new



High accuracy and resolution, essentially infinite settability, and an added measure of convenience set the GR 1493 Precision Decade Transformer apart from other "ratio boxes." All eight decade controls are easy-balancing levers with in-line readout of the type used in the GR 1615 Capacitance Bridge. The last decade is continuously adjustable for interpolating between steps of the 10^{-7} decade and providing essentially infinite resolution. It can be switched out for calibration of the step decades. All step decades are adjustable from −1 to X (or 10) to permit easy steps backward or forward through the awkward "many-zeroed" values.

Acceptable for calibration by the National Bureau of Standards, the 1493 can be used as a primary standard to calibrate other ratio transformers. Beyond this, in educational and experimental laboratories the 1493 can be used as two of the ratio arms in a variety of transformer bridge circuits for high-accuracy impedance measurements. To gain full use of the 1493 resolution in any application requires an oscillator and null detector with adequate combined sensitivity. The GR 1311-A Audio Oscillator with 100-V output and GR 1232-A Tuned Amplifier and Null Detector with better than 0.1-μV sensitivity are recommended as capable of providing the necessary 1 part in 10^9 sensitivity.

1311 Oscillator page 204

1232 Detector page 115

— See **GR Experimenter** for April 1967.

specifications

Range: −0.1111111 to +1.11111110 with 7 step decades and adjustable −1 to X (10). Continuous decade adjustable 0 to X.
continuous slide-wire decade in 10^{-8} position. Each step decade

Terminal Linearity (reference conditions 100 V, 1 kHz): Indicated ratios from 0 to 1 agree to 0.2 ppm with National Bureau of Standards calibration stated to be accurate to ± 0.2 ppm. Furthermore, independent measurements indicate that these settings are accurate to ± 0.2 ppm of true ratio. Normal operating conditions, 100 Hz to 2 kHz: Indicated ratio within 0.5 ppm of true ratio (within 1 ppm at 50 Hz). Slide-wire linearity $\pm 1\%$ of max value.

Phase Shift (at 1 kHz): $<\pm 6$ microradians for ratio settings from 0.1 to 1.0; $<\pm 40$ μrad for 0.01 to 0.1; $<\pm 125$ μrad for 0.001 to 0.01.

Max Voltage: 350 V; below 1 kHz, $0.35 f_{Hz}$ V.

Impedance: >100 kΩ at 1 kHz; >10 kΩ from 100 Hz to 10 kHz.

Direct Current: No dc should be applied to input for best accuracy; <1 ppm error from 1 mA at 100 V, 1 kHz.

OUTPUT

Impedance (dependent on ratio setting): Max: 3.5 Ω, 62 μH; min: 0.5 Ω, 6 μH. With slide-wire decade switched out, max resistance is reduced to 2.7 Ω.

Max Output Current: 1 A.

Terminals: Gold-plated GR 938 Binding Posts.

Accessories Available: Recommended generator and null detector for precise comparison or bridge applications: the 1311-A Audio Oscillator and 1232-A Tuned Amplifier and Null Detector or the combination 1240-A Bridge Oscillator-Detector.

Cabinet: Rack-bench. End-frames for bench mount or rack-mounting hardware included.

Dimensions (width x height x depth): Rack, 19 x 7 x 8⅜ in. (485 x 180 x 215 mm); bench, 19 x 7⅜ x 10¾ in. (485 x 190 x 275 mm).

Net Weight: Rack, 28 lb (12.7 kg); bench, 30 lb (13.6 kg).

Shipping Weight: Rack, 41 lb (18.7 kg); bench, 43 lb (19.6 kg).

Catalog Number	Description	Price in USA
	1493 Precision Decade Transformer	
1493-9801	Bench Model	**$1100.00**
1493-9811	Rack Model	**1100.00**

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AUTOMATIC MEASUREMENTS

AUTOMATIC BRIDGES
SYSTEMS
DATA ACQUISITION

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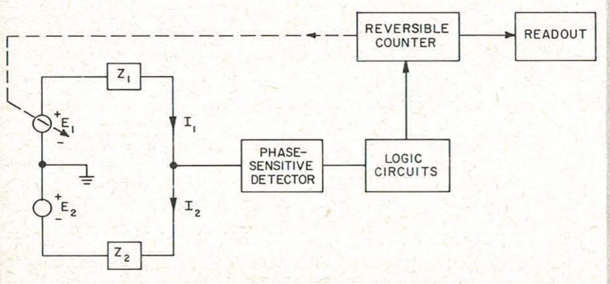
AUTOMATIC BRIDGES

GR automatic bridges combine the accuracy and stability of classical bridge techniques with digital logic circuits to form automatic instruments which permit high-speed measurements of impedance. The basic instruments feature short measurement time, completely automatic operation, and accuracies sufficient for most high-volume testing of components. They provide coded data outputs for automatic error-free recording of data and for use in completely automatic systems.

PRINCIPLES OF OPERATION

The basic bridge circuit of GR automatic bridges is similar to that of the transformer-ratio-arm bridge.[1]



Generalized Diagram of Automatic Bridges.

In this circuit the bridge is at balance when $I_1 = I_2$. If the bridge is unbalanced and, say, current I_1 is greater than I_2, the phase-sensitive detector and logic circuitry cause the reversible counter to count in a reverse direction. This counter controls electronic switches to decrease the value of the voltage E_1 until balance is achieved. At balance the counter displays the value of the unknown.

Only one set of controls has been shown — actually there are two which simultaneously balance the in-phase and quadrature components of the signal. When a null in both components is achieved, the bridge simultaneously displays the value of both the reactive and resistive parts of the component's impedance.

This bridge method is superior to the direct-measurement method which was in use before automatic bridges were first introduced in 1964. In the direct method, an ac voltage is applied directly to the component under test and the resulting current is measured with a phase-sensitive detector and digital voltmeter. While simple in principle, it is very difficult to build a phase detector with the required characteristics. To measure accurately a capacitor's dissipation factor of 0.001, for example, requires the accurate measuring of a signal in the presence of an out-of-phase signal 1000 times larger. Very small phase shifts could cause severe errors so that time-consuming adjustments were often necessary to attain the required accuracy. In GR automatic bridges, the phase detector is used only to control the direction of balance — its amplitude and exact phase characteristics are not important. In common with other bridge circuits, the accuracy is determined by the value of stable, passive impedance standards.

BRIDGE CHARACTERISTICS AND APPLICATIONS

There are two automatic bridges presently available from GR. While basically very similar they operate in a somewhat different way and are best for different applications.

1680 Automatic Capacitance Bridge Assembly

In the 1680 the impedance, Z_2, in the above figure is the capacitor under test and Z_1 a standard capacitor. The bridge indicates the value of the unknown capacitance directly on its digital readout. This is useful when a direct indication of actual value is needed or when the range of consecutive values can be wide, such as in the inspection and sorting of components. The loss component can be measured as either dissipation factor or parallel conductance.

1681 Automatic Impedance Comparator System

In the 1681, the above circuit measures an unbalance voltage, represented by E_2, by nulling it with a reference voltage, E_1 that is controlled in magnitude and phase angle by the reversible counter. The unbalance voltage comes from a second, but unbalanced, bridge circuit to which the external unknown and standard impedances are connected. In this case, the digital readout indicates the percent deviation of the unknown from the standard. This form is useful when deviation from a nominal value, and not actual value, is desired. With the 100% and 10% full-scale-deviation ranges, high resolution is possible — the bridge can measure changes as small as 10 ppm. This is particularly useful in measurements of temperature coefficient, in precise matching, and for tests on high-accuracy components. An external standard is always required. This standard can be a unit selected from those being tested so that temperature coefficient and other characteristics are matched and compensated, or the standard can be one of the many GR standard decades that are available.

[1] M. C. McGregor, J. F. Hersh, R. D. Cutkosky, F. K. Harris, and F. R Kotter, "New Apparatus at the National Bureau of Standards for Absolute Capacitance Measurements," IRE Transactions on Instrumentation, vol. I-7, pp 253-261; December, 1958. Also available as General Radio Reprint A-78.

File Courtesy of GRWiki.org

1680-A Automatic Capacitance Bridge Assembly used to make high-reliability quality-control tests. Measurement results are visible immediately to the operator and are recorded by the 1137 Data Printer. Photograph courtesy of Erie Technological Products, Inc.

MANUAL OR AUTOMATIC?

	Manual Bridges	Manual Impedance Comparators	Automatic Bridges	Automatic Bridge Systems
Measurement Rate	<300/h	300 to 3000/h		>3000/h
Data Recording and Sorting Decisions	Manual			automatic
Absolute Values	R, L, C	—	C, G	
Deviation from Standard	—	R, L, C	R, L, C	
Operator Skill Needed	moderate	low		
Equipment Costs	**<$1000**	**$1000**	**$5000**	**$7000 and up**

APPLICATION AREAS

The following table lists the application areas for each of the GR automatic impedance bridges and indicates the significant features. The major application areas for which the bridges are especially suitable are shown in color. The secondary applications represent field experience by one or more users, and while not necessarily of wide interest, may suggest other similar uses.

Application Area	1680-A	1681
Capacitance Measurements General use, mica, plastic, paper	**Wide range, fast balance**	**Wide range, fast balance**
Ceramics	**1-kHz, 1-volt signal ***	**1-kHz, 0.2- or 0.3-, 2- or 3-volt signal**
Low-loss plastic and glass	D accuracy 0.001	**D resolution 10 ppm**
Semiconductor	No errors due to strays 1-kHz, 1-volt signal *	No errors due to strays 1-kHz, 0.2 or 0.3-, 2- or 3-volt signal
Electrolytics	Useful to 1000 μF 5-s balance at 120 Hz Reads parallel capacitance	Useful to 1000 μF
Inductance Measurements	Will balance but reads out negative capacitance	**Direct reading in ΔL**
Resistance Measurements	Reads conductance 1Ω to 10^4 MΩ	**Direct reading in ΔR**
Sorting, inspection, QC	**Fast, simple operation Wide range**	**10% and 100% full-scale deviation ranges Needs external standard**
Material Studies	**Fast, automatic operation 120, 400, 1000 Hz**	**Direct reading in ΔZ to 10 ppm 120, 400, 1000 Hz**
Temperature coefficient Life tests	Direct reading to 0.1% Can read ΔC to 100 ppm	**Direct reading in ΔC to 10 ppm**
High-accuracy tests Intercomparing standards	0.02%-of-fs resolution	**10-ppm resolution**
Process control	**Programmable controls Data outputs**	Programmable controls Data outputs Deviation indicated directly

* 0.1-volt signal available on special order with reduced resolution; 2-volt signal also available.

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AUTOMATIC CAPACITANCE BRIDGE ASSEMBLY

Type 1680

- 0.01 pF to 1000 μF
- ±0.1% of reading accuracy
- 120, 400, 1000 Hz
- ½-second automatic balance at 1 kHz
- true bridge circuit — 3-terminal connection
- BCD output data

The Automatic Capacitance Bridge Assembly is a fully automatic, all-solid-state three-terminal, capacitance bridge. It is a true bridge, relying on stable, passive standards for its accuracy.

USES

The 1680-A is an accurate, fast, and economical test device for production and laboratory applications where a great many capacitance measurements are needed. Its range and accuracy cover most capacitor-measurement requirements.

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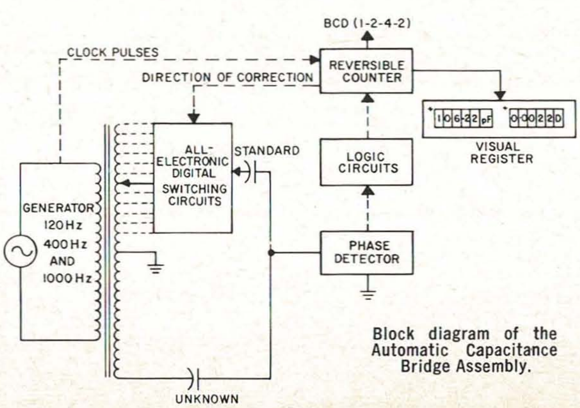
In component-inspection applications, measurement rate is up to ten times faster than is possible with manually balanced bridges.

In capacitor production applications, this bridge can be used as an integral part of automatic manufacturing processes to monitor production automatically.



Block diagram of the Automatic Capacitance Bridge Assembly.

In qualification testing, quality control, and reliability studies, freedom from stray-capacitance effects permits accurate measurements at the end of long cables, such as those necessary to connect to capacitors in environmental chambers. Lead resistance is negligible in the measurement of all but very large capacitors (see accuracy curves).

ACCESSORY EQUIPMENT

Many devices are available for more fully automated measurements with the 1680. Up to 100 components can be connected to the bridge in sequence, automatically, with the 1770 Scanner System. An integral part of an automatic sorting system is the 1781 Digital Limit Comparator. Data from the bridge can be collected fast and accurately on an 1137 Data Printer, an analog recorder, or other equipment such as card- and tape-punch machines.

DESCRIPTION

The circuit is a transformer-ratio-arm bridge. It is in balance when the currents through the standard capacitor and the unknown capacitor are equal so that the current in the phase detector is zero. The phase detector compares currents in the unknown and standard arms and produces an error signal that controls a reversible counter, which changes the voltage on the standard capacitor, in the proper direction to equalize the two currents and produce a null. At balance, the value of the unknown is displayed on an in-line digital readout, which indicates capacitance, dissipation factor or conductance, decimal points, and units. This information is also presented in binary-coded-decimal form for use with printers and other data-handling equipment.

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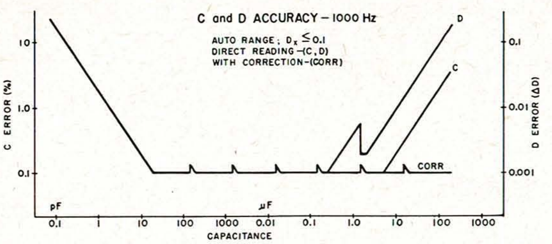
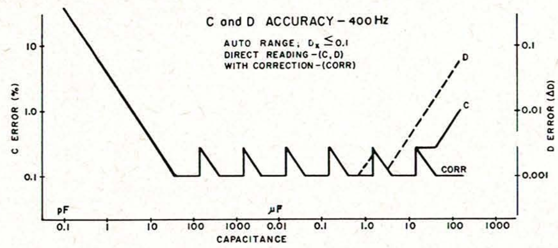
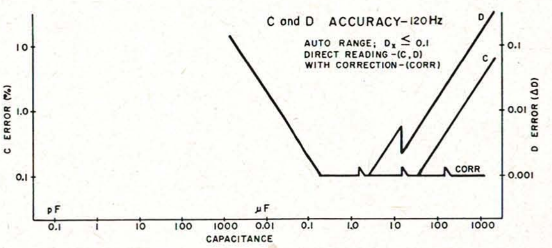
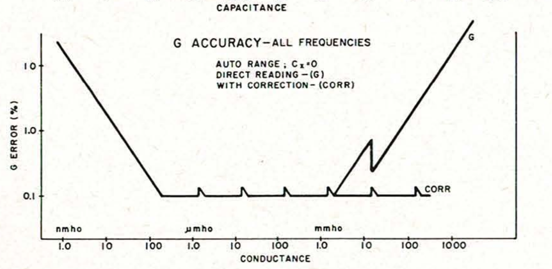








specifications

		At 120 Hz	At 400 Hz	At 1000 Hz
RANGES	Capacitance (parallel)*:	0.0001 µF-1000 µF	0.01 pF-100 µF	0.01 pF-100 µF
	Conductance (parallel):	0.1 µmho-1.0 mho	0.0001 µmho-1.0 mho	0.0001 µmho-1.0 mho
	Dissipation Factor (direct reading)	0.0001-1.00 (100%)	0.0001-1.00 (100%)	0.0001-1.00 (100%)
	(Measured as conductance):	0 to ∞	0 to ∞	0 to ∞
BASIC ACCURACY (see curves)	Capacitance:	0.1% of reading	0.1% of reading	0.1% of reading
	Conductance:	0.1% of reading	0.1% of reading	0.1% of reading
	Dissipation Factor:	1% of reading ±0.001	1% of reading ±0.001	1% of reading ±0.001
SPEED OF BALANCE (approx) (Speed may be somewhat lower than that listed when dissipation factor is measured near the low end of each range.)	Fast Modes:			
	No range changes	2.5 seconds	0.35 second	0.25 second
	With range changes	5.0 seconds	0.6 second	0.5 second
	Tracking Modes:			
	10-count change	1.0 second	0.1 second	0.1 second
	100-count change	2.0 seconds	0.35 seconds	0.2 second
	1000-count change	11.0 seconds	2.6 seconds	1.1 seconds

* For series capacitance measurements a correction (chart supplied) can be used: If $D_x = 0.1$ (10%), correction = 1%. If $D_x = 0.03$ (3%), correction = 0.1%.

Digital-Data Equipment page 60 ff

EFFECTS OF LEADS: There is no error introduced by stray capacitance if shielded cables are used. Series resistance of leads can cause errors on the highest range. Accuracy curves include the effects of up to 50 mΩ of external cable.

Voltage Across Unknown: At 120 Hz, 1 V to 1.5 µF, 100 mV to 15 µF, 10 mV to 150 µF, 1 mV to 1000 µF; at 400 and 1000 Hz, 1 V to 150 nF, 100 mV to 1.5 µF, 10 mV to 15 µF, 1 mV to 100 µF. Voltage can be set internally to as little as 1/10 these values with proportionate loss in resolution.

DISPLAY: Two 5-digit banks of bright-light, numerical indicators, with decimal points and units of measurement. Lamp burnout does not affect instrument operation or coded output. Lamps can be replaced from front panel.

DC BIAS: Can be introduced from external source.

REMOTE CONTROL: Start and balance controls can be activated remotely by contact closures.

OUTPUT SIGNALS

Numerical Data: 10 digits BCD 1-2-4-2 code (1-2-4-8 available).

Range Code (1 to 7): 1 digit BCD 1-2-4-2 code (1-2-4-8 available).

Print Command at Completion of Balance: Change from "1" level to "0" level — returns to "1" level at end of display interval.

Signal Levels: "1" level, 0 V; "0" level, −12 V; both with respect to reference line, which is at +6 V above chassis ground. Impedance of lines = 12 kΩ.

MEASUREMENT RATE: Panel control allows adjustment of measurement rate so that display time between measurements is between approx 0.1 and 5 s. The rate can be set manually (or remotely) at any rate compatible with balance time.

OPERATION AT OTHER MEASUREMENT FREQUENCIES: With internal modification, the measurement frequencies can be changed to any frequency between 100 Hz and 2 kHz.

DIFFERENCE MEASUREMENTS: By the addition of a suitable standard to terminals provided, the bridge can be made to indicate the deviation, either positive or negative, from a nominal value.

GENERAL

Power Required: 105 to 125 V, 195 to 235, or 210 to 250 V, 50 to 60 Hz, 100 W. Internal 120-Hz oscillator is locked to power line for 60-Hz operation.

Auxiliary Controls: A rear-panel sensitivity control can be used to minimize balance time by a decrease in resolution.

Dimensions (width x height x depth): 19½ x 12 x 19 in. (495 x 305 x 485 mm).

Weight: Net, 77 lb (35 kg); shipping, 150 lb (70 kg).

Catalog Number	Description	Price in USA
	1680-A Automatic Capacitance Bridge Assembly	
1680-9702	115 V, 60 Hz, Bench	**$4975.00**
1680-9703	115 V, 60 Hz, Rack	**4975.00**
1680-9704	115 V, 50 Hz, Bench	**on request**
1680-9705	115 V, 50 Hz, Rack	**on request**
1680-9706	220 V, 50 Hz, Bench	**on request**
1680-9707	220 V, 50 Hz, Rack	**on request**
1680-9708	230 V, 50 Hz, Bench	**on request**
1680-9709	230 V, 50 Hz, Rack	**on request**
1680-9601	**1680-P1 Test Fixture**	**95.00**

PATENT NOTICE. See Note 8.

1680-P1 Test Fixture facilitates connection of capacitors to the bridge. Capacitor leads are inserted in the clips and the bridge balances when bar marked PRESS is pressed.

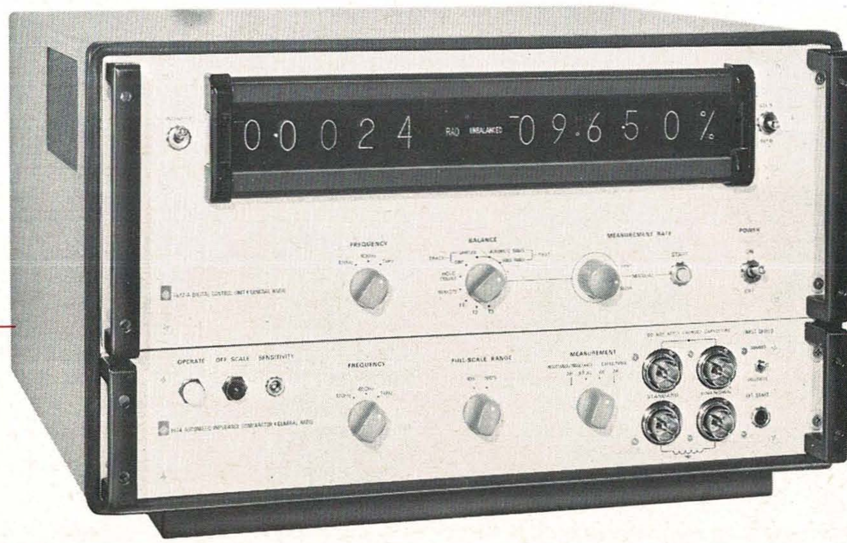
File Courtesy of GRWiki.org

AUTOMATIC IMPEDANCE COMPARATOR SYSTEM

Type 1681

- 2 ohms to 20 megohms, R, L, or C
- comparisons to 0.005% accuracy, 0.001% resolution
- 10% or 100% difference, full-scale ranges
- three-terminal connections
- 120, 400, 1000 Hz
- ½ second automatic balance
- BCD output data

new



The 1681 is a fully automatic, all-solid-state comparison bridge that is direct reading in impedance magnitude and phase angle over a wide range of impedances. It permits manual testing to be greatly accelerated and can be the nucleus of many high-speed automatic impedance-measuring systems.

USES

Typical uses for the high-precision 1681 system include:

Production Applications
- component testing and grading
- precision measuring, matching, selection of components
- fast tracking and alignment of ganged resistors, capacitors
- testing of long cables

Laboratory Applications
- D comparison of low-loss dielectric materials
- balancing transformer windings
- environmental and reliability testing of components

Impedance Standards and Decades page 65 ff

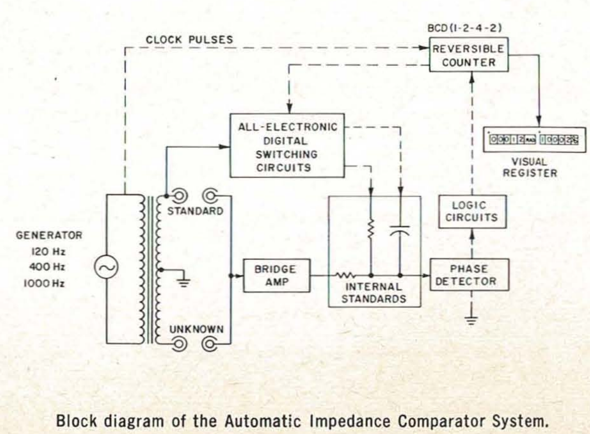
Data Systems page 60 ff

ACCESSORY EQUIPMENT

The 1680-P1 Test Fixture is available for more rapid, convenient manual testing of components. More fully automated measurements mean greater economy in both production areas and laboratory. Many instruments are available to speed the handling of both components and measurement data. General Radio can supply custom assemblies tailored to individual needs and including not only the impedance-measuring function of the 1681 but the measuring, monitoring, and data-acquisition capabilities of other GR and non-GR instruments.

DESCRIPTION

The 1681 comparator is a transformer bridge with the unknown and standard impedances serving as two of the bridge arms. When unknown and standard are unequal, an unbalance voltage results whose magnitude and phase



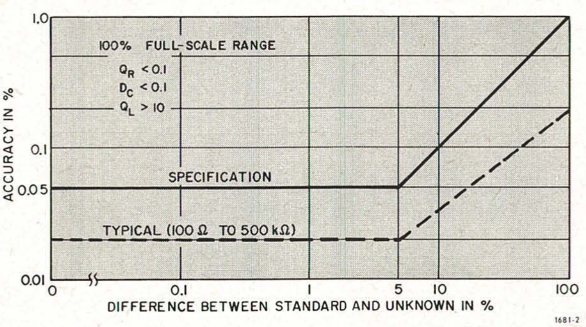
Block diagram of the Automatic Impedance Comparator System.

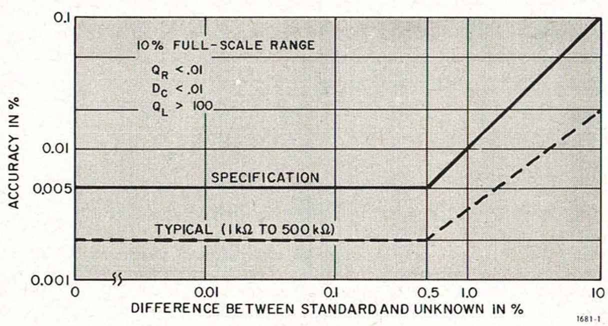
File Courtesy of GRWiki.org

angle (relative to the test voltage) are a measure of the impedance differences. The unbalance voltage is measured by balancing its in-phase and quadrature components with variable reference signals that are controlled by reversible counters and phase detectors. At balance, the counter displays the magnitude and phase-angle difference between unknown and standard on an in-line readout with positioned decimal point and measurement units. A BCD data output is also provided to operate external equipment.

specifications

	Total Useful Range	Full Scale	Ranges for Measurement with Stated Accuracy 120 Hz	400 Hz	1000 Hz
Resistance	2 Ω-20 MΩ	100%	10 Ω - 2 MΩ	10 Ω - 2 MΩ	10 Ω - 2 MΩ
		10%	500 Ω - 2 MΩ	500 Ω - 2 MΩ	500 Ω - 2 MΩ
Capacitance	20 pF-800 μF	100%	1 nF - 100 μF	400 pF - 50 μF	200 pF - 20 μF
		10%	1 nF - 5 μF	400 pF - 2 μF	200 pF - 1 μF
Inductance	400 μH-1000 H	100%	5 mH - 1000 H	2 mH - 200 H	600 μH - 100 H
		10%	200 mH - 1000 H	50 mH - 200 H	30 mH - 100 H





Accuracy of R, L, or C Difference as Percent of Standard.

FULL-SCALE RANGES

Magnitude Difference: ±10%, and +100% −40%, full scale

Phase-Angle Difference: ±0.1 and ±1 radian, full scale. The phase-angle difference is very nearly equal to the D difference (C and L) and the Q difference (R) when the D or Q is less than 0.1.

ACCURACY

ΔR, ΔL, ΔC Measurement Mode

Magnitude Difference (as % of standard): ±[1% of reading + 0.001 Δθ (in counts) + 5 counts].

Phase-Angle Difference: ±[1% of reading + 0.005 ΔZ (in counts) + 5 counts] + additional error when large magnitude differences are measured. Correction chart supplied.

Δθ Measurement Mode

Magnitude Difference (as % of average of unknown and standard): ±[1% of reading + 0.001 Δθ (in counts) + 5 counts]. Reading in this mode differs from %-of-standard when deviation ≧1%. A correction chart is supplied.

Phase-Angle Difference: ±[1% of reading + 0.005 ΔZ (in counts) + 5 counts].

Max Resolution: 0.001%, 0.00001 radian.

Effects of Leads: For high-impedance measurements with input shield guarded, shielded cables up to 3 feet long can be used without significant error from cable capacitance.

Voltage Across Standard and Unknown: 0.3 V for 100%-full-scale range; 3 V for 10% range. Test voltage can be modified on request to meet MIL Specifications MIL-C-11015C and MIL-C-39014 on ceramic capacitors.

Dc Bias: Can be introduced from external source.

Display: Two 5-digit banks of bright-light, numerical indicators with decimal point and units of measurement. Lamp burnout does not affect instrument operation or coded output. Lamps can be replaced from front panel.

Remote Control: Start and balance controls can be activated remotely by contact closures.

OUTPUT

Numerical Data: 10 digits BCD 1-2-4-2 code.

Print Command (at completion of balance): Change from "1" level to "0" level.

Signal Levels: "1" level, 0 V; "0" level, −12 V; both with respect to reference line at +6V above chassis ground. Impedance of lines 12 kΩ

Measurement Rate: Panel control allows adjustment of measurement rate so that display time between measurements is between approx 0.1 and 5 s. The rate can be set manually or remotely at any rate compatible with balance time.

Other Measurement Frequencies: With internal modification, the measurement frequencies can be changed to any value between 100 Hz and 2 kHz.

GENERAL

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 Hz, 100 W. Internal 120-Hz oscillator is locked to power line for 60-Hz operation.

Auxiliary Controls: Sensitivity control on front panel can be used to minimize balance time with a resulting decrease in accuracy. Self start (when component is connected) or ext start (by contact closure) can be selected with a rear-panel switch.

Accessories Supplied: Rack-mounting hardware with rack models; power cord and spare fuses with all models.

Accessories Available: 1680-P1 Test Fixture; R, L, and C standards and decade boxes; various GR digital-data-acquisition instruments and system components.

Mounting: Supplied with hardware for rack mounting or assembled in cabinet for bench use.

Dimensions (width x height x depth): Bench, 19½ x 12 x 19 in. (495 x 305 x 485 mm); rack, 19 x 10½ x 18 in. (485 x 270 x 460 mm).

Net Weight: Bench, 76 lb (35 kg); rack, 71 lb (33 kg).

Shipping Weight: Bench, 160 lb (74 kg); rack, 145 lb (67 kg).

Catalog Number	Description	Price in USA
	1681 Automatic Impedance Comparator System	
1681-9700	115 V, 60 Hz, Bench	**$4975.00**
1681-9701	115 V, 60 Hz, Rack	**4975.00**
1681-9702	115 V, 50 Hz, Bench	**on request**
1681-9703	115 V, 50 Hz, Rack	**on request**
1681-9704	220 V, 50 Hz, Bench	**on request**
1681-9705	220 V, 50 Hz, Rack	**on request**
1681-9706	230 V, 50 Hz, Bench	**on request**
1681-9707	230 V, 50 Hz, Rack	**on request**
1680-9601	**1680-P1 Test Fixture**	**95.00**

PATENT NOTICE. See Note 8.

Test Jig
page 57

Decade Standards
R page 111 ff
L page 104 ff
C page 86 ff

File Courtesy of GRWiki.org

AUTOMATIC MEASURING SYSTEMS

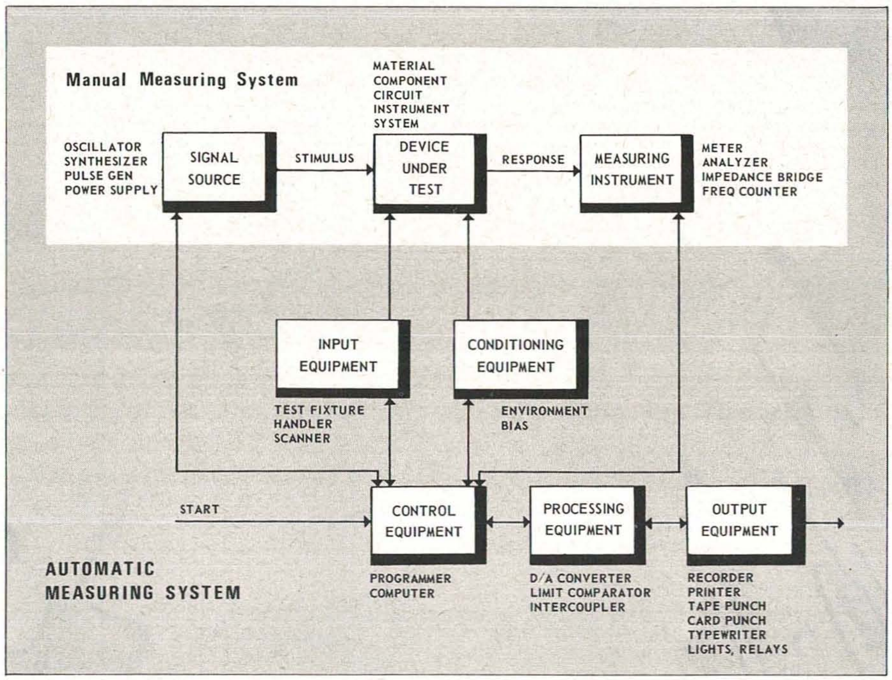
The advent of automatic measuring instruments with digital output has prompted the automation of many old and new measurement tasks. The diagram below shows the variety of functions to be found in an automatic measuring system.

The inner box contains the elements essential to any measuring system, manual or automatic. The device under test can range from a dielectric material or component to a complex system. The stimulus and response-measuring function are often combined in a single instrument.

The functions in the outer box can be added to automate all or part of the measurement task. Thus, one can add test fixtures and handlers to assist the input function or scanners for automatic connection of the devices under test to the measuring equipment. Processing equipment can operate on the measurement data and convert it to more useful forms; output equipment can be added to produce graphs, charts, or typewritten reports. Control equipment can perform various timing and switching operations. Many of these functions can be combined in a single unit.

As peripheral functions are added, the operator acts less as a mechanical part of the measurement process and can devote his attention to results rather than details of the measurement. If the results are used for automatic control of other equipment operating on the device under test, a closed-loop process-control system can be achieved.

Many General Radio instruments are useful in such systems. In addition to providing measuring instruments and peripheral system components, we welcome the opportunity to consider your entire measurement needs.



CUSTOM SYSTEMS

We define a "system" as a collection of instruments — some standard, some modified, some specially designed, some purchased — assembled to accomplish a specific measurement task.

This definition recognizes that a system is more than a group of catalog instruments and a few patch cords. The grouping must be carefully thought out, from both an electrical and mechanical standpoint. Interface problems must be identified and solved. Some instruments may have to be adapted to the requirements of the system. Others may have to be purchased or designed. Special cables, racks, and consoles may be necessary, along with special operating and maintenance instructions. The system must be thoroughly engineered; the whole must be greater than the sum of its parts.

Some typical examples of measurement systems, custom-built by GR, are shown on the next page.

File Courtesy of GRWiki.org

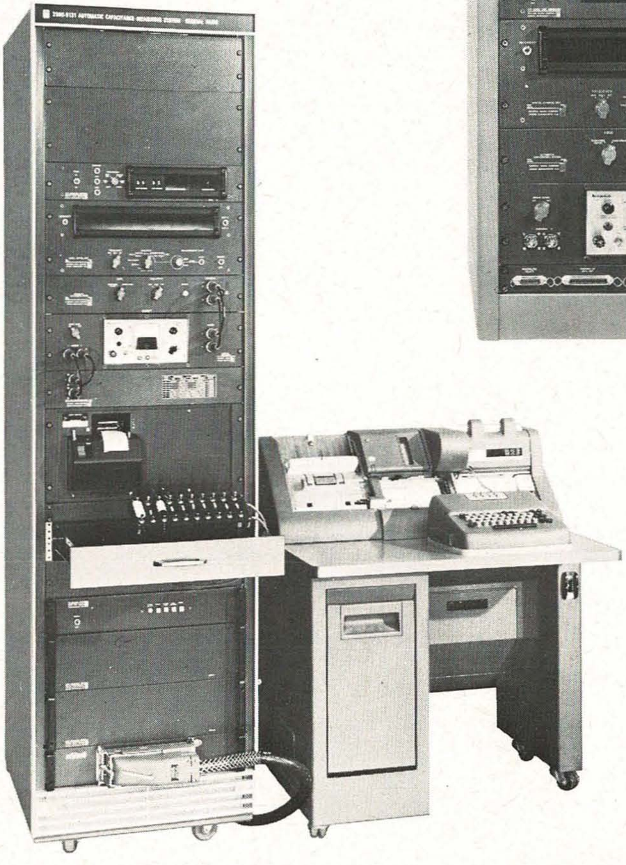
CAPACITANCE MEASURING SYSTEMS

The GR 1680 Automatic Capacitance Bridge Assembly is the basic instrument in many systems for the automatic testing and sorting of capacitors and other components. Some typical systems that have been designed and built by GR are shown below. Wide variations of capability beyond those shown are possible and always worthy of consideration. For example, the GR 1681 Automatic Impedance Comparator in system applications will enable virtually any impedances to be compared precisely and automatically.

Capacitor Sorting System

2990-9127 Used with external handling equipment to sort capacitors and resistors.

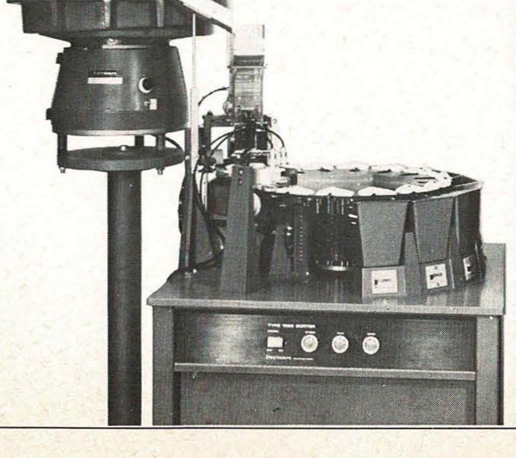
Includes:
Automatic Capacitance Bridge
Digital Limit Comparator
Bias Supply
Typical Price: **$9000**

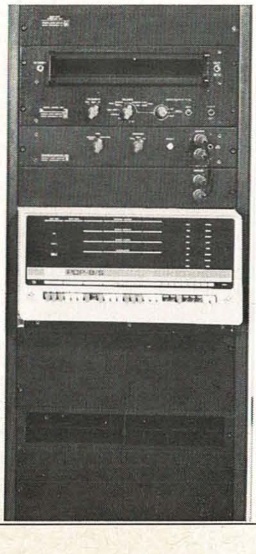


Automatic Capacitance Measuring System

2990-9131 Used to log test data during environmental testing of capacitors.

Includes:
Automatic Capacitance Bridge
100-Channel Scanner
Bias Supply
Data Printer
Card-Punch Coupler
Typical Price: **$19,000**
(Card punch not included)





Automatic Measuring System

2990-9146 Used to sort capacitors into 12 categories. Provides statistical printout.

Includes:
Automatic Capacitance Bridge
Computer
Interface Unit
Typical Price: **$25,000**
(Sorter not included)

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SYSTEM COMPONENTS

The instruments listed on the following pages can be used as building blocks in automatic measuring systems. Some are useful with measuring instruments other than those listed. For further information consult your local GR Sales Office or representative or write for detailed data sheets.

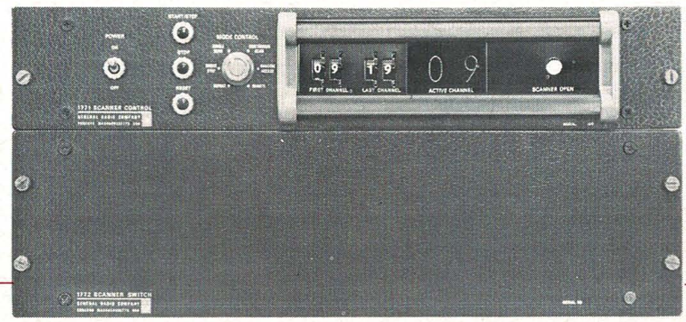
INPUT EQUIPMENT

SCANNER SYSTEM

Type 1770

- 100-channel capacity
- guard connection for capacitance measurement
- versatile modular construction

new



The 1770 Scanner System is an automatic instrument for the sequential connection of capacitors to the 1680 Automatic Capacitance Bridge. It can be used in other scanning applications as well. Modular construction offers great versatility in the number of input channels, number of lines switched per channel, and line termination possible with the 1770. Since we cannot list every combination, we invite your inquiries regarding variations to suit specific requirements.

High-temperature cable with an operating range of −75 to 250°C can be supplied for connecting the scanner system to components in environmental chambers.

Specifications are given for a typical scanner system priced at about $3500*. It can scan 50 capacitors for measurement by a 1680 Automatic Capacitance Bridge, maintaining guarded connections and switching both component terminals. Numerous other variations are possible to suit not only capacitance-measuring applications but many others as well. Your inquiries are invited.

— See **GR Experimenter** for Nov-Dec 1966.

* In USA.

specifications

MEASUREMENT-CHANNEL CHARACTERISTICS

Resistance through Scanner Module: <100 mΩ.

Capacitance Across Unknown: <0.01 pF.

Switch Contact Rating: Switching max, 25 V dc, 0.1 A or 117 V ac, 25 mA. Breakdown, 300 V dc.

GENERAL

Accessories Supplied: Two 50-foot rolls of 10-conductor shielded cable; one 14-pin plug per module for 10-line input; control cable for connection of 1771 to 1772; two BNC-to-GR874 cables and one control cable for connection to capacitance bridge; eight BNC-BNC jumpers for interconnection of switch modules; power cord.

Power Required: 105 to 125 or 195 to 235 V (210 to 250 V also available), 50 to 60 Hz, 15 W.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Rack, 1771, 19 x 3½ x 14 in. (485 x 89 x 360 mm); 1772, 19 x 5¼ x 10⅝ in. (485 x 135 x 270 mm).

SHIELDED SWITCH MODULE

Type 1772-P3

The 1772-P3 module is used to extend the capabilities of the 1770 Scanner System to the automatic scanning of signal lines. A unique combination of mechanical and electrical design ensures excellent shielding and isolation through the modules, making them well suited to carry and switch either high-frequency signals or lines particularly susceptible to interference.

Isolation between lines in the module is 120 dB at 500 kHz, 100 dB at 1 MHz, and 60 dB at 100 MHz.

Each module can switch up to 10 channels, for a total capacity of 100 channels in a 1770 system fully equipped with these modules.

APPLICATIONS

Typical of the many uses for the 1772-P3 is that of making automatic frequency-stability tests on many oscillators or signal generators. While the shielded modules connect the oscillator outputs in sequence to a single counter, the output data from the counter could also be switched, in order, to several recorders or other logging devices through other modules.

The 1772-P3 has been able to provide the solution to many difficult connection problems in scanning systems beyond the obvious needs for shielding. If you have an unusual scanning application, the 1772-P3 may solve it, too. We invite your inquiries.

File Courtesy of GRWiki.org

system components

DATA PRINTER

Type 1137-A

Portable model

- accepts BCD inputs
- 12-column capacity
- color identification for go-no go, etc

The printer provides a precise, compact, and economical means of converting decimal-coded information into permanent, printed form.

It is equipped with plug-in code modules, which accept 4-line 1-2-2-4, 1-2-4-8, or 1-2-4-2 BCD inputs. A two-color ribbon can be electrically or manually controlled to print red or black on standard 2¼-inch paper.

The capacity of the printer is 12 columns, not all of which are used for data from the associated GR instruments. Additional plug-in modules are available for printing other data. Both portable and rack models are listed.

— See **GR Experimenter** for June 1963.

specifications

Capacity: 12 columns.
Digits: 0 through 9 or blank (column suppression).
Printing Rate: 3 lines per second max.
Accuracy: Identical to input.
Printing Ribbon: 7/16-in. two-color adding-machine ribbon.
Paper: Standard 2¼-in. roll tape.
Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz, 45 W.
Accessories Supplied: Cable assembly for connection to instrument, spare fuses.
Accessories Available: Additional plug-in code modules.
Mounting: Portable metal case or rack mount.
Dimensions (width x height x depth): Portable model, 8¾ x 9 x 21 in. (225 x 230 x 540 mm); rack model, 19 x 8¾ x 17½ in. (485 x 225 x 445 mm).
Net Weight: Portable model, 35 lb (16 kg); rack model, 45 lb (20.5 kg).
Shipping Weight: Portable model, 45 lb (20.5 kg); rack model, 55 lb (25 kg).

Catalog Number	Description	Use with†	Price in USA
	1137-A Data Printer		
	6-column BCD,	1123, 1680, 1681	
1137-9743	Portable Model		**$1675.00**
1137-9744	Rack Model		**1725.00**
	8-column BCD-DTL,	1191, 1159	
1137-9702	115 V, Portable		**1885.00**
1137-9703	115 V, Rack		**1935.00**
1137-9704	230 V, Portable		**on request**
1137-9705	230 V, Rack		**on request**
	Plug-In Code Module		
1137-9604	4-line BCD	Extend columns to max of 12	**65.00**
1137-9608	4-line BCD-DTL		**75.00**

† Connectors and cables for use with other digital instruments are available on special order. Write for information.

PROCESSING EQUIPMENT

CARD-PUNCH COUPLER

Type 1791

- couples BCD data to IBM 526 card punch
- 22-digit capacity

new

The 1791 permits binary-coded digital data from a measuring device such as the GR 1680 Automatic Capacitance-Measuring Assembly to be recorded on punched cards with an IBM 526 Printing Summary Punch. Up to 22 digits of parallel data can be accepted from one or more sources and serially converted to 10-line decimal-coded contact closures required by the card punch. Other data recording or processing devices (data printer, digital comparator, etc) can be simultaneously supplied BCD information from the coupler.

The 1791 Card-Punch Coupler is available on special order only. Typical price for coupler and connector combination, $3500 in USA.

specifications

Speed: Determined by IBM 526: entries 18 columns/s, skips 80 columns/s, ejects card in ¼ second.
Accessories Supplied: Power cord, spare fuses, signal cable with connectors for 11-digit connection of GR 1680 bridge (or similar data source) to coupler input.
Accessories Available: Multiple-wire stationary connector mounted on 19 x 3 in. panel to accept cable connector from IBM 526 (available for punch located to right or left of coupler); accessory cable for additional input-digit capacity.
Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 Hz, 15 W.
Mounting: Rack-Bench Cabinet.
Dimensions (width x height x depth): 19 x 3½ x 16 in. (485 x 89 x 410 mm).
Weight (Approx): Net, 20 lb (9.5 kg); shipping, 30 lb (14 kg).

File Courtesy of GRWiki.org

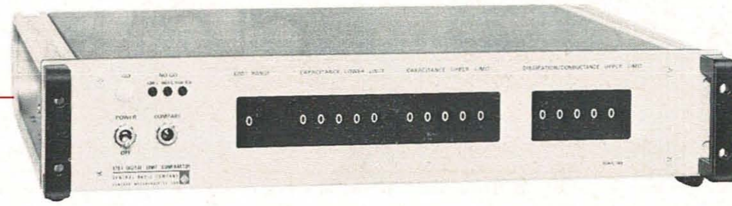
system components

DIGITAL LIMIT COMPARATOR

Type 1781

- 0.1% sorting with automatic capacitance bridge
- compares capacitance and loss with manually preset limits
- GO-NO GO visual indication and relay contacts

new



The digital limit comparator automatically compares the BCD output of the 1680 Automatic Capacitance Bridge with limits for high and low C and high D or G that are preset (with appropriate range) on front-panel thumbwheels. Panel lights show if the capacitor under test is in tolerance or, if not, the reason: HIGH C, LOW C, or HIGH D or G. Relay contacts are provided to actuate external GO-NO GO indicators or automatic sorting mechanisms. Several comparators can be used together for multiple-tolerance sorting.

— See **GR Experimenter** for November-December 1966.

specifications

RANGE OF LIMIT SETTINGS: 00000 to 19999 for both C and D/G.
ACCURACY: Same as that of data source.

INPUT
Data: 11 digits, BCD, 1-2-4-2 (1-2-4-8 optional).

OUTPUT
Data: Identical to input.
Comparison Result: BCD digit, behind 10 kΩ.
Print Command: Logic 1 to logic 0 transition, behind 2.2 kΩ.
Relay Contacts: Internal contact protection provided for 115 V, 0.1 A max. Contacts rated for 500 V max, 2 A max, 100 VA with appropriate contact protection.

GENERAL
Accessories Supplied: Power cord, spare fuses, signal cable to connect comparator to measuring instrument.
Accessories Required: If sorting equipment is used, 4205-1010 cable is also needed.
Power Required: 105 to 125 or 210 to 250 V (195 to 235 V also available), 50 to 60 Hz, 10 W.
Cabinet: Rack-bench.
Dimensions (width x height x depth): Bench, 19 x 4 x 16½ in. (485 x 105 x 420 mm); rack, 19 x 3½ x 16 in. (485 x 89 x 410 mm).
Weight: Net, 20 lb (9.5 kg); shipping, 30 lb (14.0 kg).

Catalog Number	Description	Price in USA
	1781 Digital Limit Comparator	
1781-9801	Bench Model	**$1625.00**
1781-9811	Rack Model	**1625.00**
4205-1010	**Accessory Cable** (to sorting equipment)	**65.00**

DIGITAL-TO-ANALOG CONVERTER

Type 1136

- 1-mA and 0.1-V output
- internal data storage
- ±0.1% linearity

The 1136 translates the data output from a digital-instrument into a dc voltage or current for analog recording.

The converter selects any three consecutive, or the last two, columns from an input of up to nine columns. Storage circuits in the converter permit use with intermittent as well as continuous BCD inputs.

A command pulse from the data source transfers the input data into the storage circuits of the converter. Jam transfer into storage is used so that the analog output changes only when the input data changes (no zero-set between transfers).

— See **GR Experimenter** for December 1963.

Accessories Supplied: Power cord, spare fuses, input cable for connection to the digital instrument.
Power Required: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 7 W.
Mounting: Rack-Bench Cabinet.
Dimensions (width x height x depth): Bench model, 19 x 4 x 12 in. (485 x 105 x 305 mm); rack model, 19 x 3½ x 11 in. (485 x 89 x 280 mm).
Weight: Net, 13 lb (6 kg); shipping, 21 lb (10 kg).

Catalog Number	Description	Use with	Price in USA
	1136 Digital-to-Analog Converter		
1136-9402	Bench Model	1680, 1681	**$755.00**
1136-9502	Rack Model		**755.00**
1136-9702	Bench Model	1191, 1159	**755.00**
1136-9703	Rack Model		**755.00**

PATENT NOTICE. See Note 1.

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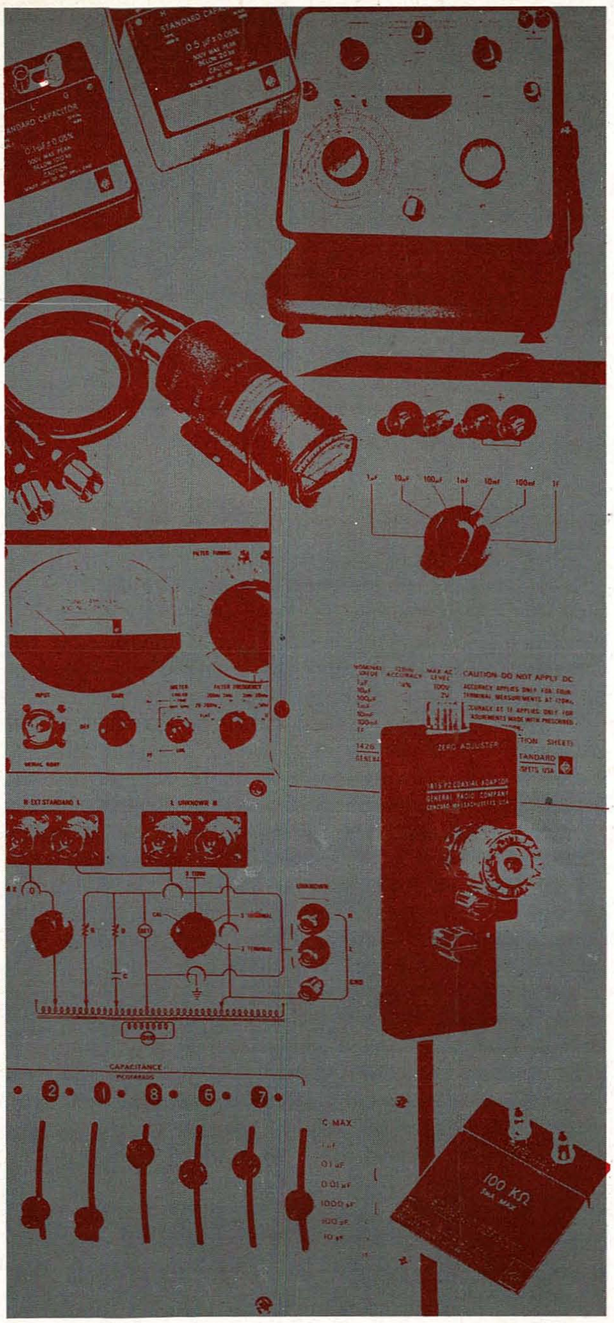


IMPEDANCE

IMPEDANCE BRIDGES
CAPACITANCE BRIDGES and STANDARDS
INDUCTANCE BRIDGES and STANDARDS
RESISTANCE BRIDGES and STANDARDS
DETECTORS

File Courtesy of GRWiki.org

IMPEDANCE MEASUREMENT

Null methods have long been recognized as the most precise way to measure all types of impedances — resistive and reactive, inductive and capacitive, from low frequencies to uhf. Most null-type instruments evolved from the century-old Wheatstone Bridge, still the fundamental circuit for measuring dc resistance. Other null circuits, such as the admittance meter and transfer-function bridge, have been developed by General Radio to meet the diverse requirements of modern measurement. In all, GR produces 18 bridges, covering virtually the entire field of impedance measurement. Some of these bridges include built-in generator and detector and are thus complete, self-contained measurement systems. Others are available in combination with various General Radio oscillators and detectors, as complete assemblies.

DC BRIDGES

The Wheatstone bridge measures an unknown resistance, R_X, in terms of calibrated standards of resistance connected as shown in Figure 1. The relation is:

$$R_X = \frac{R_N R_B}{R_A} \qquad (1)$$

which is satisfied when the voltage across the detector terminals is zero.

AC BRIDGES

The Wheatstone bridge circuit is easily adapted to ac measurement. With complex impedances, two balance conditions must be satisfied, one for the resistive component and one for the reactive component. At balance:

$$Z_X = R_X + jX_X = Z_N Y_A Z_B \qquad (2)$$

or

$$Y_X = G_X + jB_X = Y_N Z_A Y_B \qquad (3)$$

Equation (2) expresses the unknown in terms of impedance components; equation (3) expresses the unknown as an admittance. To satisfy these equations, at least one of the three arms A, B, or N must be complex.

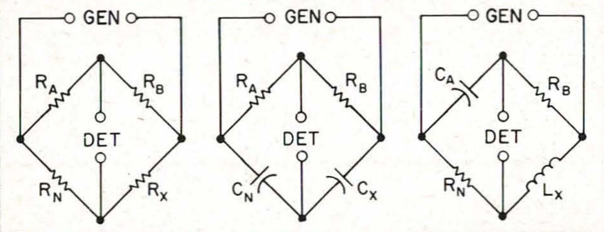
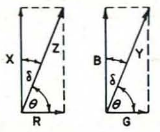


Figure 1. The general Wheatstone bridge circuit.

Figures 2 and 3. Circuits for capacitance bridges in which like reactances (left) or unlike reactances (right) are compared.



$$D = \cot\theta = \frac{R}{X} = \frac{G}{B} = \frac{1}{Q} = \tan\delta$$

Power Factor = $\cos\theta = \frac{R}{Z}$

$$Q = \tan\theta = \frac{X}{R} = \frac{B}{G} = \frac{1}{D} = \cot\delta$$

Figure 4. Vector diagram showing the relations between factors D and Q, and angles θ and δ

The reactance X_X can be measured in terms of a similar reactance in an adjacent arm (Figure 2) or an unlike reactance in the opposite arm (Figure 3).

The complex arm required to satisfy the balance conditions of equation (2) or (3) is a combination of a resistance and a reactance, in series or in parallel. With a **series** combination in an arm **adjacent** to the unknown or a **parallel** combination in the arm **opposite** the unknown, the bridge measures the equivalent series components of the unknown. Conversely, an adjacent parallel or an opposite series combination will yield a measurement of equivalent parallel components. (Every impedance can be expressed in terms of either series or parallel equivalents, as discussed below.) Examples of various combinations as used in the 1608 Impedance Bridge are shown on page 73.

If both components of this complex arm are adjustable, the balances for the real and imaginary parts of the unknown will be independent of each other and orthogonal. If only one component of the combination is adjustable, this component will be proportional to either the D or the Q of the unknown impedance. If the adjustable component is the more prominent of the two, as it is when very low-Q inductors are measured, the balance convergence is slow, if not impossible. The general-purpose 1650 Impedance Bridge and the 1617 Capacitance Bridge use a mechanical ganging of the bridge controls (called Orthonull®) to facilitate convergence.

D AND Q

An important characteristic of an inductor or a capacitor, and often of a resistor, is the ratio of resistance to reactance or of conductance to susceptance. The ratio is called dissipation factor, D, and its reciprocal is storage factor, Q. These terms are defined in Figure 4 in terms of phase angle θ and loss angle δ. Dissipation factor is directly proportional to energy dissipated, and storage factor to energy stored, per cycle. Power factor ($\cos\theta$ or $\sin\delta$) differs from dissipation factor by less than 1% when their magnitudes are less than 0.1.

In Figure 4, R and X are series resistance and reactance, and G and B are parallel conductance and susceptance, of the impedance or admittance involved.

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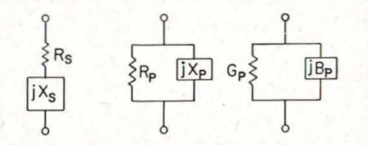


Figure 5. Series and parallel components of impedance.

Dissipation factor, D, which varies directly with power loss, is commonly used for capacitors. Storage factor, Q, is more often used for inductors because it is a measure of the voltage step-up in a tuned circuit. Q is also used for resistors, in which case it is usually very small.

Most General Radio capacitance and inductance bridges also measure D or Q.

SERIES AND PARALLEL COMPONENTS

Many GR impedance bridges give the user the option of measuring the unknown in terms of either its series or parallel equivalents. The choice is a matter of convenience for the problem at hand. Since the distinction between series and parallel equivalents is sometimes overlooked in texts, we will briefly summarize the relationships here.

Regardless of physical configuration, every impedance can be expressed, for any given frequency, as either a series or a parallel combination of resistance and reactance, as shown in Figure 5. The relations between the elements of Figure 5 are:

$$R_P = \frac{1}{G_P} = \frac{R_S^2 + X_S^2}{R_S} = R_S(1 + Q^2)$$

$$X_P = \frac{1}{B_P} = \frac{R_S^2 + X_S^2}{X_S} = X_S(1 + D^2)$$

In terms of series and parallel capacitive and inductive reactances, these relations become:

$$C_P = C_S\left(\frac{1}{1 + D^2}\right)$$

$$C_S = C_P(1 + D^2)$$

$$L_P = L_S\left(1 + \frac{1}{Q^2}\right)$$

$$L_S = L_P\left(\frac{Q^2}{1 + Q^2}\right)$$

Where:

$$Q = \frac{X_S}{R_S} = \frac{R_P}{X_P} = \frac{B_P}{G_P} = \frac{\omega L_S}{R_S} = \frac{R_P}{\omega L_P} = \frac{1}{D}$$

and

$$D = \frac{1}{Q} = \frac{R_S}{X_S} = \frac{X_P}{R_P} = \frac{G_P}{B_P} = \omega R_S C_S = \frac{1}{\omega R_P C_P} = \frac{1}{Q}$$

If Q is 10 or more (or if D is 0.1 or less), the difference between series and parallel reactance is no more than 1%. For very low Q's or high D's, however, the difference is substantial; when $Q = 1$, X_P is twice X_S. If there were no losses in the reactive elements (i.e., $D = 0$), X_S and X_P would be equal.

SUBSTITUTION METHODS

In many ac bridges, the unknown is connected in series or in parallel with the main adjustable component, and balances are made before and after the unknown is connected. The magnitude of the unknown then equals the change made in the adjustable component, since the total impedance of the unknown arm remains constant. The chief advantage of this substitution technique is that its accuracy depends only on the calibration of the adjustable arm and not on the other bridge arms (as long as they are constant). The substitution principle can also be used to advantage with any bridge if the balances are made with an external, calibrated, adjustable component.

BRIDGES WITH ACTIVE ELEMENTS

If a potentiometer-amplifier combination is connected as a bridge element, fixed capacitance and conductance standards can be used, with current adjusted by variation of voltage rather than of impedance magnitude. The principle is used in the Type 1633-A Incremental-Inductance Bridge, which can accurately measure nonlinear elements.

THE TRANSFORMER RATIO-ARM BRIDGE

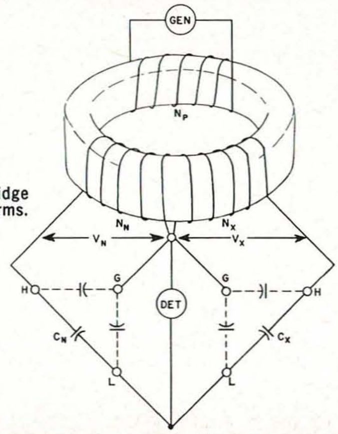
Transformer ratio arms, introduced almost a century ago, have recently come into considerable favor because of certain outstanding advantages. Ratio accuracies of a few parts per million are possible, even for transformer ratios of up to 1000 to 1, and the ratio is virtually unaffected by age, temperature, or voltage. Examples of the transformer bridge are the 1615 Capacitance Bridge and the 1680 Automatic Capacitance-Measuring Assembly.

Figure 6 shows a transformer bridge in elementary form. The balance condition for capacitance is

$$\frac{C_X}{C_N} = \frac{N_N}{N_X}$$

Figure 6 also explains the exceptional ability of the transformer bridge to make three-terminal measurements without the use of a guard circuit or auxiliary balance. Capacitances from the H terminals appear across the low-impedance transformer winding, while those from the L terminals are across the detector, where they do not enter the balance expression. These capacitances are thus excluded from the measurement of direct capacitance, C_X, between H and L terminals. Because this type of bridge can tolerate relatively large capacitances from both sides of the unknown to the guard point, long cables with guard shields can be used for remote measurement, and circuit capacitances can often be measured **in situ.**

Figure 6. A capacitance bridge with transformer ratio arms.



File Courtesy of GRWiki.org

Conventional bridges can also be adapted for three-terminal measurements (although they generally cannot tolerate as low an impedance to guard). On the Types 1650 and 1608 Impedance Bridges and 1617 Capacitance Bridge any stray capacitance is in parallel with a standard capacitor of at least 0.1 μF and usually has negligible effect. On the Type 1605 Impedance Comparator an electronic amplifier provides a guard point.

LIMIT BRIDGES AND COMPARATORS

In limit bridges, the unbalance voltage of the bridge actuates a meter, which indicates the degree of deviation of one impedance from another. The Type 1652-A Resistance Limit Bridge, which includes an adjustable standard resistor, can limit-test resistors over a wide range. The Type 1605 Impedance Comparator indicates the magnitude and phase differences between the unknown and an external standard. On this instrument, the availability of several sensitive ranges enables the user to measure small differences very accurately. For instance, the nominal $\pm 3\%$ accuracy of the comparator is translated into an actual measurement accuracy of $\pm 0.009\%$ on the $\pm 0.3\%$ full-scale range if suitable standards are used.

THE AUTOMATIC BRIDGE

The ultimate in convenience is a bridge that balances itself. The 1680-A Automatic Capacitance Bridge Assembly and 1681 Automatic Impedance Comparator System fully automate the balance procedure — selecting range, balancing, and presenting readout in both visual and digital data form.

The implications of such automatic measurement are far-reaching. The conversion of bridge-measured data into digital and binary-coded form (the 1680 and 1681 have binary-coded decimal output) gives the bridges access to the whole modern arsenal of data-processing equipment — computors, printers, tape-punchers, sorters, etc. Speed is one obvious byproduct of automatic equipment: GR's new automatic bridges take about one-half second to achieve balance.

COAXIAL-LINE INSTRUMENTS

The Slotted Line

The upper-frequency limit of conventional bridge circuits using lumped-parameter elements depends on the magnitude of the residual impedances of the elements and leads. The corrections for these usually become unmanageable at frequencies above a few hundred megacycles, and circuits based on coaxial-line techniques are more satisfactory.

One of the basic methods of measuring the impedance of a coaxial device is the measurement of the standing-wave ratio it introduces in a uniform line. The measurement is best made by a slotted line. General Radio offers two slotted lines: the Type 874-LBB, for general impedance measurements, and the highly accurate Type 900-LB, the most advanced slotted line available commercially.

The Admittance Meter

The GR 1602-B UHF Admittance Meter and 1609 UHF Bridge use adjustable loops to sample the currents flowing in three coaxial lines fed from a common source and terminated, respectively, in the unknown, a standard conductance, and a standard susceptance. The loops are adjusted so that the combined output from them is zero (a null balance). Scales associated with the three loops give the value of the unknown directly, in terms of admittance.

The Transfer-Function and Immitance Bridge

The Type 1607-A Transfer-Function and Immittance Bridge is similar to the Admittance Meter described above but also permits four-terminal measurements, such as those of forward and reverse transconductance and transsusceptance, transimpedance, and input-output voltage and current ratios. This bridge is widely used to evaluate the transfer characteristics of transistors and tubes in the vhf and uhf ranges.

GENERATORS AND DETECTORS

Several GR bridges includes both generator and detector. Some others — the Type 1615-A Capacitance Bridge and the Types 1632 and 1633 Inductance Bridges — are available as complete measuring assemblies, with generator, detector, interconnecting cables, relay rack, and other accessories. Unless one obtains such a complete system, he must carefully choose generator and detector to ensure satisfactory measurement results. (Even with a complete system, the user may at times wish to connect a different generator or detector to the bridge, and almost all GR bridges include panel connectors for such use.)

The chief generator requirements are good frequency stability, adequate power output, and low harmonic content. A wide choice of GR oscillators is available, covering the frequency range from audio to microwave.

Desirable detector characteristics are

(1) High sensitivity, preferably the ability to detect a few microvolts or less.

(2) High selectivity, to reject harmonics, noise, and other interfering signals. This is particularly important in measurements on iron-core coils and other nonlinear elements.

(3) Logarithmic or nearly logarithmic response, to minimize gain adjustment during the balancing procedure.

(4) Good shielding, to prevent errors from extraneous pickup.

At audio frequencies, GR's Type 1232-A Tuned Amplifier and Null Detector is recommended for its high sensitivity and for its general versatility in the lab. The Type 1212-A Unit Null Detector is useful up to several megacycles. Crystal mixers are available for both the detectors, extending their frequency ranges to about 60 MHz. At these and higher frequencies, the heterodyne type of detector is preferred, because of its wide frequency range and excellent shielding. Type DNT and 1241 detectors operate from 70 kHz to 2000 MHz.

One of the most popular generator-detector combinations, the Type 1311-A Audio Oscillator (50 Hz to 10 kHz) with the Type 1232-A Tuned Amplifier and Null Detector, is now available in a single assembly as the Type 1240-A Generator-Detector Assembly.

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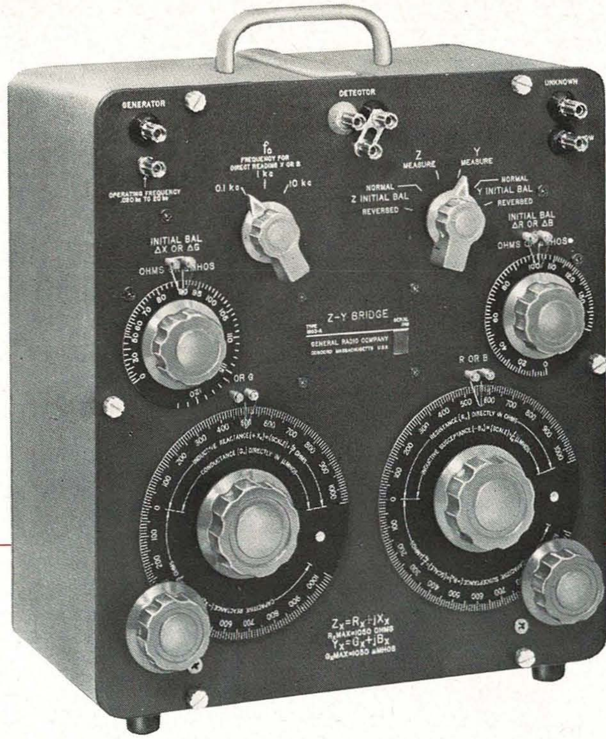
Z-Y BRIDGE

Type 1603-A



- 20 Hz to 20 kHz
- balances any impedance 0 to $\pm\infty$
- 1% accuracy

This unusual bridge can easily be balanced for any impedance connected to its terminals. For example, it can be used to measure:

R, L, and C components, or any combination of them.

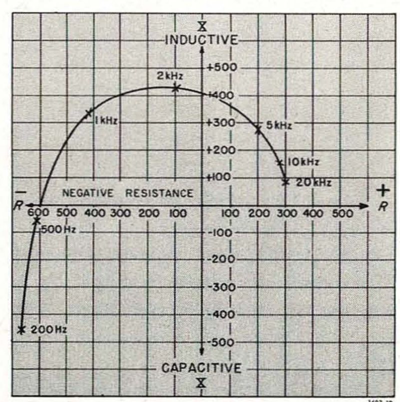
Impedances of active networks.

Complex impedance characteristics of transformers, transducers, transmission networks, and transistors.

Frequency characteristics of components, such as electrolytic capacitors and sonar elements.

The basic circuit is a resistance-capacitance bridge, and a substitution method of measurement is used. Low impedances are measured directly in terms of R and X, and high impedances (low admittances) are measured directly in terms of G and B. R and G readings are independent of frequency. X and B are direct reading at 100 Hz, 1 kHz, and 10 kHz.

By selection of detector connections, one can measure (1) the grounded impedance, (2) the direct impedance, or (3) the impedance of the equivalent delta circuit, balanced or unbalanced, of the unknown element.



Input impedance of a feedback circuit; data taken with 1603-A.

— For a more detailed description, ask for GR Reprint E-102.

specifications

RANGES OF MEASUREMENT

Frequency: 20 Hz to 20 kHz.

Impedance and Admittance: $-\infty$ to $+\infty$.

Unknown is measured as an impedance if the resistance is less than 1000 Ω and the reactance is less than 1000 $(f_o/f)\Omega$.

Unknown is measured as an admittance if the absolute conductance is less than 1000 μ℧ and the absolute susceptance is less than 1000 (f/f_o)μ℧.

ACCURACY (with unknown grounded)

R: ±1% ± (2 Ω on main dial or 0.2 Ω on ΔR dial) $\pm 0.0002\, f_{kHz}X$.

G: ±1% ± (2 μ℧ on main G dial or 0.2 μ℧ on ΔG dial) $\pm 0.0002 f_{kHz}B$.

X: ±1% ± $(2f_o/f$ Ω on main X dial or $0.2f_o/f$ Ω on ΔX dial) $\pm 0.0002 f_{kHz}R$.

B: ±1% ± $(2f/f_o$ μ℧ on main B dial or $0.2f/f_o$ μ℧ on ΔB dial) $\pm 0.0002 f_{kHz}G$.

These expressions are valid for R and G up to 20 kHz; for X and B the 1% term is valid up to 7 kHz; above 7 kHz it becomes 2%, above 15 kHz, 3%. Slightly larger errors occur at high frequencies for direct or delta measurements.

GENERAL

Accessories Supplied: 274-NP Patch Cord, 874-R34 Patch Cord.

Accessories Required: Generator and Detector. 1240-A Bridge Oscillator-Detector recommended.

Generator: 1311-A Oscillator recommended or 1210-C or 1310-A. Max safe voltage on bridge is 130 V rms, giving <32 V on unknown.

Detector: 1232-A recommended.

1311 Oscillator page 204

1232 Detector page 115

Mounting: Lab-Bench Cabinet.

Dimensions (width x height x depth): 12½ x 13½ x 8½ in. (320 x 345 x 220 mm).

Weight: Net, 21½ lb (10 kg), shipping, 31 lb (14.5 kg).

Catalog Number	Description	Price in USA
1603-9701	**1603-A Z-Y Bridge**	**$750.00**

File Courtesy of GRWiki.org

impedance bridges

IMPEDANCE COMPARATOR

Type 1605-A

- 0.1, 1.0, 10, and 100 kHz
- range: 2 Ω to 20 MΩ
  0.1 pF to 800 μF
  20 μH to 10,000 H
- 0.003% resolution with 1605-AH

The 1605 indicates directly on two panel meters the difference in impedance and phase angle between two external impedances, usually a standard and an unknown. The elements to be compared may be resistive, inductive, capacitive, or any combination. If essentially pure R, L, or C are measured, the meters read directly in ΔR, ΔL, or ΔC and ΔQ or ΔD.

Three highly desirable characteristics not usually obtained together are combined in this unique instrument:

— high accuracy
— high speed
— wide ranges of impedance and frequency.

As a result, not only does it bring laboratory accuracy to production-line inspection, but, conversely, it brings the speed of the production test to measurements in the laboratory.

TYPICAL USES

Rapid sorting and matching of precision components, subassemblies, and networks, manually or with automatic equipment.

Measuring the effects of time and environment on components, with high precision and continuous indication.

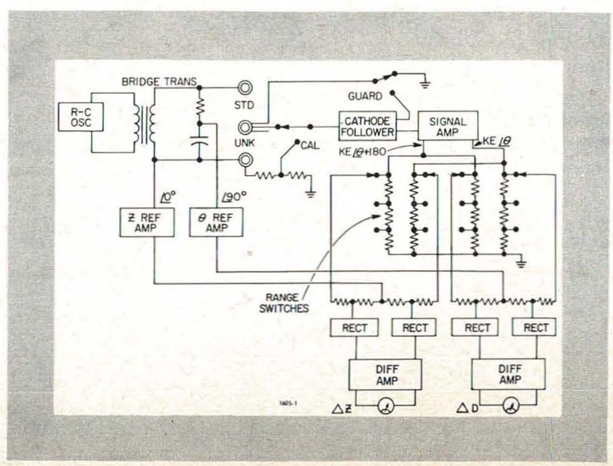
Rapid testing of the tracking of ganged potentiometers and variable capacitors.

Studying the frequency dependence of components.

Easy comparison of quantities usually requiring laboratory techniques, such as:

Small impedance differences.
D of low-loss dielectric materials.
D $\left(= \frac{1}{Q}\right)$ of inductors.
Q or phase angle of wire-wound resistors or potentiometers.
Balance of transformer windings.
Semiconductor capacitances.
Capacitance drift with temperature.

The external standard may be a component identical to the unknowns, but selected for a nominal value, or may be a calibrated fixed or, more convenient, variable standard. A wide selection of standards is available: the GR



Block schematic of the 1605-A Impedance Comparator.

File Courtesy of GRWiki.org

1422 Precision Capacitors for small values of C, the 1423, 1424, and 1425 Decade Capacitors for large values, the 1433 and 1434 Decade Resistors, and the 1491 Decade Inductors.

DESCRIPTION

The 1605 has built-in oscillator and indicators operating at four fixed frequencies, a guard connection for reducing the effect of stray impedances, and outputs for the connection of external indicators or automatic sorting or adjusting devices.

The basic circuit of the comparator is a bridge, with the unknown and standard impedances serving as two of the bridge arms and the halves of a center-tapped transformer secondary winding serving as the other two arms. The bridge unbalance voltage, resulting from inequality of standard and unknown impedances, is separated into in-phase and out-of-phase components, whose magnitudes are indicated on the panel meters.

An unusual type of cathode-follower circuit provides a very high input impedance for the bridge detector and also a guard terminal, which makes possible the measurement of high impedances at a distance from the instrument, as in an environmental test chamber.

Calibration can quickly be checked at any time by means of a simple built-in network.

For a more detailed description, ask for **GR Reprint E-103.**

specifications

RANGES AND ACCURACY

	1605-A	1605-AH
Impedance Range Resistance or Impedance Magnitude	2 Ω to 20 MΩ	20 Ω to 20 MΩ
Capacitance	40 pF* to 800 μF	40 pF* to 80 μF
Inductance	20 μH to 10,000 H	200 μH to 10,000 H
Impedance-Magnitude Difference	±0.3%, ±1%, ±3%, ±10%, full scale. Can be adjusted for maximum of 50%.	±0.1%, ±0.3%, ±1%, ±3%, full scale. Can be adjusted for maximum of 15%.
Phase-Angle Difference **	±0.003, ±0.01, ±0.03, ±0.1 radian, full scale.	±0.001, ±0.003, ±0.01, ±0.03 radian, full scale.
Accuracy	Difference readings accurate to within ±3% of full scale; i.e., for the ±0.3% impedance difference scale, accuracy is 0.009% of the impedance being measured.	

* To 0.1 pF with reduced accuracy.
** Phase-angle difference is very nearly equal to D difference for capacitors and inductors, or to Q difference for resistors, as long as D or Q is less than 0.1.

GENERAL

Test Frequency and Voltage: Internal only, 100 Hz, 1 kHz, 10 kHz, 100 kHz, all ±3%. Voltage across standard and unknown is approx 0.3 V for 1605-A and 1 V for 1605-AH.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz, approx 100 W. Operates satisfactorily on 400 Hz if line voltage is at least 115 V.

Accessories Supplied: CAP-22 Power Cord, telephone plug, external-meter plug, coaxial adaptor-plate assembly (fits panel terminals), spare fuses.

Models with other meter ranges and other frequencies are available on special order.

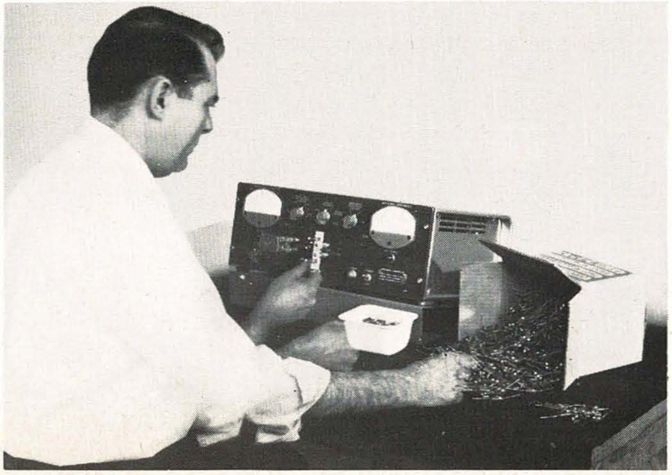
Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench, 19 x 7⅜ x 13½ in. (485 x 190 x 345 mm); rack, 19 x 7 x 12 in. (485 x 180 x 305 mm).

Weight: Net, 29½ lb (13.5 kg); shipping, 37 lb (17 kg).

Catalog Number	Description	Price in USA
	Impedance Comparator	
1605-9801	**1605-A,** Bench Model	**$1100.00**
1605-9811	**1605-A,** Rack Model	**1100.00**
1605-9951	**1605-AH,** Bench Model	**1100.00**
1605-9961	**1605-AH,** Rack Model	**1100.00**

PATENT NOTICE. See Note 15.



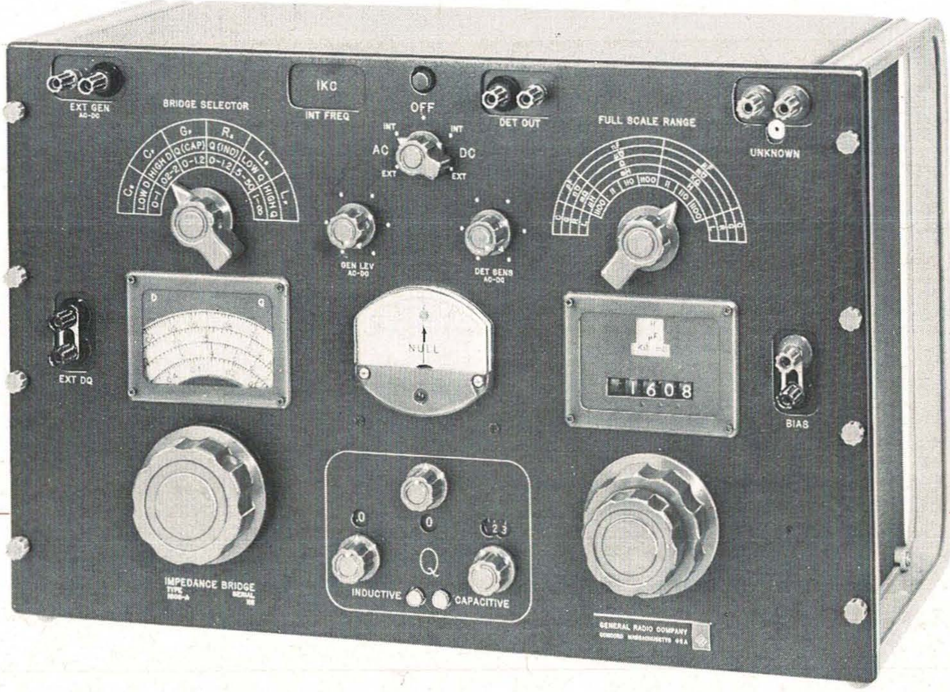
1605 Comparator permits fast manual sorting of components or can be connected to operate automatic sorting and logging devices.

File Courtesy of GRWiki.org

IMPEDANCE BRIDGE

Type 1608-A

- measures C, R, L, and G with digital readout
- ±0.1% accuracy
- 20 Hz to 20 kHz (external generator)
- internal 1-kHz oscillator and detector
- measures impedance of any phase-angle
- accurate D and Q readings



This wide-range bridge will measure precision components to an accuracy of 0.1% — capacitance, inductance, and ac as well as dc resistance and conductance. An almost error-free readout and rapid-balance adjustments allow accurate and fast laboratory or production tests. Six bridge circuits cover all possible phase angles so that any network can be measured, even such "black boxes" as filters, transducers, and equalizers.

In ac resistance and conductance measurements, a Q adjustment for precise balancing gives phase information useful in predicting high-frequency behavior. This capability is also useful for measuring lossy reactances, such as rf chokes, without a sliding null. The high phase precision of ±0.0005 radian makes D or Q measurements meaningful on low-loss reactances, which must often have tight D or Q tolerances for use in precision networks.

It will measure resistors at EIA-specified dc voltages, three-terminal capacitors and small capacitors remotely located, voltage-biased capacitors or current-biased inductors and resistors. Almost any impedance is measurable over the audio-frequency range.

The ability to measure small capacitances by a three-terminal connection makes possible the measurement of the capacitance between components, wires, or mounting structures. Long, shielded cables can be used without significantly affecting the accuracy of the measurement.

For production testing of components, a test jig, Type 1650-P1, is available.

DESCRIPTION

This self-contained bridge system includes six bridges, along with suitable ac and dc sources and detectors. The

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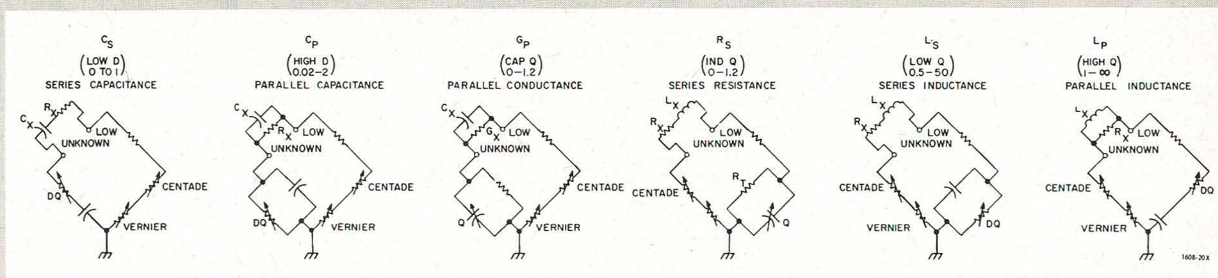


Elementary schematics of the capacitance, conductance, resistance, and reactance bridges.

bridge elements are precision units. The wire-wound resistors are similar to those used in GR decade resistance boxes; the standard capacitor is a combination silver-mica and stabilized-polystyrene unit, with a low temperature coefficient.

The readout system is digital for C, R, L, and G, as well as for the Q of resistors. D and Q for capacitors and inductors are read from a dial with the correct scale illuminated. Decimal points and units are indicated automatically, and there are no multiplying factors for any quantity at 1 kHz or dc.

The C-R-L-G readout has both coarse and fine adjustments controlled by concentric knobs.

The 1-kHz frequency-selective networks for the internal oscillator and tuned detector are on a plug-in module, which can be easily replaced with modules available for other internal test frequencies. Provision is made for use with an external oscillator and detector. Three dc supplies are included to obtain maximum sensitivity over a wide range of resistance.

— See **GR Experimenter** for March 1962.

specifications

RANGES

Capacitance: 0.05 pF to 1100 μF in seven ranges, series or parallel.

Inductance: 0.05 μH to 1100 H in seven ranges, series or parallel.

Resistance: (series) 0.05 milliohm to 1.1 megohms, ac or dc.

Conductance: (parallel) 0.05 nanomho to 1.1 mhos, ac or dc (20,000 megohms to 0.9 ohm).

D: (of series capacitance) — 0.0005 to 1 at 1 kHz.
(of parallel capacitance) — 0.02 to 2 at 1 kHz.

Q: (of series inductance) — 0.5 to 50 at 1 kHz
(of parallel inductance) — 1 to 2000 at 1 kHz.
(of series resistance) — 0.0005 to 1.2 inductive at 1 kHz.
(of parallel conductance) — 0.0005 to 1.2 capacitive at 1 kHz.

Frequency: 1 kHz with internal oscillator module supplied; 20 Hz to 20 kHz with external oscillator.

ACCURACY

C, G, R, L

At 1 kHz: ±0.1% ±0.005% of full scale except on lowest R and L ranges and highest C and G ranges, where it is ±0.2% ±0.005% of full scale.

Additional % error terms for high frequency and large phase angle:

C and L: ($\pm 0.001 f^2_{kHz} \pm 0.1 D f_{kHz} \pm 0.5 D^2$)% of measured value.
R and G: ($\pm 0.002 f^2_{kHz} \pm 0.000001 f^4_{kHz} \pm 0.1 Q$)% of measured value.

Residual Terminal Impedance: $R \simeq 0.001\ \Omega$, $L \simeq 0.15\ \mu H$, $C \simeq 0.25$ pF.

DC Resistance and Conductance: Same as for 1-kHz measurement, except that accuracy is limited by sensitivity at the range extremes. Balances to 0.1% are possible from 1 ohm to 1 megohm with the internal supply and detector.

D $\left(\text{or } \frac{1}{Q}\right)$ of C or L: ±0.0005 ±5% at 1 kHz or lower.
$\pm 0.0005 f_{kHz}$ ±5% above 1 kHz.

Q of R or G: $\pm 0.0005 f_{kHz}$ ±2%.

GENERAL

Generator: Internal, 1 kHz ±1% module normally supplied; plug-in modules for other frequencies available on special order. Level control provided. With external generator, frequency range of bridge is 20 Hz to 20 kHz. Type 1310-A or the 1210-C Oscillator recommended if external generator required. Internal dc supply 3.5, 35, and 350 V, adjustable; power limited to ⅓W or less.

Detector: Internal or external; ac; can be used either flat or selective at frequency of plug-in module (normally 1 kHz); other frequencies available; second-harmonic rejection of 25 dB. Sensitivity control provided. Type 1232-A Tuned Amplifier and Null Detector recommended when external generator is used.

Dc Bias: Capacitors can be biased to 500 V from external source; bias current can be applied to inductors up to 40 mA.

Test Jig page 75

1310 Oscillator page 201

1232 Detector page 115

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz; 10 W.

Accessories Supplied: Power cord, spare fuses, spare indicator lamps.

Accessories Available: 1650-P1 Test Jig.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench model, 19 x 12½ x 11½ in. (485 x 320 x 295 mm); rack model, 19 x 12¼ x 10 in. (485 x 315 x 255 mm).

Weight: Net, 36½ lb (17 kg); shipping, 54 lb (24.5 kg).

Catalog Number	Description	Price in USA
	1608-A Impedance Bridge	
1608-9801	Bench Model	**$1450.00**
1608-9811	Rack Model	**1450.00**

File Courtesy of GRWiki.org

IMPEDANCE BRIDGE

Type 1650-B

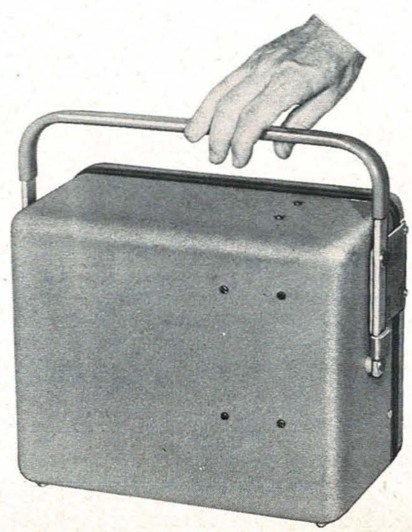
- measures L, C, and loss; R and G
- 1% accuracy
- 20 Hz to 20 kHz, internal 1 kHz and dc
- portable, self-contained, battery-operated

new

The 1650 Impedance Bridge will measure the inductance and storage factor, Q, of inductors*, the capacitance and dissipation factor, D, of capacitors, and the ac and dc resistance or conductance of resistors.

In the laboratory it is extremely useful for measuring the circuit constants in experimental equipment, testing preliminary samples, and identifying unlabeled parts. In the shop and on the test bench it has many applications for testing and component sorting.

Three-terminal measurements can be made in the presence of considerable stray capacitance to ground.



Flip-Tilt case provides protection when bridge is not in use.

DESCRIPTION

This bridge is completely self-contained and portable. Battery-powered, low-drain transistor oscillator and detector are included. The panel meter indicates both dc and ac bridge unbalances.

The measured quantities, R, G, L, C, D, and Q, are indicated directly on dials with constant-percentage-accuracy logarithmic scales. Multiplier and the units of measurement are indicated by the range setting.

The bridge circuit elements are high-quality, stable components that ensure long-term accuracy. The Orthonull® balance finder, a patented mechanical-ganging device, is used to make a low-Q (high-D) balance possible without a sliding null. This mechanism, which may be switched in or out as desired, adds accuracy as well as convenience to low-Q measurements that are practically impossible on other impedance bridges.

The Flip-Tilt case provides a handle and a captive, protective cover that allows the bridge panel to be tilted and held firmly at any angle.

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* Including such low-Q inductors as rf coils measured at 1 kHz.

File Courtesy of GRWiki.org

specifications

RANGES OF MEASUREMENT	ACCURACY 20 Hz to 20 kHz†	DC	Residuals
Capacitance 1 pF to 1100 μF, series or parallel, 7 ranges	±1% ±1 pF		≈0.5 pF
Inductance 1 μH to 1100 H, series or parallel, 7 ranges	±1% ±1 μH		≈ 0.2 μH
Resistance ac or dc, 1 mΩ to 1.1 MΩ, 7 ranges	±1% ±1 mΩ	±1%, 1 Ω to 100 kΩ, ext supply or detector required >100 kΩ and <1 Ω.	≈ 1 mΩ
Conductance ac or dc, 1 nanomho to 1.1 mhos, 7 ranges	±1% ±1 nanomho	±1%, 10 micromhos to 1 mho, ext supply or detector required <10 micromhos.	
Dissipation Factor, D, at 1 kHz, 0.001 to 1 of series C, 0.1 to 50 of parallel C.	±5% ±0.001 at 1 kHz and lower		
Storage Factor, Q, at 1 kHz, 0.02 to 10 of series L, 1 to 1000 of parallel L.	$\frac{1}{Q}$ accurate to ±5% ±0.001 at 1 kHz or lower		

† Bridge operates up to 100 kHz with reduced accuracy.

GENERAL

Generator: Internal; 1 kHz ±2%. Type 1310 or 1311 Oscillator recommended if external generator is required. Internal dc supply, 6 V, 60 mA, max.

Detector: Internal or external; internal detector response flat or selective at 1 kHz; sensitivity control provided. Type 1232-A Tuned Amplifier and Null Detector is recommended if external detector is required. Combination of 1311 oscillator and 1232 detector is available as the Type 1240 Bridge Oscillator-Detector.

DC Polarization: Capacitors can be biased to 600 V from external dc power supply for series capacitance measurements.

Power Required: 4 size-D cells, supplied.

Accessories Required: None. Earphones can be used for high precision at extremes of bridge ranges.

Accessories Available: Type 1650-P1 Test Jig.

Mounting: Flip-Tilt Cabinet.

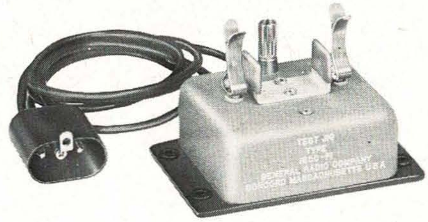
Dimensions (width x height x depth): Portable, 13 x 6¾ x 12¼ in. (330 x 175 x 315 mm); rack, 19 x 12¼ x 4⅛ in. (485 x 315 x 105 mm).

Net Weight (est): Portable, 17 lb (8 kg); rack, 18 lb (8.5 kg).

Shipping Weight (est): Portable, 21 lb (10 kg); rack, 30 lb (13.5 kg).

Catalog Number	Description	Price in USA
	1650-B Impedance Bridge	
1650-9702	Portable Model	**$450.00**
1650-9703	Rack Model	**450.00**

PATENT NOTICE. See Notes 15 and 22.



TEST JIG

Type 1650-P1

This test-jig adaptor is used to connect components quickly to a pair of terminals and can be placed on the bench directly in front of the operator. Thus, the test jig and 1650-B or 1608-A Impedance Bridge make a rapid and efficient component sorting device when the panel meter of the bridge is used as a limit indicator.

The test jig makes a three-terminal connection to the bridge, so that the residual zero capacitance is negligible.

The lead resistance (0.08 ohm total) has effect only when very low impedances are measured, and the lead capacitance affects only the measurement of the Q of inductors, introducing a small error in D $\left(\text{or } \frac{1}{Q}\right)$ of less than 0.007.

Weight: Net, 10 oz (285 grams); shipping, 4 lb (1.9 kg).

Catalog Number	Description	Price in USA
1650-9601	**1650-P1 Test Jig**	**$30.00**

File Courtesy of GRWiki.org

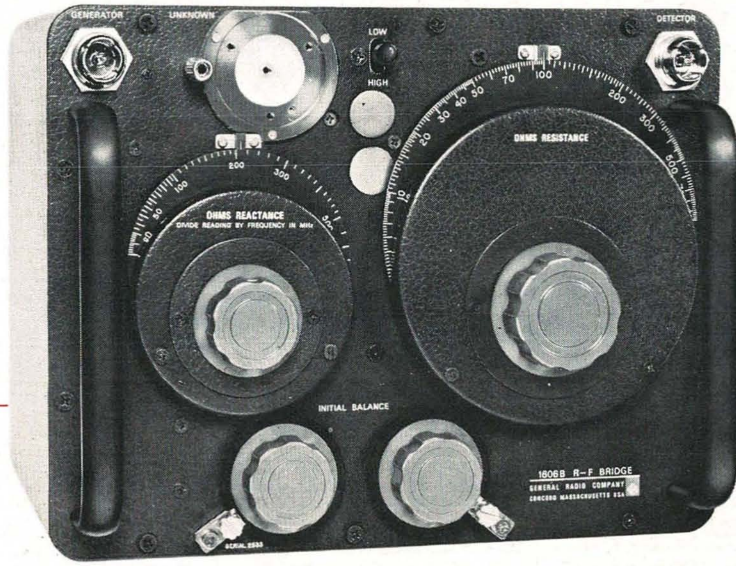
impedance bridges

RADIO-FREQUENCY BRIDGE

Type 1606-B

- 400 kHz to 60 MHz
- direct reading in ohms
- adaptable to coaxial connectors
- accurate, compact, simple operation

new



The 1606-B accurately and easily measures the resistance and reactance of antennas, transmission lines, networks, and components. It is particularly well suited for measuring low values of impedance of rf devices. Its range can be extended by means of an external parallel capacitor to measure high impedances.

PRECISION COAXIAL CONNECTIONS

In this latest model of the popular 1606 RF Bridge, the UNKNOWN terminals are adaptable to coaxial connectors, in particular the GR900. This is a significant advantage that not only permits the measurement of components having coaxial fittings but also ensures better repeatability and more accurate definition of the measurement plane. This permits the 1606 to be precision-calibrated against coaxial standards such as the 1406 Coaxial Capacitance Standards and the various GR900® precision components; open- and short-circuits, 50-, 100-, and 200-ohm Standard Terminations, and the various lengths of precision air line.

ACCESSORY ADAPTOR KIT

With the 1606-P2 adaptor kit, the 1606-B can be fitted to accept GR900 and GR874 connectors (the adaptors include compensation to match 50-ohm standards and components); it will also accept a 14-mm flange connector (a GR900 flange is included to convert GR900 connectors), or it can be adapted to other common connectors (N, BNC, TNC, etc) by the use of GR900 adaptors.

DESCRIPTION

Measurements are made by a series-substitution method in which the bridge is first balanced with a short circuit across the unknown terminals. The short is then removed, the unknown impedance connected, and the bridge rebalanced.

The entire mechanical design is such that the instrument can operate under difficult environmental conditions similar to those specified for testing military electronics equipment, which makes the 1606-B bridge an excellent instrument for field use.

— See **GR Experimenter** for September 1967.

specifications

RANGES OF MEASUREMENT	ACCURACY
Frequency: 400 kHz to 60 MHz. Satisfactory but somewhat less accurate operation can be obtained at frequencies as low as 100 kHz and somewhat above 60 MHz.	
Reactance: ±5000 Ω at 1 MHz. This range varies inversely as the frequency; at other frequencies the dial reading must be divided by the frequency in MHz.	**Reactance:** At frequencies up to 50 MHz, ±2% ±(1 + 0.0008 Rf)Ω where R is the measured resistance in ohms and f is the frequency in MHz.
Resistance: 0 to 1000 Ω.	**Resistance:** At frequencies up to 50 MHz, $\pm\left[1\% + 0.0024f^2\left(1+\frac{R}{1000}\right)\% \pm \frac{10^{-4}X}{f}\,\Omega + 0.1\,\Omega\right]$ (where X is the measured reactance in ohms). Subject to correction for residual parameters.

File Courtesy of GRWiki.org

GENERAL

Generator: External only (not supplied), to cover desired frequency range. Recommended, Type 1211-C and Type 1215-C Unit Oscillators, Type 1330-A Bridge Oscillator, Type 1310-A Oscillator, Type 1003 Standard-Signal Generator.

Detector: External only (not supplied). A heterodyne detector, Type DNT-6, is recommended for use above 3 MHz. A well shielded radio receiver is also satisfactory.

Accessories Supplied: 2 leads of different lengths to connect unknown impedance to bridge terminals; ½-in. spacer and ¾-in. screw to mount component to be measured directly on bridge terminals; 874-R22LA Patch Cord.

Accessories Available: Luggage-type carrying case, 1606-P2 Precision Coaxial Adaptor Kit.

Mounting: Welded aluminum cabinet.

Dimensions (width x height x depth): 12½ x 9½ x 10¼ in. (320 x 245 x 260 mm).

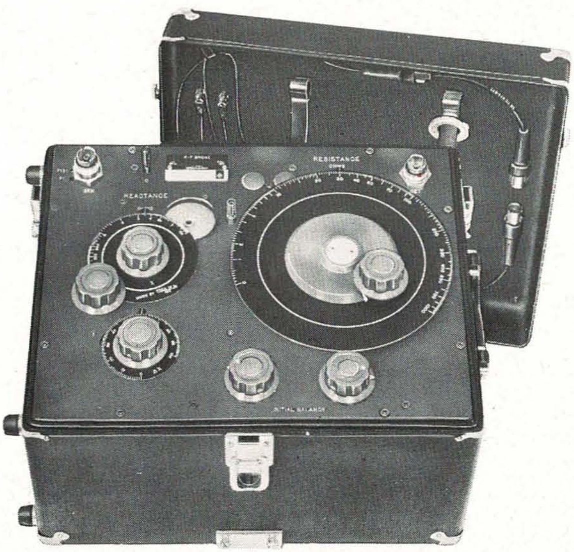
Weight. Net, 23 lb (10.5 kg), with case, 29 lb (13.5 kg); shipping, 30 lb (14 kg), with case, 31 lb (14.5 kg).

specifications for 1606-P2

Capacitance Added: By adaptor to GR900, 0.38 pF at reference plane (less fringing capacitance); by flange adaptor, 0.18 pF.

Weight: Net, 10 oz (270 g); shipping, 12 oz (340 g).

Catalog Number	Description	Price in USA
1606-9702	**1606-B Radio-Frequency Bridge**	**$1150.00**
1606-9601	**1606-P1 Luggage-Type Carrying Case**	**25.00**
1606-9602	**1606-P2 Precision Coaxial Adaptor Kit**	**95.00**



RADIO-FREQUENCY BRIDGE

Type 916-AL

- 50 kHz to 5 MHz
- wide reactance range: ±11,000 Ω, direct reading at 100 kHz
- high resolution ΔX dial

The 916-AL is excellent for antenna measurements. It uses the same series-substitution circuit as the Type 1606 to cover the low and medium frequencies between 50 kHz and 5 MHz.

An important feature is the ΔX dial, which greatly facilitates the measurement of large capacitances and small inductances.

specifications

RANGES OF MEASUREMENT

Frequency: 50 kHz to 5 MHz. Satisfactory operation for many measurements can be obtained at frequencies as low as 15 kHz.

Reactance: ±11,000 Ω at 100 kHz. This range varies inversely as the frequency; at other frequencies the dial readings must be divided by the frequency in hundreds of kHz.

ΔX Dial: 100 Ω at 100 kHz.

Resistance: 0 to 1000 Ω.

ACCURACY

Reactance: Below 3 MHz, $\pm(2\% + 0.2 \times \frac{100}{f_{kHz}}\,\Omega + 3.5 f^2_{kHz} R \times 10^{-10}\,\Omega)$, where R is the measured resistance in ohms and f_{kHz} is the frequency in kHz. The errors increase at frequencies above 3 MHz; at 5 MHz, the accuracy is $\pm(2\% + 0.01\Omega + 2.3R^{1.4} \times 10^{-3}\Omega)$.

Resistance: Below 5 MHz, ±(1% + 0.1Ω), subject to correction for residual parameters at low frequencies. The correction depends upon the frequency and upon the magnitude of the unknown reactance component.

GENERAL

Generator: External only (not supplied). 1330-A Bridge Oscillator, 1211-C Unit Oscillator, 1001-A, and 1003 Standard-Signal Generators recommended.

Detector: External only (not supplied). A heterodyne detector, the Type DNT-5, is recommended. A well shielded radio receiver is also a satisfactory detector.

Accessories Supplied: 2 leads of different lengths to connect unknown impedance to bridge terminals; 2 input transformers, one to cover lower portion of frequency range, the other the higher portion; 2 Type 874-R22LA Patch Cords to connect generator and detector.

Mounting: Luggage-type cabinet, shielded.

Dimensions (width x height x depth): 13½ x 17 x 11¼ in. (345 x 435 x 290 mm).

Weight: Net, 34½ lb (16 kg); shipping, 45 lb (20.5 kg).

Catalog Number	Description	Price in USA
0916-9831	**916-AL Radio-Frequency Bridge**	**$1200.00**

File Courtesy of GRWiki.org

CAPACITANCE BRIDGES AND STANDARDS

The following pages describe General Radio's lines of standard capacitors and capacitance bridges. Not included are the Type 1680 Automatic Capacitance Bridge Assembly and 1681 Automatic Impedance Comparator (see pages 51 through 59), and the many general-purpose GR bridges capable of measuring other impedance parameters as well as capacitance. See pages 65 through 78 for these bridges and an introductory discussion of impedance measurements in general.

CHOOSING A STANDARD CAPACITOR

A properly designed air capacitor approaches the ideal standard reactance in that it has very low loss and very small changes with time, frequency, and environment. Capacitance changes with changes in atmospheric pressure (about 18 ppm per inch Hg) and in relative humidity (about 2 ppm per % RH) can be eliminated by hermetic sealing of the capacitor. Changes with temperature can be reduced to a few ppm per °C by the use of low-temperature-coefficient materials in the capacitor. The maximum capacitance for an air-dielectric unit of practical size is of the order of 1000 pF. (See Types 1404, 1406, 1403.)

For higher capacitance, solid dielectrics are used. The preferred dielectric for standard capacitors is high-quality mica, because of its dimensional stability, low loss, and high dielectric strength. The temperature coefficient of a mica capacitor is of the order of +35 ppm per °C. At dc or extremely low frequencies the mica dielectric has the disadvantage of relatively large change of capacitance with frequency. (See Types 1409, 1423.)

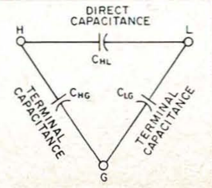
Polystyrene has a dielectric constant and dissipation factor very nearly constant with frequency, so that the capacitance change from dc to 1 kHz is a small fraction of a percent. The temperature coefficient of a polystyrene capacitor is, however, of the order of −140 ppm per °C. (See Types 1424, 1425.)

TWO-TERMINAL AND THREE-TERMINAL CONNECTIONS

Most capacitors can be represented by the three capacitances shown in Figure 1: the direct capacitance C_{HL}, capacitance between the plates of the capacitor and the two terminal capacitances, C_{HG} and C_{LG}, which are capacitances from the corresponding terminals and plates to the capacitor case, surrounding objects, and to ground (to which the case is connected either conductively or by its relatively high capacitance to ground).

In the two-terminal connection, the capacitor has the L and G terminals connected together, i.e., the L terminal is connected to the case. The terminal capacitance, C_{LG}, is thus shorted, and the total capacitance is the sum of C_{HL} and C_{HG}. Since one component of the terminal capacitance C_{HG} is the capacitance between the H terminal and surrounding objects, the total capacitance can be changed by changes in the environment, particularly by the introduction of connecting wires. Such changes can cause uncertainties of a few tenths of a picofarad in the calibration of two-terminal capacitors that use banana pins for the connection. More accurate two-terminal calibrations, with connection uncertainties no more than a few femtofarads (thousandths of a picofarad) can be made by use of precision coaxial connectors such as the GR900® connectors used on Type 1406 Coaxial Capacitance Standards. For accuracy at high frequencies, i.e. around 1 MHz, such precision two-terminal connections are necessary. At lower frequencies, i.e. around 1 kHz, precision two-terminal connections are useful, but here most of the connection uncertainties can be eliminated by the use of three-terminal capacitors and measurements*.

Figure 1.



A three-terminal capacitor (Figure 1) has connected to the G terminal a shield that completely surrounds at least one of the terminals (H), its connecting wires, and its plates except for the area that produces the desired direct capacitance to the other terminal (L). Changes in the environment and the connections can vary the terminal capacitances, C_{HG} and C_{LG}, but the direct capacitance C_{HL} is determined only by the internal geometry.

This direct capacitance can be calibrated by three-terminal measurement methods, which use guard circuits or transformer-ratio-arm bridges to exclude the terminal capacitances.

The direct capacitance can be made as small as desired, since the shield between terminals can be complete except for a suitably small aperture. The losses in the direct capacitance can also be made very low because the dielectric losses in the insulating materials can be made a part of the terminal impedances. When the three-terminal capacitor is connected as a two-terminal, the two-terminal capacitance will exceed the calibrated three-terminal value (C_{HL}) by at least the terminal capacitance C_{HG}.

Measurements on very large capacitors are subject to uncertainties due to series impedance that can be avoided by four-terminal measurements, a technique regularly used in precision measurement of low resistance. The 1617-A Capacitance Bridge and 1426 Capacitance Standard employ four-terminal connections.

FREQUENCY CHARACTERISTICS

Although the characteristics of the high-quality capacitors used as standards closely approach those of the ideal capacitor, to obtain high accuracy the small deviations from ideal performance must be examined and evaluated. The residual parameters that cause such deviations are shown in the lumped-constant, two-terminal equivalent circuit of Figure 2. R represents the metallic resistance in the leads, supports, and plates; L, the series inductance of the leads and plates; C, the capacitance between the plates; C_k, the capacitance of the supporting structure. The conductance, G, represents the dielectric losses in

*John F. Hersh, "A Close Look at Connection Errors in Capacitance Measurements," General Radio Experimenter, July 1959.

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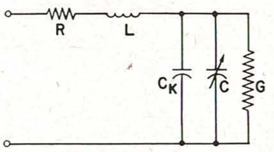


Figure 2.

the supporting insulators, the losses in the air or solid dielectric between capacitor plates, and the dc leakage conductance.

The effective terminal capacitance C_e of the capacitor becomes greater than the electrostatic or zero-frequency capacitance C_o as the frequency increases because of the inductance L. When the frequency, f, is well below the resonance frequency f_r (defined by $\omega_r^2 LC_o = 1$), the fractional increase in capacitance is approximately

$$\frac{\Delta C}{C_o} \approx \omega^2 LC_o = \left(\frac{f}{f_r}\right)^2 \qquad (1)$$

This change in capacitance with frequency for the capacitors described on the following pages is given either as a plot on logarithmic co-ordinates of the percent increase, $\Delta C/C_o$, versus frequency or as a tabulation of the values of L or f_r. Since the inductance is largely concentrated in the leads and supports, it is nearly independent of the setting of a variable capacitor. With this information, the increase in capacitance at, for example, a frequency of 1 MHz can be computed from the calibrated value at 1 kHz with high accuracy. For small increases, the accuracy may be greater than that of a measurement at 1 MHz because of the difficulties in determining the measurement errors produced by residuals in the connecting leads outside the capacitor.

The three-terminal capacitor has a similar increase in capacitance produced by inductance. The lowest resonance is determined not solely by the calibrated direct capacitance but also by the terminal capacitances, which may be much larger than the direct capacitances (see equivalent circuit of Type 1403 Capacitors).

New high-frequency capacitance standards, Types 1405 and 1406, use coaxial connectors with low-inductance design to reduce series inductance to a few nanohenries.

When the capacitor has a solid dielectric, such as mica, there is another source of capacitance change with frequency. The capacitance increases at low frequencies as the result of dielectric absorption caused by interfacial polarization in the dielectric. The change in capacitance with frequency of a 1000-pF capacitor with mica dielectric is shown in Figure 3. The dotted line slanting downward to the right represents the change in the dielectric constant of mica resulting from interfacial polarization; that slanting upward to the right shows the change in effective capacitance resulting from series inductance. The magnitude of the change at low frequencies depends upon the dielectric material and is, for example, much smaller for polystyrene than for mica.

DISSIPATION FACTOR

The dissipation factor of a capacitor is determined by the losses represented in Figure 2 by R and G. The resistance R is not usually significant until the frequency is high enough for the skin effect to be essentially complete. At such frequencies the resistance varies as the square root of frequency and may be expressed as $R_1\sqrt{f}$, where R_1 is the resistance at 1 MHz and f is the frequency in MHz. The total dissipation factor at high frequencies is then

$$D = \frac{G}{\omega C} + R_1\sqrt{f}\,\omega C \qquad (2)$$

At low frequencies only the dielectric losses represented by G are important. The leakage conductance component is negligible at frequencies above a few hertz and is important only when the capacitor is used at dc for charge storage. The dominant components at audio frequencies are the dielectric losses in the insulating structure and in the dielectric material between the plates.

In the air capacitor the losses in the air dielectric and on the plate surfaces are negligible under conditions of moderate humidity and temperature. The loss is, therefore, largely in the insulating supports. When good-quality, low-loss materials, such as quartz, ceramics, and polystyrene, are used for insulation, the conductance varies approximately linearly with frequency and the dissipation factor, D_k, of the supports is nearly constant with frequency. The total low-frequency dissipation factor of an air capacitor whose equivalent circuit is that of Figure 2 may be expressed as

$$D = \frac{G}{\omega(C + C_k)} = \frac{D_k C_k}{C + C_k} \qquad (3)$$

When the capacitance C is variable, this D is then inversely proportional to the total capacitance. Since the quantity $D_k C_k$ is nearly independent of both frequency and capacitance setting, it is a convenient figure of merit for a variable capacitor.

In a capacitor with a solid dielectric the dominant component of the conductance G is the loss in the dielectric, which varies with frequency. The resulting variation of D with frequency, shown for a mica capacitor in Figure 3, is the sum of three principal components: a constant dissipation factor caused by residual polarizations; a loss produced by interfacial polarizations, which decreases with frequency; and an ohmic loss in the leads and plates, which results in a D proportional to the 3/2 power of frequency. The total dissipation factor has a minimum value at a frequency that varies inversely with capacitance and which ranges from 1 kHz to 1 MHz for capacitance values from 1 μF to 100 pF.

The capacitors described in these pages include air-dielectric reference standards, both fixed and variable, both fixed and decade mica-dielectric, and other decades with polystyrene, mica, and paper dielectric.

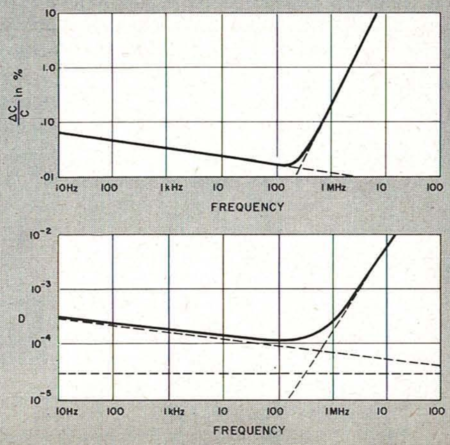


Figure 3. Variation with frequency of capacitance and dissipation factor for a 1000-pF mica capacitor, Type 1409.

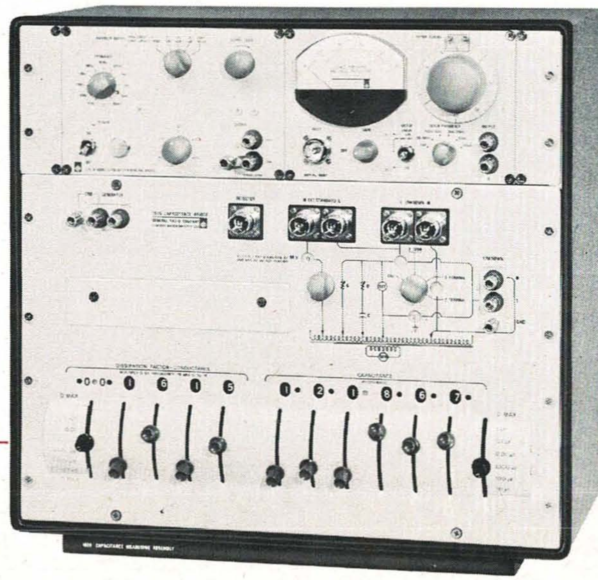
File Courtesy of GRWiki.org

capacitance measuring

CAPACITANCE-MEASURING ASSEMBLY

Type 1620-A

- 10^{-5} pF to 11.1 μF, 2- or 3-terminal
- 0.01% accuracy, 1 ppm resolution
- lever balance, in-line readout
- reads dissipation factor or conductance



1620-A Capacitance-Measuring Assembly including: 1615-A Capacitance Bridge, 1311-A Oscillator, 1232-A Tuned Amplifier and Null Detector

The 1620-A is a self-contained assembly of the GR 1615-A Capacitance Bridge with appropriate oscillator and null detector for measurements at 11 frequencies between 20 Hz and 20 kHz. For applications requiring other or higher frequencies, to 100 kHz, the 1615-A bridge can be supplied separately and the oscillator and detector selected as needed.

The 1620-A is intended for

- accurate and precise measurements of capacitance and dissipation factor
- measurement of circuit capacitances
- dielectric measurements
- intercomparison of capacitance standards differing in magnitude by as much as 1000:1

The 1615-A Capacitance Bridge brings to the measurement of capacitance, to the intercomparison of standards, and to the measurement of dielectric properties an unusual degree of accuracy, precision, range, and convenience.

High accuracy is achieved through the use of precisely wound transformer ratio arms and highly stable standards fabricated from Invar and hermetically sealed in nitrogen. For calibration these standards can be intercompared.

TWO- OR THREE-TERMINAL CONNECTION

Accurate three-terminal measurements can be made even in the presence of capacitances to ground as large as 1 μF as might be encountered with the unknown connected by means of long cables. The bridge has the necessary internal shielding to permit one terminal of the unknown to be directly grounded, so that both true two-terminal and three-terminal measurements can be made over the whole capacitance range.

CONVENIENT OPERATION

For both capacitance and dissipation factor, the balance controls are smoothly operating, lever-type switches. The readout is digital, and the decimal point is automatically positioned. Each capacitance decade has a -1 position to facilitate rapid balancing.

The circuit, shown here in elementary form, is also clearly delineated on the panel. Changes in connections and grounds are automatically indicated as the bridge terminals are switched for different measurement conditions.

EXTEND RANGE TO 11.1 μF

With the 1615-P1 Range-Extension Capacitor the 1615-A will measure to a maximum of 11.11110 μF. It plugs into front-panel bridge terminals and can be adjusted for calibration to the bridge.

— See **GR Experimenter** for August-September 1962.

specifications

(see 1615 for performance specifications)

Frequency: 50, 60, 100, 120, 200, 400, 500, 1000, 2000, 5000, and 10,000 Hz. For use below 100 Hz, 1620-AP (with preamplifier) should be used for resolution beyond 0.01% or 0.01 pF.

Generator: 1311-A Oscillator.

Detector: 1232-A Tuned Oscillator and Null Detector. 1232-P2 Preamplifier added in 1620-AP.

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 22 W for oscillator. Null detector and preamplifier operate from internal battery.

Mounting: Assembled in cabinet.

Weight: Net, 59 lb (27 kg); shipping, 96 lb (44 kg).

Catalog Number	Description	Price in USA
	Capacitance-Measuring Assembly	
1620-9701	**1620-A**	**$2380.00**
1620-9829	**1620-AP, with 1232-P2 detector preamplifier**	**2470.00**

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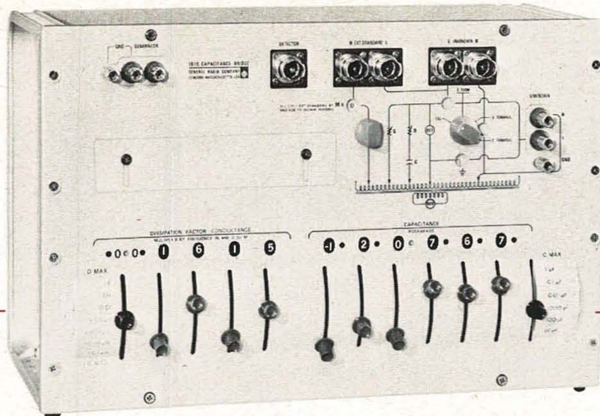
CAPACITANCE BRIDGE

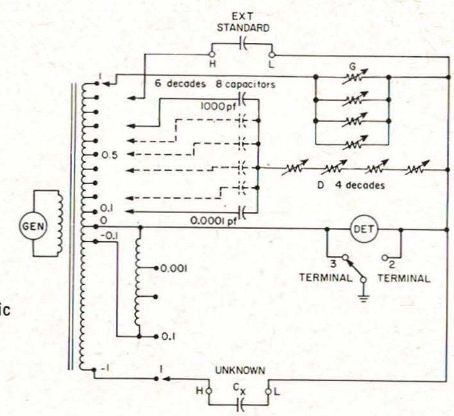
Type 1615-A



The 1615-A is an accurate, high-precision bridge for the measurement and intercomparison of standard capacitors, circuit component capacitors, or dielectric materials. It is available with oscillator and detector in the 1620 assembly listed on the previous page. Or, to take full advantage of its wide frequency range, the bridge can be ordered separately for use with oscillator and detector especially selected for the purpose or already in hand.

1615-P1

1615-P2



Elementary schematic diagram of the capacitance bridge.

specifications

RANGES OF MEASUREMENT	ACCURACY
Capacitance, 10 aF to 1.11110 μF (10^{-17} to 10^{-6} farad) in 6 ranges, direct-reading, 6-figure resolution; least count 10^{-17} F (10 aF). With Range-Extension Capacitor, upper limit is 11.11110 μF.	At 1 kHz, $\pm$(0.01% + 0.00003 pF). At higher frequencies and with high capacitance, additional error is $[\pm 3 \times 10^{-5}\% + 2 \times 10^{-3}\% \, (C_{\mu F}) \pm 3 \times 10^{-7} \text{ pF}] \times f^2_{kHz}$. At lower frequencies and with low capacitance, accuracy may be limited by bridge sensitivity. Comparison, accuracy, unknown to external standard, 1 ppm.
Dissipation Factor, D, At 1 kHz, 0.000001 to 1, 4-figure resolution; least count, 0.000001; range varies directly with frequency.	$\pm[0.1\%$ of measured value $+ 1 \times 10^{-5} (1 + f_{kHz} + 5 f_{kHz} C_{\mu F})]$
Conductance, G, 10^{-6} μ℧ to 100 μ℧, 2 ranges +, 2 ranges −, 4-figure resolution, least count 10^{-6} μ℧ independent of frequency; range varies with C range.	$\pm[1\%$ of measured value $+ 1 \times 10^{-5}$ μ℧ $+ 6 \times 10^{-2} f_{kHz} C_{\mu F} \times (1 + f_{kHz} + 5 f_{kHz} C_{\mu F})$ μ℧$]$

FREQUENCY: Approx 50 Hz to 10 kHz. Useful with reduced accuracy to 100 kHz. Below 100 Hz, resolution beyond 0.01% or 0.01 pF requires preamplifier or special detector.

GENERAL

Standards: 1000, 100, 10, 1, 0.1, 0.01, 0.001, 0.0001 pF. Temperature coefficient of capacitance is less than 5 ppm/°C for the 1000-, 100-, and 10-pF standards, slightly greater for the smaller units.

Generator: Type 1310-A or 1311-A oscillator recommended. Max safe generator voltage 30 x f_{kHz} volts, 300 V max. If generator and detector connections are interchanged, 150 to 500 V can be applied, depending on switch settings.

Detector: Type 1232-A Tuned Amplifier and Null Detector recommended. For increased sensitivity needed to measure low-loss small capacitors (on lowest C and D ranges simultaneously) at frequencies below 1 kHz,use 1232-AP.

Accessories Supplied: 874-WO Open-Circuit Termination, 874-R22A Patch Cord, 274-NL Patch Cord.

Accessories Available: Type 1615-P1 Range-Extension Capacitor. 1615-P2 Coaxial Adaptor converts 2-terminal binding-post connection on 1615 bridge to GR900 Precision Coaxial Connector for highly repeatable connections; enables measurements with adaptor to be direct-reading by compensating for terminal capacitance.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench model, 19 x 12¾ x 10½ in. (485 x 325 x 270 mm); rack model, 19 x 12¼ x 8½ in. (485 x 315 x 220 mm); 1615-P1, 3-1/16 in. dia. x 4⅞ in. (78 x 125 mm).

Weight: Net, 38½ lb (17.5 kg); shipping, 58 lb (27 kg).

Catalog Number	Description	Price in USA
	1615-A Capacitance Bridge	
1615-9801	Bench Model	**$1675.00**
1615-9811	Rack Model	**1675.00**
1615-9601	**1615-P1 Range-Extension Capacitor**	**65.00**
1615-9602	**1615-P2 Coaxial Adaptor, GR900 to binding posts**	**75.00**

Oscillators page 200 ff

1232 Detector page 115

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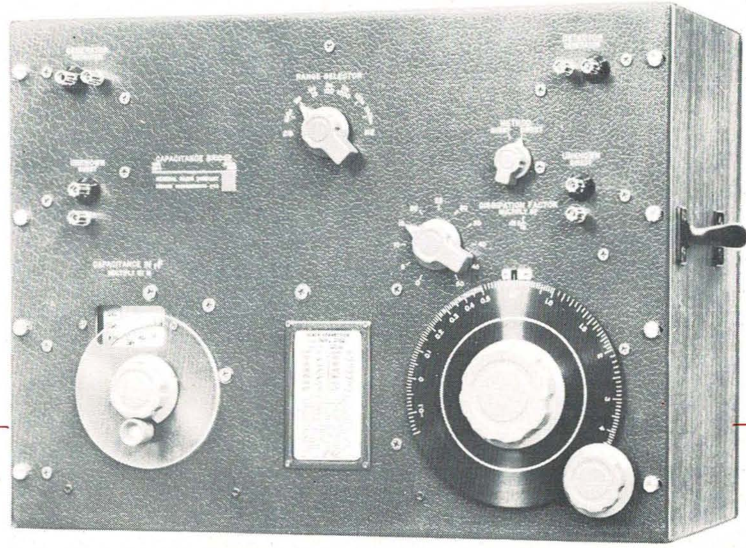
CAPACITANCE BRIDGE

Type 716-C



- 30 Hz to 300 kHz
- C: 0.1 pF to 1.1 μF, ±0.1%
- D: 0.00002 to 0.56, ±2%

The 716-C is a modified Schering bridge that measures capacitance and dissipation factor by either direct or substitution method.

This capacitance bridge is particularly well suited to the measurement of the dielectric properties of insulating materials and to the measurement of small values of capacitance and/or large values of dissipation factor at high and low frequencies. With corrections, accurate results can be obtained to 1 MHz.

By substitution methods, one can measure the inductance and Q of large inductors, the inductance and resistance of cables, the resistance and parallel capacitance of high-valued resistors, and the conductance and parallel resistance of electrolytes.

specifications

RANGES OF MEASUREMENT	ACCURACY At 30 Hz to 300 kHz
Capacitance (direct-reading) 100 pF to 1.1 μF at 1 kHz, 100 pF to 1150 pF at 100 Hz, 10 kHz, and 100 kHz.	±0.1% ±(0.6 pF × capacitance multiplier setting) when D <0.01. Residual C is approx 1 pF.
Capacitance (substitution) 0.1 pF to 1050 pF with internal standard. 0.1 pF up to value of available standard with external standard.	±1.2 pF. Correction chart for the precision capacitor is supplied, which allows a substitution measurement accuracy of ±0.05% or ±0.6 pF. With additional Precision Calibration of standard capacitor, ±0.05% or ±0.2 pF.
D (direct reading) 0.00002 to 0.56	±0.0005 or ±2% of dial reading, whichever is larger.
D (substitution) 0.00002 to 0.56 × $\frac{C_{STD}}{C_{UNK}}$	±0.00005 or ±2% for the change in D when the change is less than 0.06. Corrections are supplied for greater D's.

GENERAL

Temperature and Humidity Effects: Bridge accuracy not significantly affected by variations of temperature from 65 to 95°F. Precise measurements of dissipation factor should not be attempted when the bridge has been exposed to abnormally high relative humidity, unless it is first dried by heat or a desiccant.

Generator: External only (not supplied); 30 Hz to 300 kHz; 1 W max, which allows 200 V at 1 kHz or 50 V at 60 Hz. If generator and detector connections are interchanged, 700 V can be applied at 1 kHz and lower. Type 1311-A or 1310-A Oscillator recommended.

Detector: External only (not supplied). Type 1232-A Tuned Amplifier and Null Detector recommended for audio range; for higher frequencies, add 1232-P1 Mixer and local oscillator.

Accessories Supplied: 274-NL Shielded Patch Cord, 874-R34 Patch Cord.

Accessories Available: Type 1422 Precision Capacitor, 1409 Fixed Capacitors, and 1423 Precision Decade Capacitor as balancing capacitors for substitution measurements. Type 1690-A Dielectric Sample Holder for dielectric measurements.

Mounting: Wooden cabinet or relay rack.

Dimensions (width x height x depth): Bench model, 21¾ x 14¼ x 11¼ in. (555 x 365 x 290 mm); rack model, 19 x 14 x 9 in. (485 x 360 x 230 mm).

Net Weight: Bench model, 40½ lb (18.5 kg); rack model, 30½ lb (14 kg).

Shipping Weight: Bench model, 55 lb (25 kg); rack model, 45 lb (20.3 kg).

Catalog Number	Description	Price in USA
	716-C Capacitance Bridge	
0716-9803	Bench Model	**$1150.00**
0716-9483	with Precision Calibration	**1220.00**
0716-9813	Rack Model	**1100.00**
0716-9484	with Precision Calibration	**1170.00**

PATENT NOTICE. See Note 15.

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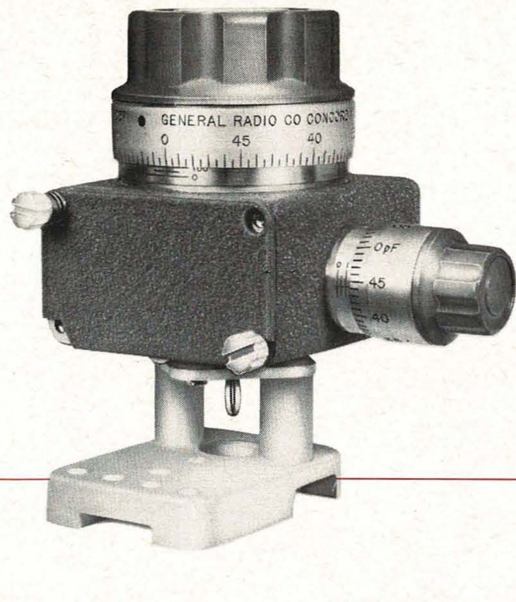
DIELECTRIC SAMPLE HOLDER

Type 1690-A



- micrometer-electrode-type for dielectric disks
- wide frequency range; fits many instruments
- calibration corrects for fringing and strays
- stable mounting, complete shielding

The 1690-A is a sample-holder of the Hartshorn and Ward type,* used for the measurement of dielectric constant, dissipation factor, and volume resistivity of 2-inch-diameter, or less, disks of dielectric material in accordance with ASTM test method D-150. It is suitable for any flat sample whose largest diameter is not over 2 inches and whose thickness is not over 0.3 inch.

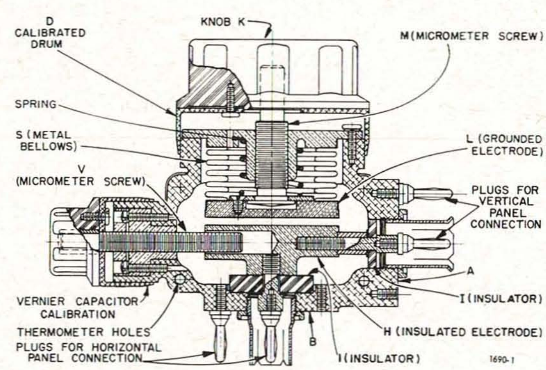
It can be used with resonant circuits for susceptance-variation or frequency-variation measurements, with the Types 1615-A and 716-C Capacitance Bridges, the 874-LBB and 900-LB Slotted Lines, the 1602-B and 1609 immittance meters, and the 1644-A Megohm Bridge.

A precision micrometer screw, M, with large instrument knob, K, drives the movable grounded electrode, L, with respect to a fixed, insulated electrode, H. An accurately divided drum, D, indicates the electrode spacing. The micrometer screw is electrically shunted by a metal bellows, S, to assure a positive, low-resistance connection. A release mechanism automatically disengages the drive to prevent damage when the electrodes are in contact. The movable electrode adjusts itself to the plane of the specimen surface.

The vernier capacitor with micrometer screw, V, is for use in the susceptance-variation method of measurement, and for precise C balance with low-loss samples.

The assembly is mounted in a rugged aluminum casting, B, which shields it on four sides. Two removable cover plates, which permit access to the electrodes, complete the shielding. The holder can be mounted on either horizontal or vertical panels.

* L. Hartshorn and W. H. Ward, Proceedings of the Institution of Electrical Engineers, Vol. 79, pp. 597-609 (1936).



specifications

Electrodes: Diameter, 2.000 in. ± 0.0025 in. Surfaces ground optically flat within a few wavelengths.

Electrode Spacing: Adjustable from zero to 0.3 in., indicated by micrometer reading in mils.

Vernier: Incremental capacitance is 5 pF, nominal.

Calibration: For main capacitor, a chart gives calculated air capacitance as a function of spacing. Correction curve gives the measured deviations from calculated values over range from 300 mils to 10 mils spacing. In accordance with recommended ASTM practice, calibration is referred to the calculated geometric value at a spacing of 100 mils. Accuracy is ±0.2% ±0.1 mil.

For vernier capacitor, correction chart is provided, from which capactance differences can be determined to an accuracy of ±0.004 pF.

Zero Capacitance: Approx 11 pF.

Operating Temperature: Up to 100°C.

Frequency: No significant error occurs at frequencies below 100 MHz.

Accessories Supplied: 1690-P1 Adaptor Assembly for mounting to 1615-A and 716-C Capacitance Bridges; hardware for mounting sample holder on 1644-A Bridge and 1862-C Megohmmeter.

Accessories Available: 1690-P2 Adaptor Assembly to 874-LBB Slotted Line or 1602-B UHF Admittance Meter; 900-Q874 Adaptor to 900-LB Precision Slotted Line and 1609 UHF Immittance Bridge.

Mechanical Data: Carrying and storage case supplied.

Dimensions: 6¼ x 5¾ x 4½ in. (160 x 150 x 115 mm).

Weight: Net, 3¾ lb (1.8 kg); shipping, 13 lb (6 kg).

Catalog Number	Description	Price in USA
1690-9701	**1690-A Dielectric Sample Holder**	**$650.00**
1690-9602	**1690-P2 Adaptor Assembly (for connecting to GR874 coaxial equipment)**	**45.00**

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CAPACITANCE BRIDGE

Type 1617-A

- 1 pF to 1.1 farads
- 20 Hz to 1 kHz
- 1% accuracy
- 2-, 3-, or 4-terminal connections

new

SELF-CONTAINED BRIDGE

The 1617-A was specifically designed for measuring capacitance, dissipation factor, and leakage current of electrolytic capacitors, but it will also find considerable use as a general-purpose 1% bridge. It is completely self-contained, including a 120-Hz generator, null detector, dc polarizing-voltage supply, and metering for bias voltage and leakage current. At frequencies other than 120 Hz, an external oscillator is needed.

Calibrate with 1426 page 92

MULTITERMINAL CONNECTIONS

An unknown capacitor can be connected to the bridge by means of three- or four-terminal connections, as well as the usual two-terminal. The four-terminal connection permits accurate measurement of large capacitance by reducing the effect of the resistance and inductance of leads and connections. Correct readings of small capacitances are assured by the three-terminal connection, which reduces the effect of stray lead capacitance. These multiterminal configurations are necessary for accurate measurement of capacitors connected by long cables as, for instance, in tests on capacitors in an environmental chamber.

This bridge includes an Orthonull® balance finder, which speeds up measurements of high-dissipation-factor capacitors by eliminating troublesome sliding balance. The operator's safety is assured by warning lights indicating the presence of voltage on the bridge terminals.

— See **GR Experimenter** for June 1966.

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specifications

Quantity	Frequency	Range	Accuracy *
Capacitance	120 Hz internal	0 to 0.11 F	±1% ±1 pF, smallest division 2 pF; residual ("zero") capacitance approx 4 pF
		0.11 F to 1.1 F	±2%
	40 Hz to 120 Hz external (useful down to 20 Hz with reduced accuracy)	0 to 1.1 F	Same as above with suitable generator
	120 Hz to 1 kHz external	0 to 1 F $\left(\frac{100}{f_{Hz}}\right)^2$	±1% ±1 pF with suitable generator and precautions
Dissipation Factor	120 Hz internal or 40 Hz to 120 Hz	0 to 10 $\frac{f_{Hz}}{120}$	±0.001 ±0.01 C ±2%
	120 Hz to 1 kHz	0 to 10	(±0.001 ±0.01 C) $\frac{f_{Hz}}{120}$ ±2%

* C is expressed in farads.

Lead-Resistance Error (4-terminal connection): Additional capacitance error of less than 1% and D error of 0.01 for a resistance of 1Ω in each lead on all but the highest range, or 0.1Ω on the highest range.

FREQUENCY RANGE

Internal Test Signal: 120 Hz (synchronized to line) for 60-Hz model; 100 Hz for 50-Hz model. Selectable amplitude less than 0.2 V, 0.5 V, or 2 V. Phase reversible.

External Test Signal: 20 Hz to 1 kHz with limited range (see above).

DC VOLTAGE AND CURRENT

Internal DC Bias Voltage and Voltmeter: 0 to 600 V in 6 ranges.

Voltmeter Accuracy: ±3% of full scale.

Internal DC Bias Current: Approx 15 mA max.

Ammeter Range: 0 to 20 mA in 6 ranges. Can detect 0.5-μA leakage.

Ammeter Accuracy: ±3% of full scale.

External Bias: 800 V max.

GENERAL

Power Required: 105 V to 125 V or 210 V to 250 V, 60 Hz, 18 W max. Models available for 50-Hz operation.

Accessories Supplied: Four-lead and shielded two-lead cable assemblies, spare fuses.

Accessories Required: None for 120-Hz measurements. The 1311-A Oscillator is recommended for measurement at spot frequencies, the 1310-A Oscillator for continuous frequency coverage.

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Mounting: Flip-Tilt Case. Rack model also available.

Dimensions (width x height x depth): Portable, 16¼ x 15 x 9 in. (415 x 385 x 230 mm); rack, 19 x 14 x 6⅛ in. (485 x 355 x 160 mm).

Net Weight: Portable model, 26 lb (12 kg); rack model, 28 lb (13 kg).

Shipping Weight: Portable model, 34 lb (15.5 kg); rack model, 43 lb (20 kg).

Catalog Number	Description	Price in USA
	1617 Capacitance Bridge	
1617-9701	Portable Model (115 V, 60 Hz)	**$1195.00**
1617-9286	Portable Model (230 V, 60 Hz)	**1195.00**
1617-9206	Portable Model (115 V, 50 Hz)	**on request**
1617-9266	Portable Model (230 V, 50 Hz)	**on request**
1617-9820	Rack Model (115 V, 60 Hz)	**1195.00**
1617-9296	Rack Model (230 V, 60 Hz)	**1195.00**
1617-9216	Rack Model (115 V, 50 Hz)	**on request**
1617-9276	Rack Model (230 V, 50 Hz)	**on request**

The 1617 Capacitance Bridge is designed especially for measuring these large-valued capacitors, as well as other electrolytic types, most of which require the special measurement conditions prescribed by MIL or EIA specifications:

Specification and Capacitor Type	Frequency	AC Level	Accuracy C	Accuracy Loss	DC Polarizing Voltage
MIL C-3965-C Tantalum Foil and Sintered Slug Capacitor	120 ± 5 Hz	Less than 30% of DCWV or 1 V, whichever is smaller	2%	R or P.F. 2%	C—Sufficient for no reversal of polarity. D—"Polarized Capacitance Bridge" Sum of ac and dc shall not exceed DCWV
MIL C-26655-B Solid Tantalum Capacitors	120 ± 5 Hz	Limited to 1V, rms	2%	D, 10%	C—Max bias 2.2 V. D—"Polarized Bridge", 2.2-V dc max.
RS 228 Tantalum Electrolytic Capacitors	120 Hz	Small enough not to change value	±2½%	D, 5%	Optional
MIL C-62 B Polarized Aluminum Capacitors	120 ± 5 Hz	Limited to 30% of DCWV or 4 V, whichever is smaller	2%	D, 2%	No bias required if ac voltage less than 1 V. However, if bias causes differences, measurements with bias shall govern.
RS 154 B Dry Aluminum Electrolytic Capacitors	120 Hz	Small enough not to change value	±2½%	R or RC	Optional, but if substantial difference occurs, rated dc should be used.
RS 205 Electrolytic Capacitors for use in Electronic Instruments	120 Hz	Small enough not to change value	±2½%	D	Optional

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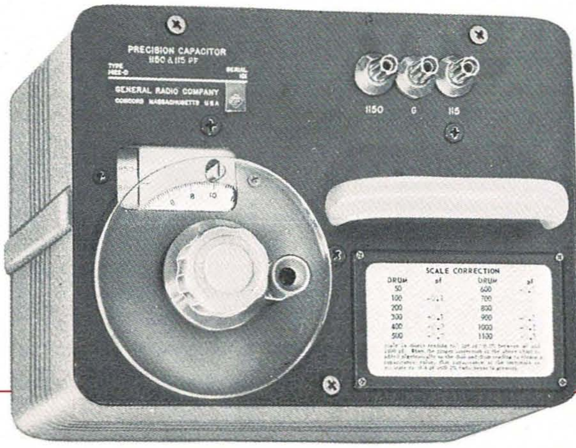
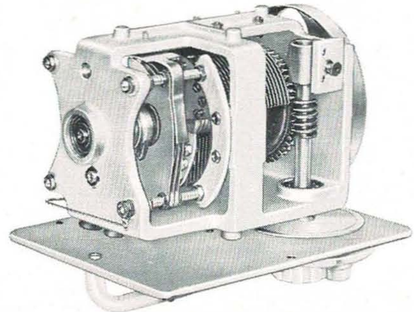
PRECISION CAPACITOR

Type 1422

- variable air capacitor
- stability: better than 0.02% full scale per year
- settable to 40 ppm
- low temperature coefficient, low losses
- wide selection to suit needs





Panel and interior views of 1422-D Precision Capacitor.

The 1422 is a stable and precise variable air capacitor intended for use as a continuously adjustable standard of capacitance.

One of the most important applications is in ac bridge measurements, either as a built-in standard or as an external standard for substitution measurements. It is available in a variety of ranges, terminal configurations, and scale arrangements to permit selection of precisely the required characteristics.

TWO-TERMINAL

The 1422-D is a dual-range, two-terminal capacitor, direct reading in total capacitance at the terminals. For high-frequency use, the 1422-N, similar to the high-capacitance section of the 1422-D, is designed to have low residual inductance and resistance.

For convenience in making substitution measurements, two 1422's have scales reading in capacitance removed, i.e., the capacitance is maximum at the zero reading. These, the 1422-MD and 1422-ME, are also dual-range, two-terminal capacitors.

THREE-TERMINAL

The 1422-CB, -CC, -CL, -CD, and -CE are three-terminal capacitors with shielded coaxial terminals for use in three-terminal measurements. The calibrated direct capacitance is independent of terminal capacitances to ground, and losses are very low. The 1422-CL has approximately the same maximum capacitance as the -CC, but with more constant and much lower terminal capacitances, so that it can be used in measurement circuits where high capacitance to guard can not be tolerated.

CONSTRUCTION

The capacitor assembly is mounted in a cast frame for rigidity. This frame and other critical parts are made of aluminum alloys selected to give the strength of brass with the lightness of aluminum. The plates of most models are also aluminum, so that all parts have the same temperature coefficient of linear expansion.

A worm drive is used to obtain high precision of setting. To avoid eccentricity, the shaft and the worm are accurately machined as one piece. The worm and worm wheel are also lapped into each other to improve smoothness. The dial end of the worm shaft runs in a self-aligning ball bearing, while the other end is supported by an adjustable spring mounting, which gives positive longitudinal anchoring to the worm shaft through the use of a pair of sealed, self-lubricating, preloaded ball bearings. Similar pairs of preloaded ball bearings provide positive and invariant axial location for the main or rotor shaft. Electrical connection to the rotor is made by means of a silver-alloy brush bearing on a silver-overlay drum to assure a low-noise electrical contact.

Stator insulation in all models is a cross-linked thermosetting modified polystyrene having low dielectric losses and very high insulation resistance. Rotor insulation, where used (Types 1422-CB, -CL, and -N), is grade L-4 steatite, silicone treated.

specifications

Initial Accuracy: See table. The errors tabulated are possible errors, i.e., the sum of error contributions from setting, adjustment, calibration, interpolation, and standards. When the capacitor is in its normal position with the panel horizontal, the actual errors are almost always smaller. The accuracy is improved when the readings are corrected using the 12 calibrated values of capacitance given on the correction chart on the capacitor panel and interpolating linearly between calibrated points. Better accuracy can be obtained from a precision calibration of approximately 100 points on the capacitor dial, which permits correction for slight residual eccentricities of the worm drive and requires interpolation over only short intervals. This precision calibration is available for all models at an extra charge. Models so calibrated are listed with the additional suffix letter, P, in the type number. A plastic-enclosed certificate of calibration is supplied, giving corrections to one more figure than the tabulated accuracy.

Stability: The capacitance change with time is less than 1 scale division (0.02% of full scale) per year. The long-term accuracy can be estimated from the stability and the initial accuracy specifications.

Calibration: The measured values are obtained by comparison at 1 kHz, with working standards whose absolute values are known to an accuracy of $\pm$(0.01% + 0.0001 pF). Each comparison is

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made to a precision better than ±0.01%. The values of the working standards are determined and maintained in terms of reference standards periodically calibrated by the National Bureau of Standards.

The indicated value of total capacitance of a two-terminal capacitor is the capacitance added when the 1422 Capacitor is plugged into a 777-Q3 Adaptor. The uncertainty of this method of connection is approx ±0.03 pF.*

Resolution: Dial can be read and set to 1/5 of a small division. The backlash is less than 1/5 small division, corresponding to 0.004% of full-scale value. If the desired setting is always approached in the direction of increasing scale reading, no error from this cause will result.

Temperature Coefficient: Approx +20 ppm/°C, for small temperature changes.

Residual Parameters: See table. The series resistance varies as the square root of the frequency above 100 kHz. Its effect is negligible below this frequency.

Frequency Characteristic: See curves for two-terminal models. The resonance frequency for the -CB and -CC models is approximately 20 MHz; for the -CD model, 60 MHz for each section; -CL, 40 MHz.

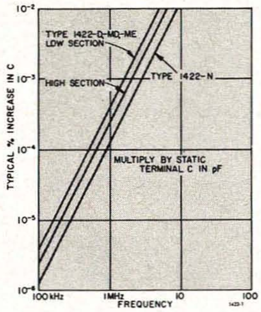
Dissipation Factor: The losses in the two-terminal capacitors are primarily in the stator supports, which are of low-loss polystyrene (DC $= 0.01 \times 10^{-12}$).

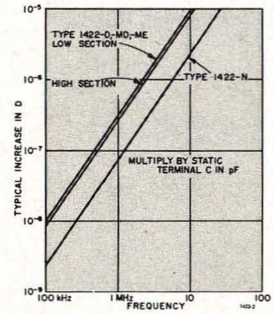
The very small dissipation factor of the direct capacitance of the three-terminal capacitors is difficult to measure and is estimated to be not greater than 20×10^{-6} for -CB and -CL, and 10×10^{-6} for -CC, -CD, and -CE.

Insulation Resistance: Under standard conditions (23°C, less than 50% RH), greater than 10^{12} ohms.

Max Voltage: All models, 1000 V, peak.

* John F. Hersh, "A Close Look at Connection Errors in Capacitance Measurements," General Radio Experimenter, July 1959.





Variation with frequency of effective capacitance and dissipation factor per pF of capacitance for two-terminal 1422 Precision Capacitors.

Terminals: Jack-top binding posts are provided on 2-terminal models; standard ¾-inch spacing is used. The rotor terminal is connected to the panel and shield. Locking GR874 Coaxial Connectors are used on three-terminal models.

Accessories Required: For connection to 3-terminal models, 2 GR874 Patch Cords or equivalent.

Accessories Available: 777-Q3 Adaptor (see Calibration above), for two-terminal units.

Mounting: Lab-Bench Cabinet.

Dimensions (width x height x depth): 9½ x 7 x 8½ in. (245 x 180 x 220 mm).

Weight: Net, 10½ to 12½ lb (4.8 to 5.7 kg), depending on model; shipping, all models, 15 lb (7 kg).

		Two-Terminal							Three-Terminal						
				RF	Reads Capacitance Removed										
TYPE 1422		-D		-N	-MD		-ME		-CB	-CC	-CL	-CD		-CE	
CAPACITANCE RANGE, pF	Min	100	35	100	0	0	0	0	50	5	10	0.5	0.05	0.05	0.005
	Max	1150	115	1150	1050	105	105	10.5	1100	110	110	11	1.1	1.1	0.11
SCALE, pF/Division:		0.2	0.02	0.2	0.2	0.02	0.02	0.002	0.2	0.02	0.02	0.002	0.0002	0.0002	0.00002
INITIAL ACCURACY: ± Picofarads Direct-Reading (Adjustment): Total Capacitance		0.6*	0.1*	0.6*	Differences from Zero				0.6	0.15	0.1	0.04	0.008	0.008	0.0016
Capacitance Difference		1.2	0.2	1.2	1	0.2	0.2	0.05	1.2	0.3	0.2	0.08	0.016	0.016	0.0032
With Corrections from Calibration Chart (supplied): Total Capacitance		0.3*	0.04*	0.3*					0.3	0.04	0.04	0.01	0.002	0.002	0.0004
Capacitance Difference†		0.6	0.08	0.6	0.6	0.08	0.08	0.02	0.6	0.08	0.08	0.02	0.004	0.004	0.0008
With Corrections from Precision Calibration (extra charge): Total Capacitance		0.1*	0.01*	0.1*					0.1	0.01	0.01	0.001	0.0002	0.0002	0.00004
Capacitance Difference†		0.2	0.02	0.2	0.2	0.02	0.02	0.004	0.2	0.02	0.02	0.002	0.0004	0.0004	0.00008
RESIDUALS (typical values): Series Inductance, μH		0.06	0.10	0.032	0.06	0.10	0.06	0.10	0.14	0.17	0.13	0.17	0.17	0.17	0.17
Series Resistance, ohms at 1 MHz		0.04	0.05	0.012	0.04	0.05	0.04	0.05	0.1		0.1				
Terminal Capacitance, pF:			high terminal to case				min scale		36	850	34	98	25	37	28
							max scale		35	560	33	74	23	35	28
			low terminal to case				min scale		58	920	58	117	115	81	81
							max scale		53	600	55	92	93	67	67
Capacitance at Zero Scale Setting, pF:					1140	135	145	35							

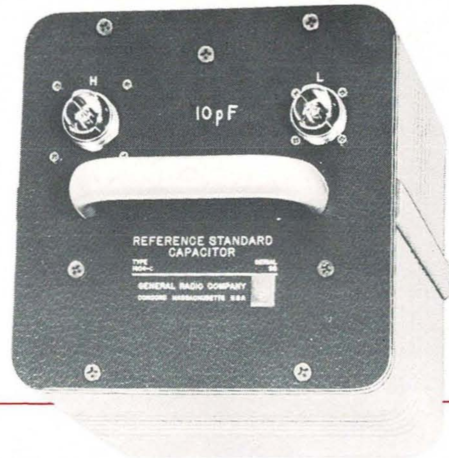
* Total capacitance is the capacitance added when the capacitor is plugged into a 777-Q3 Adaptor. † Divide error by 2 when one setting is made at a calibrated point.

Catalog Number	Description	Price in USA
	Precision Capacitors	
	with precision calibration	
1422-9904	**1422-DP**	**$620.00**
1422-9913	**1422-MDP**	**625.00**
1422-9955	**1422-MEP**	**620.00**
1422-9880	**1422-NP**	**565.00**
1422-9902	**1422-CBP**	**550.00**
1422-9903	**1422-CCP**	**535.00**
1422-9508	**1422-CLP**	**535.00**
1422-9925	**1422-CDP**	**560.00**
1422-9580	**1422-CEP**	**620.00**
	with standard calibration	
1422-9704	**1422-D**	**$510.00**
1422-9854	**1422-MD**	**515.00**
1422-9855	**1422-ME**	**510.00**
1422-9714	**1422-N**	**495.00**
1422-9916	**1422-CB**	**480.00**
1422-9809	**1422-CC**	**465.00**
1422-9933	**1422-CL**	**465.00**
1422-9823	**1422-CD**	**450.00**
1422-9833	**1422-CE**	**510.00**
0777-9803	**777-Q3 Adaptor**	**6.00**

File Courtesy of GRWiki.org

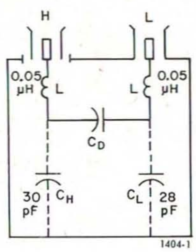
REFERENCE STANDARD CAPACITOR

Type 1404



- 10, 100, 1000 pF
- 20 ppm/year stability
- 3-terminal, coaxial connections
- hermetically sealed in dry nitrogen

These capacitors have been designed as primary reference standards of capacitance with which working standards can be compared. The 1615-A Capacitance Bridge is particularly well suited for this purpose and can be conveniently used to calibrate accurately a wide range of working standards in terms of a 1404 Reference Standard Capacitor. A single 1000- or 100-picofarad standard is also the only standard necessary to calibrate the bridge itself.



Equivalent circuit showing direct capacitance, C_D, and average values of residual inductance, L, and terminal capacitances, C_H and C_L. C_D = 1000 pF for 1404-A, 100 pF for 1404-B, and 10 pF for 1404-C.

In combination with an accurately known external resistor, this capacitor becomes a standard of dissipation factor.

All critical parts of the plate assembly are made of Invar for stability and low temperature coefficient. After heat cycling and adjustment, the assembly is mounted in a heavy brass container, which, after evacuation, is filled with dry nitrogen under pressure slightly above atmospheric and sealed. The container is mounted on an aluminum panel and protected by an outer aluminum case. Each capacitor is subjected to a series of temperature cycles to determine hysteresis and temperature coefficients and to stabilize the capacitance.

Two locking GR874 Coaxial Connectors are used as terminals. The outer shell of one is connected to the case, but the outer shell of the other is left unconnected to permit the capacitor to be used with an external resistor as a dissipation-factor standard.

— See GR Experimenter for Aug 1963 and Aug 1966.

specifications

Calibration: A certificate of calibration is supplied with each capacitor, giving the measured direct capacitance at 1 kHz and at 23° ±1°C. The measured value is obtained by a comparison to a precision better than ±1 ppm with working standards whose absolute values are known to an accuracy of ±20 ppm, determined and maintained in terms of reference standards periodically measured by the National Bureau of Standards.

Adjustment Accuracy: The capacitance is adjusted before calibration with an accuracy of ±5 ppm to a capacitance about 5 ppm above the nominal value relative to the capacitance unit maintained by the General Radio reference standards.

1615 Bridge page 80

Stability: Long-term drift is less than 20 parts per million per year. Maximum change with orientation is 10 ppm and is completely reversible.

Temperature Coefficient of Capacitance: 2 ±2 ppm/°C for 1404-A and -B, 5 ± 2 ppm/°C for 1404-C, from −20°C to +65°C. A measured value with an accuracy of ±1 ppm/°C is given on the certificate.

Temperature Cycling: For temperature cycling over range from −20° C to +65°C, hysteresis (retraceable) is less than 20 ppm at 23°C.

Dissipation Factor: Less than 10^{-5} at 1 kHz.

Residual Impedances: See equivalent circuit for typical values of internal series inductances and terminal capacitances.

Max Voltage: 750 V.

Terminals: Two locking GR874 coaxial connectors; easily convertible to other types of connectors by attachment of locking adaptors. Outer shell of one connector is ungrounded to permit capacitor to be used with external resistor as a dissipation-factor standard.

Accessories Required: For connection to 1615-A Capacitance Bridge, 2 Type 874-R20A or 874-R22LA Patch Cords.

Dimensions (width x height x depth): 6¾ x 6⅝ x 8 in. (175 x 170 x 205 mm).

Weight: Net, 8½ lb (3.9 kg); shipping, 14 lb (6.5 kg).

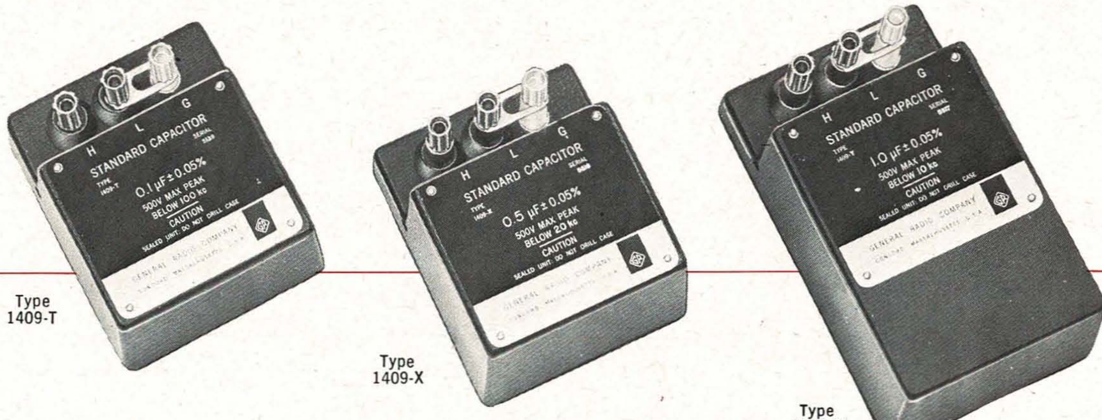
Catalog Number	Description	Price in USA
	Reference Standard Capacitor	
1404-9701	**1404-A,** 1000 pF	**$225.00**
1404-9702	**1404-B,** 100 pF	**225.00**
1404-9703	**1404-C,** 10 pF	**225.00**

File Courtesy of GRWiki.org

STANDARD CAPACITOR

Type 1409

- 0.001 to 1 μF
- ±0.01%/year stability
- calibration accuracy ±0.02%
- two- and three-terminal calibration provided



Type 1409-T

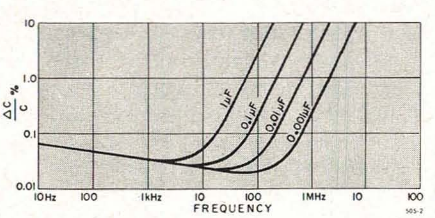
Type 1409-X

Type 1409-Y

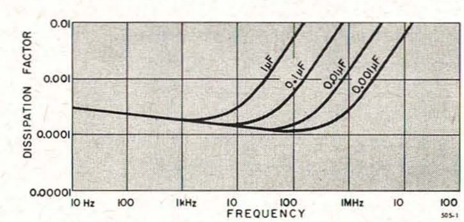
The 1409 Standard Capacitors are fixed mica capacitors of very high stability for use as two- or three-terminal reference or working standards in the laboratory.

Typical capacitors, observed over more than ten years, have shown random fluctuations of less than ±0.01% in measured capacitance with no evidence of systematic drift.

These capacitor units consist of a silvered-mica and foil pile, spring-held in a heavy metal clamping structure for mechanical stability. The units are selected for low dissipation factor and are stabilized by heat cycling. They are housed, with silica gel to provide continuous dessication, in cast aluminum cases, sealed with high-temperature potting wax. A well is provided in the wall of the case for the insertion of a dial-type thermometer. Three jack-top binding posts are provided on the top of the case and removable plugs on the bottom, for convenient parallel connection without error.



(Left) Change in capacitance as a function of frequency for typical Type 1409 Capacitors. The 1-kHz value on the plot should be used as a basis of reference in estimating frequency errors. (Right) Dissipation factor as a function of frequency.



specifications

Adjustment Accuracy: Within ±0.05% of the nominal capacitance value (two-terminal) marked on the case. Accuracy is guaranteed for two years under the terms of our standard warranty if the capacitor has not been damaged by excessive current or voltage.

Calibration: A certificate of calibration is supplied with each unit, giving both two- and three-terminal measured capacitances at 1 kHz and at a specified temperature. The measured value is the capacitance added when the standard is plugged directly into General Radio binding posts. This value is obtained by comparison, to a precision better than ±0.01%, with working standards whose absolute values are known to an accuracy typically ±0.01%, determined and maintained in terms of reference standards periodically calibrated by the National Bureau of Standards.

Stability: Capacitance change is less than 0.01% per year.

Temperature Coefficient of Capacitance: +35 ± 10 ppm per degree between 10° and 70°C.

Dissipation Factor: Less than 0.0003 at 1 kHz and 23°C (see curves). Measured dissipation factor at 1 kHz is stated in the certificate to an accuracy of ±0.00005.

Series Inductance: Typically 0.050 μH for 1409-F through -M, 0.055 μH for -R through -X, and 0.070 μH for 1409-Y.

Series Resistance at 1 MHz: 0.02 ohm, except for 1409-Y, which is 0.03 ohm.

Frequency Characteristics: See curves. Series resistance varies as the square root of the frequency for frequencies above 100 kHz.

Approx Terminal Capacitance: From H terminal to case (G), 12 to 50 pF. From L terminal (outside foils of capacitor) to case, 300 to 1300 pF.

Leakage Resistance: 5000 ohm-farads or 100 GΩ, whichever is the lesser.

Max Voltage: 500 V pk below the limiting frequencies tabulated below. At high frequencies the allowable voltage is approx inversely proportional to frequency. These limits correspond to a temperature rise of 40°C for power dissipations of 5, 6, and 7.5 W for the small, medium, and large cases, respectively.

Dimensions (width x height x depth): 1409-Y, 3¼ x 5⅝ x 2$^{11}/_{16}$ in. (85 x 145 x 70 mm); 1409-X, 3¼ x 4 x 2$^{11}/_{16}$ in. (85 x 105 x 70 mm); others, 3¼ x 4 x 2 in. (85 x 105 x 50 mm).

Weight: Net, 1¼ lb (0.6 kg); shipping, 4 lb (1.9 kg). Add approx ½ lb (0.2 kg) for 1409-X, and approx 1 lb (2.2 kg) for 1409-Y.

Catalog Number	Type	Nominal Capacitance μF	Frequency Limit for Max Volts	Price in USA
1409-9706	**1409-F**	0.001	4.7 MHz	**$ 55.00**
1409-9707	**1409-G**	0.002	2.7 MHz	**55.00**
1409-9711	**1409-K**	0.005	1.3 MHz	**55.00**
1409-9712	**1409-L**	0.01	750 kHz	**55.00**
1409-9713	**1409-M**	0.02	430 kHz	**60.00**
1409-9718	**1409-R**	0.05	210 kHz	**65.00**
1409-9720	**1409-T**	0.1	120 kHz	**70.00**
1409-9721	**1409-U**	0.2	70 kHz	**80.00**
1409-9724	**1409-X**	0.5	35 kHz	**120.00**
1409-9725	**1409-Y**	-1.0	17 kHz	**200.00**

File Courtesy of GRWiki.org

PRECISION DECADE CAPACITOR

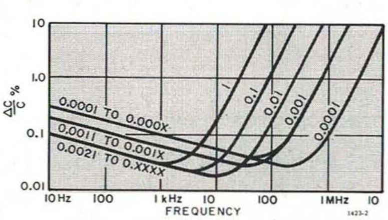
Type 1423-A

- 100 pF to 1.111 μF
- $\pm$0.05 % accuracy
- two- or three-terminal connection

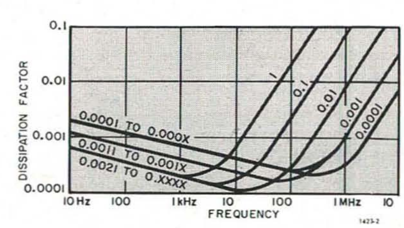
This capacitor is a versatile tool for calibration laboratories and production-line testing. With it a bridge can be standardized to an accuracy exceeded only by that of the highest quality, individually certified laboratory standards such as the GR 1404 Reference Standard Capacitors. Used with a limit bridge, such as the GR 1605-A Impedance Comparator, the 1423 facilitates fast and accurate production-line measurements of arbitrary capacitance values with minimum setup time.

Any value of capacitance from 100 pF to 1.111 μF, in steps of 100 pF, can be set on the four decades and will be known to an accuracy of 0.05%. The terminal capacitance values are set precisely to the nominal value and can be readjusted later at calibration intervals, if necessary, without disturbance of the main capacitors.

The 1423 consists of four decades of high-quality silvered-mica capacitors similar to those used in the GR 1409 Standard Capacitors. The capacitors and associated switches are mounted in an insulated metal compartment, which in turn is mounted in a complete metal cabinet. This double-shielded construction ensures that capacitance at the terminals is the same for either the three-terminal or the two-terminal method of connection (except for a constant difference of about one picofarad). This external capacitance can be included in the two-terminal calibration by the adjustment of a single trimmer.



(Left) Change in capacitance as a function of frequency. These changes are referred to the values that the capacitors would have if there were neither interfacial polarization nor series inductance. The 1-kHz value on the plot should be used as a basis of reference in estimating frequency errors. (Right) Dissipation factor as a function of frequency.



specifications

Nominal Values: 100 pF to 1.111 μF in steps of 100 pF.

Accuracy: $\pm$(0.05% + 0.05pF) at 1 kHz, calibrated in the three-terminal connection. Two-terminal connection (capacitor inserted into Type 777-Q3 Adaptor) adds about 1.3 pF reading.

Stability: $\pm$(0.01% + 0.05pF) per year.

Certificate: A certificate is supplied certifying that each component capacitor was adjusted by comparison, to a precision better than $\pm$0.01%, with working standards whose absolute values are known to an accuracy typically $\pm$0.01%, determined and maintained in terms of reference standards periodically calibrated by the National Bureau of Standards.

Frequency: See curves for typical variation of capacitance and dissipation factor with frequency.

Dissipation Factor: Not greater than 0.001, 0.0005, and 0.0003 for capacitances of 100 to 1000 pF, 1100 to 2000 pF, and 2100 pF to 1.1110 μF, respectively.

Temperature Coefficient of Capacitance: Approx +20 ppm per degree between 10° and 50°C.

Insulation Resistance: $>5 \times 10^{10}\ \Omega$ to 0.1 μF and $>5 \times 10^{9}\ \Omega$ from 0.1 μF to 1.111 μF.

Maximum Voltage: 500 V peak, up to 10 kHz.

Accessories Supplied: Two Type 777-Q3 Adaptors.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench, 19 x 7¼ x 10½ in. (485 x 185 x 270 mm); rack, 19 x 7 x 8½ in. (485 x 180 x 220 mm).

Weight (both models): Net, 26 lb (12.0 kg); shipping, 39 lb (18 kg).

Catalog Number	Description	Price in USA
	Precision Decade Capacitor	
1423-9801	**1423-A,** Bench Model	**$800.00**
1423-9811	**1423-A,** Rack Model	**800.00**

File Courtesy of GRWiki.org

new

- stable to 0.05% per year
- for rf impedance calibrations

COAXIAL CAPACITANCE STANDARDS

Type 1406

The 1406 Coaxial Capacitance Standards are stable, low-loss air capacitors with small, stable and known series inductance. This permits the accurate, traceable calibration of high-frequency bridges and other impedance-measuring instruments.

REPEATABLE COAXIAL CONNECTION

GR900® precision coaxial connectors are used on the 1406's; their stability and repeatable performance have been proven in use at frequencies as high as 9 GHz. The use of coaxial connectors also meets the high-frequency calibration requirements of the National Bureau of Standards.

INSTRUMENT CALIBRATION

The 1406 standards can be connected directly to instruments equipped with GR900 precision connectors and to others through appropriate adaptors. The Type 900-Q9 adaptor is offered to facilitate connection to ¼" x 28 threaded studs or tapped holes on ¾" to 1" centers. Series inductance and resistance have been kept low in the 900-Q9 and, when other adaptors are used, these quantities should be known to permit correcting for their effects at high frequencies.

These standards can be calibrated at audio frequencies with the GR 1615 Capacitance Bridge and the 1615-P2 Coaxial Adaptor, which has an adjustment for compensating for its capacitance and that of the binding posts and thus permits direct-reading measurements. 1615 Bridge page 81

specifications

Calibration: A certificate of calibration is supplied with each unit, giving the measured capacitance at 1 kHz and at a specified temperature and relative humidity. The measured capacitance is the capacitance at the reference plane of the GR900 connector. This value is obtained by comparison, to a precision better than ±0.01%, with working standards whose absolute values are known to an accuracy typically ±0.01%, determined and maintained in terms of reference standards periodically calibrated by the National Bureau of Standards.

Stability: The capacitance change is less than 0.05% per year.

Accuracy: Capacitance adjusted to within 0.1% of nominal value.

Residual Impedances: See table. Dissipation factor varies as the 3/2 power of frequency above about 100 kHz. Insulation resistance is greater than 10^{12} ohms at 23°C and less than 50% RH.

Temperature Coefficient of Capacitance: Typically 10 to 20 ppm/°C between 20°C and 70°C.

Accessories Available: Adaptors 1615-P2 for convenience in calibrating with 1615-A Capacitance Bridge and 900-Q9 for connecting 1406 to ¼-in. x 28 threaded stud (GR 938 Binding Post) or tapped hole.

Terminal: GR900 precision coaxial connector.

Mounting: Aluminum panel and cylindrical case.

Dimensions (diameter x height): 3¹⁄₁₆ x 5¼ in. (78 x 135 mm).

Weight: Net, 1½ lb (0.7 kg); shipping, 4 lb (1.9 kg).

Catalog Number	Type	Nominal Capacitance	Peak Volts	Typical Dissipation Factor 1 kHz (40% RH)	Typical Dissipation Factor 1 MHz	Typical Inductance	Price in USA
1406-9701	**1406-A**	1000 pF	700	3×10^{-6}	50×10^{-6}	8.6 nH	**$120.00**
1406-9702	**1406-B**	500 pF	900	5×10^{-6}	30×10^{-6}	8.4 nH	**115.00**
1406-9703	**1406-C**	200 pF	1200	20×10^{-6}	25×10^{-6}	8.1 nH	**110.00**
1406-9704	**1406-D**	100 pF	1500	30×10^{-6}	20×10^{-6}	7.6 nH	**105.00**
1406-9705	**1406-E**	50 pF	1500	50×10^{-6}	15×10^{-6}	6.7 nH	**100.00**
1615-9602	**1615-P2 Coaxial Adaptor,** GR900 to 1615 Bridge						**75.00**
0900-9874	**900-Q9 Adaptor,** GR900 to binding posts						**50.00**

new

- 1, 2, and 5 pF
- rf standards
- GR900® connectors

COAXIAL CAPACITANCE STANDARDS

Type 1405

Extending the available values of rf capacitance downward, the 1405 standards permit impedance-measuring instruments to be calibrated at even higher frequencies accurately and with traceability to the National Bureau of Standards.

specifications

Calibration: A certificate of calibration is supplied with each unit, giving the measured capacitance at 1 kHz and at a specified temperature and relative humidity. The measured capacitance is the capacitance at the reference plane of the GR900 connector. This value is obtained by comparison, to a precision better than ±0.001 pF, with working standards whose absolute values are known to an accuracy typically ±0.01%, determined and maintained in terms of reference standards periodically calibrated by the National Bureau of Standards.

Accuracy: Capacitance adjusted to within tolerance given in table.

Residual Impedances: Dissipation factor at 1 kHz, $<30 \times 10^{-6}$ for -C, -D; $<40 \times 10^{-6}$ for -E; insulation resistance is $>10^{12}\ \Omega$ at 23°C, <50% RH. Effect of series inductance and other factors is given in table below in terms of the frequency at which it causes a 10% increase in measured capacitance.

Accessories Available: Adaptors 1615-P2 for calibrating with GR 1615 bridge and 900-Q9 for connecting standard to ¼-inch x 28 threaded stud (GR 938 Binding Post) or tapped hole.

Terminal: GR900 precision coaxial connector.

Dimensions (diameter x height): 1¹⁄₁₆ x 2⁵⁄₁₆ in. (27 x 59 mm).

Weight: Net, 4 oz (103 g); shipping, 5 oz (150 g).

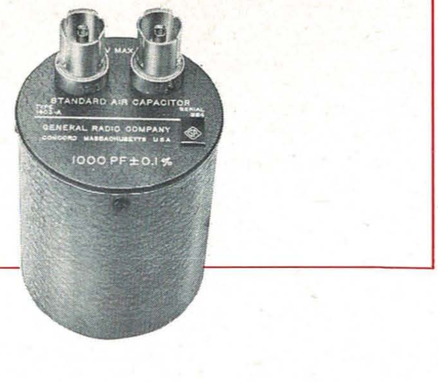
Catalog Number	Type	Nominal Capacitance	Accuracy	Peak Volts	Frequency for 10% C Increase	Price in USA
1405-9702	**1405-C**	5 pF	±0.010 pF	1 kV	0.75 GHz	**$55.00**
1405-9701	**1405-D**	2 pF	±0.005 pF	1 kV	1.7 GHz	**55.00**
1405-9700	**1405-E**	1 pF	±0.005 pF	3 kV	1.4 GHz	**55.00**

File Courtesy of GRWiki.org

STANDARD AIR CAPACITOR

Type 1403

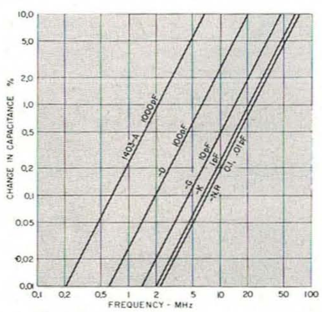
- 1000 pF to 0.001 pF
- calibration accuracy: ±0.02% ±0.01 nF



The 1403 Standard Air Capacitors are stable, three-terminal standards in decimal values from 0.001 to 1000 pF. Their terminals are arranged to plug directly into the UNKNOWN terminals of the 1615-A Capacitance Bridge.

specifications

Calibration: A certificate of calibration is supplied with each unit giving the measured capacitance at 1 kHz and at a specified temperature. The measured value is the direct capacitance between shielded terminals when the capacitor has at least one lead completely shielded and its case connected to a guard point. This value is obtained by comparison, to a precision better than ±(0.01% + 0.00001 pF), with working standards whose absolute values are known to an accuracy typically ±0.01%, determined and maintained in terms of reference standards periodically calibrated by the National Bureau of Standards.



Typical increase (percent) in effective direct capacitance, with frequency produced by residual inductance.

Stability: Capacitance change is less than 0.05% per year.

Residual Impedances: See curves for high-frequency use.

Dissipation Factor: $<20 \times 10^{-6}$ max at 1 kHz and 50% or less relative humidity.

Peak Voltage: 1500 V, except for 1403-A, which is 700 V.

Temperature Coefficient of Direct Capacitance: Typically 20 to 40 ppm per degree between 20° and 70°C. The larger coefficients apply to the smaller capacitance values.

Terminals: GR874 coaxial connectors, which provide complete shielding of the leads.

Dimensions: Diameter 3 1/16 in. (78 mm), height 5¼ in. (135 mm), over-all.

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

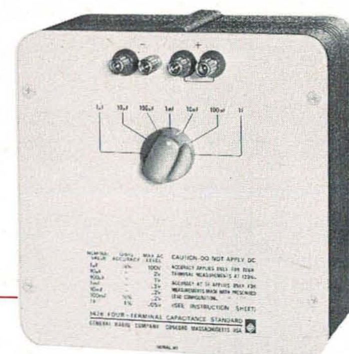
Catalog Number	Type	Nominal Capacitance - pF	Adjustment Accuracy - %	Price in USA
1403-9701	**1403-A**	1000	0.1	**$95.00**
1403-9704	**1403-D**	100	0.1	**80.00**
1403-9707	**1403-G**	10	0.1	**65.00**
1403-9711	**1403-K**	1.0	0.1	**65.00**
1403-9714	**1403-N**	0.1	0.1	**70.00**
1403-9718	**1403-R**	0.01	0.3	**70.00**
1403-9722	**1403-V**	0.001	1.0	**70.00**

FOUR-TERMINAL CAPACITANCE STANDARD

Type 1426

- 1 μF to 1 farad in decade steps
- accuracy ¼%, 1% at 1 F

new



The 1426 capacitance standard is of great value in calibrating four-terminal, high-capacitance bridges like the GR 1617. With calibration, the 1426 can be used as a two-terminal standard at 120 Hz and at settings up to 1 mF.

The 1426 consists of a 1-μF polystyrene capacitor and a transformer that multiplies the effective capacitance to higher values. This arrangement gives stability unattainable with very-high-value true capacitors. Such construction prohibits general circuit applications and particularly uses with dc applied to the capacitor.

specifications

Capacitance: 1 μF to 1 F in 7 switch-selected decade values.

Accuracy: ±¼%, except ±½% for 100 mF and ±1% for 1 F; measured at 120 Hz at 23°C at <Max Volts specified below. Measurements must use 4-terminal connections with all but the 1-μF value; at 1 F, lead arrangement must be as prescribed in operating instruction manual.

Dissipation Factor: <0.0003 for 1 μF at 120 Hz; <0.1 for larger values.

Max Ac Voltage: Voltage 10:1 larger than specified will not damage standards above 1 μF but will cause an error of approx 1%.

Capacitance	1 μF	10 μF	100 μF	1 mF	10 mF	100 mF	1 F
Max Ac Volts	100 V	2 V	1 V	0.3 V	0.2 V	0.2 V	0.05 V

Max Dc Voltage: No dc permissible as values above 1 μF are dc short circuits and could be changed in value by dc current; 100 V max for 1-μF standard only.

Temperature Coefficient: 140 ppm/°C typical.

Frequency Characteristic: 1-μF standard is true capacitor with 170-kHz resonance; other values very frequency dependent. Add ¼% error at 100 Hz, add 1% from 60 to 150 Hz.

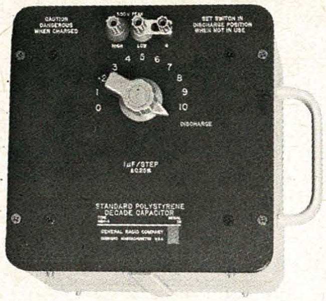
Dimensions (width x height x depth): 8 x 5⅞ x 8 in. (205 x 150 x 205 mm).

Weight: Net, 7½ lb (3.5 kg); shipping, 11 lb (5 kg).

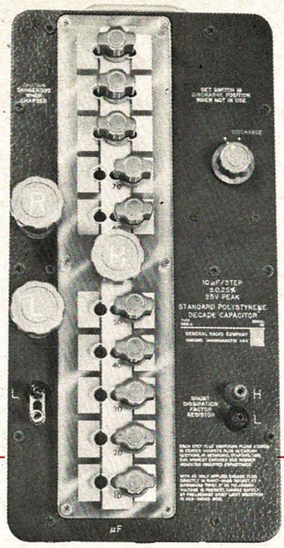
Catalog Number	Description	Price in USA
1426-9700	**1426 Four-Terminal Capacitance Standard**	**$275.00**

File Courtesy of GRWiki.org

DECADE CAPACITORS



Type 1424-A. Type 1424-M is similar in appearance.



Type 1425-A

- 10-μF Standard Decade — Polystyrene Dielectric — Type 1424-A
- 100-μF Standard Decade — Polystyrene Dielectric — Type 1425-A
- 10-μF Decade — Paper Dielectric — Type 1424-M

TYPE 1424-A

Polystyrene capacitors, combined in 10 1-μF units, are housed in two hermetically sealed, non-ferrous metal cases with Teflon*-insulated high terminals, the cases being the common (LOW) terminal. The aluminum outer cabinet and panel are insulated from both capacitor terminals, so that either two- or three-terminal connections can be used.

Residual series inductance and resistance have been minimized by the use of current-sheet conductors, ribbon leads, and multiple switch contacts.

TYPE 1424-M

This capacitor is a 1-microfarad-per-step decade, which has less rigorous performance specifications than the 1424-A and a correspondingly lower price. Sealed foil-paper capacitors of noninductive extended-foil construction are used with a viscous impregnant to improve stability.

TYPE 1425-A

Polystyrene capacitors are connected in 10-μF steps. The configuration and dimensions of binding posts, bus, studs, and current-sheet connectors are arranged to minimize residuals. Switching resistance is kept low through the use of tapered plug connectors, rather than rotary switches. Binding posts have large contact areas and are easily tightened by hand to minimize contact resistance.

— See **GR Experimenter** for July 1965.

* Registered trademark of E. I. duPont de Nemours and Company.

specifications

Accuracy: The accuracy stated in the table below is guaranteed for two years under the terms of our standard warranty, if the capacitor has not been damaged by excessive current or voltage.

Certificate: 1424-A and 1425-A: 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. 1424-M: A certificate is supplied, certifying the accuracy of adjustment in terms of reference standards, periodically measured by the National Bureau of Standards.

Frequency Characteristic: Calibration and adjustment are made at 1 kHz. Plots of typical change in capacitance and dissipation factor with frequency are given in the calibration certificate.

Type	1424-A	1425-A	1424-M
Total Capacitance	10 μF	100 μF	10 μF
Capacitance per Step	1 μF	10 μF	1 μF
Dielectric	Polystyrene	Polystyrene	Paper
Adjustment Accuracy at 1 kHz	±0.25%	±0.25%	±1%
Stability	±0.05%/year	±0.05%/year	±0.35%/year
Dissipation Factor at 1 kHz	<0.0003	<0.0004	<0.005
Insulation Resistance	>10^6 ΩF	>10^6 ΩF	>10^4 ΩF
Voltage Recovery *	<0.1%	<0.1%	<5%
Temp Coefficient of Capacitance (typical) ppm/°C	−140	−140	+180
Max Operating Temperature °C	65	65	90
Max Safe Voltage	500 V, peak, below 10 kHz	25 V, peak, below 10 kHz	500 V, peak, up to 2 kHz
Dimensions Width, height, depth; inches (mm)	9½, 7¾, 8 (245, 195, 205)	9⅜, 19⅛, 8⅛ (240, 485, 205)	9½, 6, 8 (245, 150, 205)
Net Weight lb (kg)	16½ (7.5)	46½ (21.5)	7¾ (3.6)
Shipping Weight lb (kg)	19 (9)	67 (31)	11 (5)
Catalog Number	1424-9701	1425-9701	1424-9713
Price in USA	**$410.00**	**$1950.00**	**$210.00**

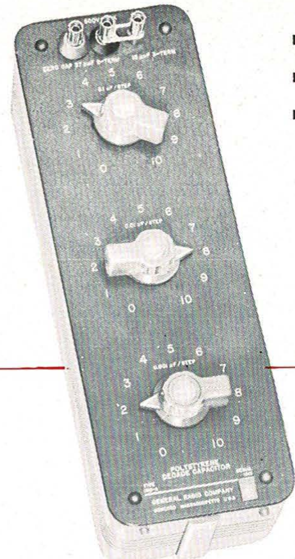
* Dielectric absorption.

File Courtesy of GRWiki.org

standard capacitors

DECADE CAPACITORS

Type 1419



- 100 pF to 1.1 μF
- choice of models
- two- or three terminal connection

Type 1419 Decade Capacitors are offered in four models using three different dielectric materials to satisfy a variety of needs.

Types 1419-A and -B (Polystyrene)

Capacitance and dissipation factor constant with frequency, essentially noninductive, very low dielectric absorption. The dielectric is specially prepared of purified high-molecular-weight polystyrene, having very high resistance and freedom from interfacial polarization. Moisture sealing with Teflon* feed-through insulators assures high performance under adverse humidity conditions.

Type 1419-K (Silvered Mica)

Higher accuracy, low dissipation factor, and +35 ±10 ppm/°C temperature coefficient (10-50°C) for use in higher ambient temperatures.

Type 1419-M (Molded Silvered Mica and Paper)

For economy and excellent performance characteristics, sealed foil-and-paper capacitors are used in the highest-value decade and EIA Characteristic-C molded silvered micas in the smaller two.

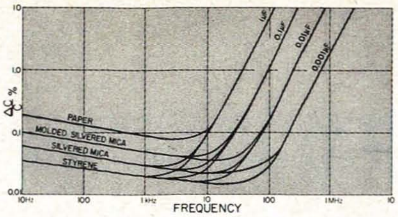
* Registered trademark of E. I. duPont de Nemours and Company.

specifications

TYPE NUMBER	1419-A	1419-B	1419-K	1419-M
Dielectric	Polystyrene	Polystyrene	Silvered Mica	Paper and Silvered Mica (Molded)
Maximum Capacitance of Box (μF)	1.110	1.1110	1.110	1.110
In Steps of (μF)	0.001	0.0001	0.001	0.001
Dials	3	4	3	3
Zero Capacitance, typical				
2-terminal connection	37 pF	50 pF	41 pF	35 pF
3-terminal connection	15 pF	20 pF	13 pF	16 pF
Accuracy[1]				
2-terminal connection[2]	±1%	±(1% + 2 pF)	±0.5%	±1.5% on highest decade ±1% on others
3-terminal connection	±1% except ±1.5% on smallest decade	+1% or −(2% + 4 pF)	±0.5% except ±1% on smallest decade	±1.5% on highest decade ±1% on others
Dissipation Factor at 1 kHz	<0.0002		<0.0003	<0.005
Insulation Resistance at 100 V, 25°C, 50% RH, (ohms), typical	$>10^{12}$		$>5 \times 10^9$	$>10^9$
Max Voltage[3] (dc or peak)	500 V up to 35 kHz		500 V up to 10 kHz	500 V up to 1 kHz
Max Operating Temperature (C)	65		75	90
Voltage Recovery[4]	<0.1%		<3%	<5% on highest decade
Resonant Frequencies (typical)	1 μF—400 kHz; 0.1 μF—1MHz; 0.01 μF—2.7 MHz; 0.001 μF—7.8 MHz; 0.0001 μF—23 MHz			
Dc Cap/1-kHz Cap	<1.001		Typically 1.03	
Cabinet	Lab-bench			
Over-all Dimensions — in. (mm)	13 x 4 5/16 x 5 (330 x 110 x 130)	16 5/16 x 4 5/16 x 5 (415 x 110 x 130)	14 1/8 x 5 1/2 x 6 (359 x 140 x 153)	14 1/8 x 5 1/2 x 6 (359 x 140 x 153)
Net Weight — lb (kg)	8 3/8 (3.8)	10 1/2 (4.8)	11 1/4 (5.5)	6 1/4 (2.9)
Shipping Weight — lb (kg)	10 (4.6)	11 (5)	18 (8.5)	8 (3.7)
Catalog Number	1419-9701	1419-9702	1419-9711	1419-9713
Price in USA	**$210.00**	**$270.00**	**$435.00**	**$200.00**

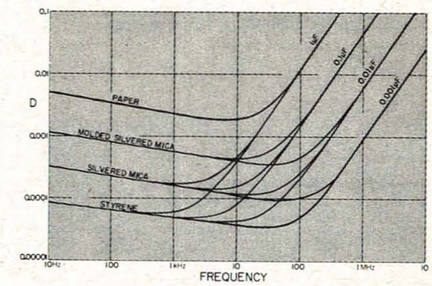
[1] Capacitance increments from zero position are within this percentage of the indicated value for any setting at 1 kHz.
[2] Units are checked with switch mechanism high, electrically, and the common lead and case grounded.
[3] At frequencies above the indicated max, the allowable voltage decreases and is (approx) inversely proportional to frequency. These limits correspond to a temperature of 40°C at max setting of each decade in box.
[4] Final % of original charging voltage after a charging period of one hour and a 10-second discharge through a resistance equal to one ohm per volt of charging.

File Courtesy of GRWiki.org



1419 Decades

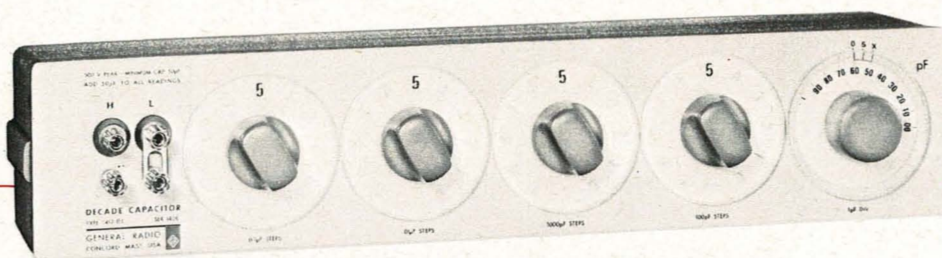
(Left) Typical plot of change in capacitance at maximum setting of each decade as a function of frequency. The capacitance curves are referred to the value the capacitor would have if there were no interfacial polarization and no series inductance. Since the capacitors are adjusted to their rated accuracy at 1 kHz, the 1-kHz value on the plots should be used as a basis of reference in estimating the frequency error. (Right) Typical plot of dissipation factor as a function of frequency.



- 50 pF to 1.11115 μF
- better than 1-pF resolution
- accuracy ±(1% + 5 pF)
- low loss, leakage, dielectric absorption

DECADE CAPACITOR

Type 1412-BC

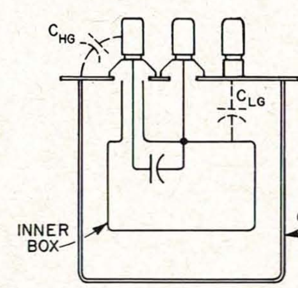


The wide capacitance range and high resolution of this decade capacitance box make it exceptionally useful in both laboratory and test shop. Owing to its fine adjustment of capacitance, it is a convenient variable capacitor to use with the 1605-A Impedance Comparator. The polystyrene dielectric used in the decade steps is necessary for applications requiring low dielectric absorption and constancy of both capacitance and dissipation factor with frequency.

Four decades of polystyrene capacitors and a variable air capacitor are used, mounted in a double-shield box. The double shielding provides 2-terminal and 3-terminal capacitances that are the same except for the capacitance between the terminals. The variable air capacitor with a linear ΔC of 100 pF and a resolution of better than 1 pF provides continuous adjustment between the 100-pF steps of the smallest decade.

— See **GR Experimenter** for August 1966.

The double shielding used in the 1412-BC Decade Capacitor keeps C_{HG} very small. This capacitance is the difference between the 3-terminal and 2-terminal capacitance of the box; C_{LG} is approx 125 pF.



specifications

Capacitance: 50 pF to 1.11115 μF in steps of 100 pF with a 0- to 100-pF variable air capacitor providing continuous adjustment with divisions of 1 pF. Capacitances for 2- and 3-terminal connections differ by about 1 pF.

Min Capacitance: 50 pF with all controls set at zero.

Dielectric: Polystyrene for decade steps.

Accuracy: ±(1.0% + 5 pF) at 1 kHz, for total capacitance including 50-pF minimum.

Temperature Coefficient: −140 ppm/°C (nominal).

Frequency Characteristics: Dc Cap/1-kHz Cap <1.001. At higher frequencies the increase is approx $\Delta C/C = (f/f_r)^2$. The resonant frequency, f_r, varies from over 400 kHz for a capacitance of 1 μF to about 27 MHz for a capacitance of 150 pF when connections are made to the front terminals. f_r is about 300 kHz and 70 MHz for rear connections and the same capacitances.

Max Operating Temperature: 65°C.

Dielectric Absorption (Voltage Recovery): 0.1% max.

Dissipation Factor: 150 to 1000 pF, 0.001, max, at 1 kHz; over 1000 pF, 0.0002, max, at 1 kHz.

Insulation Resistance: 10^{12} ohms, min.

Max Voltage: 500 V peak up to 35 kHz.

Terminals: Four 938 Binding Posts with grounding link are provided on the panel. Two of the binding posts are connected to the case and located for convenient use with patch cords in 3-terminal applications. Access is also provided to rear terminals for relay-rack applications.

Mounting: Lab-Bench Cabinet. Brackets are provided for rack mounting.

Dimensions (width x height x depth): 17¼ x 3½ x 6 in. (440 x 89 x 155 mm).

Weight: Net, 8½ lb (3.9 kg); shipping, 10 lb (4.6 kg).

Catalog Number	Description	Price in USA
1412-9410	**1412-BC Decade Capacitor**	**$250.00**

File Courtesy of GRWiki.org

INDUCTANCE BRIDGES AND STANDARDS

CONSTRUCTION

For minimum generation of, or pickup from, external magnetic fields, the toroidal inductor is preferable to the solenoid. The symmetry of the toroid contributes both to stability and to a constant temperature coefficient.

An air core in the inductor results in the highest stability and a negligible variation of inductance with current, but at the expense of a relatively low Q. Because stability is the prime requirement in a laboratory standard, the Type 1482 Standard Inductors have air cores.

For a given volume, a larger inductance and Q can be obtained from a core of the high-permeability ferromagnetic materials, often termed "iron," although they usually are special alloys. Since the permeability of the material can change with age and particularly with current, the iron-core inductor is inherently less stable than the air-core type. Good stability can still be realized in iron-core inductors by proper design and choice of core materials, as in the Type 940 Decade Inductors and 1491 decade boxes.

INDUCTANCE CHANGES

The inductance depends not only upon the geometry and the permeability of the core but upon the residual impedances, which are shown in the equivalent circuit of Figure 1. The largest changes of inductance with frequency are produced by the effective shunt capacitance, C_o, of the winding and the terminals. When the frequency, f, is well below the resonance frequency, f_r, the fractional increase in inductance is approximately

$$\frac{\Delta L}{L_o} \approx \omega^2 L_o C_o = \left(\frac{f}{f_r}\right)^2, \qquad (1)$$

where L_o is the zero-frequency inductance.

There is practically no change in inductance with current when the core is air, but ferromagnetic core materials have a permeability that changes with magnetizing force, and the change is usually appreciable. The curves shown on page 104 for the Type 940 Inductors are typical. The inductance increases linearly over a small region near zero current, then rises rapidly to a maximum followed by a sudden decrease as saturation is approached. To make these curves independent of the inductance magnitude, the current has been normalized to a value, I_1, which is that current which produces a specified fractional increase in inductance at a specified permeability.

Q CHANGES

The storage factor, $Q = \omega L/R$, of an inductor is simply proportional to frequency when L and R are constant. But, as noted above, L can vary with frequency, and the losses are also functions of frequency. The components of loss are best described in terms of dissipation factor, $D = 1/Q$, since the total D is the sum of the component D's and these can be plotted as straight lines in logarithmic coordinates, as shown in Figure 2.

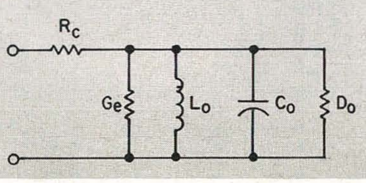


Figure 1. Equivalent circuit of an air-core inductor. R_c is the series resistance, G_e is the conductance due to eddy-current loss, and D_o is the dissipation factor of the distributed capacitance.

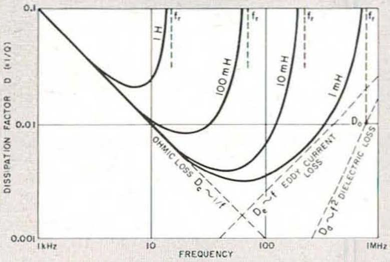


Figure 2. Dissipation-factor variation with frequency in typical air-core Type 1482 Standard Inductors.

$$D \simeq \frac{1}{1 - \left(\frac{f}{f_r}\right)^2} \left[\frac{R_c}{\omega L_o} + G_e \omega L_o + \left(\frac{f}{f_r}\right)^2 D_o\right] \qquad (2)$$

Resonance Factor; Ohmic Loss, D_c; Eddy-Current Loss, D_e; Dielectric Loss, D_d

The higher permeability of an iron core makes possible lower values of D_c and D_e, while f_r is slightly reduced and D_o is not changed. The core adds three more components to the dissipation factor: one from eddy currents in the core, proportional to frequency, another from hysteresis loss in the core, independent of frequency, and a third from residual losses in the core, constant with frequency and relatively small. The effects of these losses are shown in the plots of Q versus frequency for Type 940 Decade Inductors.

CALIBRATION

The calibrated inductance of a standard inductor is the change in the measured inductance of a circuit when a portion of that circuit is removed and replaced by the inductor. This measured inductance includes small and variable mutual inductances between the inductor and the rest of the circuit, which are negligible when the calibrated inductance is larger than, say, 100 microhenrys, but which can introduce accuracy-limiting uncertainties into the calibration of smaller inductances. These uncertainties can be reduced to less than one nanohenry to permit accurate calibrations down to one microhenry, if the mutual components are made a definite part of the calibrated inductance. One method of achieving this, used in the Type 1482 Standard Inductors of 200 microhenrys and less, is to provide, on the inductor, a switching link, which connects either the inductor coil or a short circuit through internal leads to the external connection terminals. The calibrated inductance, which is the measured difference of the connection terminals when the switch is moved from coil to short, is to a high degree independent of the external connections or environment.*

Since the inductance usually varies with frequency, an accurate calibration requires that the frequency be specified. When, as in inductors with iron cores, the inductance also varies with current, the calibration must also specify a corresponding current or voltage. Since the frequency or current at which the inductor will be used is not usually known, a convenient reference level is zero frequency and zero current (initial permeability). Measurements made at two currents within the linear range and at well below resonant frequency are extrapolated to obtain inductance at zero current and initial permeability of the core material.

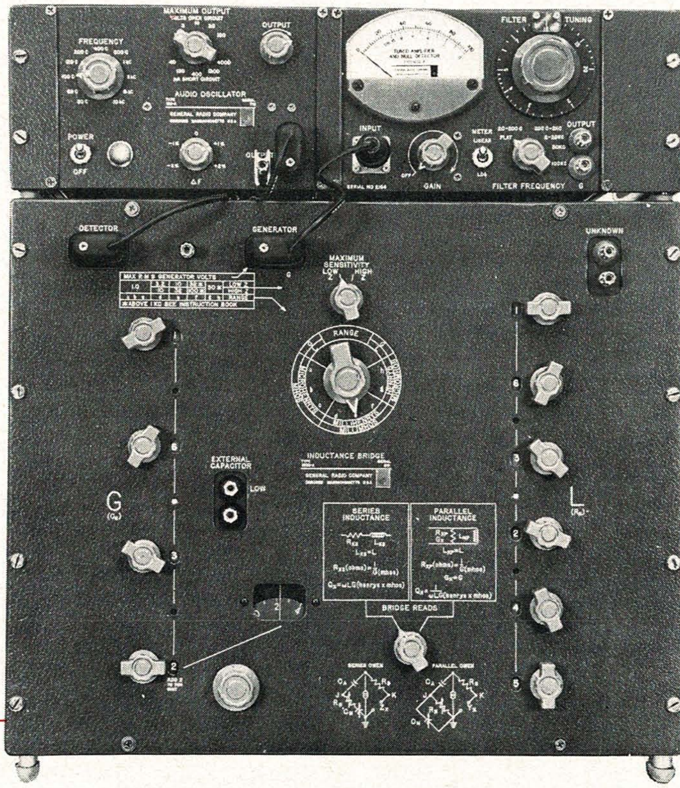
*John F. Hersh, "Connection Errors in Inductance Measurement," General Radio Experimenter, 34, 10, October, 1960.

File Courtesy of GRWiki.org

PRECISION INDUCTANCE-MEASURING ASSEMBLY

Type 1660-A

- 0.1 nH to 1.1 kH, ±0.1% accuracy
- comparison to 6-figure resolution
- series or parallel L, no sliding balance
- in-line readout, automatic decimal point



1660-A Precision Inductance-Measuring Assembly including: 1632-A Inductance Bridge, 1311-A Oscillator, 1232-A Tuned Amplifier and Null Detector.

The 1660-A assembly contains the 1632-A Inductance Bridge with appropriate oscillator and null detector, assembled, interconnected, and measurement-ready. The inductance bridge can be supplied alone if a suitable oscillator and detector are otherwise available or if measurements are required at frequencies other than the 11 provided by the oscillator in the assembly.

The 1632 measures series or parallel components of two-terminal grounded inductors, at audio frequencies. Its high accuracy makes it suitable for the most demanding direct-reading measurements, while its six-place resolution makes possible high-precision intercomparisons of inductance standards by substitution methods.

The bridge circuit is shown schematically on the panel. The standard reactance is a capacitor, which, owing to its very low residual impedances, exhibits a negligible change in its effective capacitance over the audio range. The Owen circuit also makes possible the use of the high accuracy of decade resistors for the inductance balance.

Inductance is indicated by the setting of a six-decade control, conductance by the setting of four decades and a continuously variable control. The dials, which show only the pertinent digit of each decade, indicate inductance directly. Resistance, either series or parallel, is the reciprocal of the conductance setting. An eight-position multiplier automatically indicates both the decimal point and the units of measurement.

For maximum accuracy in the measurement of both large and small values of inductance, the residual impedances associated with the unknown terminals have been minimized.

File Courtesy of GRWiki.org

specifications

RANGE AND ACCURACY

Inductance: Range, 0.1 nH to 1111 H. Accuracy, ±0.1%, direct reading, except at extremes of inductance, frequency, and Q ranges; ±1% on lowest range (0.1 nH to 111 μH). If Q is less than 1, accuracy is reduced to $(+0.05 \pm Q_B)\%/Q_X$. Values of Q_B at 1 kHz are:

Range	a, b, c	d- Low Z	d- High Z e- Low Z	e- High Z f- Low Z	f- High Z g	h
R_B	1 Ω	10 Ω	100 Ω	1 kΩ	10 kΩ	100 kΩ
Q_B at 1 kHz	±0.03%	±0.005%	±0.002%	±0.002%	±0.02%	±0.1 %

Above 1 kHz, multiply Q_B values by f_{kHz}. Additional error of $0.1 \times 10^{-8} f^2_{kHz}\%$ on lowest L range and of $4 \times 10^{-8} f^2_{kHz}\%$ on highest range. Two nearly equal inductors can be intercompared to a precision of 10 ppm or better. Bridge adds about 1 pF to capacitance across inductor.

Conductance: Range, 0.1 n℧ to 1111 ℧. Accuracy, ±1%, direct reading, reduced at extremes of inductance, conductance, frequency, and Q ranges. C_N capacitor decades are adjusted within ±1% + 2 pF.

If Q is greater than 10, the error in either series resistance or parallel conductance is increased to $Q_X\ (+0.05 \pm Q_B)\%$. (See above table for values of Q_B at 1 kHz, and, above 1 kHz, multiply Q_B values by f_{kHz}.) When bridge reads series conductance, there is an additional error in series resistance of 0.15 Q_X% at 1 kHz, when the L decades are set at 1/10 full scale (R_N = 10 kΩ); this error is proportional to frequency (with constant Q_X) and approximately proportional to resistance (R_N) of L decades.

Maximum Measurable Q: Series connection, proportional to frequency, 60 at 100 Hz; parallel connection, 80 at 100 Hz and R_N of 100 kΩ, inversely proportional to frequency and to R_N.

Frequency Range: Nominally 1 kHz and lower. Usable to 10 kHz with accuracy considerations discussed above. Oscillator in 1660 assembly generates 50, 60, 100, 120, 200, 400, and 500 Hz, 1, 2, 5, and 10 kHz only.

GENERAL

Generator: Type 1311-A Oscillator supplied in 1660 assembly. Type 1310-A or 1210-C is recommended for continuous frequency coverage. Max safe bridge voltage is 1 V on low-L ranges to 100 V on high ranges; values engraved on panel.

Detector: Type 1232-A Tuned Amplifier and Null Detector supplied in 1660 assembly and recommended for general use.

Accessories Supplied: 274-NL Shielded Patch Cord and 874-R34 Patch Cord for generator and detector connection; 1632-P1 Transformer to match low bridge input impedances to 600-Ω generator.

Power Required: For 1660, 105 to 125 or 210 to 250 V, 50 to 400 Hz, 22 W for 1311-A Oscillator. Null Detector operates from internal battery supply. Bridge requires no power.

Mounting: 1660 supplied assembled in cabinet. 1632 in Rack-Bench Cabinet.

Dimensions (width x height x depth): 1660 assembly, 19 x 23 x 10½ in. (485 x 590 x 270 mm); 1632 bench model, 19 x 16 x 10½ in. (485 x 410 x 270 mm); 1632 rack model, 19 x 15¾ x 8½ in. (485 x 400 x 230 mm)

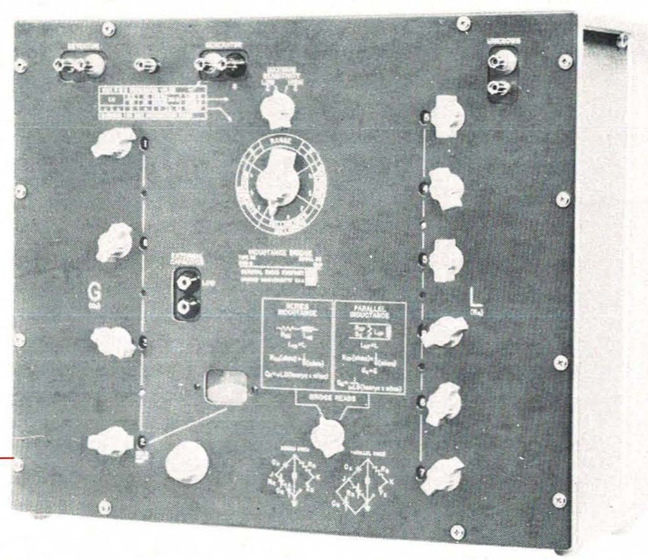
Net Weight: 1660 assembly, 62 lb (29 kg); 1632 bridge, 40 lb (18.5 kg).

Shipping Weight: 1660 assembly, 92 lb (42 kg); 1632 bridge, 53 lb (24.5 kg).

Catalog Number	Description	Price in USA
1660-9701	**1660-A Precision Inductance-Measuring Assembly**	**$2105.00**

INDUCTANCE BRIDGE

Type 1632-A



Oscillators page 198 ff

Detectors page 115 ff

Although available in the Type 1660-A assembly with oscillator and null detector, the 1632-A Inductance Bridge is offered separately for those who have the necessary companion instruments or wish to use frequencies not provided.

The 1632 is ideally suited to the measurement of standard inductors, by direct measurement to ±0.1%, or by substitution measurement, in comparison to external standards to a resolution of up to 1 ppm. Specifications for the bridge alone are as given above for the assembly, except as noted.

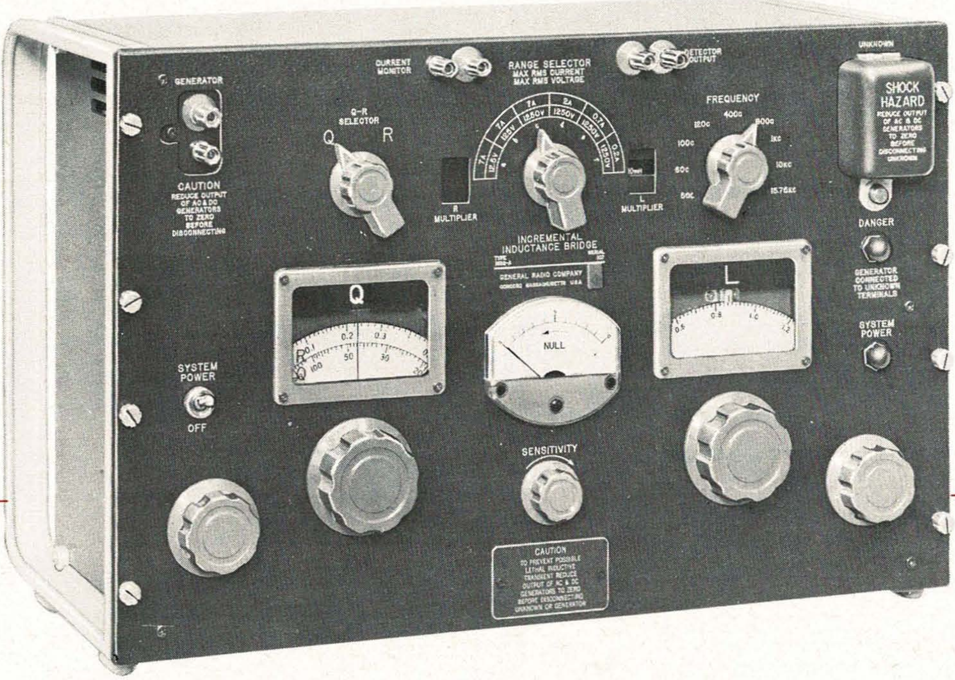
Catalog Number	Description	Price in USA
	1632-A Inductance Bridge	
1632-9801	Bench Mount	**$1395.00**
1632-9811	Rack Mount	**1395.00**

File Courtesy of GRWiki.org

- direct reading at 9 frequencies in series L and R or Q
- 0.2 μH to 1000 H
- 20 Hz to 20 kHz
- accuracy $\pm 1\%$
- apply up to 1250 V and 50 A, ac and dc
- numerous safety features

INCREMENTAL-INDUCTANCE BRIDGE

Type 1633-A



The 1633-A was designed primarily for measuring inductance and loss of transformers, chokes, and similar components at very high levels of ac and dc excitation and over a wide frequency range. Easy to operate and flexible in application, it can also measure other nonlinear elements such as Zener diodes, rectifiers, thermistors, and lamps. The bridge contains a highly selective nine-frequency detector for effective harmonic rejection and can be supplied complete with high-power ac and dc supplies as the Type 1630 Inductance-Measuring Assembly.

The incremental-inductance bridge uses a new circuit that incorporates active elements* in stable operational amplifiers. Although large signal and bias levels may be applied to the unknown, this circuit keeps signals in the bridge small, minimizes corrections, and eliminates sliding balance. Current and voltage in the unknown are nearly identical in magnitude and waveform to those applied at the GENERATOR terminals. In many instances measurements can be made while the unknown is actually operating in the circuit.

Up to 7 amperes, rms (combined ac and dc), at up to 1250 volts, can be impressed on the sample, and, with a 1633-P1 Range-Extension Unit, up to 50 amperes. Two power supplies are available, a dc supply and a variable-frequency oscillator, which are designed specifically for use with the bridge. Most conventional power supplies are not suitable.

The internal detector is highly selective at nine frequencies between 50 Hz and 15.75 kHz. Owing to high detector sensitivity and low noise, measurements can be made at excitation levels below one volt on the highest inductance ranges and 10 millivolts on the lowest range.

* H. P. Hall, R. G. Fulks, "The Use of Active Devices in Precision Bridges," Electrical Engineering, May 1962.

— See **GR Experimenter** for May 1962.

File Courtesy of GRWiki.org

specifications

RANGES OF MEASUREMENT

Measurement	Frequency	Full-Scale Ranges a	b	c	d	e	f	Lowest Scale Division	ACCURACY
Inductance	50, 60, 100, 120 Hz	10 mH	100 mH	1 H	10 H	100 H	1000 H	20 μH	±(1% of reading or 0.1% of full scale) $\pm 2\pi/100 \times f_{kHz}/Q_x)$%
	400, 800, 1000 Hz	1 mH	10 mH	100 mH	1 H	10 H	100 H	2 μH	
	10, 15.75 kHz	100 μH	1 mH	10 mH	100 mH	1 H	10 H	0.2 μH	
Resistance	All	10 Ω	100 Ω	1 kΩ	10 kΩ	100 kΩ	1 MΩ	10 mΩ	±(2% of reading or 0.1% of full scale) $\pm \frac{Q_x/f_{kHz}}{2\pi}$%
Q		∞ to 1, direct reading at above frequencies						1000	1/Q accuracy = ± 2% ±0.001 ±0.0005f_{kHz}
Max rms volts		12.5	125	1250	1250	1250	1250		
Min rms volts for 1% accuracy (internal detector)	50, 60 Hz	0.025	0.25	2.5	2.5	2.5	2.5		
	1 kHz	0.006	0.06	0.6	0.6	0.6	0.6		
Max rms amperes*		7	7	7	2	0.7	0.2	Max rms current = $\sqrt{I^2_{dc} + I^2_{ac}}$	

* If application requires more than 7 A, 1633-P1 Range-Extension Unit, which contains a 0.1-Ω resistor, can be externally connected to shunt R_B on the 3 lowest bridge ranges; inductance and resistance values are then reduced by a factor of 10. With this resistor, measurements up to 50 A, ac or dc, are possible.

GENERAL

Generator: External only (not supplied). For optimum performance when dc bias is used, ac supply must be able to withstand large dc currents in output circuit, and dc supply large ac currents. For dc bias, use 1265-A Adjustable DC Power Supply, 200 W; over the audio-frequency range, use 1308-A Audio Oscillator and Power Amplifier, 200 VA.

Detector: Internal or external. Internal, selective at any one of above 9 frequencies; response varies <3 dB for frequencies within 1% of nominal; second-harmonic response about 50 dB below fundamental. External, for continuous coverage from 20 Hz to 20 kHz, use 1232-A Tuned Amplifier and Null Detector.

Power Required: 105 to 125 or 210 to 250 V, about 6 W, 50 to 60 Hz.

Accessories Supplied: Power cord, spare fuses.

Accessories Available: 1633-P1 Range-Extension Unit.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench model, 19 x 12¾ x 10¼ in. (485 x 325 x 260 mm); rack model, 19 x 12¼ x 8¾ in. (485 x 315 x 225 mm).

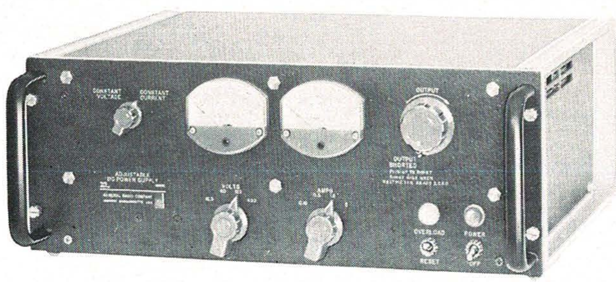
Weight, Net, 31 lb (14.5 kg); shipping, 48 lb (21.8 kg).

Catalog Number	Description	Price in USA
	1633-A Incremental-Inductance Bridge	
1633-9801	Bench Model	**$1395.00**
1633-9811	Rack Model	**1395.00**

PATENT NOTICE. See Notes 1 and 15.

ADJUSTABLE DC POWER SUPPLY

Type 1265-A



The 1265-A supplies dc bias for the 1633-A Incremental-Inductance Bridge. Its characteristics include wide ranges of current and voltage, a passive low-impedance output circuit that will pass high alternating currents, and a choice of voltage or current regulation.

The instrument has four voltage ranges and four current ranges and will deliver its maximum rated power of 200 watts to 8, 80, or 800 ohms. Ranges are interconnected to prevent overloading. Damage from overloads is prevented by an electronic overload circuit.

specifications

Full-Scale Output Ranges: 12.5, 40, 125, 400 V dc; 0.16, 0.5, 1.6, 5 A dc; in any combination up to 200 W.

Meters: Voltage and current; ranges switch with output ranges.

Overload Protection: Overload circuit trips at approx 1½ times full-scale current.

Regulation (Voltage or Current): 0.2% for 10% line-voltage change; 1% for 100% load change.

Speed of Response: Approx 0.1 second.

Hum Level (rms): Approx 70 dB below full-scale dc output (55 dB on 5-A ranges).

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz, 380 W at rated load. (Specify if for 50 Hz.)

Accessories Supplied: Power cord, spare fuses.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench model, 19 x 7½ x 17¼ in. (485 x 190 x 440 mm); rack model, 19 x 7 x 15 in. (485 x 180 x 385 mm).

Weight: Net, 70 lb (32 kg); shipping, 124 lb (57 kg).

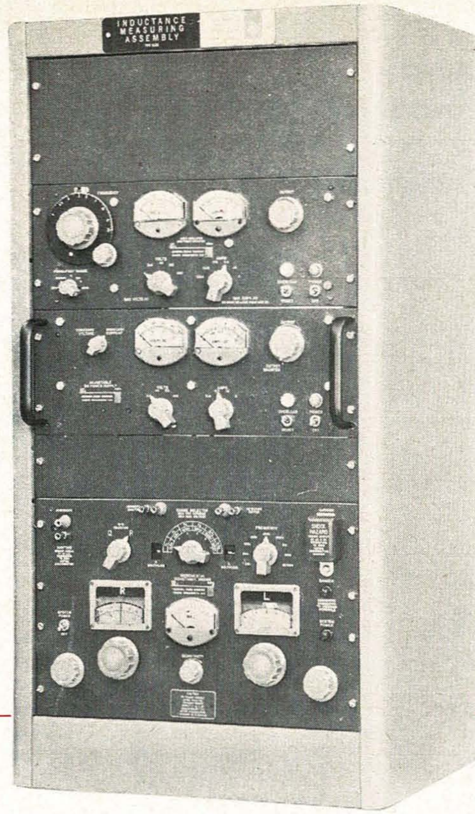
Catalog Number	Description	Price in USA
	1265-A Adjustable DC Power Supply	
1265-9801	Bench Model	**$1250.00**
1265-9811	Rack Model	**1250.00**

PATENT NOTICE. See Notes 1 and 15.

File Courtesy of GRWiki.org

INDUCTANCE-MEASURING ASSEMBLY

Type 1630-AV



- For measurements at 50, 60, 100, 120, 400, and 800 Hz, and 1, 10, and 15.75 kHz.

This assembly is a complete system for the measurement of inductance and loss of coils with ferromagnetic cores. It consists of a 1633 Incremental-Inductance Bridge, a 1265 Adjustable DC Power Supply, and a 1308 Audio Oscillator and Power Amplifier in a cabinet-type rack with all necessary interconnecting cables.

The supplies can produce 200-voltampere outputs into a wide range of load impedances and are designed to pass the large dc and ac currents required.

Space is provided at the top of the rack for the addition of an oscilloscope, which permits the current waveform or the hysteresis loop to be viewed during the measurements.

The 1308-A oscillator provides continuous coverage from 20 Hz to 20 kHz. When measurements are required at frequencies other than the nine internal-bridge-detector frequencies, the 1232-A Tuned Amplifier and Null Detector should be used. Order also 480-P308 Rack Adaptor Set, so that the detector can be installed in the rack.

Dimensions (width x height x depth): 22½ x 43 x 20 in. (580 x 1100 x 510 mm).

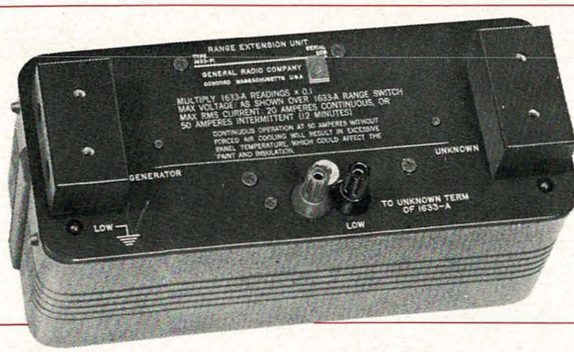
Weight, Net, 310 lb (145 kg); shipping, 460 lb (215 kg).

Catalog Number	Description	Price in USA
1630-9827	**1630-AV Inductance-Measuring Assembly**	**$4215.00**

PATENT NOTICE. See Notes 1 and 15.

RANGE-EXTENSION UNIT

Type 1633-P1



The 1633-P1 can be used with the 1633-A Incremental-Inductance Bridge to extend the current ratings to 50 amperes. It connects a 250-watt, 0.1-ohm resistor in parallel with one of the bridge arms.

specifications

Range: Upper limit is 100 mH up to 120 Hz and 10 mH up to 1 kHz. (Bridge readings must be multiplied by 0.1.) Only a, b, and c ranges can be used; bridge operation otherwise unchanged.

Accuracy: Additional ±1% up to 400 Hz. Correction can be made for errors at higher frequencies.

Temperature Coefficient (of power resistor): 20 ppm/°C.

Rating: 20 A continuous, or 50 A intermittent, ac or dc. Forced-air cooling required for continuous 50-A operation.

Terminals: High-current type for up to ¼-in.-dia leads to generator and unknown.

Accessories Supplied: Cable for connection to bridge.

Dimensions (width x height x depth): 10½ x 4¼ x 5 in. (270 x 110 x 130 mm).

Weight: Net, 5¼ lb (2.4 kg); shipping, 7 lb (3.2 kg).

Catalog Number	Description	Price in USA
1633-9601	**1633-P1 Range-Extension Unit**	**$165.00**

File Courtesy of GRWiki.org

standard inductors

STANDARD INDUCTOR

Type 1482

- stable within ±0.01% per year
- low, known temperature coefficient
- minimized connection errors
- toroidal — free from external fields

1482-A

1482-D

The 1482 is an accurate, highly stable standard of self inductance for use as a low-frequency reference or working standard in the laboratory. Records extending over 11 years, including those of inductors that traveled to national laboratories in several countries for calibration, show long-term stabilities well within ±0.01%.

Each inductor is a uniformly wound toroid on a ceramic core. It has a negligible external magnetic field and hence essentially no pickup from external fields. The inductor is resiliently supported in a mixture of ground cork and silica gel, after which the whole assembly is cast with a potting compound into a cubical aluminum case.

1632 Bridge page 97

Sizes of 500 μH and above have three terminals, two for the inductor leads and the third connected to the case, to provide either a two- or three-terminal standard. The 50-, 100-, and 200-μH sizes have three additional terminals for the switching used to minimize connection errors, as described in the introduction to the inductance section.

For comparing other inductors with these standards, the 1632-A Inductance Bridge is recommended.

specifications

Inductance Range: See table.

Accuracy of Adjustment: See table.

Calibration: A certificate of calibration is provided with each unit, giving measured values of inductance at 100, 200, 400, and 1000 Hz, with temperature and method of measurement specified. These values are obtained by comparison, to a precision, typically, of better than ±0.005%, with working standards whose absolute values, determined and maintained in terms of reference standards periodically certified by the National Bureau of Standards, are known to an accuracy typically ±(0.02% + 0.1 μH) at 100 Hz.

Stability: Inductance change is less than ±0.01% per year.

Dc Resistance: See table for representative values. A measured value of resistance at a specified temperature is given on the certificate of calibration.

Low-Frequency Storage Factor Q: See table for representative values of Q at 100 Hz (essentially from dc resistance). An individual value of Q, calculated from the measured dc resistance, is given on each certificate of calibration.

Temperature Coefficient of Inductance: Approx 30 ppm per °C. Minute temperature corrections may be computed from dc resistance changes. A 1% increase in resistance, produced by a temperature increase of 2.54°C. corresponds to 0.0076% increase in inductance.

Resonant Frequency: See table for representative values. A measured value is given on the certificate of calibration.

Max Input Power: For a rise of 20°C, 3 W; for precise work, a rise of 1.5°C, 200 mW. See table for corresponding current limits.

Terminals: Jack-top binding posts on ¾-in. spacing with removable ground strap.

Mounting: Aluminum cabinet with handle and rubber feet.

Dimensions (width x height x depth): 6½ x 6½ x 8 in. (165 x 165 x 205 mm).

Weight: Net, 11½ lb (5.5 kg); shipping, 13 lb (6 kg).

Catalog Number	Description	Nominal Inductance	Adjustment Accuracy (Percent)	*Resonant Frequency (kHz)	*Dc Resistance (Ohms)	*Q at 100 Hz	Milliamperes, rms for, 200 mW	3 W	Price in USA
	Standard Inductor								
1482-9701	**1482-A**	50 μH	±0.5	3100	0.039	0.81	2260	8770	**$195.00**
1482-9702	**1482-B**	100 μH	±0.25	2250	0.083	0.76	1550	6010	**195.00**
1482-9703	**1482-C**	200 μH	±0.25	1400	0.15	0.84	1150	4470	**195.00**
1482-9704	**1482-D**	500 μH	±0.1	960	0.38	0.83	725	2810	**195.00**
1482-9705	**1482-E**	1 mH	±0.1	800	0.84	0.75	490	1890	**175.00**
1482-9706	**1482-F**	2 mH	±0.1	580	1.52	0.83	360	1400	**155.00**
1482-9707	**1482-G**	5 mH	±0.1	320	3.8	0.83	230	890	**150.00**
1482-9708	**1482-H**	10 mH	±0.1	220	8.2	0.77	156	600	**145.00**
1482-9710	**1482-J**	20 mH	±0.1	145	14.5	0.87	117	450	**145.00**
1482-9711	**1482-K**	50 mH	±0.1	84	36.8	0.85	74	280	**145.00**
1482-9712	**1482-L**	100 mH	±0.1	71	81	0.78	50	192	**150.00**
1482-9713	**1482-M**	200 mH	±0.1	39.0	109	1.15	43	166	**155.00**
1482-9714	**1482-N**	500 mM	±0.1	24.5	280	1.12	27	103	**160.00**
1482-9716	**1482-P**	1 H	±0.1	14.6	616	1.02	18	70	**190.00**
1482-9717	**1482-Q**	2 H	±0.1	10.6	1125	1.12	13.3	52	**220.00**
1482-9718	**1482-R**	5 H	±0.1	6.8	2920	1.08	8.3	32	**290.00**
1482-9720	**1482-T**	10 H	±0.1	4.9	6400	0.98	5.6	22	**385.00**

* Representative values. Actual values given on certificate.

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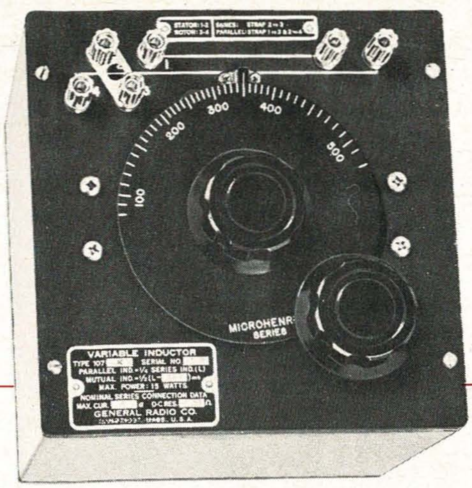
VARIABLE INDUCTOR

Type 107



- 20:1 continuous variation with series or parallel connections
- mutual- and self-inductance calibration

The 107 finds its greatest uses in the laboratory as an adjustable standard of moderate accuracy for measurements of self and mutual inductance, and as a circuit element in bridges, oscillators, and similar equipment.

Rotor and stator coils are mounted concentrically. The effective inductance depends upon the position of the rotor with respect to the stator.

In most models stranded wire is used, in which the separate strands are insulated from one another. The coils are impregnated and baked in a synthetic varnish before being securely mounted on the phenolic panel.

Dial is direct reading in inductance for the series connection of the coils. Inductance for the parallel connection is one-fourth the value shown by the dial.

specifications

Inductance Range: See table below. Dial is direct reading in inductance for the series connection.

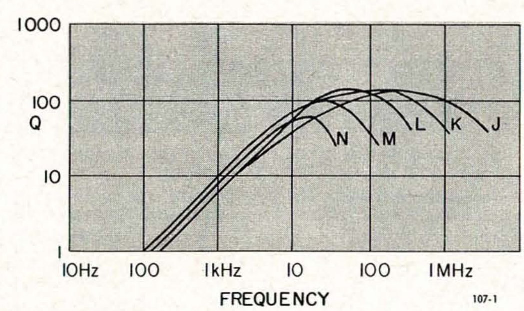
Accuracy: Series connection, ±1% of full scale at 1 kHz. Inductance for parallel connection is one-fourth the series value within ±(1% + 0.01 μH) of the former. Mutual-inductance accuracy is ±2.5% of full-scale (mutual) value. The formula for mutual inductance is engraved on the nameplate. Under our standard warranty, this accuracy is guaranteed for 2 years.

Frequency Characteristics: The fractional increase in inductance with frequency will be f^2/f_r^2 where f is the operating frequency and f_r the natural frequency, which can be calculated from $f_r = \frac{1}{2\pi\sqrt{LC_o}}$. Values of C_o are tabulated below. See plot for change in Q with frequency.

Max Power and Current: Current for 15 W max dissipation, corresponding to a temperature rise of 40°C, is given in the table below and is engraved on the nameplate.

Dc Resistance: See table below. These series-connection values are engraved on the nameplate. For parallel connections the resistance is approx ¼ the tabulated values.

Terminals: Standard ¾-in. spacing, jack-top binding posts provide separate connections to rotor and stator. Series and parallel connections are made by means of links.



Storage factor, Q, versus frequency at full-scale series connection.

Mounting: All units are mounted on phenolic panels and enclosed in unshielded hardwood cabinets.

Dimensions: 6½ x 6½ x 8¾ in. (165 x 165 x 220 mm).

Weight: Net, 5 lb (2.3 kg); shipping, 10 lb (4.6 kg).

Catalog Number	Description	Self-Inductance Series	Self-Inductance Parallel	Mutual Inductance	Typical C_o Values Series	Typical C_o Values Parallel	Dc Resistance ohms	Maximum Current amperes	Price in USA
	Variable Inductor								
0107-9710	**107-J**	9-50 μH	2.25-12.5 μH	0-10.8 μH	35 pF	57 pF	0.05	16	**$150.00**
0107-9711	**107-K**	90-500 μH	22.5-125 μH	0-110 μH	40 pF	72 pF	0.38	6	**150.00**
0107-9712	**107-L**	0.9-5 mH	0.225-1.25 mH	0-1.1 mH	39 pF	73 pF	5.0	1.7	**150.00**
0107-9713	**107-M**	9-50 mH	2.25-12.5 mH	0-11 mH	34 pF	41 pF	36	0.65	**150.00**
0107-9714	**107-N**	90-500 mH	22.5-125 mH	0-110 mH	34 pF	41 pF	450	0.17	**150.00**

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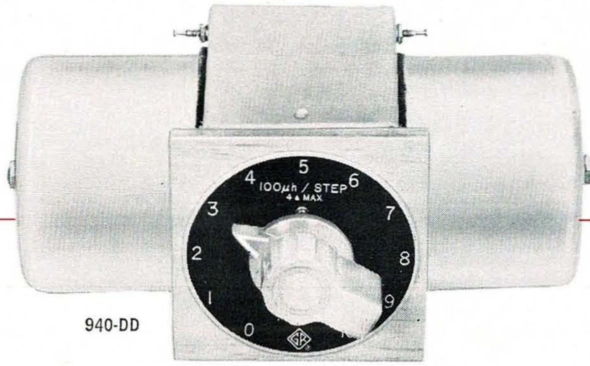
standard inductors

DECADE-INDUCTOR UNIT

Type 940



940-DD

Each 940 Decade-Inductor Unit is an assembly of four inductors (relative values, 1, 2, 2, 5) wound on molybdenum-permalloy dust cores, which are combined by switching to give the eleven successive values from 0 to 10. The decade switch has high-quality ceramic stator-and-rotor members and well-defined ball-and-socket detents. All contacts are made of a silver alloy and have a positive wiping action.

specifications

Accuracy: Each unit is adjusted so that its inductance at zero frequency and initial permeability will be the nominal value within the accuracy tolerance given in the following table:

Unit	940-DD	940-E	940-F	940-G	940-H
Inductance per step	100 µH	1 mH	10 mH	100 mH	1 H
Accuracy	±2%	±2%	±1%	±0.6%	±0.6%

Under our standard warranty, this accuracy is guaranteed for 2 years if the inductor has not been damaged.

Frequency Characteristics: For any specific operating frequency, Figure 2 shows the percentage increase in effective series inductance (above the value when f = 0), which is encountered with the extreme settings of each of the five decade-inductor units when the chassis is floating. Interpolation may be used for intermediate settings.

Change in Inductance with Current: Fractional change in initial inductance with ac current for each type of toroid is shown in the normal curves, Figure 1, in terms of the ratio of the operating current, I, to I_1, the current for 0.25% change, solid line (0.1%, broken line). For ratios below unity, inductance change is directly proportional to current. Values of I_1, listed below, are approximate and are based on the largest inductor in the circuit for each setting.

Incremental Inductance: Dc bias current I_b will reduce the initial inductance as shown in the incremental curves, Figure 1.

Switch Setting	RMS I_1 (mA): 0.1% Increase	RMS I_1 (mA): 0.25% Increase			
	940-DD	940-E	940-F	940-G	940-H
1	141	17	5.4	1.7	0.54
2, 3, 4	100	12	3.8	1.2	0.38
5, 6, 7, 8, 9, 10	63	8	2.4	0.8	0.24

Storage Factor Q: See Figure 3.

Dc Resistance: Approx 45 Ω per henry.

Temperature Coefficient: Approx −25 ppm per degree C between 16° and 32°C.

Max Safe Current: Approx 200 times the pertinent I_1 value (30 times for the 940-DD). Max current engraved on dial.

Terminals: Solder lugs. Circuit insulated from chassis.

Mounting: Hardware included, with dial plate and knob.

Dimensions (width x height x depth): 8 x 3½ x 4¼ in. (205 x 90 x 110 mm).

Weight: Net, 3½ lb (1.6 kg); shipping, 6 lb (2.8 kg).

Catalog Number	Description	Inductance Total	Inductance Steps	Price in USA
	Decade Inductor			
0940-9810	**940-DD**	1 mH	100 µH	**$180.00**
0940-9705	**940-E**	0.01 H	0.001 H	**170.00**
0940-9706	**940-F**	0.1 H	0.01 H	**120.00**
0940-9707	**940-G**	1 H	0.1 H	**180.00**
0940-9708	**940-H**	10 H	1 H	**195.00**

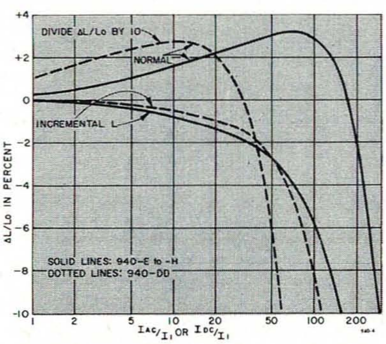


Figure 1. Percentage change in normal and incremental inductance with ac and bias current. Incremental curve is limited to an ac excitation less than I_1.

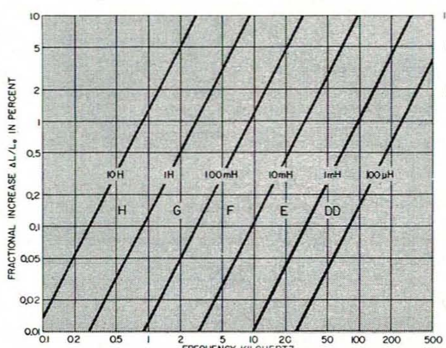


Figure 2. Change in effective inductance with frequency for the 940 Decade-Inductor Units.

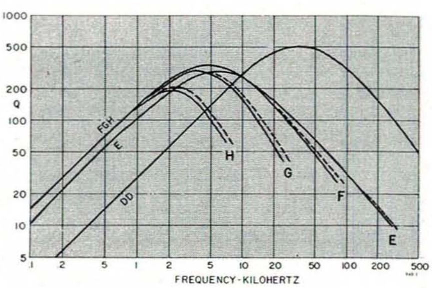


Figure 3. Variation of Q for the maximum inductance of each 940 Decade-Inductor Unit at low excitation levels. Dashed curves correspond to use with chassis floating.

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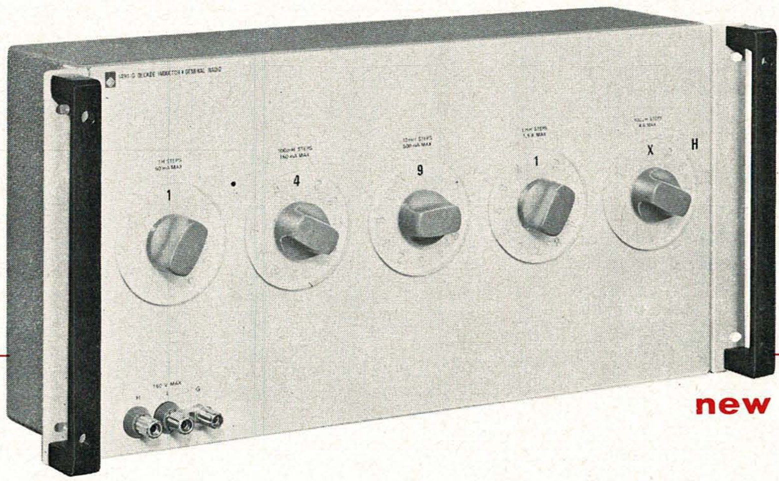
DECADE INDUCTOR

Type 1491



1491-G

new

- high-Q
- shielded toroidal cores for
  small mutual inductance
  little effect from external fields
- sealed against moisture

The 1491 Decade Inductor is an assembly of several 940 Decade-Inductor Units in a single metal cabinet. The units have no electrical connection to the panel, but a separate ground terminal is provided, which can be connected to the adjacent low terminal, leading to the smallest decade.

These inductance decades are convenient elements for use in wave filters, equalizers, and tuned circuits throughout the range of audio and low radio frequencies. As components in oscillators, analyzers, and similar equipment, they are especially useful during the preliminary design period, when the ability to vary circuit elements over relatively wide ranges is necessary to determine optimum operating values. As moderately precise standards of inductance they have values of low-frequency storage factor, Q, that are much larger than those of air-core coils.

specifications (see also specifications for 940 decade units)

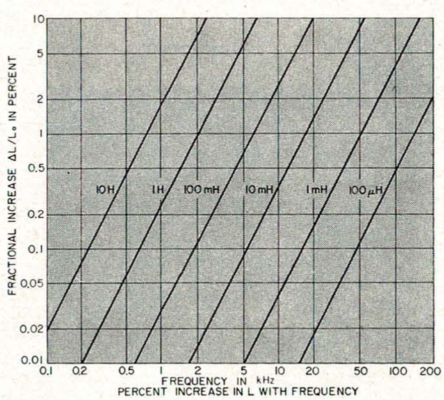
Frequency Characteristics: Percentage increase in effective series inductance (above the zero-frequency value, L_0) may be obtained by interpolation in accompanying graph for any setting of the highest-value decade used, when LOW terminal is grounded to cabinet.

Zero Inductance: Approx 1 μH.

Max Voltage: 500 V rms. Switch will break circuit at 500 V if turned rapidly, but voltages above 150 V may cause destructive arcing with switch between detent positions.

Terminals: Binding posts on ¾-in. centers; separate ground terminal provided.

Mounting: Lab-Bench Cabinet.



Variation of inductance with frequency, for the 1491 Decade Inductors.

Dimensions (width x height x depth):

1491-A, -B, -C		
Bench	12¾ x 8¾ x 6½ in.	325 x 225 x 170 mm
Rack	19 x 8¾ x 4⅞ in.	485 x 225 x 125 mm
1491-D, -F, -G		
Bench	17 x 8¾ x 6½ in.	435 x 225 x 170 mm
Rack	19 x 8¾ x 4⅞ in.	485 x 225 x 125 mm

Weight (bench models; add 1¾ lb (0.8 kg) for rack models):

	Net	Shipping (est)
1491-A, -B, -C	18 lb (8.5 kg)	25 lb (11.7 kg)
1491-D, -F	23 lb (10.5 kg)	30 lb (13.7 kg)
1491-G	26½ lb (12.5 kg)	34 lb (15.5 kg)

Catalog Number		Description	Inductance		940's	Price in USA	
Bench	Rack		Total	Steps	Included	Bench	Rack
		Decade Inductor					
1491-9701	1491-9711	**1491-A**	0.111 H	0.0001 H	DD, E, F	**$515.00**	**$540.00**
1491-9706	1491-9716	**1491-F**	1.111 H	0.0001 H	DD, E, F, G	**715.00**	**735.00**
1491-9703	1491-9713	**1491-C**	1.11 H	0.001 H	E, F, G	**540.00**	**565.00**
1491-9707	1491-9717	**1491-G**	11.111 H	0.0001 H	DD, E, F, G, H	**895.00**	**915.00**
1491-9704	1491-9714	**1491-D**	11.11 H	0.001 H	E, F, G, H	**725.00**	**745.00**
1491-9702	1491-9712	**1491-B**	11.1 H	0.01 H	F, G, H	**600.00**	**625.00**

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RESISTANCE BRIDGES AND STANDARDS

STANDARD RESISTORS

Because of its accuracy of adjustment, long-term stability, low and uniform temperature coefficient, and relative immunity to ambient humidity conditions, the wire-wound resistor is the most suitable type for use as a laboratory standard at audio and low radio frequencies, as well as at dc.

AC CONSIDERATIONS

Resistors designed for ac use differ from those intended for use only at dc in that low series reactance and constancy of resistance as frequency is varied are important design objectives. The residual capacitance and inductance become increasingly important as the frequency is raised, acting to change the terminal resistance from its low-frequency value.

For frequencies where the resistance and its associated residual reactances behave as lumped parameters, the equivalent circuit of a resistor can be represented as shown in Figure 1. L is the equivalent inductance in series with the resistance, and C is the equivalent capacitance across the terminals of the resistor.

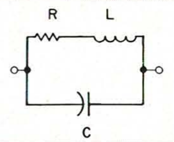


Figure 1.

It is necessary to differentiate clearly between the concepts of equivalent series and equivalent parallel circuits. The two-terminal circuit of Figure 1 can be described as an impedance $R_s + jX_s$ or as an admittance $G + jB = \frac{1}{R_p} + \frac{1}{jX_p}$, wherein the parameters are a function of frequency. This distinction between series and parallel components is more than a mathematical exercise — the use to which the resistor is to be put will frequently determine which component is of principal interest.

The expression for the effective series impedance is:

$$Z_s = R_s + jX_s = \frac{R + j\omega\left[L\left(1 - \frac{\omega^2}{\omega_r^2}\right) - R^2C\right]}{\left(1 - \frac{\omega^2}{\omega_r^2}\right)^2 + (\omega RC)^2}$$

where $\omega_r = \frac{1}{\sqrt{LC}}$ and $\frac{\omega^2}{\omega_r^2} = \omega^2 LC$.

The effective parallel admittance is given by:

$$Y = G + jB = \frac{1}{R_p} + \frac{1}{jX_p} = \frac{\frac{1}{R} + j\omega\left[C - \frac{L}{R^2}\left(1 - \frac{\omega^2}{\omega_r^2}\right)\right]}{1 + \left(\frac{\omega L}{R}\right)^2}$$

At low frequencies where terms in ω^2 are negligible, the resistor may be represented by a two-element network consisting of the dc resistance, R, in series with an inductance equal to $L - R^2C$ or in parallel with a capacitance equal to $C - L/R^2$. Because of the presence of the R^2 term in the equivalent reactive parameters, shunt capacitance is the dominating residual for high values of resistance, while for low values the series inductance invariably predominates. Generally, individual wire-wound resistors above a few kilohms are capacitive, while decades are capacitive at somewhat lower values.

In the simplified circuit of Figure 1, the effective parallel resistance of a high-valued resistor in which capacitance dominates would be independent of frequency. Actually, other effects may cause the parallel resistance to decrease with frequency. For example, dielectric losses in the shunt capacitance, C, are equivalent to a resistance

$$R_d = \frac{1}{D\omega C}$$

(where D is the dissipation factor of the distributed capacitance), which decreases with frequency and causes the effective parallel resistance to decrease rapidly beyond a certain frequency. In addition, distributed capacitance along the winding causes a similar rapid decrease in resistance even if its dielectric loss is negligible. The equations above indicate that the effective series resistance of low-valued resistors would be independent of frequency up to quite high frequencies. In practice, if the residual inductance and capacitance are kept small, skin effect becomes the main cause for departure from the low-frequency values of these resistors.

General Radio wire-wound resistance elements are designed to minimize inductance in low-resistance values and to minimize capacitance for high values of resistance. All units up through 200 ohms utilize an Ayrton-Perry winding. For very low-valued units, the residual inductance of such a winding is about 1% of that of a corresponding single winding.

Elements having 500-ohm resistance or higher are unifilar-wound on flat rectangular "cards," and have inherently less inductance than so-called "noninductive" spool-wound types because of the low cross-sectional area of the winding (refer to Figure 2). The capacitance of a card-type resistor is also much lower than that of a spool type because the turns of wire are not piled up but are evenly wound in one layer.

DECADE BOXES

In decade boxes, the residual impedances of the switches, wiring, and cabinet are added to those of the resistors themselves. For multiple-decade boxes, the series inductances are additive, but the capacitance is approximately that across the highest valued decade used (see specifications for each type).

The effect of the residual reactance depends greatly upon the way the resistor is connected in the circuit. For example, parallel capacitance can often be compensated for when the resistor is connected in parallel with a capacitor. For high-valued resistors, the upper frequency limit for a given error is some ten times higher in the effective parallel resistance than it is for the series connection.

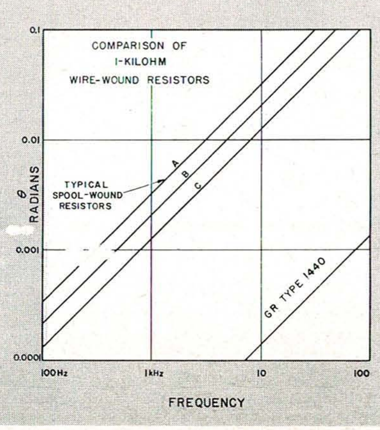


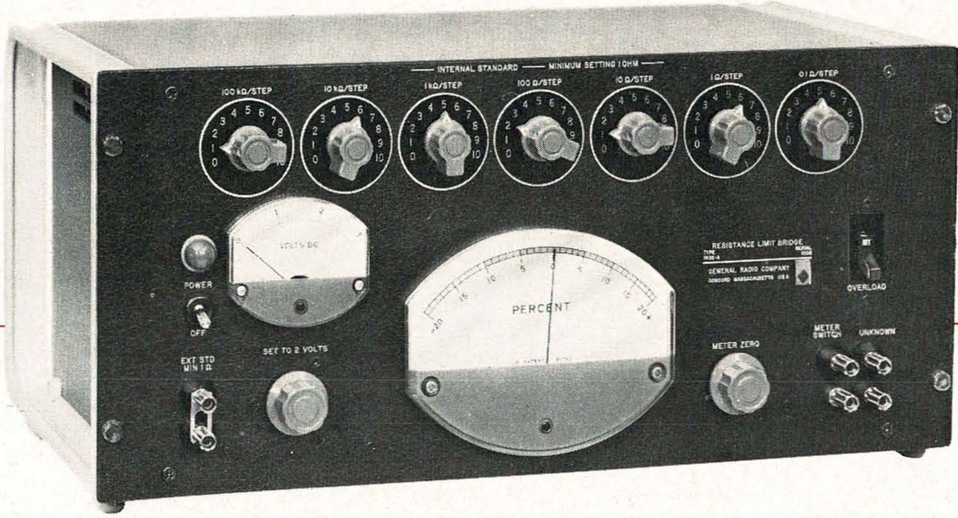
Figure 2.

File Courtesy of GRWiki.org

- 1 ohm to 1.11 megohms
- accuracy better than ±0.5%
- use internal or external standards
- fast, accurate limit tests, null measurements

RESISTANCE LIMIT BRIDGE

Type 1652-A



This resistance limit bridge is intended for the production testing of resistors at dc. It can be used:

- To indicate deviation from nominal value.
- To match pairs of resistors.
- To compare resistors to a standard sample.
- To measure resistance by the null method.

For manufacturers and users of resistors, this bridge is a rapid and accurate means for sorting into tolerance classifications, for selection to close tolerances, and for matching pairs of resistors for balanced circuits.

In the laboratory, its accuracy is adequate for all but the most exacting requirements, and it will measure resistors up to one megohm.

For automatic sorting, a relay and amplifier can be connected to actuate a selector mechanism.

DESCRIPTION

The circuit is a conventional equal-arm Wheatstone bridge, supplied from a constant-voltage dc source. The meter indicates percent deviation directly. The internal standard consists of seven Type 510 Decade-Resistance Units and is adjustable in 0.1-ohm steps from one ohm to 1,111,111 ohms.

For limit testing, the standard is set to the desired nominal value, and the percentage deviation is read from the meter. Terminals are provided for connection of a test jig such as the Type 1650-P1.

For matching pairs, the resistor to be matched is substituted for the internal standard.

For null measurements, the internal standard is adjusted to equality with the unknown resistor.

specifications

RESISTANCE RANGES	ACCURACY
As Limit Bridge	
With internal standard, 1 to 1,111,111 Ω	±0.5% of measured value
With external standard, 1 to 2,000,000 Ω	±0.2% + tolerance of standard
Meter reads from −20 to +20%; standard EIA (RETMA) ±5% and ±10% tolerances indicated by gold and silver lettering, respectively.	
As Null Bridge	
With internal standard, 1 to 1,111,111 Ω	±0.25% of measured value above 100 Ω; ±0.4% between 10 Ω and 1 Ω.
With external standard, 1 to 2,000,000 Ω	±0.2% + tolerance of standard
For matching, 1 to 2,000,000 Ω	±0.2%

Test Voltages: Varies with meter indication, from 0.9 V at −20% reading to 1.1 V at +20%.

Power Required: 105 to 125 or 210 to 250 V, 60 Hz (50-Hz model available), about 30 W.

Accessories Supplied: Power cord, spare fuses.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench model, 19 x 9 x 12¼ in. (485 x 230 x 315 mm); rack model, 19 x 8¾ x 11 in. (485 x 225 x 280 mm).

Weight: Net, 29 lb (13.5 kg); shipping, 43 lb (19.6 kg).

Catalog Number	Description	Price in USA
	Resistance Limit Bridge	
1652-9801	**1652-A, 60-Hz supply,** Bench Model	**$895.00**
1652-9811	**1652-A, 60-Hz supply,** Rack Model	**895.00**
1652-9495	**1652-AQ1, 50-Hz supply,** Bench Model	**on request**
1652-9496	**1652-AQ1, 50-Hz supply,** Rack Model	**on request**

PATENT NOTICE. See Note 15.

File Courtesy of GRWiki.org

MEGOHM BRIDGE

Type 1644-A

- 10^3 to 10^{15} ohms
- 1% accuracy to 10^{12} ohms
- ΔR measurements to ±0.2%
- seven test voltages
- self-checking internal standards

The 1644-A will measure:

- **Insulation Resistance** of cables, transformers, chokes, components, connectors, wiring, terminals, resistors, capacitors, relays, printed circuits, rotating machines, switches, circuit breakers, meters, strain gages, thermocouples, delay lines, slip rings, commutators, heaters, filters, lightning arresters, and other devices.
- **Resistance** of high-valued resistors, rersistance films, diodes, transistors, and piezoelectric elements.
- **Voltage and Temperature Coefficients** of resistance.
- **Volume and Surface Resistivity** of solids, s uch as printed-board material, resins, plastics, potting and casting compounds, rubber, refractories, and semiconductors; of liquids, such as oils, plasticizers, and solvents; and of sheet materials, including plastics, recording tape, and varnished fabrics.

The circuit is a dc Wheatstone bridge with a high-impedance, high-sensitivity detector. Precision, wire-wound resistors are used for the fixed bridge arm and the lower-valued decade-step arms. Metal-film and carbon-film resistors are used for the higher decade steps, with trimmers for precise adjustment in terms of the wire-wound standards. The balancing arm is a wire-wound variable resistor.

The guard terminal eliminates the effects of stray resistances to ground. For capacitor leakage resistance measurement, charging time is a fraction of a second.

— See **GR Experimenter** for July 1964.

specifications

Resistance Range: 1 kΩ to 1000 TΩ (10^3 to 10^{15} Ω) in ten ranges.
Accuracy: 10^3 Ω to 10^{10} Ω, ±1%. After self-calibration: 10^{10} to 10^{12} Ω, ±1%*; 10^{13} Ω, ±2%; 10^{14} Ω, ±10%; 10^{15} Ω, ± one scale division.
ΔR% Dial: ±5% range; accurate to ±0.2% or, for small changes, to ±0.1%.
Test Voltage: Voltage accuracy is ±3% ±0.5 V.

Fixed Voltages	10	20	50	100	200	500	1000	V
Minimum Unknown R	1	3	7	20	50	150	500	kΩ

Minimum Test Voltage for 1% Resolution: for approx 1-mm meter deflection	Multiplier Setting	Max R_x	Volts
	100 G or less	10^{11}	10
	100 G	10^{12}	100
	1 T	10^{13}	200

* At high voltages; 1% accuracy is obtainable at 10 V up to 10^{11} Ω; see above.

Short-Circuit Current: <15 mA, 10-50 V; <10 mA, 100-1000 V.
Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz, 13 W.
Mounting: Flip-Tilt Case or rack mount.
Dimensions (width x height x depth): Portable model, 12¾ x 12½ x 7¾ in. (325 x 320 x 200 mm); rack model, 19 x 12¼ x 5 in. (485 x 315 x 130 mm).
Weight: Net, 19 lb (9 kg); shipping, 31 lb (14.5 kg).

Catalog Number	Description	Price in USA
	1644-A Megohm Bridge	
1644-9701	Portable Model	**$795.00**
1644-9820	Rack Model	**795.00**

PATENT NOTICE. See Notes 1, 15, and 22.

File Courtesy of GRWiki.org

MEGOHMMETER

Type 1862-C

- 0.5 to 2,000,000 megohms
- 100- and 500-V test voltage
- direct reading, fast, easy

Rugged, versatile, and safe, this megohmmeter rapidly measures wide ranges of resistance at either of two test voltages. The 100-volt level is the EIA standard for measurement of composition, film, and wire-wound resistors above 100 kilohms. The 500-volt level is a standard value in the measurement of the insulation resistance of rotating machinery, transformers, cables, capacitors, appliances, and other electrical equipment.

Regulated power supply and charging circuit permit rapid and accurate measurement of the leakage resistance of capacitors.

Guard and ground terminals permit measurement of grounded or ungrounded two- or three-terminal resistors.

A panel warning light indicates when voltage is applied to the test terminals and thus permits connections to be made safely.

The megohmmeter consists of a regulated power supply, a complement of resistance standards, and a balanced, dc, vacuum-tube voltmeter with very high input resistance.

— See **GR Experimenter** for July 1963.

For measurements of resistance to 5 x 10^{14} ohms, as well as of very low voltages and currents, consider the **1230-A Electrometer and DC Amplifier.**

specifications

Resistance Range: 0.5 MΩ to 2 TΩ (5×10^5 to 2×10^{12} Ω) at 500 V; 0.5 MΩ to 0.2 TΩ at 100 V; 6 decade ranges; 90% of meter scale utilized for resistance scales up to 500,000 MΩ; center-scale values are 1, 10, 100, 1000, 10,000 and 100,000 MΩ for 500-V operation.

Accuracy: ±3% of indication at low-resistance end of each decade to ±12% (accuracy to which scale can be read) at high-resistance end up to 50,000 MΩ; possible additional ±2% error at top decade. Switch position provided for standardizing calibration at 500 V.

Test Voltage: 100 ±4 V or 500 ±10 V, as selected by front-panel switch. Available current is limited to safe values: approx 2 mA at 100 V, 10 mA at 500 V.

Power Required: 105 to 125 or 210 to 250 V, 40 to 60 Hz (operates satisfactorily up to 400 Hz), 25 W.

Accessories Supplied: Spare fuses, 2 color-coded test leads.

Mounting: Flip-Tilt Case. Rack-mount version also available.

Dimensions (width x height x depth): Portable model, 8½ x 11½ x 7½ in. (210 x 295 x 190 mm); rack model, 19 x 10½ x 5 in. (485 x 270 x 130 mm).

Net Weight: Portable model, 9 lb (4.1 kg); rack model, 10 lb (4.6 kg).

Shipping Weight: Portable model, 12 lb (5.5 kg); rack model, 23 lb (10.5 kg).

Catalog Number	Description	Price in USA
1862-9703	**1862-C Megohmmeter,** Portable Model	**$385.00**
1862-9844	**1862-C Megohmmeter,** Rack Model	**385.00**

PATENT NOTICE. See Notes 15 and 22.

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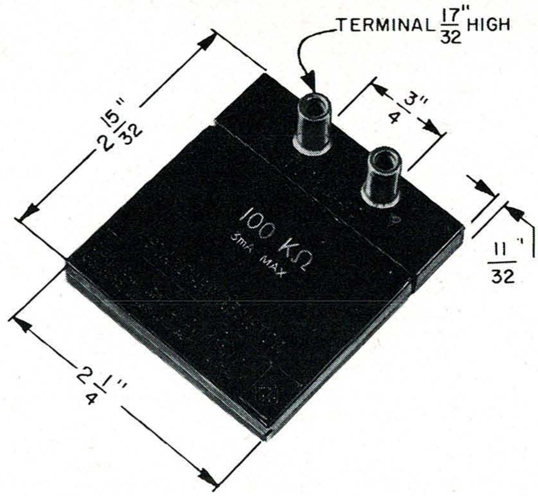
STANDARD RESISTOR

Type 1440



- accuracy ±0.01%
- stability ±10 ppm per year
- low thermal emf to copper

These extremely stable resistors are intended for use as laboratory or production standards for calibrating resistance bridges and for substitution measurements.

They are card-type, wire-wound resistors, carefully wound and adjusted. Low-temperature-coefficient Evanohm* wire is used for values above 10 ohms, manganin for the lower-resistance units. All units are heat cycled to reduce strains and are repeatedly checked to eliminate any that show abnormal behavior. They are encased in sealed, oil-filled, diallylphthalate boxes to promote long-term stability and to provide mechanical protection.

The 1440 resistors have low-thermal-emf binding posts and removable banana plugs to provide the four terminals necessary for accurate measurements at low values of resistance. A label on the reverse side lists initial calibration and date, space for future calibration data, and serial number.

— See **GR Experimenter** for October 1965.

* Registered trademark of the Wilbur B. Driver Company.

specifications

Accuracy: ±0.01% for all units except those of 1 Ω, which are ±0.02%. This accuracy is guaranteed for our standard warranty period of two years, unless the resistor has been damaged by excessive current. Measurements on the low-value units should be made with a four-terminal connection. All measurements at 23°C.

Calibration Accuracy: Resistors are calibrated by comparison, to a precision of ±20 ppm, with working standards whose absolute values are known typically to ±10 ppm as determined and measured in terms of reference standards periodically measured by the National Bureau of Standards. The measured deviation from nominal value, at 23°C and 0.01 watt, is entered on the label on the reverse side of the resistor.

Stability: Typically ±10 ppm per year.

Temperature Coefficient (Max): ±10 ppm/°C for resistances above 10 Ω; ±20 ppm/°C for 10 Ω and below.

Power Rating: 1 W. The corresponding current is indicated on the resistor and in the table below. This dissipation will cause a temperature rise of approx 25°C and a resulting temporary resistance change due to the temperature coefficient. If this rating is exceeded, permanent changes may result.

Residual Impedances: Approx shunt capacitance (2-terminal measurement), 2.5 pF; less for 3-terminal measurement. Typical series inductance, see table.

Approx Frequency Characteristic: See table.

Terminals: Gold-plated jack-top copper binding posts (¾-in. spacing) with banana plugs that are removable and can be replaced by 6-32 screws for installation of soldering lugs.

Dimensions (less terminals): 2¼ x 2 15/32 x 11/32 in. (58 x 64 x 10 mm).

Net Weight (approx): 2 oz (60 g).

Catalog Number	Resistance	Max Current	Typical Inductance	Approx Frequency for 0.1% Resistance Change		Price in USA
				Series R	Parallel R	
1440-9601	1 Ω	1.0 A	0.12 μH	300 kHz	30 kHz	**$30.00**
1440-9611	10 Ω	310 mA	0.13 μH	1 MHz	300 kHz	**30.00**
1440-9621	100 Ω	100 mA	0.20 μH	3 MHz	1 MHz	**30.00**
1440-9631	1 kΩ	30 mA	2.5 μH	2 MHz	1 MHz	**30.00**
1440-9641	10 kΩ	10 mA		200 kHz	1 MHz	**30.00**
1440-9651	100 kΩ	3 mA		20 kHz	100 kHz	**33.00**
1440-9661	1 MΩ	1 mA		2 kHz	10 kHz	**37.00**

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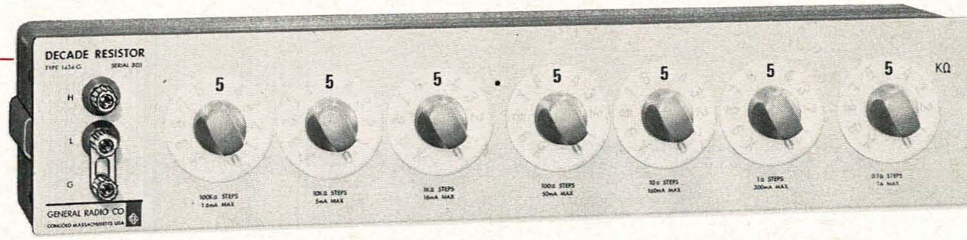
- ±0.05% accuracy
- 5-, 6-, or 7-dial settability
- excellent stability, low cost

DECADE RESISTOR

Type 1434



These laboratory-quality, budget-priced decade boxes are designed for maximum usefulness and economy in laboratory measurement, testing, and development work. Their accuracy is adequate for all but the most exacting applications and their small size and clear readout should be particularly useful in experimental setups using small, modern components.

The 1434-M, -N, and -P contain five step decades of resistance in a small cabinet. The 1434-B and -X, 6-dial boxes, permit small as well as large values of resistance to be set with 3- or 4-place resolution and accuracy. The 1434-QC, a "best buy," has four step decades plus a rheostat to provide 1-ohm resolution in a 1-megohm box.

The larger, seven-decade, 1434-G box is easily converted into a 3½-inch relay-rack unit by the addition of angle brackets and dress strips, which are furnished. This box has lug terminals available at the rear, as well as at panel binding posts.

DESCRIPTION

High-quality, wire-wound resistors are used in these decades. The low price is made possible by the use of only six resistors per decade instead of ten. These are combined by switching in such a way that there are no discontinuities, that is, the resistance increases stepwise just as if ten resistors were used. The switches have solid-silver-alloy contacts for low resistance and long life.

Resistors are of low-temperature-coefficient Evanohm* wire, except the 1-ohm/step decade, which uses manganin wire, and the 0.1-ohm/step decade, which uses manganin ribbon. The resistors of the 100-ohm/step, 10-ohm/step, and 1-ohm/step decades are Ayrton-Perry wound to minimize inductance.

— See **GR Experimenter** for October 1965.

* Registered trademark of the Wilbur B. Driver Company.

specifications

Accuracy

Long-term: Two-year warranty applies to the tolerances given barring damage by excessive current. Tolerances apply at low currents and at dc or low-frequency ac.

Over-all: The resistance difference between that at any setting and at the zero setting is equal to the indicated value ±(0.05% + 5 mΩ).

Incremental: See table. This is the accuracy of the change in resistance between any two settings of the same dial.

Zero Resistance: Approx 3 mΩ per dial at low frequencies except for the 1434-QC for which it is approx 30 mΩ.

Max Current: See table; these values also appear on the panel of each decade box. When this max current is passed through a decade, the temporary change in value will be less than the accuracy specification. Currents appreciably higher than this will cause permanent damage.

Total Resistance of Decade	Resistance Per Step	Incremental Accuracy*	Max Current
1 Ω	0.1 Ω	±3.0%	1 A
10 Ω	1.0 Ω	±0.3%	0.3 A
100 Ω	10 Ω	±0.08%	160 mA
1 kΩ	100 Ω	±0.05%	50 mA
10 kΩ	1 kΩ	±0.05%	16 mA
100 kΩ	10 kΩ	±0.05%	5 mA
1 MΩ	100 kΩ	±0.05%	1.6 mA
100-Ω Rheostat**	1 Ω/div	±1 Ω	200 mA

* At low currents and low frequencies. ** Used in 1434-QC.

Temperature Coefficient: <±10 ppm/°C at room temperature, except for the low-valued units where the +0.4%/°C temperature coefficient of the zero resistance must be added.

Frequency Characteristics: Generally similar to those of the 1433 Decades.

Switches: Multiple, solid-silver-alloy switches are used to obtain low and stable zero resistance.

Terminals: Jack-top binding posts on standard ¾-in. spacing. A shield terminal is also provided. The 1434-G has lug connections accessible from the rear.

Mounting: All types except the 1434-G are in small cabinets for bench use. The 1434-G is also designed for bench use but, with the addition of mounting hardware, becomes 3½-in. high, 19-in. relay-rack unit.

Mechanical Data:

Models	Width		Height		Depth		Net Weight		Shipping Weight	
	in.	mm	in.	mm	in.	mm	lb	kg	lb	kg
M, N, P, QC	11¾	300	2¾	70	4¼	110	3	1.4	4	1.9
B, X	13¾	350	2¾	70	4¼	110	3¼	1.5	4	1.9
G (bench)	17⁵⁄₁₆	442	3½	89	5	130	6	2.8	7	3.2
G (rack)	19	485	3½	89	3½	89	6	2.8	7	3.2

Catalog Number	Description	Total Resistance (Ω)	Resistance Per Step	Number of Decades	Price in USA
	Decade Resistor				
1434-9714	**1434-N**	11,111	0.1 Ω	5	**$124.00**
1434-9713	**1434-M**	111,110	1.0 Ω	5	**119.00**
1434-9716	**1434-P**	1,111,100	10 Ω	5	**137.00**
1434-9576	**1434-QC**	1,111,105	1 Ω/div	4 + rheostat	**124.00**
1434-9702	**1434-B**	1,111,100	1.0 Ω	6	**165.00**
1434-9724	**1434-X**	111,111	0.1 Ω	6	**155.00**
1434-9707	**1434-G**	1,111,111	0.1 Ω	7	**193.00**

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DECADE RESISTOR

Type 1433

- ±0.02% accuracy
- good frequency characteristics
- low temperature coefficient
- excellent stability
- low zero resistance

The 1433 Decade Resistors are primarily intended for precision measurement applications where their excellent accuracy, stability, and low zero resistance are important. They are convenient resistance standards for checking the accuracy of resistance-measuring devices and are used as components in dc and audio-frequency impedance bridges. Many of the models can be used up into the radio-frequency range. While they are also useful as substitution boxes for optimizing electronic circuitry, the less expensive Type 1434 Decade Resistors are recommended for such less exacting applications.

The individual decades (510 Decade-Resistance Units) are available for applications requiring only one decade or as components to be built into experimental equipment, production test equipment, or commercial instruments.

DESCRIPTION

The 1433 Decade Resistor is an assembly of 510 Decade-Resistance Units in a single cabinet. Mechanical as well as electrical shielding of the units and switch contacts is provided by the attractive aluminum cabinet and panel. The resistance elements have no electrical connection to the cabinet and panel, for which a separate shield terminal is provided.

Each Type 510 Decade-Resistance Unit is enclosed in an aluminum shield, and a knob and etched-metal dial plate are supplied. Each decade has ten resistors in series; the contacts in the lower-valued decades have a silver overlay to ensure stability of resistance, and all the decades have a silver contact on the zero setting to give low and constant zero resistance. Winding methods are chosen to reduce the effects of residual reactances.

specifications

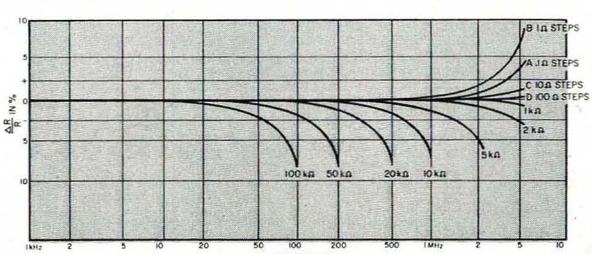
Long-Term Accuracy: Our two-year warranty applies to the tolerances given below unless the resistor is damaged by excessive current. These tolerances apply for low-current measurement at dc or low-frequency ac (see below).

Over-all Accuracy: The resistance difference between that at any setting and at the zero setting is equal to the indicated value ±(0.02% + 2 mΩ).

Incremental Accuracy: See table. This is the accuracy of the change in resistance between any two settings on the same dial.

Max Current: The max current for each decade is given in the table below and also appears on the panel of each decade box and on the dial plate of each decade resistance unit.

Frequency Characteristic: The accompanying plot shows the max percentage change in effective series resistance, as a function of



Max percentage change in series resistance as a function of frequency for Type 510 Decade-Resistance Units.

frequency for the individual decade units. For low-resistance decades the error is due almost entirely to skin effect and is independent of switch setting, while for the high-resistance units the error is due almost entirely to the shunt capacitance and its losses and is approx proportional to the square of the resistance setting.

The high-resistance decades (510-E, -F, -G, and -H) are very commonly used as parallel resistance elements in resonant circuits, in which the shunt capacitance of the decades becomes part of the tuning capacitance. The parallel resistance changes by only a fraction (between a tenth and a hundredth) of the series-resistance change, depending on frequency and the insulating material in the switch.

Characteristics of the 1433's are similar to those of the individual 510's modified by the increased series inductance, L_o, and shunt capacitance, C, due to the wiring and the presence of more than one decade in the assembly. At total resistance settings of approx 1000 ohms or less, the frequency characteristics of any of these decade resistors are substantially the same as those shown for the 510's. At higher settings, shunt capacitance becomes the controlling factor, and the effective value of this capacitance depends upon the settings of the individual decades.

Typical Values of R_o, L_o, and C for the Decade Resistors:

Zero Resistance (R_o): 0.001 Ω per dial at dc; 0.04 Ω per dial at 1 MHz; proportional to square root of frequency at all frequencies above 100 kHz.

Zero Inductance (L_o): 0.1 μH per dial + 0.2 μH.

Effective Shunt Capacitance (C): This value is determined largely by the highest decade in use. With the low terminal connected to the shield, a value of 15 to 10 pF per decade may be

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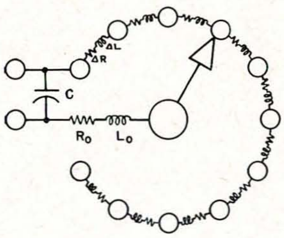


Equivalent circuit of a resistance decade, showing location and nature of residual impedances.

assumed, counting decades down from the highest. Thus, if the third decade from the top is the highest resistance decade in circuit (i.e., not set at zero), the shunting terminal capacitance is 45 to 30 pF. If the highest decade in the assembly is in use, the effective capacitance is 15 to 10 pF, regardless of the settings of the lower-resistance decades.

Temperature Coefficient of Resistance: Less than ±10 ppm per degree C for values above 100 Ω and ±20 ppm per degree C for 100 Ω and below, at room temperatures. For the 1433's the box wiring will increase the over-all temperature coefficient of the 0.1- and 0.01-Ω decades.

Switches: Quadruple-leaf brushes bear on lubricated contact studs of ⅜-in. diameter in such a manner as to avoid cutting but yet give a good wiping action. A cam-type detent is provided. There are eleven contact points (0 to 10 inclusive). The switch resistance is less than 0.0005 Ω. The effective capacitance is of the order of 5 pF, with a dissipation factor of 0.06 at 1 kHz for the standard cellulose-filled molded phenolic switch form and 0.01 on the mica-filled phenolic form used in the 510-G and 510-H units.

Max Voltage to Case: 2000 V pk.

Terminals: For 1433, low-thermal-emf jack-top binding posts on standard ¾-in. spacing; also provisions for rear-panel connections. Shield terminal is provided; 510's have soldering lugs.

Mounting: 1433's in lab-bench cabinet, rack models include mounting hardware; 510's complete with dial plate, knob, template, and mounting screws.

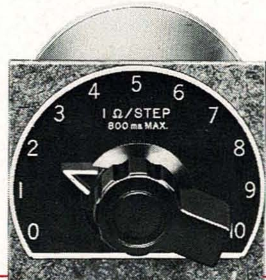
Dimensions and Weights: in. (mm), lb (kg):

	4-dial U, K, J, L, Q	5-dial T, N, M, P, Y	6-dial W, X, B, Z	7-dial F, G, H
Width*	12¼ (315)	14¾ (375)	17¼ (445)	
Height	3½ (89)			5¼ (135)
Depth	5 in. over-all, 4 in. behind panel			
Net Wt*	4¾ (2.2)	5¾ (2.7)	7 (3.2)	8¾ (4.0)
Ship. Wt*	5½ (2.5)	6½ (3.0)	8½ (3.9)	10¼ (4.7)

*Data given for bench models. All rack models same except 19 in. wide. Add approx 1 lb for rack-mount hardware.

Type 510's 3$\frac{1}{16}$ in. (78 mm) diameter, 3$\frac{5}{16}$ in. (85 mm) behind panel, 11 oz (0.4 kg) net weight.

Catalog Number Bench	Catalog Number Rack	Type	Total Ohms	Ohms per Step	No. of Dials	Type 510 Decades Used	Price in USA Bench	Price in USA Rack
1433-9700	1433-9701	**1433-U**	111.1	0.01	4	AA, A, B, C	$120.00	$128.00
1433-9702	1433-9703	**1433-K**	1111	0.1	4	A, B, C, D	122.00	130.00
1433-9704	1433-9705	**1433-J**	11,110	1	4	B, C, D, E	125.00	133.00
1433-9706	1433-9707	**1433-L**	111,100	10	4	C, D, E, F	120.00	128.00
1433-9708	1433-9709	**1433-Q**	1,111,000	100	4	D, E, F, G	154.00	162.00
1433-9710	1433-9711	**1433-T**	1111.1	0.01	5	AA, A, B, C, D	146.50	154.50
1433-9712	1433-9713	**1433-N**	11,111	0.1	5	A, B, C, D, E	144.00	152.00
1433-9714	1433-9715	**1433-M**	111,110	1	5	B, C, D, E, F	147.50	155.50
1433-9716	1433-9717	**1433-P**	1,111,100	10	5	C, D, E, F, G	182.50	190.50
1433-9718	1433-9719	**1433-Y**	11,111,000	100	5	D, E, F, G, H	247.50	255.50
1433-9720	1433-9721	**1433-W**	11,111.1	0.01	6	AA, A, B, C, D, E	168.50	176.50
1433-9722	1433-9723	**1433-X**	111,111	0.1	6	A, B, C, D, E, F	166.50	174.50
1433-9724	1433-9725	**1433-B**	1,111,110	1	6	B, C, D, E, F, G	210.00	218.00
1433-9726	1433-9728	**1433-Z**	11,111,100	10	6	C, D, E, F, G, H	276.00	284.00
1433-9729	1433-9730	**1433-F**	111,111.1	0.01	7	AA, A, B, C, D, E, F	160.00	168.00
1433-9731	1433-9732	**1433-G**	1,111,111	0.1	7	A, B, C, D, E, F, G	229.00	237.00
1433-9733	1433-9734	**1433-H**	11,111,110	1	7	B, C, D, E, F, G, H	303.50	311.50



DECADE-RESISTANCE UNITS

Type 510

Catalog Number	Type	Total Resistance Ohms	Resistance Per Step (ΔR) Ohms	Accuracy of Resistance Increments	Max Current 40° C Rise	Per Step Watts	Power ΔL μH	C** pF	L_o μH	Price in USA
0510-9806	**510-AA**	0.1	0.01	±2%	4 A	0.16	0.01	7.7–4.5	0.023	$23.00
0510-9701	**510-A**	1	0.1	±0.4%	1.6 A	0.25	0.014	7.7–4.5	0.023	17.50
0510-9702	**510-B**	10	1	±0.1%	800 mA	0.6	0.056	7.7–4.5	0.023	26.00
0510-9703	**510-C**	100	10	±0.04%	250 mA	0.6	0.11	7.7–4.5	0.023	27.00
0510-9704	**510-D**	1000	100	±0.02%	80 mA	0.6	0.29	7.7–4.5	0.023	25.00
0510-9705	**510-E**	10,000	1000	±0.02%	23 mA	0.5	13	7.7–4.5	0.023	20.50
0510-9706	**510-F**	100,000	10,000	±0.02%	7 mA	0.5	70	7.7–4.5	0.023	21.00
0510-9707	**510-G**	1,000,000	100,000	±0.02%	2.3 mA	0.5	—	7.7–4.5	0.023	61.00
0510-9708	**510-H**	10,000,000	1,000,000	±0.02%	0.7* mA	0.5	—	7.5–4.5	0.023	92.00
0510-9604	**510-P4**	Switch only	(Black Phenolic Frame)							11.00
0510-9511	**510-P4L**	Switch only	(Low-Loss Phenolic Frame)							12.00

*Or a max of 4000 V, pk.

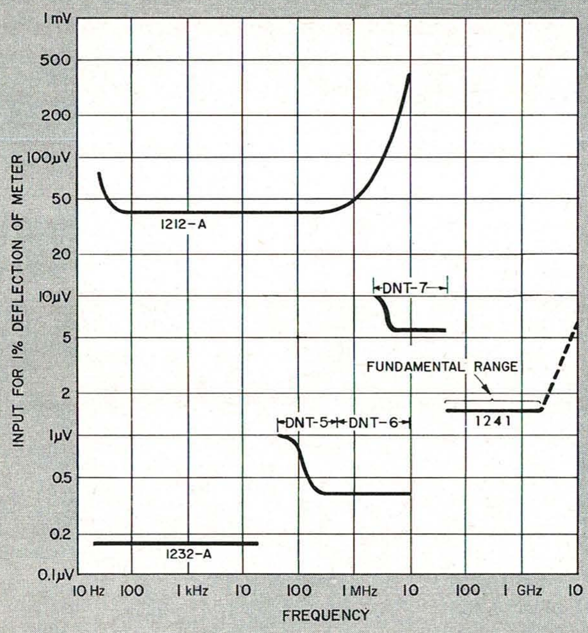
**The larger capacitance occurs at the highest setting of the decade. The values given are for units without the shield cans in place. With the shield cans in place, the shunt capacitance is from 0 to 20 pF greater than indicated here, depending on whether the shield is tied to the switch or to the zero end of the decade.

File Courtesy of GRWiki.org

DETECTORS

In most types of electrical measurements, a detector is used for aural or visual indication of the desired measurement condition. Such devices as null indicators, demodulators, and voltmeters are usually combined with filters and amplifiers to constitute detectors for specific purposes. Different types of measurement impose different requirements on the detector. Thus, bridge measurements require both selectivity and shielding to reduce extraneous signals and high sensitivity for maximum precision of measurement. For measurement of relative signal levels (gain or loss), a wide linear range is desirable, as well as an accurately calibrated level indication. In demodulators, distortion must be minimized to ensure faithful reproduction of the modulation envelope.

A simple rectifier followed by a meter or earphones can be used to convert an ac signal to dc or to demodulate an rf signal, but such a system has inherently low sensitivity. For higher sensitivity, some form of amplifier is necessary. At audio frequencies, the signal is usually amplified directly and then rectified to operate a meter, although with null detectors, earphones can be used at the user's option. At radio frequencies, a radio receiver, if well shielded, is a satisfactory detector, but a broadband heterodyne detector employing a wide-range local oscillator is usually more flexible in application. Here, the incoming signal is heterodyned with that of a local oscillator to produce the difference frequency, which is amplified in an intermediate-frequency amplifier.



Sensitivity and frequency ranges of various detectors.

General Radio offers detectors using all three types of amplifiers — untuned, tunable, and fixed-tuned intermediate frequency.

The 1212-A Unit Null Detector is an untuned detector, which covers a wide frequency range and uses limiting amplifiers to produce a nonlinear compression of the meter scale so as to cover a range of at least 100 dB, thus eliminating the need for amplifier gain adjustments during bridge-balancing operations. Accessory 1-MHz and high-pass filters will increase the effective sensitivity of the 1212, while an rf mixer is available to extend its frequency coverage to 60 MHz or more in conjunction with appropriate local oscillators; see DNT Heterodyne Detectors.

The 1232-A Tuned Amplifier and Null Detector is tunable over the audio-frequency range, with two additional fixed frequencies of 50 and 100 kHz. Its unusually high sensitivity, low noise level, excellent selectivity, and high gain make it suitable for the most exacting bridge-measurement requirements. With the 1232-P1 RF Mixer, it can be used as the i-f amplifier in a heterodyne-detector system at frequencies up to 10 MHz. An accessory preamplifier, the 1232-P2, will improve is effective sensitivity in low-frequency, high-impedance applications.

For audio-frequency bridge measurements, the 1240-A Bridge Oscillator-Detector provides both the bridge power source and the detector in a simple, compact structure.

Complete heterodyne-detector systems, the DNT-5, DNT-6, and DNT-7, are available, which use the above amplifiers and mixers.

For VHF and UHF measurements, the Type 1241 Heterodyne Detectors are useful. With the 1236 I-F Amplifier as the amplifier/indicator, these three assemblies include the 874-MRAL Mixer and a local oscillator appropriate to the desired frequency range.

Simple rectifiers are often used at the high frequencies. The 874-VQ Voltmeter Detector and 874-VR Voltmeter Rectifier, used with an audio amplifier such as the 1234 Standing-Wave Meter or 1232 amplifier, are sensitive detectors of modulated signals over a wide range of frequencies.

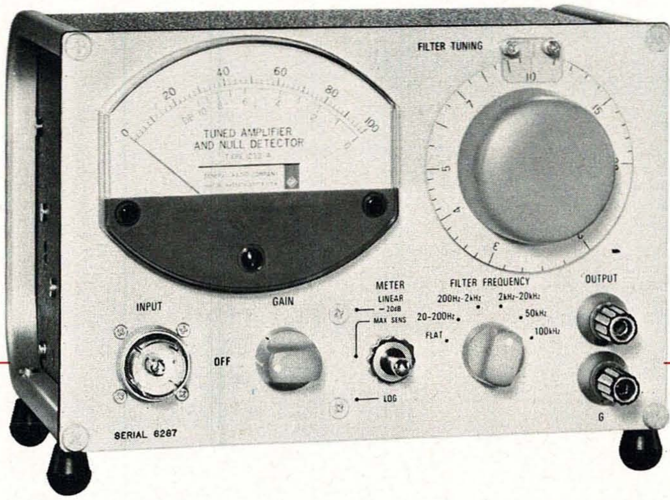
OTHER DETECTORS

Elsewhere in this catalog are detectors in disguise. For example, the GR sound-level meters, 1551-C, 1561, and 1565, are excellent very high sensitivity, untuned audio-frequency detectors. Among the GR analyzers are several highly selective tuned amplifiers well suited to serve as detectors, the 1900-A and 1568-A Wave Analyzers, for example.

File Courtesy of GRWiki.org

TUNED AMPLIFIER AND NULL DETECTOR

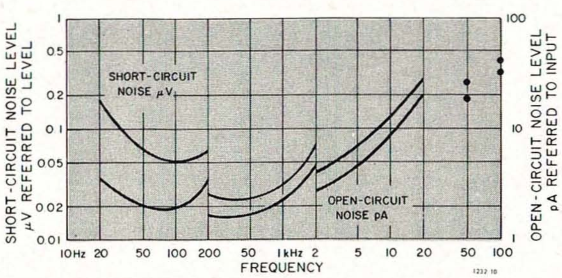
Type 1232-A



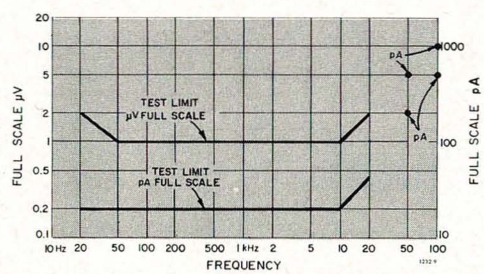
- 20 Hz to 20 kHz, 50 and 100 kHz
- 0.1-μV sensitivity
- bandwidth approx 5%
- 120-dB gain

This battery-operated, solid-state amplifier will excel in common applications and fit many unusual requirements with its combined high sensitivity, low noise, choice of narrow or broad bandwidth, high gain, portability, and accessories for added versatility. Use it as a

- bridge detector at audio frequencies; with the 1232-P2 Preamplifier it is equally sensitive for extremely high-impedance, low-frequency balances. With the 1232-P1 RF Mixer it is a sensitive, heterodyne, rf detector to 10 MHz with excellent harmonic rejection.
- audio preamplifier and general-purpose, tunable or broadband audio amplifier
- a-m detector for 0.5- to 500-MHz carrier frequencies when used with an 874-VQ Voltmeter Detector;
- sensitive audio wave analyzer for approximate measurements.



(Left) Typical noise levels as a function of frequency. (Right) Minimum input for full-scale meter deflection as a function of frequency, when amplifier is tuned to peak response.



specifications

Frequency Response:

Tunable Filters — 20 Hz to 20 kHz in 3 ranges; between 2% and 6% bandwidth to 15 kHz; 2nd harmonic at least 34 dB down from peak, 3rd at least 40 dB down; rejection filter on two highest ranges reduces 60-Hz level to at least 60 dB below peak (50 dB at 50 Hz). Dial accuracy is ±3%.

50- and 100-kHz Filters — 2nd harmonic 44 and 53 dB down, respectively.

Flat Response — ±3 dB 20 Hz to 100 kHz.

Sensitivity: See plot. Typically better than 0.1 μV over most of the frequency range.

Noise Level Referred to Input: See plot. Noise figure at 1 kHz is less than 2 dB at an optimum source impedance of 27 kΩ.

Noise Level Referred to Output: Less than 5 mV on FLAT filter-frequency position, min gain setting, and —20-dB switch position; less than 50 mV in MAX SENS position.

Input Impedance: Approx 50 kΩ at max gain; varies inversely with gain to 1 MΩ at min gain.

Max Safe Input Voltage: 200 V ac or 400 V dc.

Voltage Gain: Approx 120 dB on the tunable ranges; 100 dB, flat range; 106 dB at 50 kHz; 100 dB at 100-kHz position.

Output: 1 V into 10,000 Ω. Internal impedance is 3000 Ω.

Meter Linearity: DB differences are accurate to ±5% ±0.1 division for input of less than 0.3 V.

Compression (on LOG position): Reduces full-scale sensitivity by 40 dB. Does not affect bottom 20% of scale.

20-dB Position: Reduces gain by 20 dB in linear mode.

Distortion (in FLAT position): Less than 5% (from meter rectifiers).

Power Supply: 12 V dc, from 9 mercury (M72) cells in series. Est battery life 1500 hours. Optionally, a rechargeable battery (non-mercury) can be supplied on special order.

Accessories Available: 1232-P1 RF Mixer for heterodyne operation to 10 MHz; 1232-P2 Preamplifier to maintain sensitivity of 1232-A at low frequencies when operating from a source impedance above 100 kΩ; rack-adaptor sets (see below) convert 1232 and companion instruments to 19-in. rack-mount width.

Terminals: Input, GR874 coaxial connector; output, binding posts.

Mounting: Convertible-Bench Cabinet.

Dimensions (width x height x depth): 8 x 6 x 7½ in. (205 x 155 x 190 mm).

Weight: Net, 5¾ lb (2.7 kg); shipping, 8 lb (3.7 kg).

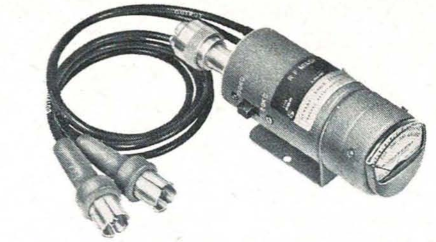
Catalog Number	Description	Price in USA
1232-9701	**1232-A Tuned Amplifier and Null Detector**	$395.00
1232-9829	**1232-AP Tuned Amplifier and Null Detector,** with preamplifier	495.00
	Rack-Adaptor Sets	
0480-9838	**480-P308,** for 1232-A alone	7.00
0480-9836	**480-P316,** for 1232-A with 1310 or 1311 oscillator or similar 8-in. wide instrument with convertible-bench cabinet	6.00
0480-9837	**480-P317,** for 1232-AP (with preamp) and companion 8-in. instrument	6.00

PATENT NOTICE. See Note 15.

File Courtesy of GRWiki.org

RF MIXER

Type 1232-P1



With the 1232-A, this mixer can be used from 70 kHz to 10 MHz as a heterodyne detector with high harmonic rejection, a level indicator in attenuation measurements, or, with a swept local oscillator and oscilloscope, for approximate spectrum analysis.

— See **GR Experimenter** for December 1963.

specifications

Frequency Range: 70 kHz to 10 MHz. (Can be used up to 60 MHz, with care in the selection and identification of local-oscillator frequencies.) Recommended local oscillators for the 70-kHz to 0.5-MHz and the 0.5- to 10-MHz ranges are 1210-C and 1211-C, respectively.

I-F Output Frequencies: Switch-selected, 20 kHz or 100 kHz.

Bandwidth: 0.8 kHz in 20-kHz position, 10 kHz in 100-kHz position with a 20-kΩ output load (1232-P1 RF Mixer alone).

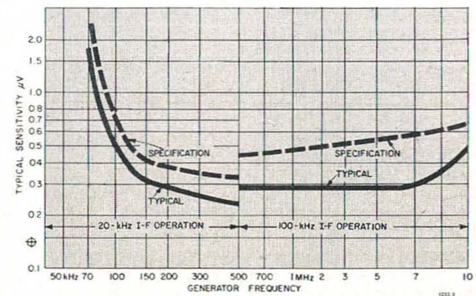
Sensitivity: See plot.

Input Impedance: Approx 200 Ω.

Output Impedance: Approx 20,000 Ω.

Dimensions: 2¼ in. (58 mm) dia., 6¾ in. (175 mm) long.

Weight: Net, 1 lb (0.5 kg); shipping, 3 lb (1.4 kg).



Sensitivity (open-circuit voltage from 50-ohm source, equivalent to noise level).

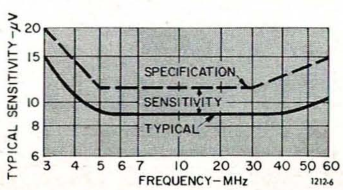
Catalog Number	Description	Price in USA
1232-9601	**1232-P1 RF Mixer**	**$125.00**

RF MIXER

Type 1212-P3

The 1212-P3, which is similar to the 1232-P1, combines with the 1212-A Unit Null Detector to form a sensitive heterodyne null detector from 3 to 60 MHz.

This combination may also be used as a receiver or as an approximate spectrum analyzer and sensitive level indicator throughout its frequency range.



Sensitivity as a function of frequency.

specifications

Frequency Range: 3 to 60 MHz. (Can be used up to 150 MHz if care is taken in the selection and identification of local-oscillator frequency.)

Sensitivity: See plot.

I-F Output Frequency: 1 MHz.

Bandwidth: 25 kHz with 1212-A.

Input Impedance: 200 Ω (approx).

Output Impedance: 50 kΩ (approx).

Terminals: GR874 coaxial connectors.

Dimensions: Diameter 2¼, length 6¾ in. (58 x 175 mm).

Weight: Net, 1 lb (0.5 kg); shipping, 2 lb (1 kg).

Catalog Number	Description	Price in USA
1212-9603	**1212-P3 RF Mixer**	**$115.00**

File Courtesy of GRWiki.org

PREAMPLIFIER

Type 1232-P2

new

1232-P2 Preamplifier shown with 1232-A Tuned Amplifier and Null Detector

The 1232-P2 is an accessory for the 1232-A Tuned Amplifier and Null Detector. It improves the signal-to-noise ratio and therefore improves the effective sensitivity of the detector when the source impedance of the input signal exceeds 100 kilohms. A front-panel switch allows the preamplifier to be bypassed; direct connection to the 1232-A is necessary with lower source impedances.

The 1232-P2 has particular application to measurements with the 1615-A Capacitance Bridge. It increases sensitivity for measurements made at frequencies well below 1000 Hz if the bridge is set to both its lowest C and D (not G) ranges simultaneously. Low-frequency measurement of small samples of dielectric materials can be made more accurately with the addition of this preamplifier.

— See **GR Experimenter** for February 1967.

specifications

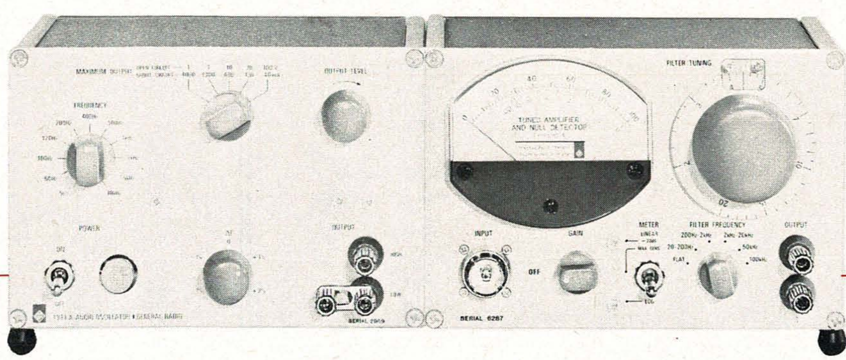
Input Impedance: Greater than 100 MΩ in parallel with 70 pF.
Output Impedance: 10 kΩ.
Voltage Gain: Approx 0.7.
Noise (referred to input): Open-circuit equivalent, 0.1 pA; short-circuit equivalent, 0.3 μV (when used with Type 1232-A tuned to 100 Hz).
Optimum Source Impedance: 3 MΩ.
Connectors: GR874 on cables, input and output.

Power Required: 12 V, 200 μA, supplied by 1232-A.
Dimensions (width x height x depth): 3¾ x 6 x 7½ in. (20 x 150 x 190 mm).
Weight: Net, 15 oz (425 g); shipping, (est) 3 lb (1.4 kg).

Catalog Number	Description	Price in USA
1232-9602	**1232-P2 Preamplifier**	**$95.00**

BRIDGE OSCILLATOR-DETECTOR

Type 1240



The 1232-A Tuned Amplifier and Null Detector and the 1311-A Audio Oscillator have been combined for use with audio-frequency bridges and other null-balance devices. This assembly occupies a minimum of bench space and is supplied with removable panel extensions, which adapt it for rack mounting.

The oscillator supplies 11 fixed frequencies from 50 Hz to 10 kHz. The detector is tunable continuously from 20 Hz to 20 kHz, with additional spot frequencies of 50 kHz to 100 kHz. The assembly is also available with the 1232-P2 Preamplifier included.

specifications

Power Required: Null detector, internal battery; oscillator, 105 to 125 or 210 to 250 V, 50 to 400 Hz, 22 W max.
Dimensions (width x height x depth): 19 x 6 x 7¾ in. (485 x 155 x 200 mm), with panel extensions.
Weight: Net, 13½ lb (6.5 kg); shipping, 28 lb (13 kg).

Catalog Number	Description	Price in USA
1240-9701	**1240-A Bridge Oscillator-Detector**	**$670.00**
1240-9829	**1240-AP Bridge Oscillator-Detector,** with preamp	**770.00**

File Courtesy of GRWiki.org

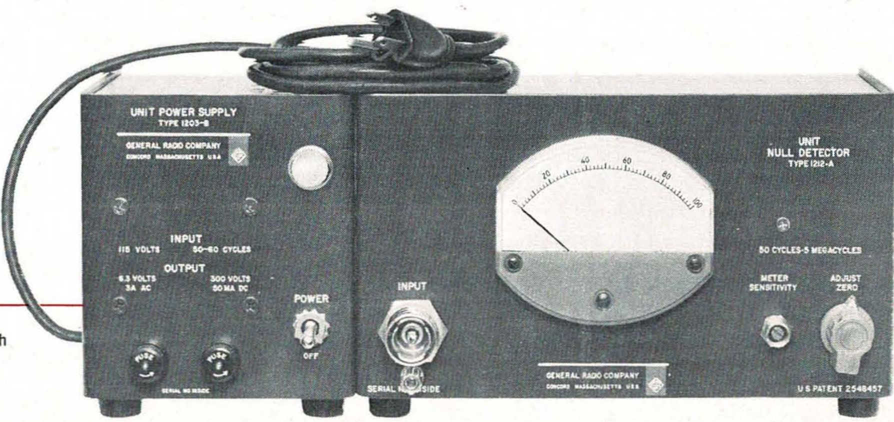
UNIT NULL DETECTOR

Type 1212-A

- 50 Hz to 5 MHz
- 120-dB dynamic range, typically
- 40-μV sensitivity for 1% deflection

1212-P1

1212-P2



1212-A Unit Null Detector with 1203-B Unit Power Supply

This unit null detector is an inexpensive, broadband balance indicator for ac bridge measurements from 50 Hz to 5 MHz. With the 1212-P3 RF Mixer and a local oscillator, its range can be extended to 60 MHz as a heterodyne detector.

The instrument consists of a three-stage, broadband amplifier. Germanium-diode clippers are used between stages to obtain the quasi-logarithmic response. The output meter has a linear scale. Earphone terminals are provided.

Type 1212-P1 HIGH-PASS FILTER

This shielded RC filter provides about 50-dB attenuation at 60 Hz. Plugs into detector input connector.

Nominal Load Impedance: 1 MΩ.

Input Voltage Limit: 150 V max.

Terminals: GR874 coaxial connector at each end.

Dimensions: Diameter 7/8, length 4¾ in. (25 x 110 mm).

Weight: Net, 3 oz (0.1 kg); shipping, 1 lb (0.5 kg).

Type 1212-P2 1-MHz FILTER

This shielded, tuned LC filter provides insertion gain at 1 MHz and attenuates higher and lower frequencies. Plugs into detector connector.

Insertion Gain: Between 22 dB and 32 dB at 1 MHz.

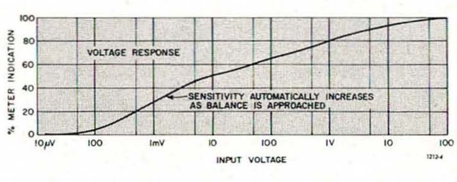
Second-Harmonic Rejection: At least 39 dB.

Maximum Input Voltage: 200 V.

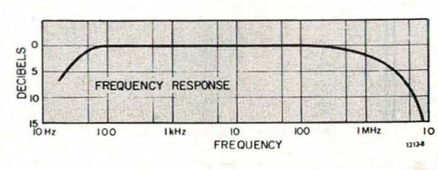
Terminals: GR874 coaxial connector at each end.

Dimensions: Diameter 2, length 5 in. (50 x 130 mm).

Weight: Net, 9 oz (0.3 kg); shipping, 1 lb (0.5 kg).



Meter indication vs input voltage.



Frequency response characteristic.

specifications

Frequency Response: See plot.

Sensitivity: Less than 40 μV at 1 kHz for 1% of full scale.

Power Required: 1203-B (or 1203-BQ18) Unit Power Supply.

Hum and Noise Level: Hum, 20 μV; broadband noise, 30 μV.

Input Terminal: Locking GR874 coaxial connector.

Accessories Supplied: Power-supply plug.

Accessories Available: 1212-P1 and -P2 Filters, 1212-P3 RF Mixer (see below); GR874 patch cords for input connection.

Mounting: Unit-Instrument Cabinet.

Dimensions (width x height x depth): 15 x 5¾ x 6¼ in. (385 x 150 x 160 mm), with power supply.

Weight: Net, 9¾ lb (4.5 kg); shipping, 13 lb (6 kg).

Catalog Number	Description	Price in USA
1212-9701	**1212-A Unit Null Detector**	**$215.00**
1203-9702	**1203-B Unit Power Supply** (for 115 V)	**75.00**
1203-9818	**1203-BQ18 Unit Power Supply** (for 230 V)	**on request**
1212-9601	**1212-P1 High-Pass Filter**	**17.00**
1212-9602	**1212-P2 1-MHz Filter**	**45.00**
0480-9986	**480-P4U3 Relay-Rack Adaptor Set**	**12.00**

PATENT NOTICE. See Note 15.

File Courtesy of GRWiki.org

I-F AMPLIFIER

Type 1236

new

- 30-MHz precision lab receiver
- bandwidths: 0.5 and 4 MHz
- 2-dB noise figure, 3.5-μV sensitivity
- preamplifier and 70-dB attenuator

The 1236 will meet the many critical demands placed upon a precision laboratory receiver. More than an amplifier, it is a complete 30-MHz measuring receiver with preamplifier, wide-range calibrated attenuator, and a large meter with normal, expanded, and compressed scales. The high sensitivity, or low noise figure, with narrow bandwidth will provide good small-signal performance and noise rejection for improved measurement accuracy. The availability of a wider bandwidth also greatly simplifies use at higher frequencies where sources are generally less stable.

Gain stability during a measurement is ensured by a fully regulated power supply; 10% line-voltage variations change gain less than 0.05 dB. Frequency stability of the local oscillator can be achieved by use of the 30-MHz i-f output of the amplifier to drive an external afc loop.

PRECISION ATTENUATION MEASUREMENT

Large values of attenuation can be measured with particular ease with the 1236 owing to the wide dynamic range of its preamplifier and attenuator. A 1-dB full-scale, expanded meter scale is provided, which facilitates measurement of small values of, or changes in, attenuation. A continuous gain control permits setting initial readings for easy subtraction in substitution measurements.

VSWR MEASUREMENT

The 1236 is recommended for the most precise VSWR measurements, of both high and low values. The expanded VSWR scale in dB is equivalent to 1.12:1 full scale. The high sensitivity of the 1236 permits the VSWR of solid-state devices to be measured at signal levels low enough to avoid the effects of device nonlinearity.

As a null detector, the 1236 offers the advantages of its compressed (agc) meter scale for convenience in rapid null balancing and its added sensitivity for sharp nulls and more precise data. It will also find application in noise-figure measurements.

PRECISION HETERODYNE RECEIVERS

The 1236 I-F Amplifier is available in combination with an appropriate local oscillator (power supply for which is built into the 1236), mixer, low-pass filter, and connecting coaxial components to make up complete precision test receivers. These Type 1241 Heterodyne Detectors are available for use in any one of three frequency ranges from 40 to 2030 MHz.

Local Oscillators page 209 ff

1241 Detectors page 120

— See **GR Experimenter** for July-Aug 1967.

specifications

Center Frequency: 30 MHz.

Bandwidth: Wide band approx 4 MHz, narrow band approx 0.5 MHz, selectable by panel switch.

Noise Figure: Typically 2 dB.

Sensitivity: <9 μV (wide band), <3.5 μV (narrow band) open-circuit voltage behind 400-Ω source for a 3-dB increase of meter deflection.

Meter Characteristics

Normal Scale: −2 to 10 dB. **Linearity:** ±0.2 dB over 0 to 10-dB range.

Expanded Scale: 1-dB full scale, 1.12:1 VSWR. **Linearity:** ±0.03 dB.

Compressed Scale: 40-dB min range.

Attenuator

Range: 70 dB in 10-dB steps.

Accuracy: ±(0.1 dB + 0.1 dB/10 dB) at 30 MHz.

Continuous Gain Control: 10 dB min range.

Video Output (Modulation): 1.5 V max behind 600 Ω; bandwidth, 1 MHz.

I-F Output: 0.5 V max into 50 Ω.

Power-Supply Output: 150 to 300 V dc adjustable, at 30 mA, regulated; 6.3 V ac at 1 A.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 Hz, 22 W (without oscillator).

Accessories Supplied: Power cord, spare fuse.

Accessories Available: As local oscillator, GR 1362, 1363, and 1218; 874-MRAL Mixer; GR874 low-pass filters, attenuators, and adaptors.

GR874 page 174 ff

Mounting: Convertible-Bench Cabinet.

Dimensions (width x height x depth): 8 x 7⅜ x 8 in. (205 x 190 x 205 mm).

Weight: Net, 12½ lb (6 kg); shipping, 14¾ lb (7 kg).

Catalog Number	Description	Price in USA
1236-9701	**1236 I-F Amplifier**	**$735.00**

File Courtesy of GRWiki.org

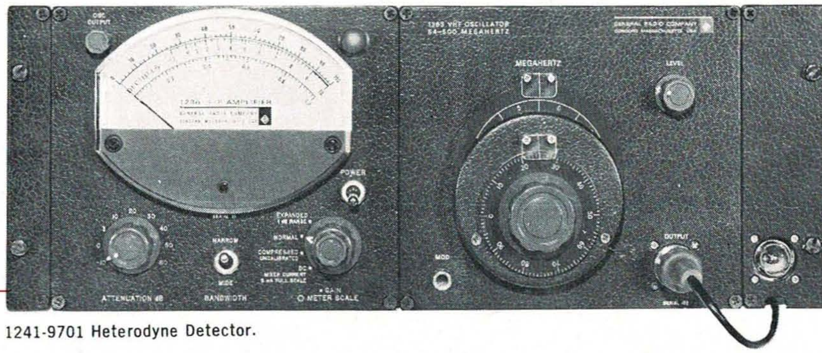
HETERODYNE DETECTOR

Type 1241

40 to 2030 MHz

- high sensitivity
- choice of bandwidth
- AGC for null detection
- 70-dB calibrated attenuator

new



1241-9701 Heterodyne Detector.

This general-purpose instrument is a highly sensitive high-frequency detector for relative signal-level measurements and for use as a null detector.

Its excellent shielding makes it suitable for low-level measurements in the presence of high-level external fields.

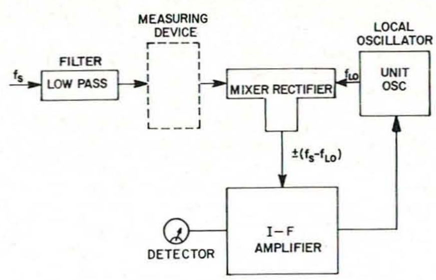
GAIN, LOSS, SIGNAL LEVEL

It can be used: to measure insertion loss and attenuation, crosstalk in multiterminal devices such as switches, and antenna gain and radiation patterns; as a field-strength indicator; and as a laboratory high-frequency receiver.

Signal levels can be measured over an 80-dB range, more with the use of external attenuators.

RF VOLTMETER

When calibrated at one signal level and frequency with the aid of a standard-signal generator, the 1241 Detector can be used at that frequency as a selective voltmeter in a 50-ohm system.



Block diagram of the heterodyne detector.

874 Filters page 145

HF Oscillators page 209 ff

DETECTOR

It is the recommended null detector for the 1602-B UHF Admittance Meter, 1609 Precision UHF Bridge, and the 1607-A Transfer-Function and Immittance Bridge.

As a standing-wave indicator with the 874-LBB and 900-LB Slotted Lines, it is particularly useful for measurements on nonlinear elements, where a high degree of harmonic rejection and small applied signal level are required.

The expanded 1-dB-full-scale range (equivalent to 1.12 VSWR) makes accurate low-VSWR measurements possible at low signal levels.

DESCRIPTION

Each assembly comprises one 874-MRAL Mixer, one 1236 I-F Amplifier, one 874-G10L 10-dB Pad, one 874-EL-L 90° Ell, plus one oscillator and one filter, both depending on the frequency range desired (see price table). For maximum shielding, components are equipped with locking GR874 coaxial connectors, which can be used interchangeably with the nonlocking type.

The frequency range can be extended through the use of oscillator harmonics, but with reduced sensitivity and dynamic range.

To cover wide frequency ranges, however, it is recommended that one complete detector be ordered, plus the necessary oscillators and filters for the additional frequency ranges desired. For instance, for the range from 40 to 950 MHz, one would order a 1241-9700 detector, plus one 1362 UHF Oscillator and one 874-F1000L Filter.

specifications

Frequency Range: See sensitivity curves and price table.

Sensitivity: Typically 4 μV behind 50 Ω (—100 dBm) for 3-dB meter deflection over residual noise reading (narrow bandwidth).

Mixer: Type 874-MRAL Mixer.

Input Terminal: Mixer input terminal is a locking GR874 coaxial connector. For connection to other coaxial types, see GR874 coaxial adaptors.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz, 40 W.

Mounting: Rack models, i-f amplifier, oscillator mixer and filter mounted on 19-in. panel; bench models, constituents supplied individually.

Dimensions (width x height x depth): Rack, 19 x 7 x 8¼ in. (485 x 180 x 210 mm), except 1241-9705 is 14-in. high; bench, see specifications for individual components.

Weights (est): Net, 1241-9700, 20 lb (9.5 kg); 1241-9702, 23½ lb (11 kg); 1241-9704, 28½ lb (13 kg). Add approx 6 lb (2.8 kg) for shipping weight, approx 2 lb (1.0 kg) for rack models.

Catalog Number		Frequency Range — MHz				Local Oscillator Supplied	Filter Supplied	Price in USA	
Bench	Rack	Fundamental	2nd Harmonic*	3rd Harmonic*	4th Harmonic*			Bench	Rack
1241-9700	1241-9701	40†-530	82-1030	138-1530	194-2030	**1363**	**874-F500L**	**$1270.00**	**$1295.00**
1241-9702	1241-9703	190-950	410-1870	630-2790	850-3710	**1362**	**874-F1000L**	**1265.00**	**1295.00**
1241-9704	1241-9705	870-2030	1770-4030	2670-6030	3570-8030	**1218**	**874-F2000L**	**1565.00**	**1610.00**

* For harmonic operation, the appropriate low-pass filter must be used.

† 40 MHz is the practical low-frequency limit.

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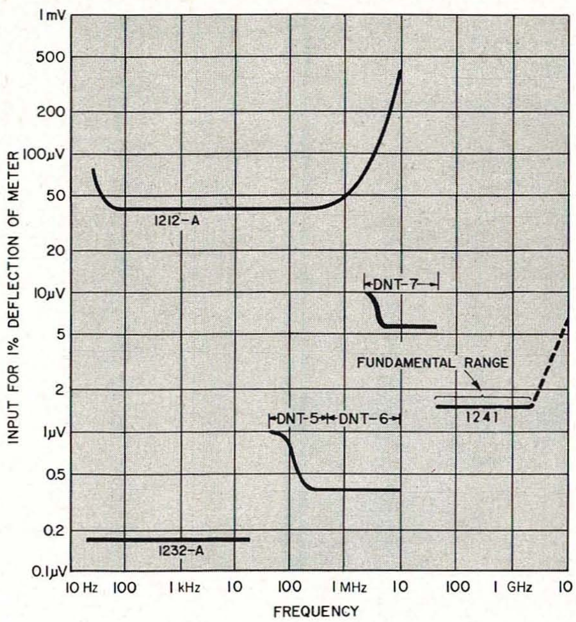
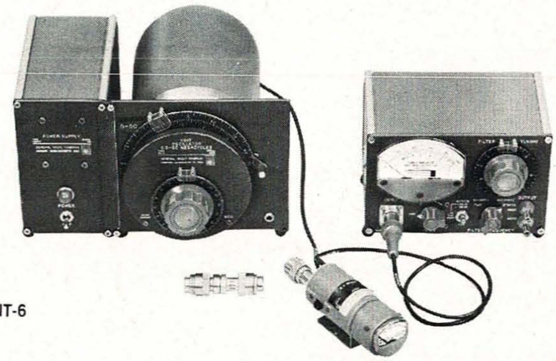
HETERODYNE DETECTOR

Types DNT-5, -6, -7

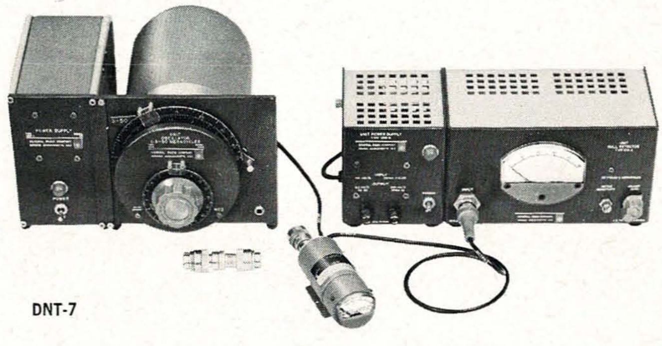
70 kHz to 50 MHz



DNT-5



DNT-6



DNT-7

The DNT-5 and -6 Heterodyne Detectors use the Type 1232-A Tuned Amplifier and Null Detector as the i-f amplifier — DNT-5 at 20 kHz and DNT-6 at 100 kHz. The DNT-7 uses the Type 1212-A Unit Null Detector, 1 MHz. All three are well shielded from external fields and are ideal for low-level measurements.

They are excellent detectors for the 1606-B and 916-AL RF Bridges. With the addition of an external calibrated attenuator, such as the Type 874-GAL, a substitution method can be used in the several voltage-level measurements listed on the preceding page. For detailed specifications, see the listing of the various components, as indicated.

specifications

Frequency Range	70 to 500 kHz	0.5 to 10 MHz	3 to 50 MHz
Type	DNT-5	DNT-6	DNT-7
Null Detector	**1232-A**	**1232-A**	**1212-A**
Oscillator	**1210-C**	**1211-C**	**1211-C**
Rf Mixer	**1232-P1**	**1232-P1**	**1212-P3**
Fixed Attenuator	**874-G10L**	**874-G10L**	**874-G10L**
Power Supplies	**1203**	**1269-A**	**1269-A** **1203**
Net Wt, lb (kg)	17½ (8)	24½ (11.5)	28½ (13)
Ship. Wt, lb (kg)	24 (11)	33 (15)	39 (18)

Catalog Number	Description	Price in USA
	Heterodyne Detector	
1235-9605	**DNT-5,** for 105 to 125 V	**$ 862.50**
1235-9795	for 195 to 250 V	**on request**
1235-9606	**DNT-6,** for 105 to 125 or 195 to 235 or 210 to 250 V	**1107.50**
1235-9607	**DNT-7,** for 105 to 125 V	**1002.50**
1235-9797	for 195 to 250 V	**on request**

PATENT NOTICE. See Note 15.

1232 Det page 115
1212 Det page 118
1210 Osc page 206
1211 Osc page 210 ff

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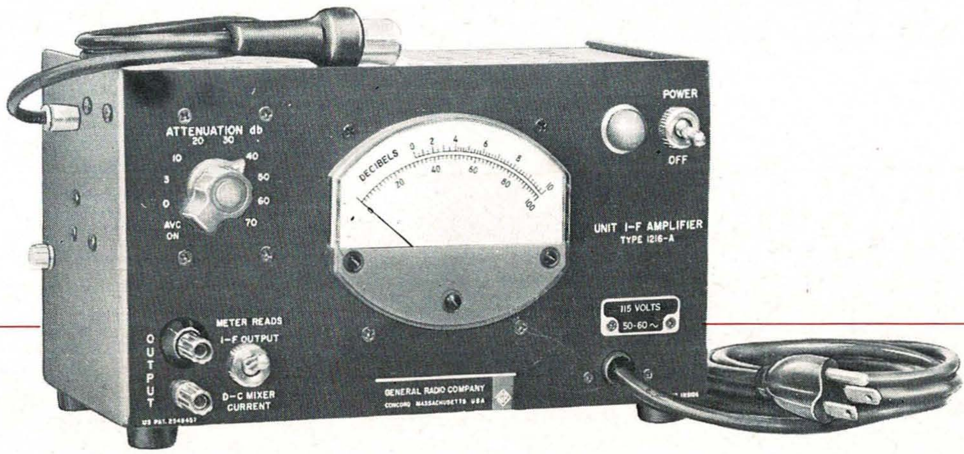
UNIT I-F AMPLIFIER

Type 1216-A

- 30-MHz center frequency
- 2-μV sensitivity, for 1% deflection



The 1216-A Unit I-F Amplifier consists of four tuned i-f amplifier stages, a detector, a video amplifier stage, an accurate rf attenuator, and two power supplies. It is designed to operate from the output of the 874-MRL Mixer Rectifier.

The automatic volume control, which facilitates bridge balancing and other null-type measurements, can be switched out for voltage-level measurements.

A built-in, precision, step attenuator makes possible accurate measurements of relative signal levels. The meter is calibrated in dB, as well as in linear units, for convenient interpolation between the 10-dB attenuator steps.

Provision is made for measuring crystal-mixer current. A knowledge of this current is important if attenuation measurements are to be made, since the oscillator voltage must be above a certain limit if the applied rf signal is large. The current is also an indication that the oscillator is functioning.

One of the internal power supplies furnishes power for a heterodyning oscillator.

Modulation on the input signal is available at the output terminals.

Features:

- high sensitivity
- excellent shielding
- avc for null detector use
- amplifier provides power for local oscillator
- broad bandwidth with good selectivity
- wide-range calibrated attenuator.

specifications

Center Frequency: 30 MHz.

Bandwidth: >0.5 MHz at 3 dB down; 9.5 MHz at 60 dB down

Sensitivity: From a 400-Ω source, 2-μV input for 1% deflection (above noise); 50-μV input for full-scale deflection. These are open-circuit source voltages.

Noise Figure: Approx 5 dB.

Attenuator: 0 to 70 dB in 10-dB steps.

Accuracy: ±(0.3 dB +1 dB/10 dB).

30-MHz Output-Circuit Bandwidth (Modulation): 0.4 MHz.

Output Impedance: 600 Ω.

Max Output Voltage: 2 V, open circuit.

Terminals: Input, GR874 connector on 2-ft cable; output ¾-in. spaced binding posts.

Power Supply Output: 300 V, dc, at 30 mA; 6.3 V, ac, at 1 A.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz. Power input, 45 W at full load. Can also be operated at 400 Hz where line voltage does not drop below 110 (or 220) V.

Accessories Supplied: Spare fuses.

Mounting: Unit-Instrument Cabinet.

Dimensions (width x height x depth): 10¼ x 5¾ x 6¼ in. (260 x 150 x 160 mm).

Weight: Net, 8¼ lb (3.8 kg); shipping, 10 lb (4.6 kg).

Catalog Number	Description	Price in USA
1216-9701	**1216-A Unit I-F Amplifier**	**$475.00**

PATENT NOTICE. See Note 15.

File Courtesy of GRWiki.org

STANDING-WAVE METER

Type 1234

new

- 1.05 full-scale VSWR
- large meter, light-keyed scales
- precision attenuators
- high sensitivity

The 1234 Standing-Wave Meter incorporates many features to simplify its primary use in measuring VSWR with a slotted line, such as the GR 874-LBB or the 900-LB Precision Slotted Line. Accurate measurements of low voltage SWR are possible with the expanded 1.05 scale on the oversize meter face. Reading the wrong meter scale is virtually impossible, as the correct scale is identified by a small meter light.

Panel controls give the operator quick control over (1) the exact frequency of the 1-kHz amplifier, to permit matching exactly the frequency of the modulating oscillator, (2) bandwidth, for optimizing signal-to-noise ratio, without affecting amplifier gain, and (3) meter damping, for reduced meter fluctuations due to noise. These, with the other more usual controls, give the user control over instrument characteristics adequate for a wide variety of measurement conditions.

In attenuation measurements, the 1234 also offers many advantages. Three precision attenuators have a total range of 70 dB in 1-, 5-, and 10-dB steps. Meter scales and attenuators are calibrated for use with a square-law detector. Readings can be interpolated with extremely high resolution on the 1.6- and 0.45-dB full-scale meter ranges. The wide-range, 5-dB/step attenuator control has a "memory" dial that permits rapid substitution measurements without subtraction and thus reduces the possibility of error.

specifications

Meter Scales: VSWR, 1 to 4, 3.2 to 10, 1 to 1.2, and 1 to 1.05; dB, 0 to 10, 0 to 1.6, and 0 to 0.45; bolometer current, 0 to 10 mA.

Meter Accuracy: 0 to 10-dB scale, ±(0.01 dB + 1.5% of reading); 0 to 1.6-dB scale, ±0.02 dB; 0 to 0.45-dB scale, ±0.007 dB.

Attenuator: Three separate attenuators: 20 dB in 10-dB steps, accuracy ±0.1 dB/10 dB; 45 dB in 5-dB steps, accuracy ±0.05 dB/5 dB; 5 dB in 1-dB steps, accuracy ±0.01 dB/1 dB.

INPUT	Crystal				Bolometer
Optimum Source R	35 kΩ	20 kΩ	2 kΩ	200 Ω	200 Ω
Input Impedance	1 MΩ	350 kΩ// 80 H	35 kΩ// 8 H	3.5 kΩ// 0.8 H	3.5 kΩ// 0.8 H
Sensitivity (fs)	1.2 μV	1 μV	0.32 μV	0.1 μV	0.1 μV
Noise*	0.2 μV	0.2 μV	0.06 μV	0.02 μV	0.02 μV

* Equivalent input noise level with source resistance equal to optimum and with minimum bandwidth.

Bandwidth: 10 to 100 Hz, adjustable with constant gain.

Frequency: 1 kHz, adjustable ±30 Hz.

Gain Control: Coarse and fine, 6-dB range.

Bolometer Bias Current: 4.3 and 8.7 mA, adjustable ±10%. Voltage limited for bolometer protection.

Meter Speed: Slow and fast, switch selected.

Outputs: Dc, 1.5 V max behind 1500 Ω. Ac, 0.1 V rms (1 to 4 VSWR range), 0.3 V rms (1 to 1.2 range), and 1 V rms (1 to 1.05 range); 500-Ω source impedance. Load resistance >6000 Ω.

GENERAL

Power Required: 100 to 125 or 200 to 250 V, 50 to 60 Hz. Or 22 to 35 V dc, 90 mA from ext battery, 1538-P3 Battery and Charger suitable.

Accessories Supplied: Spare fuse, battery connector.

Accessories Available: 1538-P3 Battery and Charger.

1538-P3 page 244

Mounting: Flip-Tilt case.

Dimensions (width x height x depth): 8⅜ x 8¾ x 11¼ in. (215 x 225 x 290 mm).

Weight: Net, 9 lb (4.1 kg); shipping, 12½ lb (6.0 kg).

Catalog Number	Description	Price in USA
1234-9701	**1234 Standing-Wave Meter**	**$495.00**

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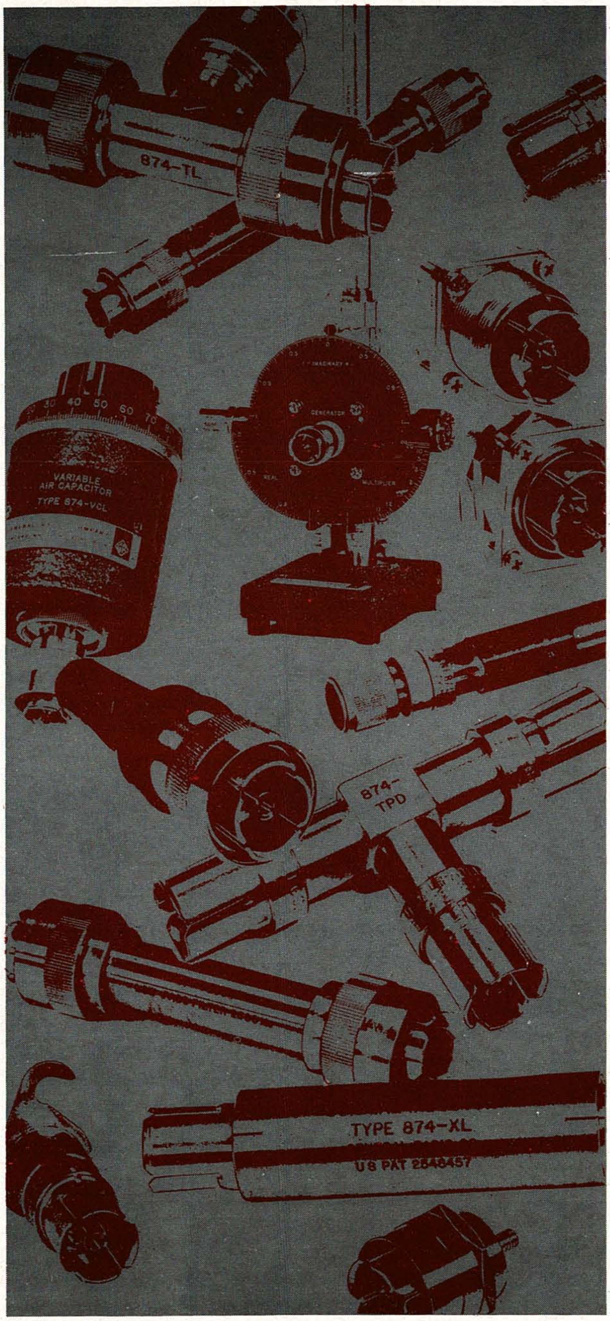

INDEX

COAXIAL ELEMENTS

GR874

GR900®

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MICROWAVE COAXIAL EQUIPMENT — DC TO MICROWAVE

GR874

GR900®

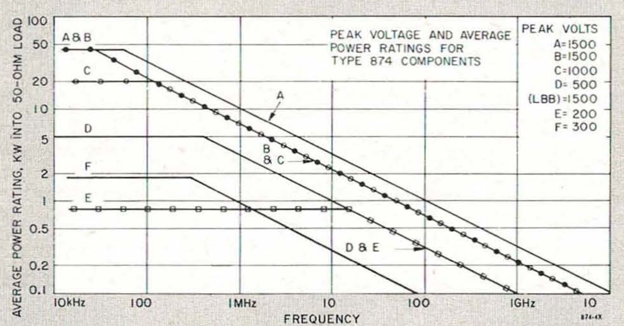
14 mm - 50 ohms

GR900
page 152 ff

Described on the following pages is one of the most comprehensive lines of coaxial equipment available anywhere. There are two basic classifications: the GR874 series, whose common element is the general-purpose GR874 coaxial connector, and the GR900® series, based on the GR900 precision coaxial connector. Each series includes connectors, adaptors, and circuit elements, as well as a slotted line, so that measurement setups can be conveniently assembled.

GR874

General Radio entered the coaxial-component field over 20 years ago, with the introduction of the GR874 connector, which offered not only excellent electrical performance but a major convenience feature: any two, although identical, could be mated. The hermaphrodite, quick-connect GR874 was soon joined by a family of circuit elements and adaptors using the new connector. GR874-equipped instruments — notably the slotted line and the admittance meter — were added to solve the special measurement problems of vhf and uhf. The availability of precise measuring instruments in turn made possible a continuous refinement of the basic connector. An important development was the locking version of the GR874 connector, particularly useful in microwave applications where the needs for mechanical stability and repeatability are demanding. Locking and nonlocking versions of the GR874 connector are fully compatible.



GR900

True precision came to coaxial measurements in 1963, in the form of the GR900 precision coaxial connector and associated equipment. Until that breakthrough, the development of more accurate instruments for coaxial measurements had been retarded for want of a precise connector. The GR900 connector opened the door to the development of a new, precision slotted line, new measuring techniques, and new applications for coaxial lines where only waveguide had gone before. Today, the GR900 line includes adaptors, standards, terminations, air-line sections, and other components.

HIGH PRECISION, REPEATABILITY

Another significant figure has been added to coaxial measurement: Where one formerly spoke of a VSWR of 1.03, one now speaks of a VSWR of, say, 1.034, with confidence in the last figure. In terms of accuracy, resolution and repeatability attained, the GR900 development must rank as one of the most significant of the past decade.

ORIGINAL EQUIPMENT USERS

Both the GR874 and the GR900 connectors have gained wide popularity, not only as circuit elements but also among instrument manufacturers, who have put the electrical and physical advantages of these connectors to good use on their products.

Category	Applicable Type 874 Items	See Curve	Peak Volts
Adaptors	-QHJA, -QHPA, -QLJA, -QLPA, -QLTJ, -QLTP, -Q900L	A	1500
	-QCP, -QCJA, -QCJL, -QNP, -QNPL, -QNJA, -QNJL, -QSCP, -QSCJ, -QSCJL, -QAP7L	C	1000
	-QBJA, -QBJL, -QBPA, -QTNJ, -QTNJL, -QTNP, -QUJ, -QUJL, -QUP	D	500
	-QMDJ, -QMDJL, -QMDP, -QMMJ, -QMMJL, -QMMP, -QMMPL	F	300
Air Lines			
Adjustable	-LAL, -LK10L, -LK20L	B	1500
Fixed	-L10, -L10L, -L20, -L20L, -L30, -L30L	A	1500
Connectors	-B, -BBL, -PLT, -PRLT, -PFL	A	1500
	-CA, -CLA, -C8A, -CL8A, -PBA, -PB8A, -PLA, -PL8A, -PRLA, -PRL8A -PBRLA, -PBRL8A	C	1000
	-C58A, -CL58A, -C62A, -CL62A, -PB58A, -PB62A, -PL58A, -PL62A, -PRL58A, -PRL62A, -PBRL58A, -PBRL62A	D	500
	-C174A, -CL174A, -PB174A, -PL174A, -PRL174A, -PBRL174A	F	300
Elements	-EL, -EL-L, -T, -TL	A	1500
	-K, -KL	D	500
Filters	-F185L, -F500L, -F1000L, -F2000L, -F4000L	E	200
Patch Cords	-R20A, -R20LA	C	1000
	-R22A, -R22LA	D	500
Slotted Line	-LBB	D	1500

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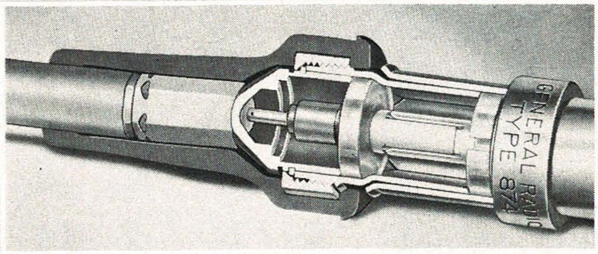
coaxial

GR874 SERIES

14 mm - 50 ohms



Cutaway view of GR874 basic connector mated with GR874 cable connector.

Based on the GR874 connector is a complete line of coaxial components and instruments, including a Slotted Line, Admittance Meter, Transfer-Function and Immittance Bridge, adaptors, stubs, attenuators, filters, and many other devices. The user of the GR874-equipped laboratory need seldom turn to other connector types for a needed element. If he does, he will be able to select a GR874 adaptor to connect to almost any other common type of connector.

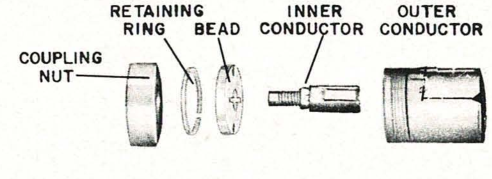
New members of the GR874 line are constantly being developed, so that equipping a laboratory with the GR874 line today will seem an even wiser choice tomorrow.

LOCKING CONNECTORS

The GR874 connector is also available in a locking version similar to, and compatible with, the nonlocking, quick-disconnect version. The locking version, however, has a threaded coupling nut that permits the two connectors to be mechanically locked together in a stable, semipermanent connection for better electrical repeatability, low leakage, and less chance of accidental disconnection, while retaining the other performance advantages of the nonlocking GR874 connector. The quick connect/disconnect feature is retained if the coupling nut is not engaged. Many GR874 components are now available equipped with locking or nonlocking connectors; a final L in the type number designates a locking version. Most GR874-equipped instruments use the locking connector by which the adaptors to other connector types can be semipermanently attached to the instrument.

ELECTRICAL CHARACTERISTICS

The GR874 connector has the lowest reflection characteristics of any standard, general-purpose, 50-ohm coaxial connector in the dc-to-9-GHz frequency range. Its small reflections at high frequencies makes the GR874 of particular value in pulse applications and in time-domain reflectometry. Its VSWR performance is typically superior to that of the type N connector. GR874 cable connectors, in fact, offer VSWR performance superior to that of any cable with which they can be used, and therefore add no significant reflections when used in measurement setups.



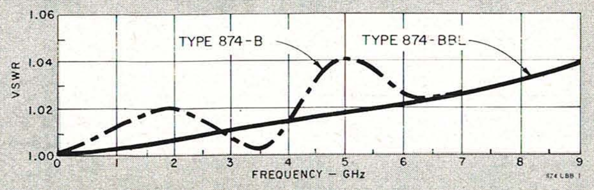
Exploded view of Type 874-B Basic Connector.

MECHANICAL CHARACTERISTICS

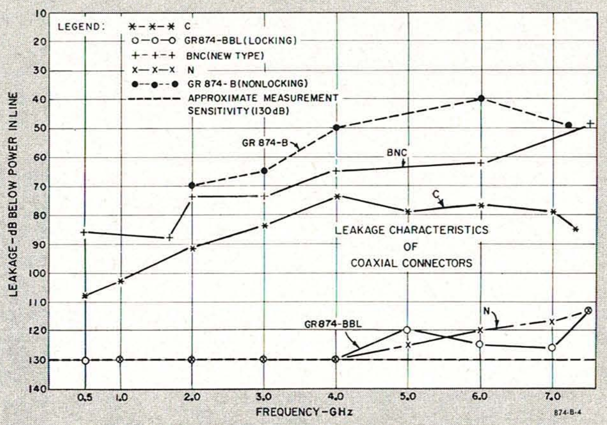
The elements of a GR874 connector, as shown in the exploded view, are an inner conductor, an outer conductor, a supporting polystyrene bead, a phosphor-bronze retaining ring, and a threaded coupling nut. All metal parts are machined and formed to very close tolerances, and all are made of hard-drawn brass, except for the center conductor, which is heat-treated beryllium copper to ensure good gripping capability and long wear. A bright-alloy finish on all surfaces produces high conductivity for low loss and gives long-lasting protection against tarnish.

Inner and outer conductors are similar in principle; each is a tube with four longitudinal slots in one end, with two opposite quadrants displaced inward. When two connectors are joined, the undisplaced quadrants of one overlap the displaced quadrants of the other (see cutaway view).

PATENT NOTICE. See Note 4.



Typical VSWR of pairs of Type 874-B and -BBL Connectors



Typical leakage characteristics of GR874 connectors compared with other types.

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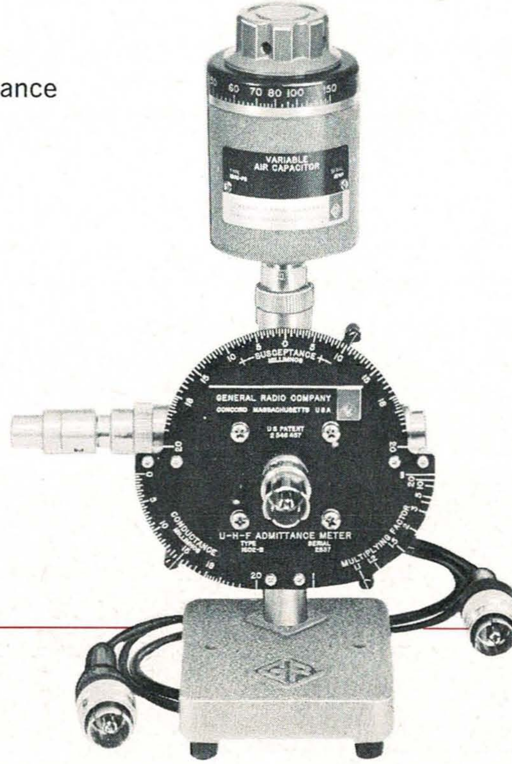
UHF ADMITTANCE METER AND VSWR BRIDGE

Type 1602-B

- 20 to 1500 MHz
- direct reading — conductance and susceptance
- measures VSWR directly

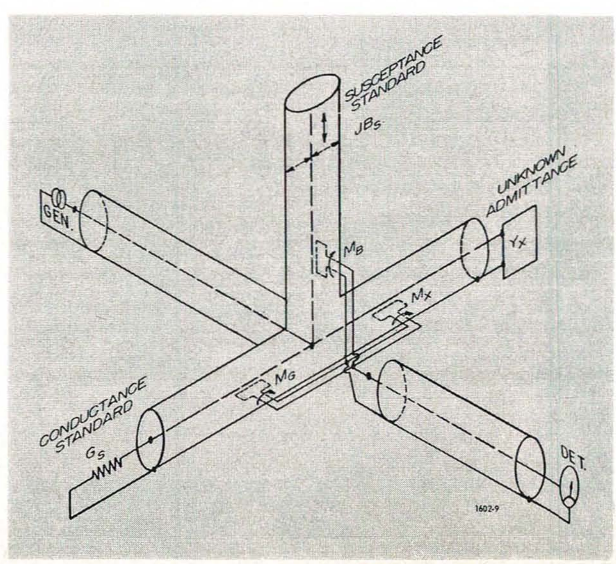


This null-type instrument measures complex impedance and admittance in coaxial systems and, as a reflectometer, can be used to determine voltage standing-wave ratio (request Reprint E-112 for more details), impedance magnitude, and reflection coefficient magnitude.

It can be used for adjusting a network to a predetermined admittance, for matching one network to another, and for matching antennas and other networks to 50-ohm circuits.

A full line of accessories is available to adapt the Admittance Meter to specific types of measurements:

The 874-LK20L Constant-Impedance Adjustable Line, which can be set to one-half wavelength to eliminate corrections for the length of transmission line between the unknown and the measuring point. When the line is set to one-quarter wavelength, the Admittance Meter dials



Schematic diagram of admittance-meter circuit, with standards, generator, and null detector connected for admittance measurements.

File Courtesy of GRWiki.org

read in impedance parameters, i.e., the series resistance and reactance of the unknown.

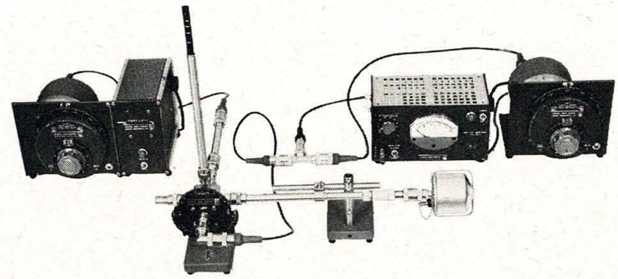
The 874-UBL Balun, for use with balanced impedances.

The 874-ML Component Mount, for the connection of lumped elements (resistors, capacitors, or inductors).

Low-VSWR adaptors (which can be locked in place) for conversion to types N, BNC, TNC, etc. With these adaptors and the adjustable line mentioned above, the over-all accuracy of measurement is more than adequate for measurements in the design, test, and installation of antennas.

For measurements demanding higher accuracy and repeatability, consider the Type 1609 Precision UHF Bridge. Operating on the same principle as the 1602-B and over the same frequency range, the 1609 is equipped with GR900® precision coaxial connectors and vernier controls for minimized uncertainty and high balance precision. The 1609 is described in full in the section on GR900 coaxial instruments.

The 1602-B UHF Admittance Meter comprises three identical loops, in parallel, driving a null detector and magnetically coupled to three coaxial lines. All these lines are fed from the same voltage, so the current in each line,



The Admittance Meter assembled for component measurements, with Unit Oscillator and DNT Detector. A line stretcher (Type 874-LKL) connects the component mount to the unknown terminal of the Admittance Meter.

hence the magnetic field, is proportional to the terminating impedance. One of these lines is terminated with a standard resistance, one with a reactance standard, and one with the unknown admittance. The coupling of each loop is adjusted until a null is obtained on the detector. Each loop has a calibrated scale and the settings at null condition indicate the value of the unknown.

GR 1609 page 156

specifications

RANGES OF MEASUREMENT

Conductance: 0.01 to 4000 millimhos.

Susceptance: —4000 to +4000 millimhos.

Standing-wave ratios of less than 1.2 can be measured by a direct reading method; VSWR as high as 10 can be readily measured by a voltage-ratio method.

Frequency: 40 to 1500 MHz, direct reading. Range is extended downward to 20 MHz, with a frequency correction applied to the susceptance reading.

Accuracy (for both conductance and susceptance):

Up to 1000 MHz,

from 0 to 20 millimhos, $\pm$ (3% $+$ 0.2 millimho)

from 20 to ∞ millimhos, $\pm(3\sqrt{M}\% + 0.2$ millimho) where M is the scale-multiplying factor.

Above 1000 MHz, errors increase slightly, and, at 1500 MHz, the basic figure of 3% in the expression above becomes 5%. For matching impedances to 50 ohms, the accuracy is 3% up to 1500 MHz.

GENERAL

Accessories Supplied: Two 1602-P4 50-Ω Terminations, for use as conductance standards; one 1602-P1 Adjustable Stub and one 1602-P3 Variable Air Capacitor, for susceptance standards; two 874-R22LA Patch Cords for connections to generator and detector; 1602-P10 and -P11 Multiplier Plates. A wooden storage case is furnished.

Generator: External only (not supplied). Generator must supply 1 to 10 V.

Detector: External only (not supplied). Sensitivity must be 10 μV or better. Type DNT and 1241 Detectors are recommended.

Accessories Available: 874-FBL Bias Insertion Unit, coaxial adaptors, line-stretcher, balun, component mount, Smith charts.

Terminals: GR874 coaxial connectors, all locking-type except for detector terminal. Can be easily converted to type N or other common connector with GR874 adaptors.

Dimensions (width x height x depth): 5½ x 7½ x 5½ in. (140 x 190 x 140 mm).

Weight: Net, 8¼ lb (3.8 kg); shipping, 18 lb (8.5 kg).

Detectors page 119 ff

Generators page 209 ff

Catalog Number	Description	Price in USA
1602-9702	**1602-B UHF Admittance Meter**	**$465.00**

PATENT NOTICE. See Note 4.

Accessories supplied with the GR 1602-B Admittance Meter

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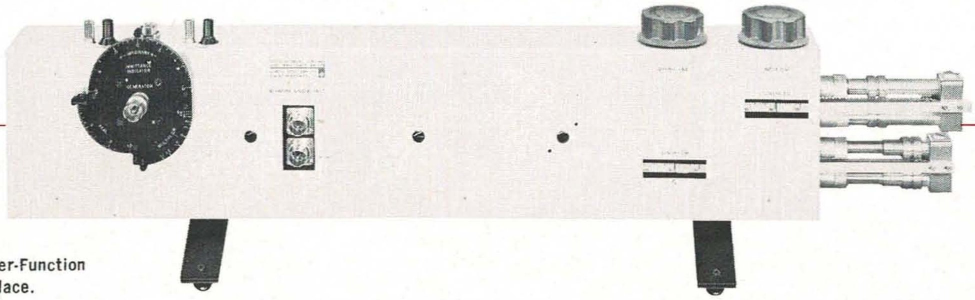
impedance bridge—coaxial

TRANSFER-FUNCTION AND IMMITTANCE BRIDGE

Type 1607-A

- 25 to 1500 MHz
- measure transistors, IC's, diodes, networks:
  - 2-terminal admittance and impedance (Y and Z)
  - 4-terminal transfer functions
  - transistor S- and h-parameters
  - active or passive devices



Instrument with Transfer-Function Indicator mounted in place.

The Transfer-Function and Immittance* Bridge is a null-type instrument for vhf and uhf measurements of the forward and reverse complex transfer functions and the input and output impedances and admittances of four-terminal electrical networks, either active or passive. Thus, transistor parameters for the preparation of Linvill charts can be easily measured. Two-terminal circuits or components can also be measured.

Among these measurements are:

Transistors** — h_f(α or β), and $|\beta|$, h_r, h_i, h_o, y_c, y_o, y_f, y_r.

Tunnel Diodes — Equivalent circuit parameters.

General two-terminal or four-terminal networks —
Z_{11}, Z_{22}, Z_{21}, Z_{12} and Y_{11}, Y_{22}, Y_{21}, Y_{12}.
I_2/I_1, I_1/I_2 and E_2/E_1, E_1/E_2.

Ungrounded components —
Inductors — inductance and self-resonance.
Capacitors — capacitance and resonances.
Resistors — resistance and shunt capacitance.

Components, Coaxial Lines, and Other Grounded Elements — Z, Y, $|\Gamma|$, VSWR.

The 1607-A Transfer-Function and Immittance Bridge comprises three identical loops, fed from a common source and magnetically coupled to three coaxial lines. One of these lines is terminated with a resistance standard, one with a reactance standard, and one with the network to be tested. The coupling of each loop is adjusted until a null is obtained on an external detector in which the three lines are terminated.

Two interchangeable loop-and-scale assemblies (Transfer-Function Indicator and Immittance Indicator, respectively) allow either four-terminal or two-terminal networks to be measured with equal ease.

Two built-in constant-impedance, adjustable-length lines eliminate line-length corrections.

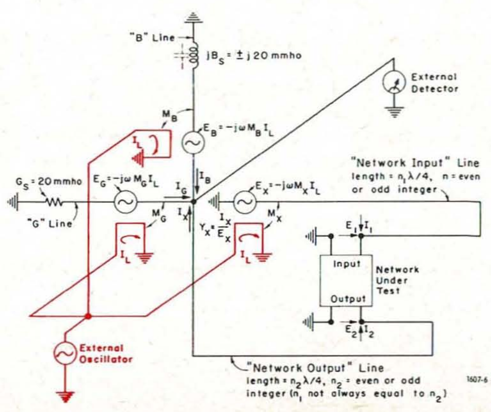
*Immittance = impedance and/or admittance.
**S-parameters to 500 MHz.

specifications

Frequency Range: 25 to 1500 MHz, with reduced accuracy above 1000 MHz, or when flexible cable is used in the lines. The use of cable is generally required below 150 MHz and is optional at other frequencies.

Measurement Range:	Accuracy (25 to 1000 MHz):*
Voltage and Current Ratios (R) 0-30, 0-300†	$2.5\,(1+\sqrt{R})\,\%+0.025$**
Transimpedance (Z_{21}) 0-1500 Ω, 0-15,000 Ω†	$2.5\left(1+\sqrt{\frac{Z_{21}}{50}}\right)\%+1.25\,\Omega$**
Transadmittance (Y_{21}) 0-600 m℧, 0-6000 m℧†	$2.5\left(1+\sqrt{\frac{Y_{21}}{20}}\right)\%+0.5\,$m℧**
Impedance (Z_{11}) 0-1000 Ω, 0-10,000 Ω†	$2.0\left(1+\sqrt{\frac{Z_{11}}{50}}\right)\%+1.0\,\Omega$**
Admittance (Y_{11}) 0-400 m℧, 0-4000 m℧†	$2.0\left(1+\sqrt{\frac{Y_{11}}{20}}\right)\%+0.4\,$m℧**

*These specifications apply individually to the real and imaginary components.
**When a 1607-P10 or -P11 Multiplier Plate is used, the fixed errors (shown after the % sign) are significantly reduced.
†With multiplier plate.



Schematic diagram of rf circuits of the Transfer-Function and Immittance Bridge.

File Courtesy of GRWiki.org

Dc Bias: Bias terminals are provided. Maximum current, 2.5 A, continuous; higher currents are permissible for short periods; maximum voltage, 400 V.

Generator and Detector: External only, not included; GR Unit Oscillators and DNT Detectors are recommended.

Accessories Supplied: Range-Extension Unit; Transfer-Function Indicator; Immittance Indicator; 6 terminations (open, short, matched, etc.); standards; 10-dB attenuator; 8 air lines (21.5 and 43 cm); 3 U-line sections; constant-impedance adjustable line; a special tee; two 0.1 multiplier plates; 10 patch cords; storage case for instrument and accessories.

Accessories Required: Mount for unknown device. See below for mounts available. Note that termination kit is required for some transistor mounts.

Accessories Available: Smith Charts.

Dimensions (width x height x depth): 40 x 11½ x 14½ in. (1020 x 295 x 370 mm).

Weight: Net, 63 lb (29 kg); shipping, 132 lb (61 kg).

—For a more detailed description, request **GR Reprints E107** and **E109.**

Catalog Number	Description	Price in USA
1607-9701	**1607-A Transfer-Function and Immittance Bridge**	**$2150.00**

PATENT NOTICE. See Note 4.

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Type 1607 Transistor and Component Mounts

The mounts listed below permit the three-terminal measurement of a variety of devices with the 1607-A Transfer-Function and Immittance Bridge. When the recommended short- and open-circuit terminations are used, the reference plane for the measurements is precisely established at the transistor socket or other appropriate surface. By this means the effects of coaxial line lengths and of the mount itself between unknown and instrument are eliminated.

In the transistor mounts, the leads are inserted into hollow contact tubes that are the center conductors of small coaxial lines. Thus, all but about 1/32 inch of the leads at the header are completely shielded, bends or irregularities of the leads have no effect, and the discontinuity at the transistor-to-mount connection is minimized. Additional advantages: complete accessibility to the socket, provisions for bolting a heat sink to the mount, and a fourth lead in the mount socket, which is dc ground.

specifications

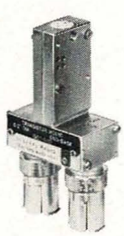
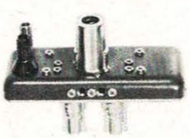
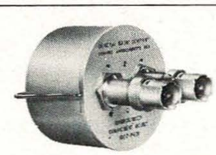
Mount Type	Transistor, diode, and tube packages accepted
1607-P41 and -P42	TO-5, 9, 11, 12, 16, 26, 31, 33, 37, 38, 39, 43; MD-14; MM-4, 8; MT-13, 20, 28, 37; RO-2, 3, 4, 5, 10, 24, 30, 33, 34, 46, 49, 50, 61, 62, 79, etc.
1607-P43 and -P44	TO-18, 28, 52, 54; MT-30, -38; RO-44, 48, 51, 64, 65, 66, 70, 73, 78; U-3; X-8; etc.
1607-P201	Type 6AN4 and similarly based tubes

Accessories Supplied: Two damper resistors (10 and 50 Ω) with each transistor mount, to control oscillations in measurement of wide-band, high-gain transistors.

Accessories Required: Terminations and U-Block (see below).

Net Weight: Mount, approx 12 oz (0.4 kg); Termination Kit, approx 1 lb (0.5 kg).

Shipping Weight: One mount, 2 lb (1 kg); Termination Kit, 2½ lb (1.2 kg).

		Grounded Connection	Pin Circle Dia (in.)	Leads	Terminations Required	Type	Catalog Number	Price in USA
Transistor Mounts (2-inch max lead length)		base	0.2	4	1607-P40 Termination Kit (see below)	**1607-P41 Transistor Mount**	1607-9641	**$160.00**
		emitter or collector	0.2			**1607-P42 Transistor Mount**	1607-9642	**160.00**
		base	0.1			**1607-P43 Transistor Mount**	1607-9643	**160.00**
		emitter or collector	0.1			**1607-P44 Transistor Mount**	1607-9644	**160.00**
Tube Mount		cathode	7-pin miniature tube: 6AN4 and similarly based tubes		**874-WO5, 874-WN5, and U-block supplied with 1607-A**	**1607-P201 Tube Mount**	1607-9995	**90.00**
Component Mount		For measuring lumped-component admittance as a transfer-function to eliminate effect of stray impedances to ground.				**1607-P601 Ungrounded Component Mount**	1607-9997	**45.00**
Termination Kit		Terminations: **874-U10 U-Line Section, 874-WN10 Short-Circuit, and 874-WO10 Open-Circuit.**				**1607-P40 Termination Kit**	1607-9640	**50.00**

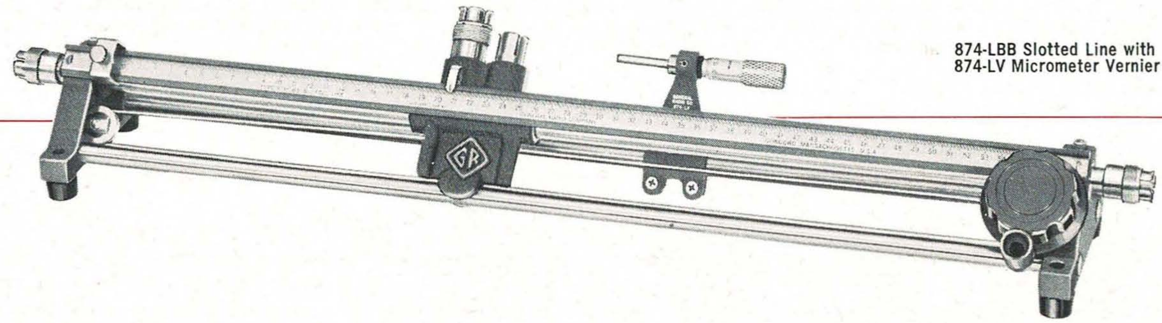
File Courtesy of GRWiki.org

coaxial

SLOTTED LINE

Type 874-LBB

- 300 MHz to 9 GHz
- residual VSWR: <1.02 to 1 GHz
  <1.035 to 4 GHz
  <1.10 to 8.5 GHz
- rugged construction
- many lines in one with GR874 adaptors



874-LBB Slotted Line with 874-LV Micrometer Vernier

900-LB page 154

One of the most important basic measuring instruments used at uhf and higher frequencies is the slotted line. General Radio makes two slotted lines, one based on the GR874 connector, the other on the GR900® precision connector. The GR874 line, while not so accurate as the 900-LB precision type, is satisfactory for most everyday measurements, and thousands are in use throughout the world. It is particularly well suited to the student laboratory. It can be converted in seconds to use any of the popular UG connectors through GR874 low-VSWR adaptors, available for BNC, C, HN, LC, Microdot, N, OSM*, SC, TNC, GR900 and Amphenol APC-7 connectors. A complete set of adaptors will convert the 874-LBB into the equivalent of 23 low-VSWR slotted lines. See curves in **GR Experimenter** for August 1966.

The slotted line is used to determine the standing-wave pattern of the electric field in a coaxial transmission line. From a knowledge of the standing-wave pattern, one can determine several characteristics of the circuit connected to the load end of the slotted line. For instance, the degree of mismatch between the load and the transmission line can be calculated from the ratio of the maximum amplitude of the wave to the minimum: VSWR. The load impedance can be calculated from the standing-wave ratio and the position of a minimum point on the line with respect to the load. These capabilities make the slotted line a valuable instrument for measurements on antennas, components, coaxial elements, networks, transistors, and diodes.

The 874-LBB Slotted Line is a 50-ohm, air-dielectric, coaxial line whose electric field is sampled by a probe, which projects through a longitudinal slot in the outer conductor. The probe rides on a carriage, which is driven by a pulley-and-cord linkage conveniently operated from one end of the line. Both the position of the probe and the degree of coupling can be precisely set. A diode rectifier, built into the carriage, can be tuned to the operating frequency by means of a 900-DP Probe Tuner or adjustable stub.

A source of about one milliwatt rf power is adequate for most measurements. A convenient source is one of the GR oscillators, available in several models and offering a wide choice of frequency range. The detector can be a standing-wave indicator, the GR 1234, for instance, or one of the GR Type DNT or 1241 Heterodyne Detectors.

— See **GR Experimenter** for August 1966.

* Registered trademark of Omni Spectra, Inc.

specifications

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Characteristic Impedance: 50 Ω ± 0.5%.

Probe Travel: 50 cm. Scale in cm; 1 mm per division.

Scale Accuracy: ± (0.1 mm + 0.05%).

Frequency Range: 300 MHz to 8.5 GHz (usable to 9 GHz). Operation below 300 MHz (where probe travel equals one-half wavelength) is possible by use of lengths of GR874 air line.

Constancy of Probe Pickup: ±1.25%.

Residual VSWR: $<1.01 + 0.0016\ f^2_{GHz}$ to 7.5 GHz; <1.10 from 7.5 to 8.5 GHz.

Accessories Supplied: Storage box, rf probe, and 2 microwave diodes.

Accessories Required: 900-DP Probe Tuner (recommended) or 874-D20L Adustable Stub for tuning diode when audio-frequency detector is used; suitable generator and detector; one each 874-R22LA and 874-R22A Patch Cords (supplied with DNT Detectors and GR oscillators).

Accessories Available: The 874-LBB with accessories required for impedance and VSWR measurements is available as the 874-EKA Basic Slotted-Line Kit. For measurement of VSWR >10 the 874-LV Micrometer Vernier is recommended. Also available are Smith Charts and adaptors to other popular connectors.

Dimensions (width x height x depth): 26 x 4½ x 3½ in. (660 x 115 x 89 mm).

Weight: Net, 8½ lb (3.9 kg); shipping, 23 lb (10.5 kg).

Catalog Number	Description	Price in USA
0874-9651	**874-LBB Slotted Line**	**$395.00**

File Courtesy of GRWiki.org

SLOTTED-LINE ACCESSORIES

GENERATORS

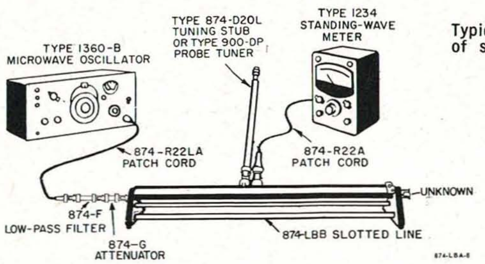
Oscillators suitable for use with the 874-LBB are described in the Generator section of this catalog. The GR RF Oscillators can be square-wave modulated with the 1264-B Modulating Power Supply. The 1360-B Microwave Oscillator for use at higher frequencies has internal 1-kHz square-wave modulation.

DETECTORS

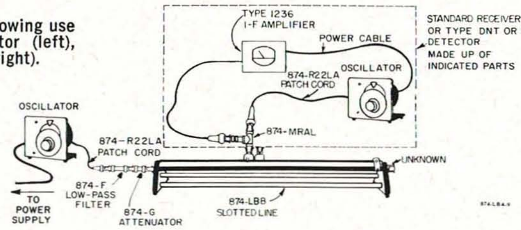
The GR 1234 Standing-Wave Meter is recommended as a fine general-purpose detector capable of measuring a wide range of VSWR values with ease. A probe tuner such as the 900-DP is required.

The heterodyne detector is a general-purpose laboratory detector. It is excellent for measurements of nonlinear circuits and of high values of VSWR, where a high degree of harmonic rejection is necessary, and for precise electrical-length measurements. The GR DNT and 1241 Detectors cover the frequency range from 40 to 2030 MHz (up to 5 GHz by the use of harmonics).

A low-pass coaxial filter should be used to eliminate harmonics of the signal source, and a 874-G10L Fixed Attenuator to isolate the oscillator from the effects of load changes.



Typical measurement setups showing use of slotted line, VSWR indicator (left), and heterodyne detector (right).



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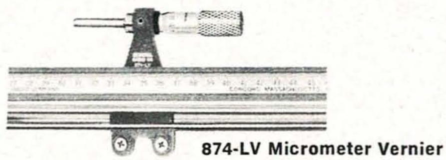
MICROMETER VERNIER — 874-LV

For precise measurements of high VSWR by the width-of-minimum method, and for precise phase measurements. Consists of a micrometer head calibrated in centimeters (calibrated to 0.001 cm), mounted on an arm that can be attached to the rear base rod of the slotted line. One turn of the micrometer barrel advances the head by 0.5 mm. Maximum range is 2.5 cm. Can be read to ±0.002 mm.



	Catalog Number	Price in USA
874-LV Micrometer Vernier	0874-9652	**$ 37.50**

PROBE TUNER — 900-DP

An accessory for the 874-LBB, this Probe Tuner can be used in place of an rf probe and adjustable stub. It has convenient, calibrated probe-depth adjustment and vernier tuning for resonance at any frequency from 300 MHz to 9 GHz.

Frequency Range: 0.3 to 9 GHz. **Tuning:** Shunt.
Probe Depth Scale: Calibrated in inches (0.001/div).
Stub Tuner: Calibrated in cm.
Dimensions: Length 11 in. (280 mm), dia 7/8 in. (23 mm), closed.
Net Weight: 8½ oz (245 g).

	Catalog Number	Price in USA
900-DP Probe Tuner	0900-9654	**140.00**

BASIC SLOTTED-LINE KIT — 874-EKA

For impedance and VSWR measurements with the slotted line. The coaxial elements listed below are available as the 874-EKA. The 874-LBB Slotted Line is included in the kit, but the generator and detector are not.
Shipping Weight: 38 lb (17.5 kg).

Type	Description
874-A2	**Coaxial Cable** (25 ft)
874-A3	**Coaxial Cable** (25 ft)
874-BBL	**Basic Connector**, Locking (2)
874-B	**Basic Connector** (2)
874-CA	**Cable Connector** (2)
874-C8A	**Cable Connector** (2)
874-CLA	**Cable Connector**, Locking (2)
874-C58A	**Cable Connector** (2)
874-CL58A	**Cable Connector**, Locking (2)
874-D20L	**Adjustable Stub**
874-D50L	**Adjustable Stub**
874-LAL	**Adjustable Line**
874-LBB	**Slotted Line**
874-PL58A	**Panel Connector**, Locking
874-PRL58A	**Panel Connector**, Locking, Recessed
874-QBJL	**Adaptor**, Locking, Connects to type BNC Plug
874-QNJL	**Adaptor**, Locking, Connects to type N Plug
874-QNPL	**Adaptor**, Connects to type N Jack
874-R22A	**Patch Cord**
874-R22LA	**Patch Cord**, Locking
874-R34	**Patch Cord**
874-TL	**Tee**, Locking
874-W50BL	**50-ohm Termination**
874-WN	**Short-Circuit Termination**
874-WO	**Open-Circuit Termination**
874-TOK	**Tool Kit**
874-Z	**Stand**

	Catalog Number	Price in USA
874-EKA Basic Slotted-Line Kit	0874-9521	**717.50**

CABLE MEASUREMENTS

Various combinations of GR874 coaxial elements can be used very effectively with GR oscillators and associated equipment to measure attenuation, characteristic impedance, velocity of propagation, and capacitance of both coaxial and twin-conductor cables.

For convenience in ordering, the necessary equipment is offered in assemblies for specific types of measurement. These kits and their use are described in General Radio Reprint E-104, "The Measurement of Cable Characteristics," available on request.

File Courtesy of GRWiki.org

coaxial

GR874 ADAPTORS

14 mm — 50 ohms

Thirty-six different low-VSWR adaptors provide easy conversion from the GR874 connector to most popular military and commercial coaxial connectors. Many of the adaptors are available with locking-type GR874 connectors to allow semipermanent attachment of the adaptor while ensuring stable electrical performance.

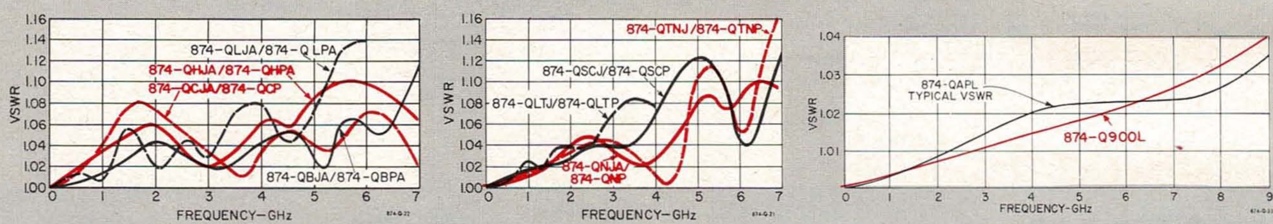
GR874 adaptors extend the usefulness of GR874 connectors without sacrificing electrical performance. The VSWR of the combination of GR874 connector and GR874 adaptor is actually comparable to that of the "other series" connector alone.

ORIGINAL EQUIPMENT USES

Original-equipment manufacturers will recognize the possibilities of these adaptors in combination with the GR874 locking recessed panel connector. An instrument originally equipped with these connectors can, by means of appropriate GR874 adaptors, be quickly converted to almost any coaxial connector series, with the resulting panel connector rigidly attached and protruding less than an inch beyond the panel surface.

REPLACES COUNTLESS ADAPTORS

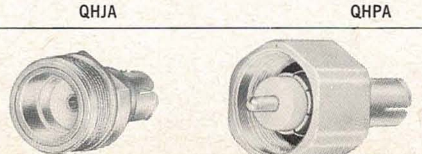
Because any two GR874 adaptors mate, a few of them can perform a cross-connection task that would otherwise involve a costly collection of direct adaptors. For instance, interconnection of all possible combinations of types N, C, BNC, TNC, UHF, and Microdot plugs and jacks would require 72 direct adaptors, whereas only 12 GR874 adaptors are needed to do the same job.



Typical VSWR introduced in line by pairs of GR874 adaptors plugged together.

GR874 ADAPTORS

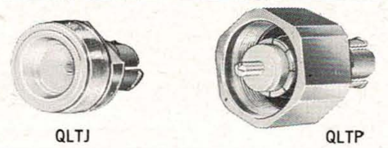
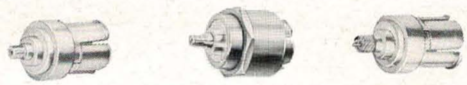
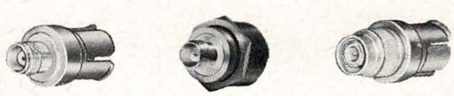
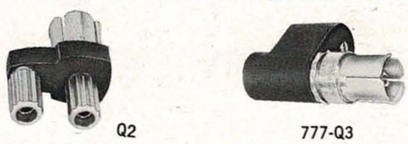
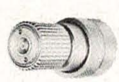
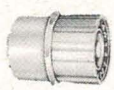
In ordering adaptors by type number, note that the P or J suffix letter identifies the connector on **the adaptor**, not the connector that the adaptor fits. (For instance, the Type 874-QNJ Adaptor **contains** a type N **jack**, and therefore fits a type N plug.) A final L in the type designation indicates a locking adaptor.

ADAPTORS TO:		Contains GR874 and . . .	Type Nonlocking	Type Locking	Catalog Number	Price in USA
BNC	 QBJA QBJL QBPA	BNC Jack	874-QBJA		0874-9700	$ 5.25
		BNC Jack		874-QBJL	0874-9701	6.50
		BNC Plug	874-QBPA		0874-9800	7.00
		BNC Plug		874-QBPAL	0874-9801	8.25
C	 QCJA QCJL QCP	C Jack	874-QCJA		0874-9702	7.50
		C Jack		874-QCJL	0874-9703	8.75
		C Plug	874-QCP		0874-9802	7.00
HN	 QHJA QHPA	HN Jack	874-QHJA		0874-9704	7.00
		HN Plug	874-QHPA		0874-9804	8.50
LC	 QLJA QLPA	LC Jack	874-QLJA		0874-9706	14.00
		LC Plug	874-QLPA		0874-9806	38.00

File Courtesy of GRWiki.org

GR874 ADAPTORS

Weights are 1 to 8 oz, depending on adaptor.
See page 126 for power and voltage ratings.

ADAPTORS TO:		Contains GR874 and . . .	Type Nonlocking	Type Locking	Catalog Number	Price in USA
LT	 QLTJ QLTP	LT Jack LT Plug	874-QLTJ 874-QLTP		0874-9708 0874-9808	26.00 82.00
Microdot	 QMDJ QMDJL QMDP	Microdot Jack Microdot Jack Microdot Plug	874-QMDJ 874-QMDP	 874-QMDJL 	0874-9720 0874-9721 0874-9820	6.75 8.00 11.00
N	 QNJL QNPL	N Jack N Jack N Plug N Plug	874-QNJA 874-QNP 	 874-QNJL 874-QNPL	0874-9710 0874-9711 0874-9810 0874-9811	5.00 6.25 6.00 7.25
OSM*/ BRM	 QMMJ QMMP	** OSM/BRM Jack OSM/BRM Jack OSM/BRM Plug OSM/BRM Plug	874-QMMJ 874-QMMP 	 874-QMMJL 874-QMMPL	0874-9722 0874-9723 0874-9822 0874-9823	16.00 17.25 22.00 23.25
SC	 QSCJ QSCJL QSCP	SC Jack SC Jack SC Plug	874-QSCJ 874-QSCP	 874-QSCJL 	0874-9712 0874-9713 0874-9812	14.75 16.00 16.00
TNC	 QTNJ QTNJL QTNP	TNC Jack TNC Jack TNC Plug	874-QTNJ 874-QTNP	 874-QTNJL 	0874-9716 0874-9717 0874-9816	8.50 9.75 10.00
UHF	 QUJ QUJL QUP	UHF Jack UHF Jack UHF Plug	874-QUJ 874-QUP	 874-QUJL 	0874-9718 0874-9719 0874-9818	5.50 6.75 5.00
GR 274	 Q2 777-Q3	274 Jack 938 Jack	874-Q2 777-Q3		0874-9870 0777-9703	4.50 6.00
Amphenol APC-7 Connector		7-mm precision connector		874-QAP7L	0874-9791	60.00
GR900® Connector		GR 900-AB		874-Q900L	0874-9709	15.00

* Registered trademark of Omni Spectra, Inc. ** Also mates with NPM, STM, and others.

File Courtesy of GRWiki.org

coaxial

GR874 STANDARD TERMINATIONS

These terminations are used to establish known impedance at a specific location on coaxial lines.

Resistive terminations are useful for checking accuracy of directional couplers, bridges, and admittance meters. The known location of a purely resistive termination permits the production of many known complex impedances through the addition of sections of 874-L Air Line, fixed or adjustable.

Open- and short-circuit terminations are useful in establishing initial coaxial line-length conditions for impedance measurements.

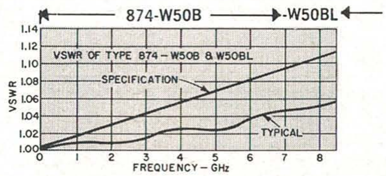
Catalog Number | Price in USA

RESISTIVE TERMINATIONS

50-OHM

Available with either locking or nonlocking connectors, these terminations consist of a 50-ohm cylindrical resistor mounted in a specially tapered coaxial holder. They are useful up to 9 GHz for impedance matching, establishment of reference conditions, and as terminations.

VSWR: <1.005 + 0.013f~GHz~.
DC Resistance: 50 Ω ±0.5%.
Max Power: 2 W continuous.



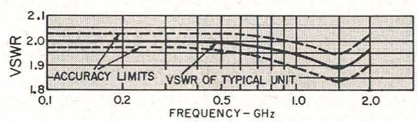
874-W50B

874-W50BL

	Catalog Number	Price in USA
874-W50B 50-ohm Termination	0874-9954	**$25.00**
874-W50BL 50-ohm Termination, locking	0874-9955	**26.25**

100-OHM

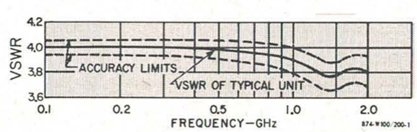
DC Resistance: 100 Ω ±1%.
Max Power: ⅓ W continuous, 150 W peak.



	Catalog Number	Price in USA
874-W100 100-ohm Coaxial Standard	0874-9956	**40.00**

200-OHM

DC Resistance: 200 Ω ±1%.
Max Power: ¼ W continuous, 50 W peak.



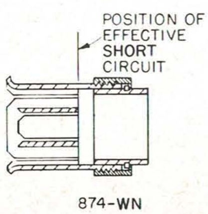
	Catalog Number	Price in USA
874-W200 200-ohm Coaxial Standard	0874-9958	**40.00**

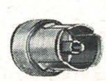
SHORT-CIRCUIT TERMINATIONS

Type 874-WN

A fixed short circuit mounted in a GR874 connector for establishing reference conditions on coaxial lines.

Position of Short-Circuit Plane: 0 to 0.07 cm toward load, dc to 7 GHz.





	Catalog Number	Price in USA
874-WN Short-Circuit Termination	0874-9970	**6.50**

File Courtesy of GRWiki.org

GR874 STANDARD TERMINATIONS

(continued)

Type 874-WNL

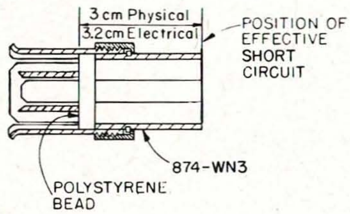
Similar to 874-WN but with locking GR874 connector.

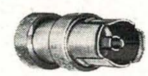
Position of Short-Circuit Plane: 0 to 0.07 cm toward load, dc to 9 GHz.

	Catalog Number	Price in USA
874-WNL Short-Circuit Termination, locking	0874-9971	**7.75**

Type 874-WN3

Same as 874-WN except that short circuit is 3.2 cm (electrical distance) beyond face of bead in GR874 connector. This distance corresponds to the bead-to-reference-plane distance in 874-ML Component Mount and 874-UBL Balun.





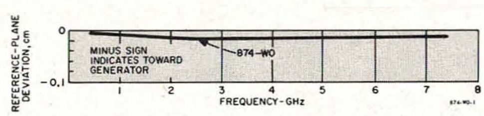
	Catalog Number	Price in USA
874-WN3 Short-Circuit Termination	0874-9972	**6.50**

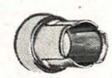
OPEN-CIRCUIT TERMINATIONS

Type 874-WO

Produces an open circuit at the same point that the 874-WN produces a short. Acts as a shielding cap for open-circuited lines.

Position of Open-Circuit Plane: 0 to 0.05 cm toward load, dc to 7 GHz.





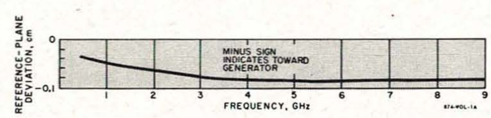
	Catalog Number	Price in USA
874-WO Open-Circuit Termination	0874-9980	**5.00**

Type 874-WOL

Similar to 874-WO but with GR874 locking connector.

Position of Open-Circuit Plane: 0 to 0.10 cm toward load, dc to 9 GHz.

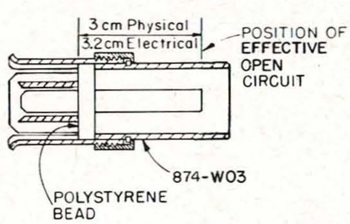
Typical Reference-Plane Deviation (toward generator):

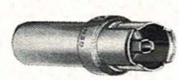


	Catalog Number	Price in USA
874-WOL Open-Circuit Termination, locking	0874-9981	**6.25**

Type 874-WO3

Same as 874-WO except that open circuit is at a position corresponding to that of short circuit in 874-WN3 and to the bead-to-reference-plane distance in the 874-ML Component Mount and 874-UBL Balun.





	Catalog Number	Price in USA
874-WO3 Open-Circuit Termination	0874-9982	**5.00**

File Courtesy of GRWiki.org

coaxial

GR874 ATTENUATORS
— 50 ohms

		Catalog Number	Price in USA

FIXED ATTENUATORS

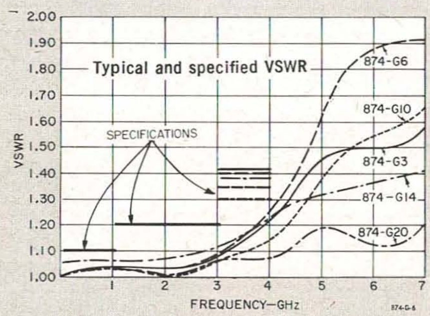
Single-section, T-type resistance pads, for insertion of fixed attenuation in 50-ohm systems and for isolation and matching to 50 ohms over a broad frequency range. Each attenuator consists of one disk and two cylindrical resistors, as shunt and series elements, respectively. The 6-, 14-, and 20-dB attenuators are particularly convenient in pulse applications as X2, X5, and X10 voltage dividers, respectively.

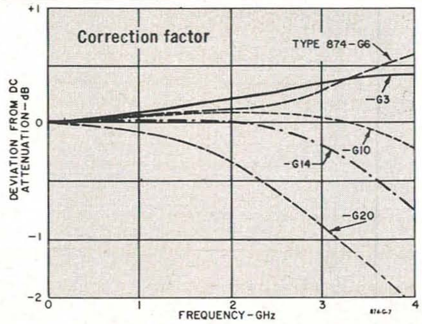
DC Resistance: 50 Ω ±1% when terminated in 50 Ω.

Attenuation Accuracy (relative to correction curves shown): ±0.2 dB to 1 GHz, ±0.4 dB to 2 GHz, ±0.6 dB to 4 GHz.

Temperature Coefficient: <0.0003 dB/°C/dB.

Max Power: CW, 1 W; pulse, 2000 W peak, 1 W average.
Length: 3½ in. (89 mm).





Attenuation at dc (dB)	Type	Catalog Number	Price in USA
	Fixed Attenuator		
3±0.045	**874-G3**	0874-9564	**$36.00**
	874-G3L*	0874-9565	**38.50**
6 ±0.09	**874-G6**	0874-9568	**30.00**
	874-G6L*	0874-9569	**32.50**
10 ±0.15	**874-G10**	0874-9570	**30.00**
	874-G10L*	0874-9571	**32.50**
14 ±0.21	**874-G14**	0874-9560	**30.00**
	874-G14L*	0874-9561	**32.50**
20 ±0.30	**874-G20**	0874-9572	**30.00**
	874-G20L*	0874-9573	**32.50**

*Locking Connectors

ADJUSTABLE ATTENUATOR

A waveguide-below-cutoff type, useful as a calibrated attenuator or as a sampling device. Calibrated in decibels, on a micrometer-type scale. Absolute attenuation is the sum of insertion loss and scale reading. Phase shift is essentially constant as attenuation is varied. The main line is a short coaxial section with locking GR874 connectors, one end for source, the other for load. It introduces minimum discontinuity when inserted in a 50-ohm line. The loop output is brought out through three feet of 50-ohm cable with locking GR874 connector.

Calibrated Range: 120 dB (relative attenuation) with input line terminated in 50 Ω; 129 dB with input line terminated in adjustable stub to minimize the electric field at the coupling point (scale reads −9 to 120 dB).

Insertion Loss (from input connector to end of output cable at 1 GHz, when signal source impedance is 50 Ω):
With input line terminated in 50 Ω, and scale set at 0 dB, 30.4 dB ±2 dB; **set at −9 dB,** 17 ±2 dB (settings below 0 are not accurate).

With input line terminated in adjustable stub (which extends the range over which the calibration is accurate to the −9 dB scale setting), 19 ±2 dB minimum.
(Insertion loss is approximately inversely proportional to frequency up to 1 GHz.)

Insertion Loss Directly Through Tee: Negligible.

Accuracy of Attenuation:
Stub-terminated input, ±(0.01 times difference in attenuation reading +0.2) dB, direct-reading.
50-Ω terminated input, ±(0.015 times difference in attenuation reading +0.2) dB, when corrected. Correction chart supplied.

VSWR Introduced into Line: <1.03 at 1 GHz; <1.12 from 1 to 4 GHz.

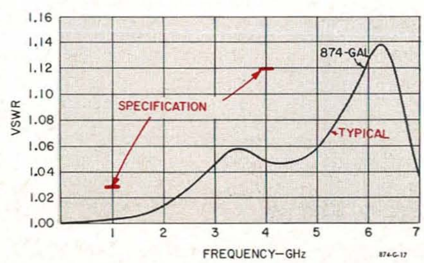
VSWR of Output: <4 at 1 GHz; <5 from 1 to 4 GHz.

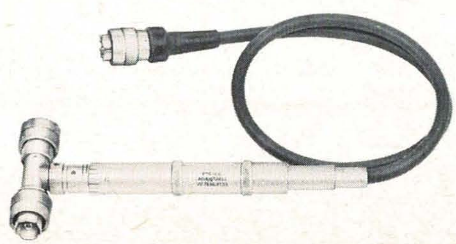
Max Power: Input power limit inversely proportional to square root of frequency. Power should not exceed 300 W at 1 GHz. Output power should not exceed ½ W.

Frequency Range: 100 MHz to 4 GHz.

Net Weight: 1¼ lb (0.6 kg).

VSWR introduced into line:





	Catalog Number	Price in USA
874-GAL Adjustable Attenuator	0874-9577	**$105.00**

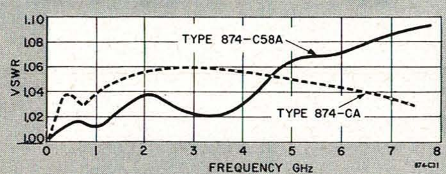
File Courtesy of GRWiki.org

GR874 CONNECTORS
14 mm — 50 ohms

CABLE CONNECTORS

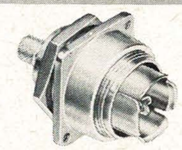
The GR874 cable connector is available in 10 types to accommodate five basic cable sizes in both locking and non-locking versions. These connectors fit more than 40 different RG types of coaxial cable, as well as General Radio Types 874-A2 and -A3 cable. Each cable connector consists of a basic connector plus inner and outer transition pieces, a soft-copper ferrule, a heat disk, and a flexible cable guard. The transition pieces maintain the 50-ohm characteristic impedance of the connector throughout the reduction to the cable diameter. The cable inner conductor is soldered to the inner transition piece, and the cable braid and jacket are crimped to the outer transition by the ferrule. Braid and jacket are thus kept from working loose to cause reflections and leakage.

A Neoprene cable guard serves as a protective handle. Sized to grip the cable securely without compressing it, the cable guard adds to the quick-connect-disconnect convenience of the connector.



Average VSWR of single connector on infinite length of 50-ohm cable.

PANEL CONNECTORS



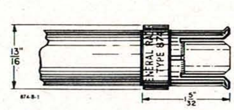
Panel connectors are available to fit the five popular cable sizes (as are cable connectors), to accept wire leads, and in four configurations: nonlocking, locking, recessed, and nonrotational. They are mounted to a panel by means of a flange and four screws; the nonlocking connector can be mounted either front or back. The recessed connectors reduce the front protrusion to ⅛ inch to save space and present a neat appearance. The keyed, locking panel connector, which adds a nonrotation feature to the locking connector, is for use where accidental loosening or turning of the connector might damage an attached component.

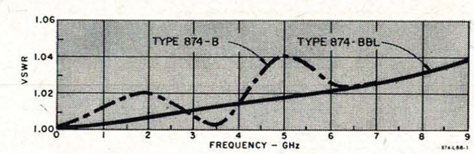
The GR874 line of coaxial connectors includes 34 different types, as listed in the following chart.

GR874 RIGID OR AIR-LINE CONNECTORS
14 mm — 50 ohms

For custom building coaxial components or sections of rigid 14-mm, 50-ohm air line using inner-conductor rod, 0874-9508, and outer-conductor tube, 0874-9509, listed elsewhere in this section.

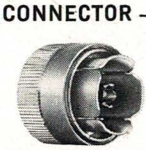
BASIC CONNECTOR — NONLOCKING

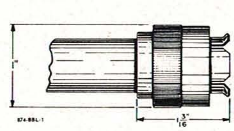




Typical VSWR of pairs of 874-B and -BBL Connectors.

BASIC CONNECTOR — LOCKING





	Catalog Number	Price* in USA
874-B	0874-9400	$2.25
874-BBL	0874-9403	3.50

See page 126 for power and voltage ratings.
Weights: 1-4 oz.

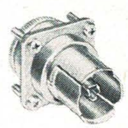
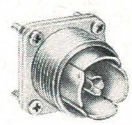
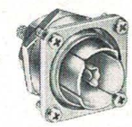
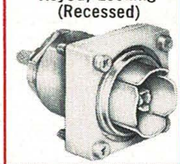
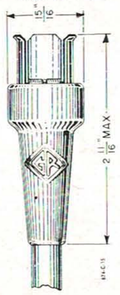
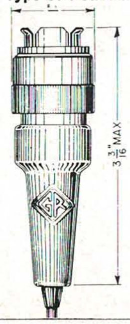
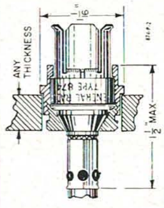
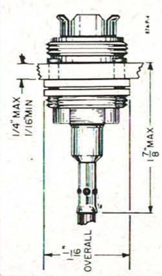
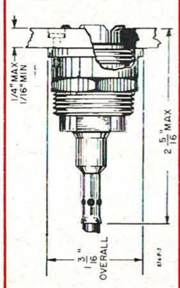
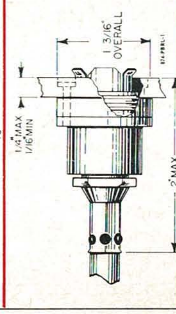
* 1-99. Quantity prices on request

File Courtesy of GRWiki.org

coaxial

GR874 CABLE CONNECTORS

GR874 CABLE CONNECTORS (for flexible cables)

Cable Types	Cable-Mounted Nonlocking	Cable-Mounted Locking	Panel-Mounted Nonlocking	Panel-Mounted Locking	Panel-Mounted Locking, Recessed	Panel-Mounted Keyed, Locking (Recessed)	
							
874-A2	**874-CA** 0874-9410 **$3.00**	**874-CLA** 0874-9411 **$4.25**	**874-PBA** 0874-9440 **$4.50**	**874-PLA** 0874-9441 **$4.00**	**874-PRLA** 0874-9461 **$4.50**	**874-PBRLA** 0874-9481 **$6.60**	Type Catalog Number Price in USA*
50-OHM: RG-8A/U, RG-9B/U, RG-10A/U, RG-87A/U, RG-116/U, RG-156/U, RG-165/U, RG-166/U, RG-213/U, RG-214/U, RG-215/U, RG-225/U, RG-227/U **NON 50-OHM**: RG-11A/U, RG-12A/U, RG-13A/U, RG-63B/U, RG-79B/U, RG-89/U, RG-144/U, RG-146/U, RG-149/U, RG-216/U	**874-C8A** 0874-9412 **$3.00**	**874-CL8A** 0874-9413 **$4.25**	**874-PB8A** 0874-9442 **$4.50**	**874-PL8A** 0874-9443 **$4.00**	**874-PRL8A** 0874-9463 **$4.50**	**874-PBRL8A** 0874-9483 **$6.60**	Type Catalog Number Price in USA*
50-OHM: 874-A3, RG-29/U, RG-55/U (Series), RG-58A/U (Series), RG-141A/U, RG-142A/U, RG-159/U, RG-223/U	**874-C58A** 0874-9414 **$3.00**	**874-CL58A** 0874-9415 **$4.25**	**874-PB58A** 0874-9444 **$4.50**	**874-PL58A** 0874-9445 **$4.00**	**874-PRL58A** 0874-9465 **$4.50**	**874-PBRL58A** 0874-9485 **$6.60**	Type Catalog Number Price in USA*
NON 50-OHM: RG-59/U, RG-62/U (Series), RG-71B/U, RG-140/U, RG-210/U	**874-C62A** 0874-9416 **$3.00**	**874-CL62A** 0874-9417 **$4.25**	**874-PB62A** 0874-9446 **$4.50**	**874-PL62A** 0874-9447 **$4.00**	**874-PRL62A** 0874-9467 **$4.50**	**874-PBRL62A** 0874-9487 **$6.60**	Type Catalog Number Price in USA*
50-OHM: RG-174/U, RG-188/U, RG-316/U **NON 50-OHM**: RG-161/U, RG-187/U, RG-179/U	**874-C174A** 0874-9418 **$6.00**	**874-CL174A** 0874-9419 **$7.25**	**874-PB174A** 0874-9448 **$6.00**	**874-PL174A** 0874-9449 **$5.50**	**874-PRL174A** 0874-9469 **$6.00**	**874-PBRL174A** 0874-9489 **$7.95**	Type Catalog Number Price in USA*
Wire Leads	—	—	—	**874-PLT** 0874-9459 **$4.00**	**874-PRLT** 0874-9479 **$4.50**	—	Type Catalog Number Price in USA*
	Type 874-CA 	**Type 874-CL174A** 	**Type 874-PBA** 	**Type 874-PL58A** 	**Type 874-PRL58A** 	**Type 874-PBRLA** 	

See page 126 for power and voltage ratings.
Weights: 1-4 oz.

* 1-99. Quantity prices on request

File Courtesy of GRWiki.org

GR874 AIR LINES

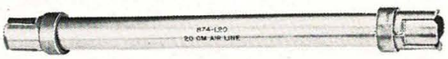
14 mm — 50 ohms

	Catalog Number	Price in USA

RIGID AIR LINES

For spacing stubs or other elements of a coaxial system; also useful as time-delay elements and as absolute impedance in time-domain reflectometers. Each air line (10, 20, or 30 cm) consists of a length of 50-ohm, air-dielectric coaxial line with a GR874 coaxial connector, either regular or locking, at each end. Locking versions use 874-BBL Basic Connectors and are thus usable up to 9 GHz.

Characteristic Impedance: 50 Ω ±0.4%.



874-L20

Electrical Length	Time Delay	Air Line Type	Catalog Number	Price in USA
10.086 ± 0.06 cm	0.3362 ± 0.00018 ns	**874-L10** **874-L10L,** locking	0874-9604 0874-9605	$10.50 14.50
20.096 ± 0.06 cm	0.6698 ± 0.00018 ns	**874-L20** **874-L20L,** locking	0874-9608 0874-9609	12.50 15.00
30.111 ±0.06 cm	1.0036 ± 0.00018 ns	**874-L30** **874-L30L,** locking	0874-9612 0874-9613	14.50 17.00

ADJUSTABLE LINES

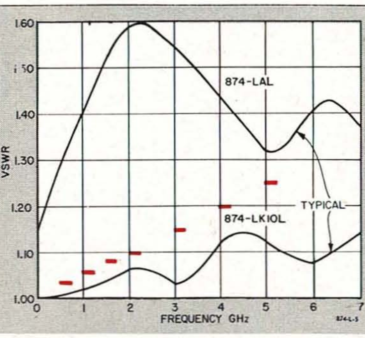
Type 874-LAL

An air-dielectric coaxial line that can be telescoped to change its length. Used in matching networks, as a phase shifter, and as a variable time-delay element. Contacts are made by multiple-spring fingers. Connectors are locking GR874.

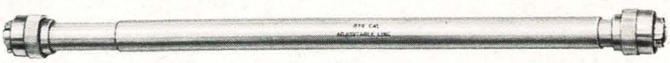
Characteristic Impedance: Not constant — approx 50 Ω when fully collapsed, approx 57 Ω when fully extended.

Adjustment Range: 25 cm.

Physical Length: 33 cm (min) to 58 cm (max).



Curves shown are typical VSWR; dashed points are specifications.



	Catalog Number	Price in USA
874-LAL Adjustable Line	0874-9621	35.00

CONSTANT-IMPEDANCE — 874-LK

A line stretcher with a very low VSWR and a uniform characteristic impedance of 50 ohms. Especially useful for eliminating the usual Smith-chart corrections for length of line between unknown and impedance-measuring device. These lines are useful as impedance-matching transformers and phase-adjustment elements in coaxial systems. Locking GR874 connectors.

Characteristic Impedance: 50 Ω.

Adjustment Range: 874-LK10L, 10 cm (half wavelength at 1.5 GHz); 874-LK20L, 22 cm (half wavelength at 680 MHz).

Physical Length: 874-LK10L, 35 to 45 cm; 874-LK20L, 58 to 80 cm.

VSWR: 874-LK20L, <1.03 at 500 MHz, <1.06 at 1 GHz, <1.08 at 1.5 GHz, <1.10 at 2 GHz. Type 874-LK10L, same as 874-LK20L to 2 GHz, <1.15 at 3 GHz, <1.2 at 4 GHz, <1.25 at 5 GHz. See typical curve above.

	Catalog Number	Price in USA
Constant-Impedance Adjustable Line		
874-LK10L, 10 cm	0874-9627	55.00
874-LK20L, 20 cm	0874-9631	60.00

TROMBONE CONSTANT-IMPEDANCE — 874-LTL

With this line stretcher, built like a trombone slide, the user can vary the length of a 50-ohm transmission line between two fixed terminals without moving the terminals or using flexible cables. Consists of two 874-LK20L Adjustable Lines joined at one end by a U-shaped section to form a rigid assembly. Can be plugged into two adjacent GR874 coaxial connectors or inserted in a line by means of two ells (not included) when installed vertically to save bench space. Low VSWR. An excellent phase shifter, and variable time delay.

Characteristic Impedance: 50 Ω.

Frequency Range: Dc to 2 GHz (874-LK10L is recommended above 2 GHz).

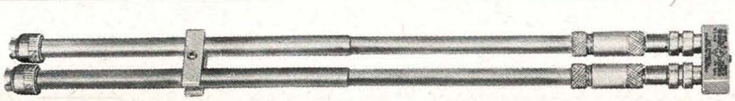
Adjustment Range: 44 cm (half wave at 340 MHz).

Physical Length: 61 to 83 cm.

Spacing: 1$\frac{3}{16}$ inches between centers.

VSWR: <1.10 to 1 GHz, and <1.25 to 2 GHz.

Net Weight: 2¼ lb (1.1 kg).



	Catalog Number	Price in USA
874-LTL Trombone Constant-Impedance Adjustable Line	0874-9645	140.00

File Courtesy of GRWiki.org

coaxial

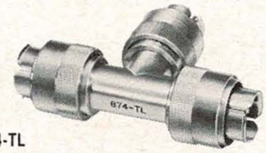
GR874 COUPLING ELEMENTS — 3-PORT

TEE — 874-T

For connecting stubs and other elements in shunt with a coaxial line. Available with regular or locking connectors.

Dimensions: 3⅜ x 2¼ in. (86 x 58 mm).

Net Weight: 874-T, 4 oz (115 g); 874-TL, 5 oz (145 g).



874-TL

	Catalog Number	Price in USA
874-T Tee	0874-9910	$15.00
874-TL Tee, locking	0874-9911	18.75

MIXER — 874-MRAL

A broadband mixer of improved design for use in general applications and, with the GR 1236 I-F Amplifier, as a heterodyne detector. It offers a wider frequency range, increased sensitivity, lower VSWR, low-leakage locking connectors, and reduced local-oscillator power required.

Frequency Range: 10 MHz to 9 GHz.

Max I-F: 60 MHz.

Local Oscillator Power: Typically less than 6 mW required for 0.2-mA rectified current (signal and L.O. source impedances = 50 Ω).

Output Impedance: 400 Ω average, paralleled by 7 pF.

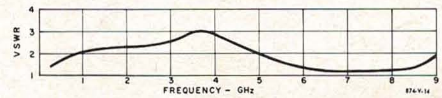
Diode: 1N23C.

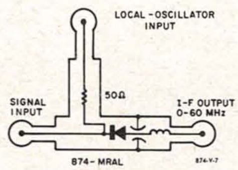
Sensitivity: Typically < 6-μV input behind 50 Ω will increase output of i-f amplifier (30-MHz i-f, 0.5-MHz bandwidth, 2-dB noise figure) by 3 dB, for mixer current of 0.5 mA.

Dimensions: 4⅝ x 2½ in. (120 x 64 mm).

Net Weight: 8 oz (230 g).

Typical VSWR: (mixer current = 0.5 mA).





new

	Catalog Number	Price in USA
874-MRAL Mixer	0874-9947	65.00

MIXER RECTIFIER — 874-MR

A broadband rf mixer for use with the 1216-A Unit I-F Amplifier as a heterodyne detector.

Frequency Range: 40 MHz to 5 GHz; at lower and higher frequencies with less sensitivity.

Max I-F: 30 MHz.

Max Input from Local Oscillator: 2 V.

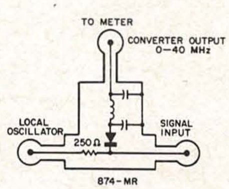
Sensitivity: Typically <5 μV for discernible deflection on meter of 1216-A Unit I-F Amplifier. (Equivalent to about 10 μV behind 50 Ω to increase 1216-A output by 3 dB).

Output Impedance: Approx 400 Ω.

Diode: 1N21B.

Dimensions: 3¾ x 3½ in. (96 x 89 mm).

Net Weight: 874-MR, 7 oz (200 g); 874-MRL, 8 oz. (230 g).



874-MRL

	Catalog Number	Price in USA
874-MR Mixer Rectifier	0874-9944	40.00
874-MRL Mixer Rectifier, locking	0874-9945	42.50

VOLTMETER RECTIFIER — 874-VR

The 874-VR is used to monitor the voltage in a coaxial system. Similar to the 874-VQ, the 874-VR has a 50-ohm resistor in series with the output-port center conductor. In combination with a signal source and properly calibrated indicator it can simulate a 50-ohm generator with known open-circuit voltage. It is used in this manner with the GR 1263-C in an oscillator amplitude-regulating system.

Frequency Range (as Calibrated Voltmeter): 15 MHz to 2.5 GHz.

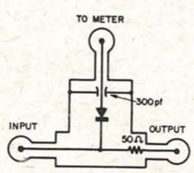
Max Voltage: 2 V.

Bypass Capacitance: Approx 300 pF.

Diode: 1N23B.

Dimensions: 3¾ x 2½ in. (96 x 64 mm).

Net Weight: 874-VR, 5 oz (145 g); 874-VRL, 6 oz (170 g).



Type 874-VRL

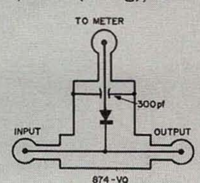
	Catalog Number	Price in USA
874-VR Voltmeter Rectifier	0874-9942	35.00
874-VRL Voltmeter Rectifier, locking	0874-9943	37.50

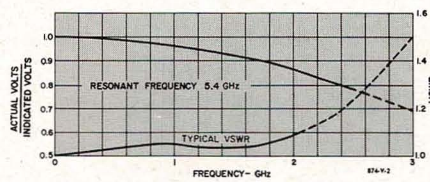
File Courtesy of GRWiki.org

VOLTMETER DETECTOR — 874-VQ

For use as a general purpose detector of rf level using a dc indicator or of modulated signals using a sensitive amplifier. It can be inserted into a 50-ohm line, introducing no appreciable discontinuity, or, with a GR874 50-ohm termination, used as a matched detector to terminate a line.

Frequency Range (as Matched Detector): 0.5 MHz to 2 GHz. Usable from 60 Hz to 7 GHz.
Max Voltage: 2 V.
VSWR: <1.1 at 1 GHz; <1.2 at 2 GHz.
Bypass Capacitance: Approx 300 pF.
Diode: 1N23B.
Dimensions: 3¾ x 2½ in. (96 x 64 mm).
Net Weight: 874-VQ, 5 oz (145 g); 874-VQL, 6 oz (170 g).





Typical VSWR for 874-VQ and correction factor for 874-VQ and 874-VR.

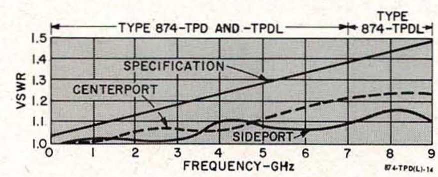
874-VQL

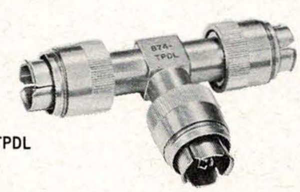
	Catalog Number	Price in USA
874-VQ Voltmeter Detector	0874-9940	**$30.00**
874-VQL Voltmeter Detector, locking	0874-9941	**32.50**

POWER DIVIDER — 874-TPD

A coaxial tee with a 16.67-ohm resistor in each leg, connected so that the tee is matched at any port when the other two ports are terminated in 50-ohm loads. The match holds throughout the wide frequency range. The use of stable deposited-carbon-film resistors and the linear VSWR-frequency relationship makes the power divider particularly valuable for pulse work.

Frequency Range: 874-TPD, dc to 7 GHz; 874-TPDL, dc to 9 GHz.
VSWR: ≲1.03 + 0.05 f_{GHz} (see curve).
Insertion Loss: Input to each output, 6 dB (+2, −0.5 dB).
Equality of Power Division: 0.3 dB (symmetrically fed).
Phase Difference Between Outputs: 0°.
Max Input Power: 2 W continuous.
Dimensions: 4 x 2⅜ in. (105 x 61 mm).
Net Weight: 6 oz (170 g).





874-TPDL

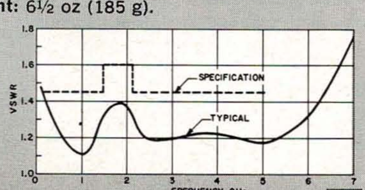
	Catalog Number	Price in USA
874-TPD Power Divider	0874-9912	**70.00**
874-TPDL Power Divider, locking	0874-9913	**73.75**

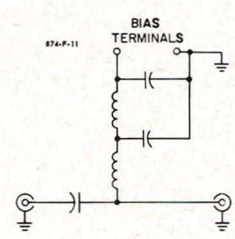
BIAS INSERTION UNIT — 874-FBL

Used with slotted lines, the GR 1602-B Admittance Meter, and 1609 UHF Admittance Bridge for immittance and similar measurements where bias is to be applied to diodes, transistors, and other solid-state devices. It comprises a blocking capacitor in series with the line, an isolating choke, and a low-pass filter.

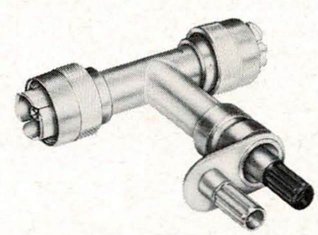
In slotted-line measurements, it is inserted at the source end of the line and therefore introduces no reflections at the measurement terminals.

Dc Current: 2.5 A, max.
Dc Voltage: 400 V, max.
VSWR: See curves.
Insertion Loss: Typically, <1.7 dB from 300 MHz to 3 GHz, <0.8 dB from 3 GHz to 5 GHz.
Dimensions: 4⅜ x 3⅞ in. (115 x 99 mm).
Net Weight: 6½ oz (185 g).





Schematic Diagram of 874-FBL



	Catalog Number	Price in USA
874-FBL Bias Insertion Unit	0874-9759	**75.00**

File Courtesy of GRWiki.org

GR874 COAXIAL ELEMENTS — 2-PORT

COUPLING CAPACITOR (Dc block) — 874-K

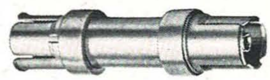
A short length of coaxial line having a disk capacitor in series with the inner conductor. High frequencies are transmitted with small reflections, but dc and low audio frequencies are blocked. Available with regular or locking connectors.

Coupling Capacitance: 4700 pF, −20%, +50%.

VSWR: <1.06 at 1 GHz; <1.15 at 2 GHz; <1.3 from 2 to 4 GHz.

Voltage Rating: 500 V.

Length: 3 in. (77 mm).



	Catalog Number	Price in USA
874-K Coupling Capacitor	0874-9596	**$11.00**
874-KL Coupling Capacitor, locking	0874-9597	**13.50**

90° ELL — 874-EL

Convenient right-angle line section with GR874 coaxial connector at each end. Available with regular or locking connectors.

Characteristic Impedance: 50 Ω.

Electrical Length: Approx 7 cm.

VSWR: <1.06 at 2 GHz; <1.15 at 4 GHz.

Dimensions: 2¼ in. (57 mm) on a side.

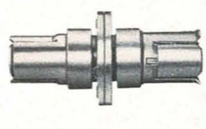
	Catalog Number	Price in USA
874-EL 90° Ell	0874-9526	**12.00**
874-EL-L 90° Ell, locking	0874-9527	**14.50**

ROTARY JOINT — 874-JR

Used when one part of a coaxial system must be rotated with respect to another part. Not for motor-driven applications.

VSWR: <1.06 at 1 GHz; <1.3 at 4 GHz.

Length: 2½ in. (64 mm).



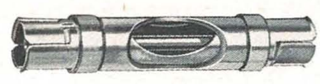
	Catalog Number	Price in USA
874-JR Rotary Joint	0874-9590	**17.00**

RADIATING LINE — 874-LR

Leakage coupler for fields within a coaxial system. Short coaxial line with opening in outer conductor that can be partly or completely covered by a rotatable sleeve.

VSWR: Closed, <1.10 at 1 GHz, <1.4 at 3 GHz, and <1.35 at 4 GHz.

Length: 4⅜ in. (112 mm).



	Catalog Number	Price in USA
874-LR Radiating Line	0874-9660	**15.00**

COUPLING PROBE — 874-MB

Electrostatic probe consisting of a binding post mounted on a GR874 coaxial connector.

Length: 3 in. (77 mm).

	Catalog Number	Price in USA
874-MB Coupling Probe	0874-9666	**6.00**

INSERTION UNIT — 874-X

Small components, pads, vhf transformers, filters, or other networks mounted within the 2-inch long, 5/16-inch diameter space in the 874-X can be conveniently inserted into a 50-ohm coaxial system with minimum leakage and discontinuity.

Length: 4⅜ in. (115 mm).

	Catalog Number	Price in USA
874-X Insertion Unit	0874-9990	**16.00**

SERIES INDUCTOR — 874-XL

Used as a general-purpose tuning element in resonant-line circuits, matching transformers, and baluns at low frequencies.

Series Inductance: 0.226 μH ±5% at 1 kHz.

Net Weight: 3½ oz (98 g).

	Catalog Number	Price in USA
874-XL Series Inductor	0874-9998	**21.00**

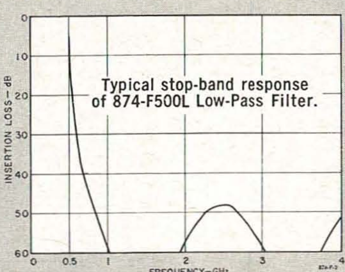
File Courtesy of GRWiki.org

GR874 COUPLING ELEMENTS — 2-PORT

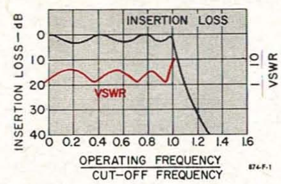
		Catalog Number	Price in USA

LOW-PASS FILTERS — 874-F

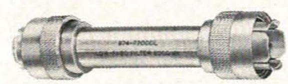
Recommended for use in immittance- or voltage-measuring systems to reduce harmonics, and especially in systems containing nonlinear elements or sections that might resonate at a harmonic. Also useful in slotted-line measurements. Filters are Tschebyscheff type, which produce a very steep cutoff characteristic at the expense of pass-band flatness. Spurious responses in the stopband are very small. All filters are equipped with locking GR874 connectors.



Typical insertion loss and VSWR, Type 874-F Filters.



874-F2000L



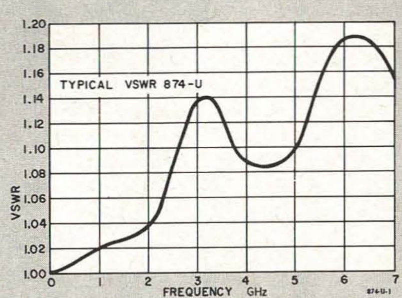
	Length	Catalog Number	Price in USA
874-F185L 185-MHz Low-Pass Filter	17⅝ in.	0874-9533	**$40.00**
874-F500L 500-MHz Low-Pass Filter	10¾ in.	0874-9537	**26.00**
874-F1000L 1-GHz Low-Pass Filter	7⅛ in.	0874-9541	**24.00**
874-F2000L 2-GHz Low-Pass Filter	4⅜ in.	0874-9545	**24.00**
874-F4000L 4-GHz Low-Pass Filter	2⅞ in.	0874-9549	**24.00**

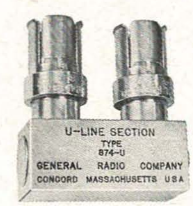
U-LINE SECTION — 874-U

A coaxial line section in the shape of a U, with GR874 connectors. Supplied as an accessory with the 1607-A Transfer-Function and Immittance Bridge, but useful in many other coaxial setups as well.

Dimensions: 2¼ x 2 x ⅞ in. (58 x 51 x 23 mm).

Weight: 7½ oz (215 g).





	Catalog Number	Price in USA
874-U U-Line Section	0874-9528	**25.00**

COMPONENT MOUNT — 874-ML

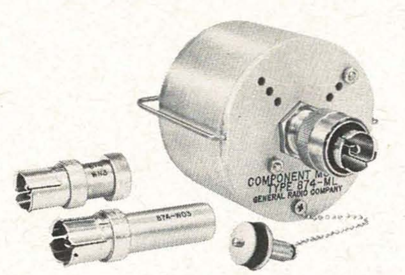
A shielded enclosure for convenient mounting of small components being measured. Use of mount minimizes stray capacitance in impedance measurements of circuit elements and networks from dc to 5 GHz. Locking GR874 coaxial connector.

Accessories Supplied: One 874-WN3 Short-Circuit Termination, one 874-WO3 Open-Circuit Termination.

Accessory Recommended: One 874-LK20L Constant-Impedance Adjustable Line for use with 1602-B UHF Admittance Meter.

Dimensions: Diameter 3 in. (77 mm); height of shield can 2⅝ in. (67 mm).

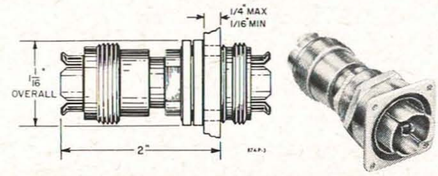
Net Weight: 10½ oz (295 g).



	Catalog Number	Price in USA
874-ML Component Mount	0874-9663	**40.00**

PANEL CONNECTOR — LOCKING FEEDTHROUGH

Mates any pair of GR874 connectors directly through a panel or wall. Can be mounted as recessed or nonrecessed panel locking connector. Can be mounted through bulkheads 2 in. or more thick.



	Catalog Number	Price in USA
874-PFL Panel Feedthrough Connector, locking	0874-9451	**10.00**

File Courtesy of GRWiki.org

GR874 COAXIAL CABLE AND PATCH CORDS

(See also page 268)

COAXIAL CABLE — 874-A2

This is a flexible, double-shielded, low-loss coaxial cable, consisting of No. 14 stranded inner conductor separated from the two tinned-copper braids by 0.244-inch-OD polyethylene dielectric and a 0.375-inch-OD, gray, noncontaminating polyvinyl-chloride jacket.

Characteristic Impedance: 50 Ω ±5%.

Capacitance: 32 pF/ft, max.

Attenuation: Approx 2.6 dB/100 ft at 100 MHz; 10.5 dB/100 ft at 1 GHz.

Propagation Velocity Factor: 66%.

Net Weight: 2¾ lb (1.3 kg) per 25 ft.

Use GR875 connectors: Types 874-CA, -CLA, -PBA, -PLA, -PRLA, and -PBRLA.

	Catalog Number	Price in USA
874-A2 Coaxial Cable	0874-9500	**$0.60/ft (0.40/ft in lengths of >25 ft)**

COAXIAL CABLE — 874-A3

This cable is more flexible than the 874-A2 but with somewhat higher losses; the same as RG-58A/U but with double-braid shielding. The inner conductor is 19 strands of 0.0071-inch tinned soft-copper wire, separated from the double braid by 0.116-inch-OD polyethylene dielectric. The jacket is 0.206-inch-OD, black, noncontaminating polyvinyl chloride. This cable is recommended for most general-purpose applications.

Use GR874 connectors: Types 874-C58A, -CL58A, -PB58A, -PL58A, -PRL58A, and -PBRL58A.

Characteristic Impedance: 50 Ω ±5%.

Nominal Capacitance: 29 pF/ft.

Attenuation: Approx 5.3 dB/100 ft at 100 MHz; 22 dB/100 ft at 1 GHz.; 45 dB/100 ft at 3 GHz.

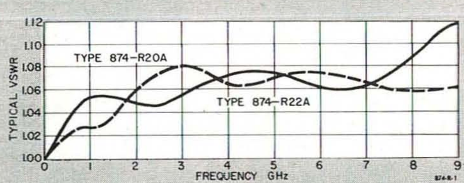
Propagation Velocity Factor: 66%.

Net Weight: 1 lb (0.5 kg) per 25 ft.

	Catalog Number	Price in USA
874-A3 Coaxial Cable	0874-9501	**$0.35/ft (0.20/ft in lengths of >25 ft)**

PATCH CORDS

These three-foot coaxial patch cords meet the need for flexible connections in the measurements laboratory. The 874-R20A and -R22A Patch Cords have very low VSWR characteristics (see curves) and are available with either locking or nonlocking GR874 connectors. Frequency range to 9 GHz.



The 874-R33 Patch Cord terminates in a pair of banana plugs, one connected to the center conductor and the other to the braid through a 5-inch pigtail. These plugs mate directly with GR 274 and 938 Jacks and 938 Binding Posts. The 874-R34 Patch Cord terminates in a 274-NK Shielded Double Plug.

874-R33

874-R20A

874-R34

874-R22LA

Other patch cords and cables on pages 266 through 268.

Patch Cord Type	Cable Type	Catalog Number	Price in USA
874-R20A	**874-A2**	0874-9680	**$13.50**
874-R20LA locking	**874-A2**	0874-9681	**16.00**
874-R22A	**874-A3**	0874-9682	**12.00**
874-R22LA locking	**874-A3**	0874-9683	**14.50**
874-R33	**low C, 72 Ω coaxial**	0874-9690	**8.00**
874-R34	**RG-58C/U**	0874-9692	**8.00**

File Courtesy of GRWiki.org

GR874 TUNING ELEMENTS

VARIABLE CAPACITOR — 874-VCL

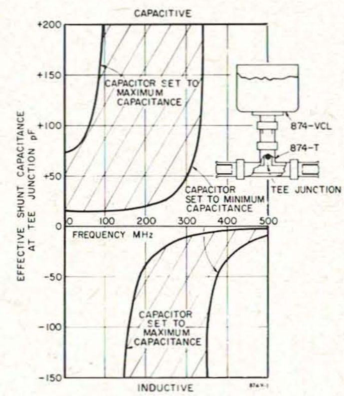
Tuning element for resonant-line circuits, matching transformers, and baluns at low frequencies where line-type elements are awkward to use. Well shielded, high-temperature polystyrene insulation, precision ball bearings, locking connector.

Scale: 0 to 100.

Capacitance Range: Low frequencies, 14 to 70 pF at connector, 16.5 to 72.5 at junction of 874-T Tee. Linear capacitance variation.

Dimensions: 2½ in. dia, 5¼ in. height, (64 x 135 mm).

Net Weight: 12½ oz (350 g).



	Catalog Number	Price in USA
874-VCL Variable Capacitor	0874-9931	**$85.00**

ADJUSTABLE STUBS — 874-D20L and -D50L

For matching or tuning, for use as adjustable short-circuit terminations, and as reactive elements. With an external indicator, the stub can function as a reaction-type wavemeter. Consists of a coaxial line with a sliding short circuit of the multiple-spring-finger type. The 20-centimeter stub is calibrated in electrical distance from junction in 874-T Tee. The 50-centimeter stub is not calibrated but has an adjustable reference marker. Each is equipped with a locking connector.

Characteristic Impedance: 50 Ω.

Max Travel: 874-D20L, 20 cm; 874-D50L, 50 cm.

Physical Length: 874-D20L, 28 to 48 cm; 874-D50L, 58 to 109 cm.

Net Weight: 874-D20L, 7 oz (196 g); 874-D50L, 13 oz (364 g).

Adjustable Stub	Catalog Number	Price in USA
874-D20L, 20-cm	0874-9511	**23.50**
874-D50L, 50-cm	0874-9513	**28.00**

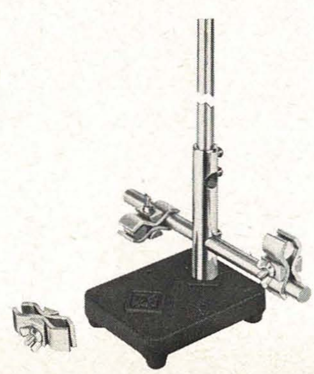
GR874 MISCELLANEOUS

Type 874-Z STAND

A solid, stable support for components of coaxial systems. Consists of a heavy cast-iron base with rubber feet, 22-inch and 8-inch stainless-steel rods, and three universal clamps. The vertical rod can be used to hold long tuning stubs. The horizontal rod can be moved longitudinally or can be interchanged with the vertical rod. One 22-inch rod can be clamped to two bases to support a long horizontal run of coaxial parts. Clamps fit a range of diameters. Base can be bolted to bench top.

Dimensions: Base, 3½ x 4$\frac{7}{16}$ in. (89 x 115 mm); rod lengths, 22 and 8 in. (560 and 205 mm).

Net Weight: 5½ lb (2.5 kg).



	Catalog Number	Price in USA
874-Z Stand	0874-9996	**25.00**
874-ZC Extra Clamp	0874-9997	**2.25**

File Courtesy of GRWiki.org

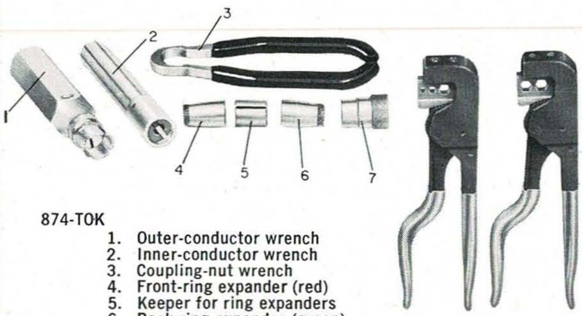
	Catalog Number	Price in USA

TOOLS

Several special tools are available to facilitate assembly of GR874 connectors — these tools ensure quick assembly, neat, uniform appearance, and best electrical and mechanical performance.

The 874-TOK Tool Kit consists of an inner-conductor wrench to install both the insulating bead and the inner conductor and an outer-conductor wrench to install the outer conductor and to tighten the coupling nut. The other pieces aid in installation of the retaining ring.

When a GR874 connector is installed on cable, the ferrule must be crimped to secure the cable to the connector. Pliers can be used to crimp the ferrule, but, for the neatest crimp in the shortest time, use of a 874-TO58 or -TO8 Crimping Tool is recommended.



874-TOK
1. Outer-conductor wrench
2. Inner-conductor wrench
3. Coupling-nut wrench
4. Front-ring expander (red)
5. Keeper for ring expanders
6. Back-ring expander (green)
7. Ring pusher

874-TO8 874-TO58

	Use on following GR874 cable connectors	Catalog Number	Price in USA
874-TOK Tool Kit	all	0874-9902	**$30.00**
874-TO8 Crimping Tool	874-( )8A family	0874-9900	**110.00**
874-TO58 Crimping Tool	all others	0874-9901	**110.00**

Type 874-VI VOLTMETER INDICATOR

Measures dc output of either 874-VQ or 874-VR at any level between 0.1 and 2 volts. A built-in 60-Hz calibration system eliminates errors arising from differences in crystal rectification efficiencies.

Input Resistance: 600 Ω min, 10,000 Ω max.

Range and Accuracy of Calibrating Voltage: 0.1 to 2 V, ±0.05 V.

Crystal Current for Full-Scale Indication: 200 μA.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz.

	Catalog Number	Price in USA
874-VI Voltmeter Indicator	0874-9936	**120.00**

GR874 INNER-CONDUCTOR ROD*

For use in constructing 14-mm, 50-ohm rigid coaxial air lines and elements to meet special needs. Ends are machined to accept GR874 connectors.

Material: High-conductivity silver-plated brass.

Length: 15⅞ in. **Diameter:** 0.24425 ±0.00025 in.
Both ends have tapped hole to accept 874-BBL or 874-B connector.

	Catalog Number	Price in USA
Inner-Conductor Rod	0874-9508	**4.00**

GR874 OUTER-CONDUCTOR TUBE*

For use in constructing 14-mm, 50-ohm rigid coaxial air lines and elements to meet special needs. Ends are machined to accept GR874 connectors.

Material: Brass, bright-alloy plated.

Length: 15⅞ in. **Diameter:** O.D., 0.624 +0.000, −0.002 in.; I.D., 0.5625 ±0.0010 in.
Both ends grooved and slotted to accept 874-BBL or 874-B connector.

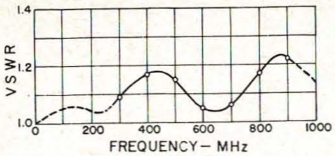
* Characteristic impedance of GR874 Tube and Rod is 50 Ω ±0.375% (±0.1875 Ω).

	Catalog Number	Price in USA
Outer-Conductor Tube	0874-9509	**4.00**

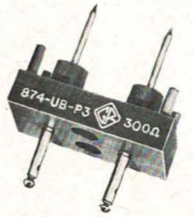
File Courtesy of GRWiki.org

BALUN

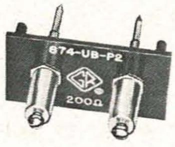
Type 874-UBL



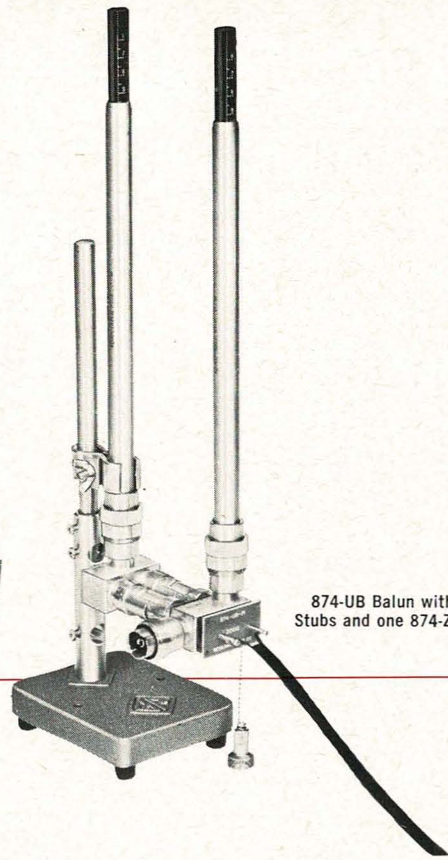
Typical VSWR of 874-UB-P2.



874-UB-P3



874-UB-P2



874-UB Balun with two Stubs and one 874-Z Stand.

The 874-UBL Balun is a tuned coaxial 4:1 transformer that matches 50-ohm coaxial line to 200-ohm balanced line and thus extends the usefulness of generally available coaxial instruments to balanced devices. Used with the slotted line, admittance meter, or transfer-function and immittance bridge, the balun permits measurements on balanced components over a frequency range from 54 MHz to 1 GHz without appreciable insertion loss or transformation error.

Tuning elements required for various frequency ranges are listed below. These elements are not supplied with the balun but must be purchased separately.

specifications

Frequency Range: 54 MHz to 1 GHz with accessory tuning elements as listed below.

Frequency Range MHz	Tuning Elements Required
54-88	2 Type 874-VCL and 2 Type 874-XL
88-140	2 Type 874-VCL and 2 Type 874-L30
140-174	2 Type 874-VCL and 2 Type 874-L20
174-216	2 Type 874-VCL and 2 Type 874-L10
170-280	2 Type 874-D50L and 2 Type 874-L30
225-280	2 Type 874-D20L and 2 Type 874-L30
275-380	2 Type 874-D20L and 2 Type 874-L20
350-525	2 Type 874-D20L and 2 Type 874-L10
470-1000	2 Type 874-D20L

Accessories Supplied: One 874-UB-P1 300-ohm Terminal, one 874-WN3 Short-Circuit Termination, and one 874-WO3 Open-Circuit Termination.

Accessories Recommended: 874-LK20L Adjustable Line (for use with 1602-B UHF Admittance Meter) one 874-Z Stand, and tuning elements listed below.

Dimensions: 3⅛ x 3⅜ x 2⅜ in. (79 x 81 x 60 mm).

Net Weight: 1¼ lb (0.6 kg).

Catalog Number	Description	Price in USA
0874-9921	**874-UBL Balun**	**$140.00**

BALUN ACCESSORIES

874-UB-P2 200-OHM TERMINAL UNIT

Connects the balun directly to 200-ohm transmission line or to balanced components via screw terminals.

Characteristic Impedance: 200 Ω.

Frequency Range: Dc to 1 GHz.

Recommended Transmission Line: RG-86/U.

VSWR: 1.2 to 300 MHz, 1.3 to 1 GHz.

Dimensions: 1 x 1¾ x 1⅞ in. (25 x 44 x 48 mm).

Net Weight: 1 oz (28 g).

874-UB-P3 300-OHM TERMINAL PAD

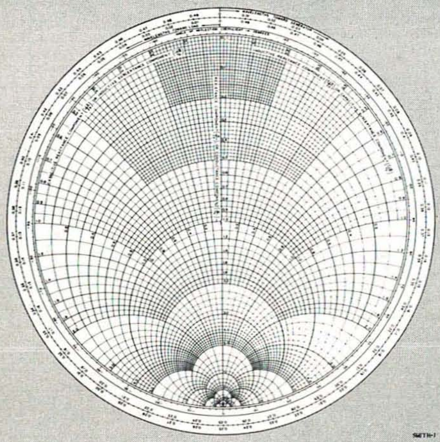
Converts the 200-ohm balanced output impedance produced by the balun to 300 ohms. Facilitates power and voltage measurements on balanced 300-ohm systems with signal generators and detectors designed for use with 50-ohm coaxial circuits.

Catalog Number	Description	Price in USA
0874-9923	**874-UB-P2 200-ohm Terminal Unit**	**12.00**
0874-9924	**874-UB-P3 300-ohm Terminal Pad**	**30.00**

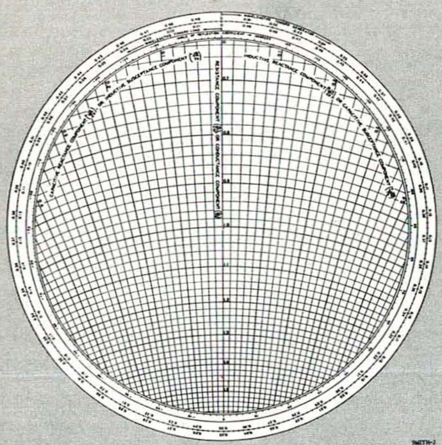
File Courtesy of GRWiki.org

SMITH CHARTS

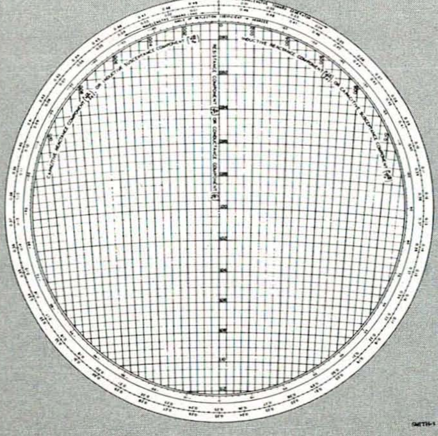
The Smith Chart facilitates measurements made with slotted lines. It can be used to determine the impedance corresponding to any VSWR and to convert from impedance to admittance, and vice versa. Five forms of Smith Chart are available. Those with normalized coordinates are for use with lines of any impedance. The 50-ohm characteristic impedance (20-millimho characteristic admittance) is common to all General Radio coaxial equipment. Type NX charts are 22½ x 35 in., all others are 8½ x 11 in.



Description	Catalog Number	Price in USA	
Type NX Smith Chart (wall size), normalized coordinates (about 75 charts per pad)	5301-7563	pads	per pad
		1	**$6.00**
		2-3	**5.75**
		4-9	**5.50**
		10-19	**5.00**
		20 & over	**4.75**
Type N Smith Chart normalized coordinates	5301-7560		
Type Y Smith Chart 20-millimho admittance coordinates	5301-7568		
Type Z Smith Chart 50-ohm impedance coordinates	5301-7569		

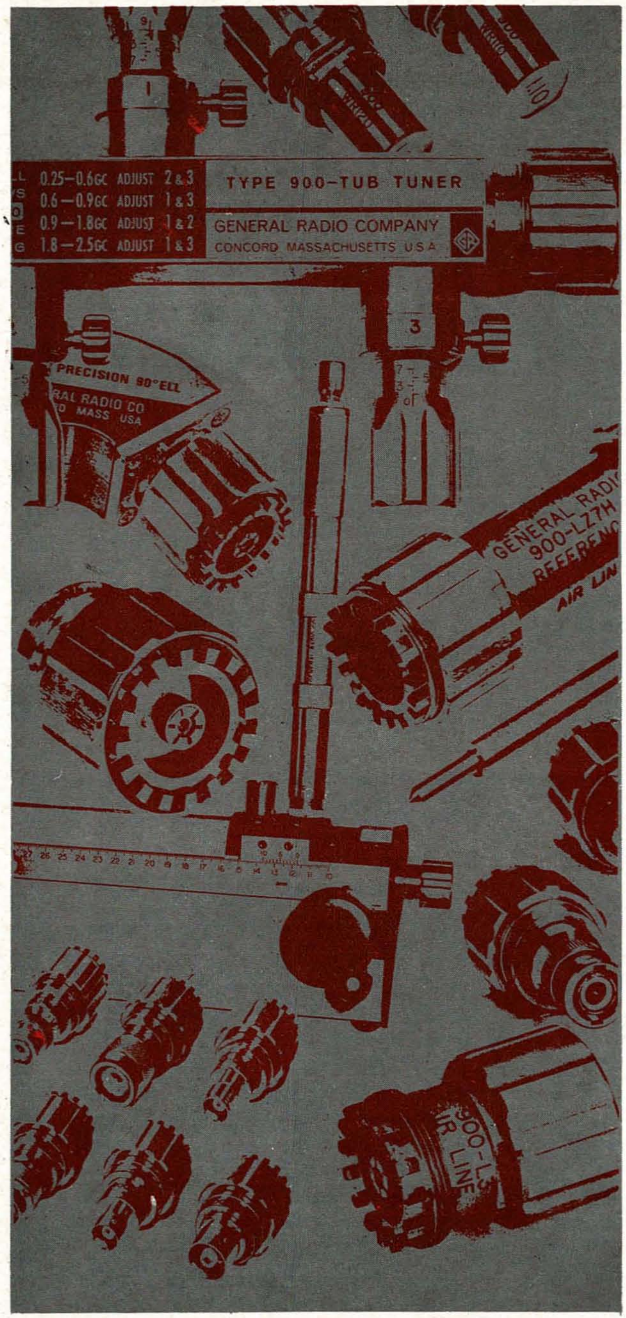


Description	Catalog Number	Price in USA	
		supplied in units of 50 charts	
		units	per unit
		1	**$2.00**
		2-3	**1.90**
Type NE Smith Chart normalized, expanded coordinates	5301-7561	4-9	**1.75**
		10-19	**1.40**
(for use when VSWR ≤1.58)		20 & over	**1.25**



Description	Catalog Number
Type HE Smith Chart normalized, highly expanded coordinates (for use when VSWR ≤1.12)	5301-7562

File Courtesy of GRWiki.org



GR900®

INSTRUMENTS AND ELEMENTS

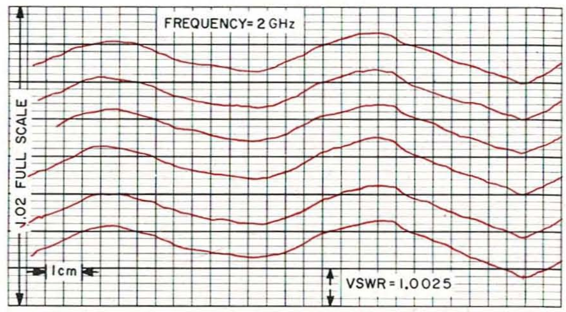
File Courtesy of GRWiki.org

GR900® PRECISION COAXIAL COMPONENTS AND STANDARDS 14 mm — 50 ohms

For many years the coaxial connector had been the limiting factor in the design of highly accurate measuring equipment. Not only was it impossible to design such equipment without a precision connector, it was not even worth trying, since any improvements would be obscured by the connector deficiencies. It was obvious that the first step in the development of a line of ultra-precise coaxial instruments had to be the development of a precision connector. General Radio, using its long experience in coaxial-connector development, thus designed the first commercial coaxial connector that could honestly be called "precision" — the GR900® connector.

The design objective was a connector far better electrically than any existing type and one that could be sold at a reasonable price. The design tolerance on characteristic impedance was set at ±0.1%. Extensive production engineering was required to find economical methods of manufacturing to such a close tolerance.

The successful completion of the GR900 connector development signaled the initiation of an entire line of precision coaxial components and instruments. The GR900 line, which includes a precision slotted line and recording system, uhf immittance bridge, air-line sections, adaptors, standard terminations, and tuners, is well on its way to becoming the standard of precision in the microwave industry.



Repeatability run showing typical consistency of performance as Type 900-BT Precision Coaxial Connector is rotated to six different orientations. Multiple plot was produced at 2 GHz by Type 1640-A Slotted Line Recorder System.

Electrical Characteristics

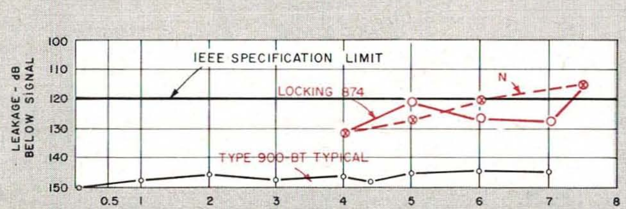
VSWR

Probably the most important single characteristic of a precision connector is its VSWR, that is, the extent to which it introduces reflections into an otherwise matched transmission line. The VSWR test specification of $1.001 + 0.001f_{GHz}$ applies both to single 900-BT Connectors and to those supplied in pairs with a calibration certificate.

Repeatability

Of vital importance to many precision measurements is the consistency of performance of the connector as the connection is broken and remade. The VSWR repeatability of a pair of GR900 connectors is typically within 0.03%. In an attenuation measurement, for example, this would result in an insertion-loss repeatability of ±0.002 dB, typically.

Further, extremely close tolerances on repeatability of phase (within 0.008° at 1 GHz) gives added assurance of small connector error in precision coaxial measurements.



Typical leakage curve of mated pair of Type 900-BT Precision Coaxial Connectors compared with other popular types.

Leakage

Leakage of the GR900 connector (see graph) is better than 130 dB below signal level — lower than that of any other commonly used coaxial connector. This is due to the triple shielding action of the butt contact of the outer conductors, the interlocking and overlapping of the centering gear rings and the outer locking nut, and the precise machining of the mating surfaces.

Insertion Loss

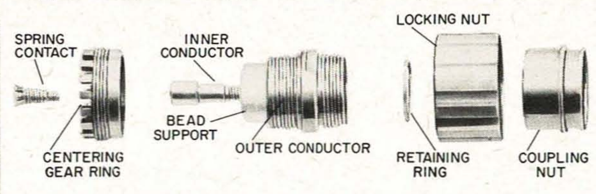
The insertion loss, or attenuation, of the GR900 connector is extremely small. It has been minimized by the use of Teflon* for the bead, by the use of solid silver alloys for both inner and outer conductors, and, in particular, by the unique design of the contact.

Electrical Length

The electrical length of a pair of Type 900-BT Connectors is 3.50 cm and is virtually independent of frequency. The dc resistance of a mated pair is typically 0.4 milliohm

* Registered trademark of the E. I. du Pont de Nemours and Company.

File Courtesy of GRWiki.org



Exploded view of Type 900-BT Precision Coaxial Connector.

for the inner conductors, 0.04 milliohm for the outer conductors.

The standard GR900 connector (Type 900-BT) meets all the specifications contained in Part III, Section 1 of the IEEE Recommended Practice for Precision Coaxial Connectors. The Type 900-BT Connector is also available in pairs with calibration certificate, which verifies that combined VSWR of the **two** connectors is within the limits specified in the IEEE document.

Other Members of the GR900® Family

One of the most important advantages of the GR900 connector over other precision types is the broad and rapidly expanding line of instruments and components equipped with it. Moreover, the availability of GR900 cable connectors and of kits for fabricating GR900 panel and component connectors and air-line sections brings GR900 precision to every corner of the laboratory.

Mechanical Features

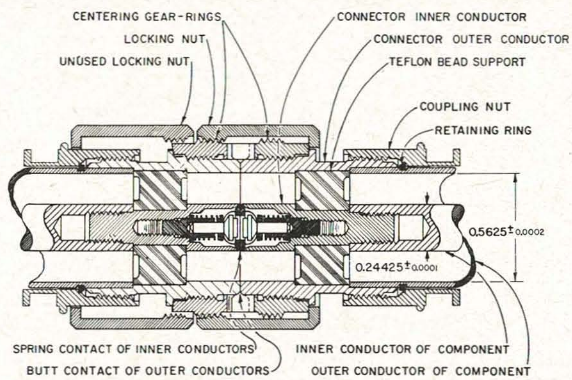
The basic GR900 connector (Type 900-BT) is designed for use on rigid, air-dielectric, 50-ohm, 14-mm (9/16-inch) coaxial transmission line (principal dimensions: 0.5625 inch and 0.24425 inch). The eight parts of the connector are shown in the accompanying exploded view. The spring contact and inner conductor are of gold-plated solid silver alloy, the bead support Teflon, the centering gear ring stainless steel, the outer conductor gold-plated coin silver, the retaining ring phospor-bronze, and the coupling and locking nuts chrome-plated brass.

When the parts are assembled onto an air line, the coupling nut and retaining ring attach the outer conductor of the connector to the outer conductor of the line (see cross-section drawing). The inner conductor is threaded into the center conductor of the air line and is supported by the Teflon bead.

When two GR900 connectors are mated, the centering gear rings interlock and overlap to center the connectors with respect to each other. This also prevents the connectors from rotating against each other with possible impairment of repeatability and reliability. The front surfaces of the outer conductors butt firmly together under the pressure of the locking nut. Only one of the locking nuts is used in a connection; the other is backed off to a storage position.

The front surfaces of the inner conductors are recessed 0.001 inch with respect to the surfaces of the outer conductors to ensure outer-conductor contact. Inner-conductor contact is made by a spring-contact assembly, which projects slightly beyond the surface of the outer conductors until the connector is mated. The spring-contact assembly consists of six independently sprung segments, which are forced back and spread upon mating, thereby making a wiping contact both with the other spring contact and with the inside of the inner conductor. This method avoids the reflections caused by slots in the inner and outer conductors and eliminates changes in the electrical diameter due to wear. Only one spring contact is necessary for a good electrical connection; the spring contact will mate with any flat surface.

When two connectors are mated, the outer conductors meet in the midpoint of the connection, and this point becomes the electrical reference plane. The over-all diameter of the mated pair is 1-1/16 inches.



Cross-section view of mated Type 900-BT Precision Coaxial Connectors.

Index to GR900® Coaxial Elements

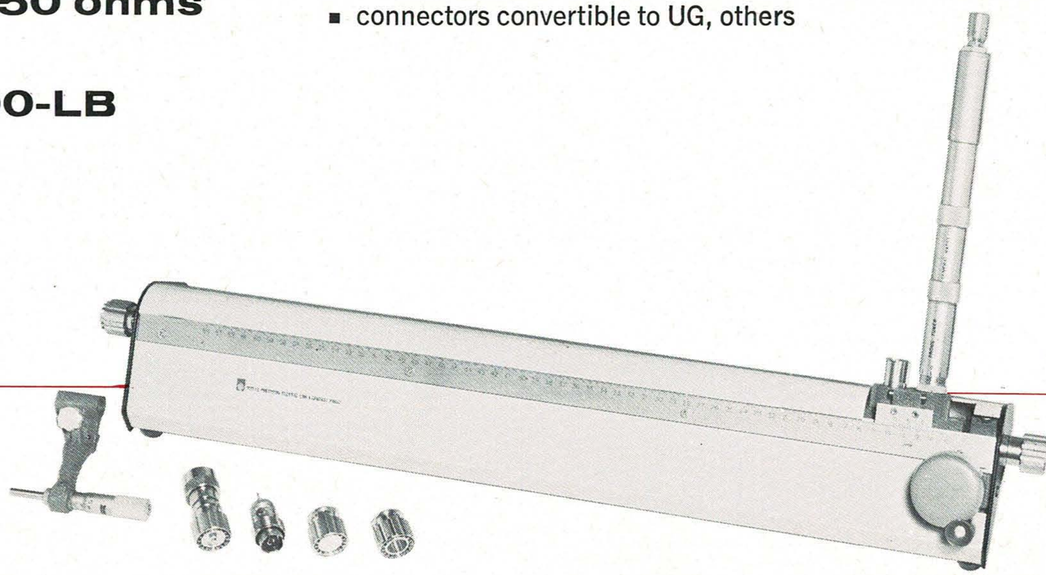
File Courtesy of GRWiki.org

coaxial

PRECISION SLOTTED LINE 14 mm–50 ohms

Type 900-LB

- 300 MHz to 8.5 GHz
- VSWR: <1.002 at 1 GHz, <1.01 at 8.5 GHz
- 50 ohms ±0.1% impedance
- connectors convertible to UG, others



The most precise coaxial connector, the GR900, and a nearly perfect section of coaxial transmission line combine to give the 900-LB Precision Slotted Line unparalleled performance specifications. The residual VSWR of the instrument is that of its GR900® connector: 1.001 + 0.001 f_{GHz}. For those whose applications demand the ultimate in accuracy, the 900-LB can be calibrated against a 900-LZ Reference Air Line, an impedance standard with a VSWR under 1.0025 at 9 GHz.

In the field of microwave impedance measurement, the slotted line is **the** fundamental instrument, because of its inherent accuracy, broadband characteristics, and phase-measuring capabilities. Among the many transmission-line parameters that can be determined with the slotted line are VSWR, reflection-coefficient magnitude and phase, attenuation or insertion loss, and wavelength. The admittance or impedance of source or termination can be measured and so also can transistor and diode characteristics and dielectric constant. It gives the design engineer all the information he needs to evaluate the over-all performance of devices and networks over a wide band.

The outstandingly low VSWR of the 900-LB should save users the many hours required to calibrate less accurate instruments.

Equipped with the appropriate GR900 low-VSWR adaptor, the 900-LB becomes a type N, BNC, TNC, etc slotted line whose specifications still exceed those of slotted lines originally equipped with the other series (see curve below).

Included with the slotted line is a full set of accessories; no additional parts are needed for common measurements, except the generator and detector, which should be selected according to frequency range of interest.

specifications

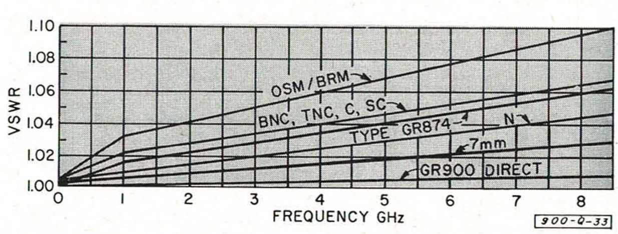
Characteristic Impedance: 50.0 Ω ±0.1%.

Probe Travel: 50 cm. Scale calibrated in centimeters from reference plane. Attached vernier can be read to 0.1 mm, micrometer carriage drive (supplied) to 0.002 mm.

Scale Accuracy: ±(0.1 mm + 0.05%).

Generators page 209 ff

Detectors page 119 ff



Specified residual VSWR of the 900-LB Precision Slotted Line in combination with various GR900® precision adaptors.

Frequency Range: 0.3 to 8.5 GHz. At 300 MHz, covers a half wavelength. Operates below 300 MHz with Type 900-L or -LZ Air Line.

Constancy of Probe Pickup (Flatness): ±0.5%.

Residual VSWR: Less than 1.001 + 0.001 f_{GHz} (unknown connector side). VSWR calibration data is supplied.

Repeatability: Within 0.05% (0.0005 in VSWR).

Connector Contact Resistance (900-BT Connector): Inner conductor less than 0.5 mΩ.

Accessories Supplied: Adjustable probe-tuner assembly; rf probe; micrometer carriage drive (accurate to 0.01 mm); 900-WN Precision Short-Circuit Termination; 900-WO Precision Open-Circuit Termination; 874-R22A Patch Cord; adaptor 874-Q900L; 1N21C and 1N23C detector diodes; Smith charts; storage case.

Accessories Required: Generator and detector.

Dimensions (width x height x depth): 27½ x 10 x 4¾ in. (700 x 255 x 125 mm).

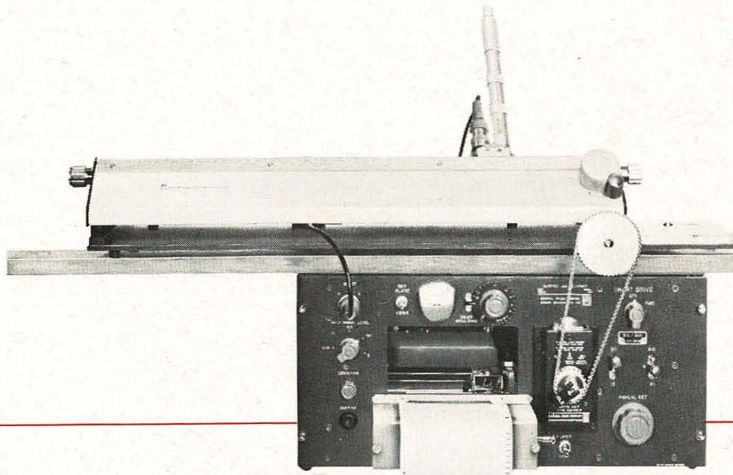
Weight: Net, 10¾ lb (4.9 kg); shipping, 34 lb (15.5 kg).

Catalog Number	Description	Price in USA
0900-9651	**900-LB Precision Slotted Line**	**$1090.00**

File Courtesy of GRWiki.org

SLOTTED LINE RECORDER SYSTEM

Type 1640



- VSWR range 1.008 to 1.20 full scale
- residual VSWR $< 1.001 + 0.001 f_{GHz}$
- frequency 0.6 to 8.5 GHz
- accessories included

The 1640 Slotted Line Recorder System automatically produces a strip-chart record of standing-wave patterns and other slotted-line measurement phenomena. Such a recording far exceeds, in resolution and in usefulness, a VSWR-meter readout. The chart record can be stored, reproduced, or analyzed graphically.

A direct measurement of VSWR or phase with the slotted line recorder system is quick and easy. At any frequency from 0.6 to 8.5 GHz, two full cycles of the standing-wave pattern can be scanned in 10 seconds, without perceptible distortion of the pattern. Multiple recordings can be run to measure repeatability and insertion VSWR, and to make measurements by the substitution-air-line method,[1] by which accuracy can be increased by a factor of from 2 to 5, depending on frequency. Graphic recording also makes it easy to eliminate the effects of line attenuation (slope) and other irregularities, though small, from a precision measurement.

The 1640 comprises a 900-LB Precision Slotted Line, a 1521-SL Slotted Line Recorder, and the necessary accessories. The recorder is a transistorized, servo-type instrument, whose accuracy depends only on three stable, custom-calibrated, wire-wound potentiometers in the servo loop. The chart drive has four speeds, which, combined with the two sprockets supplied, permit a total of eight possible slotted-line carriage-drive speeds, from 5 to 0.08 centimeters per second.

The recording on this page is an actual chart record made with a 1640. It represents one of the many measurements possible with this new concept in instrumentation.

[1] A. E. Sanderson, "A New High-Precision Method for the Measurement of the VSWR of Coaxial Connectors," IRE Transactions on Microwave Theory and Techniques," Vol. MTT-9, No. 6, November 1961, p. 524-528. (GR reprint A-92.)

specifications

SLOTTED LINE: 900-LB supplied complete with accessories. See following pages for complete description and specifications.

RECORDER (TYPE 1521-SL)

Sensitivity: Continuously adjustable from 0.05 to 2.0 mV full-scale.

Frequency: 990 Hz ±2%.

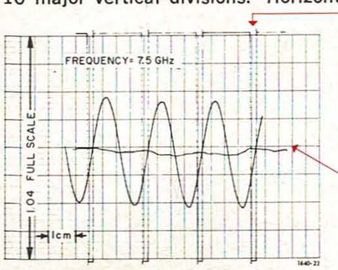
Bandwidth: 35 Hz ±7 Hz (at 3 dB).

VSWR Range: Continuously adjustable from 1.008 (0.8%) to 1.20 (20%) full-scale; accurate to within one minor division. Can be adapted to measure higher values.

Noise Level (referred to input): Short-circuit, less than 0.1 μV; open-circuit, less than 3.0 pA. Noise figure less than 5 dB at optimum source resistance (about 30 kΩ).

Power Required: 105 to 125 or 210 to 250 V, 60 Hz, 35 W. 1521-SLQ1 Recorder, supplied with 1640-AQ1 System, 50 Hz.

Chart Paper: 4-inch recording on 5-inch paper; 50 minor and 10 major vertical divisions. Horizontal scale ruling, ¼ inch.



Reference plane established by short-circuit termination for graphic phase measurement.

Baseline established by precision 50-Ω termination. Permits compensation for line's residual VSWR and slope.

Typical measurement, with 1640-A, of VSWR of a pair of GR900® adaptors.

Paper Speeds: Adjustable, 2.5 to 75 inches per minute; plots correspond to 5- to 300-cm/min carriage travel on slotted line. Two interchangeable sprockets advance paper 1 or 2 horizontal divisions per cm probe travel.

Servo Bandwidth of Pen Drive: More than 4 Hz.

Input Connector: GR874 coaxial connector, locking, recessed.

Accessories Supplied: 12 disposable pens with variety of ink colors, potentiometer cleaner, 5 rolls of chart paper 1521-9428, 5 rolls of chart paper 1521-9310, power cord, spare fuses.

SYSTEM

Bench Space Required: Width 48, depth 14 in. (1220 x 355 mm); height above bench 12 in., depth below bench 9 in. (315 x 230 mm).

Weight: Net, 67 lb (31 kg); shipping, 120 lb (55 kg).

Catalog Number	Description	in USA Price
1640-9701	**1640-A Slotted Line Recorder System** (60 Hz)	**$2645.00**
1640-9494	**1640-AQ1 Slotted Line Recorder System** (50 Hz)	**on request**
1521-9428	**Chart Paper,** 40 vert div 100-ft roll	**2.75**
1521-9310	**Chart Paper,** 50 vert div 100-ft roll	**2.75**
	fastrak Marker Set (12 disposable pens)	
1521-9446	**Red**	**15.00**
1521-9447	**Green**	**15.00**
1521-9448	**Blue**	**15.00**
1521-9439	**Pen Conversion Kit** (for older 1521 recorders)	**25.00**

PATENT NOTICE. See Notes 1 and 18.

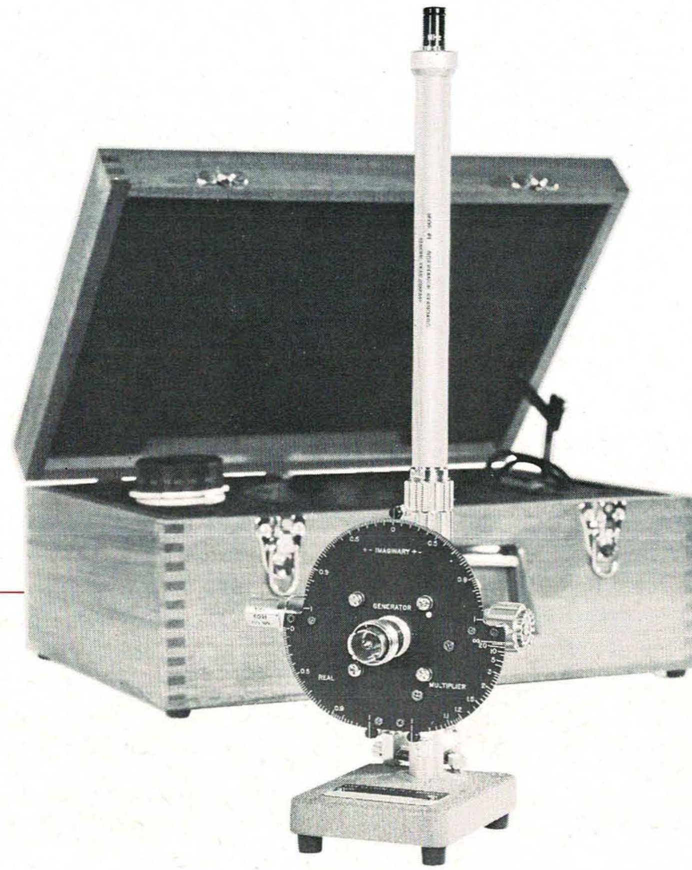
File Courtesy of GRWiki.org

PRECISION UHF BRIDGE

Type 1609

- 20 to 1500 MHz
- direct reading
- GR900® precision coaxial connectors
- reflectometer for fast VSWR measurement

new



The 1609 Precision UHF Bridge adds precision and stability to the long list of advantages that have made its forebear, the 1602 Admittance Meter, a favorite: ease and speed of use, the inherent accuracy of null techniques, convenient size.

The use of GR900® precision coaxial connectors puts the 1609 in a class with the 900-LB Slotted Line, extending precision coaxial measurements to much lower frequencies. The low reflection coefficient and high repeatability of the GR900 connectors make the 1609 particularly good for the measurement of near-50-ohm impedances and for substitution measurements; accuracies of 0.2% can be realized when the 1609 is used as a transfer bridge with GR 900-LZ Reference Air Lines as 50-ohm standards. GR900 precision terminations, standard mismatches, and other GR900-equipped impedance standards can also be used to calibrate the 1609. With GR900 low-VSWR adaptors, the 1609 can be converted to a type N precision UHF bridge (or TNC, BNC, etc).

The 1609 includes many mechanical improvements, not the least of which is an over-all ruggedization for better stability and instrument repeatability. The use of more stable standards with locking mechanisms and a detented multiplier arm further contribute to more repeatable measurements. Vernier drives can be used on both balance arms, permitting finer balance, greater precision; a locking mechanism is incorporated.

APPLICATIONS

The Precision UHF Bridge will measure admittance (and impedance) over a wide range of values and frequencies, indicating both real and imaginary terms. It is ideal for measuring antennas, transmission lines, and circuits at frequencies where neither lumped-parameter bridges nor slotted-line techniques are adequate.

It can be used for setting a network to a predetermined admittance, for matching one network or termination to another, and for matching antennas and other devices to 50-ohm circuits.

As a comparator, the 1609 is used to determine impedance magnitude, reflection-coefficient magnitude, and, by a fast and simple meter-readout method, voltage standing-wave ratio.

Rf standard impedances can be intercompared to unusually high precision with the GR900-equipped 1609. In addition, it can be used to evaluate the high-frequency performance of impedance standards calibrated at low frequencies. Thus the useful frequency range of high-quality standards with small or well controlled residuals can be extended into the microwave region.

File Courtesy of GRWiki.org

specifications

Frequency Range: 40 to 1500 MHz, direct reading; down to 20 MHz with correction factor applied to imaginary term.

Measurement Range: 0 to 400 m℧ or 0 to 1000 Ω, direct reading; can be extended to 4000 m℧ or 10,000 Ω with multiplier plates (supplied). Instrument measures admittance 4.9 cm on bridge side of mating plane of GR900® connector; readings normalized with respect to 20 m℧ (50 Ω). The addition of air line of appropriate length makes instrument direct-reading in Y or Z at any desired reference plane.

Accuracy: Applies to each term of normalized admittance reading separately.

Frequency	Larger term <1	Larger term 1 to 20
20 - 500 MHz	$\pm(0.02\|Y_N\| + 0.01)$	$\pm(0.02\sqrt{M}\|Y_N\| + 0.01M)$
500 - 1000 MHz	$\pm(0.03\|Y_N\| + 0.01)$	$\pm(0.03\sqrt{M}\|Y_N\| + 0.01M)$
1000 - 1500 MHz	$\pm(0.05\|Y_N\| + 0.01)$	$\pm(0.05\sqrt{M}\|Y_N\| + 0.02M)$

$|Y_N|$ = magnitude of bridge reading (normalized units) $= \sqrt{(\text{real term})^2 + (\text{imag term})^2}$

M = setting of multiplier arm; values of >1 to 20 required if normalized real or imaginary term is >1.

Impedance accuracy same as above substituting $|Z_N|$ for $|Y_N|$. VSWR accuracy ±2% from 20 to 1000 MHz, ±4% from 1000 to 1500 MHz, for measurements near unity (matching to 50-Ω system).

Accessories Supplied: 20-m℧ (50-Ω) conductance standard, adjustable stub and variable air capacitor for susceptance standards, two multiplier plates, 874-R22LA Patch Cord, mahogany storage case.

Accessories Required: Generator with 20-mW to 2-W output, detector with better than 10-μV sensitivity. Recommended, GR oscillators, GR Type DNT and 1241 Detectors or 1236 I-F Amplifier, 874-MRAL Mixer, and appropriate oscillator; 900-WN Short-Circuit Termination.

Accessories Available: 900-LZ Reference Air Lines as impedance standards, GR900 standard terminations and standard mismatches for calibration, GR900 adaptors to other connector types.

Dimensions (width x height x depth): 5 x 7¼ x 5½ in. (130 x 185 x 140 mm).

Weight: Net, 16 lb (7.5 kg); shipping, 20 lb (9.5 kg).

Catalog Number	Description	Price in USA
1609-9701	**1609 Precision UHF Bridge**	**$795.00**

Oscillators page 209 ff

Detectors page 119 ff

GR900® ADAPTORS
50-ohm

new

The availability of precision adaptors from the GR900® connectors to other popular coaxial connectors means that the user of GR900-equipped instruments can convert to other series and still retain precision performance. For example, a 900-LB Precision Slotted Line equipped with a 900-QNJ or -QNP Adaptor becomes a type N slotted line with an over-all residual VSWR (line plus adaptor) of only 1.02 at 3 GHz. Conversely, users of instruments equipped with OSM*, TNC, N, C, and GR874 connectors can, by means of adaptors, take advantage of the precision offered by GR900 tuners, air-line standards, terminations, and other elements.

Each GR900 adaptor includes a 900-BT Precision Coaxial Connector and an optimally designed connector of the other series. When ordering, note that the suffix letter "J" or "P" denotes the type of other-series connector (jack or plug) **included** in the adaptor. To obtain an adaptor to mate with a BNC plug, therefore, one would order a 900-QBJ Adaptor.

A set of the most commonly used GR900 precision adaptors is available, supplied in an attractive mahogany storage case. The set consists of one each of the plug and jack versions of the GR900 adaptors to types BNC, C, N, SC, OSM*/BRM, and TNC, as well as the GR900 adaptors to Amphenol APC-7, R&S Precifix 7-mm, and GR874 connectors. The storage case with recessed foam inserts can be supplied separately for use with an individually selected assortment of adaptors. Shipping weight of set is 12 lb (5.5 kg), of case alone is 8 lb (3.7 kg).

Catalog Number	Description	Price in USA
0900-9451	**GR900 precision-adaptor set**	**$1210.00**
0900-9450	**GR900 storage case, only**	**35.00**

* Registered trademark of Omni Spectra, Inc.

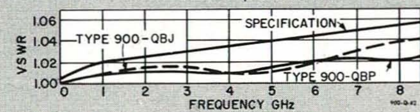
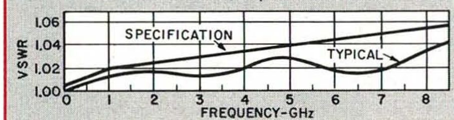
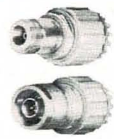
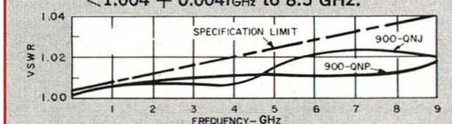
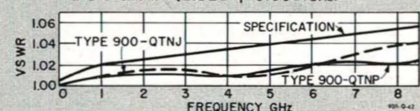
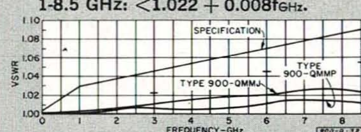
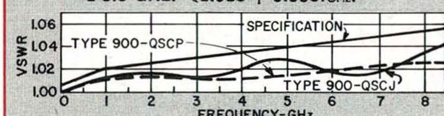
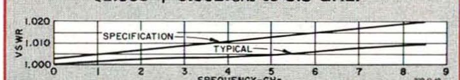
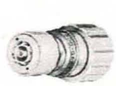
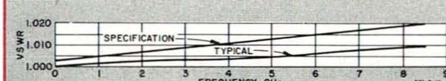
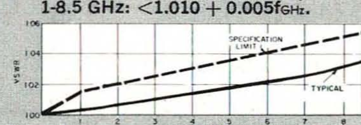
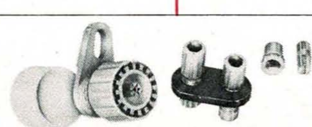
Individual Adaptors, next page

File Courtesy of GRWiki.org

coaxial

GR900 ADAPTORS

Net Weights: 4 oz (115 g) or less.
Lengths: 2⅝ in. (65 mm) or less.

Adaptor to Type	Type		Contains GR900® adaptor and	VSWR for single adaptor (50-Ω characteristic impedance)	Max Voltage, Max Power [1] (to 1 MHz)	Catalog Number	Price in USA
BNC	900-QBJ		BNC Jack	to 1 GHz: $<1.005 + 0.015f_{GHz}$, 1-8.5 GHz: $<1.015 + 0.005f_{GHz}$. 	500 V, 3 kW.	0900-9701	$ 75.00
	900-QBP		BNC Plug			0900-9801	75.00
C	900-QCJ		C Jack	to 1 GHz: $<1.005 + 0.015f_{GHz}$, 1-8.5 GHz: $<1.015 + 0.005f_{GHz}$. 	1000 V, 7 kW.	0900-9703	75.00
	900-QCP		C Plug			0900-9803	80.00
N	900-QNJ		N Jack	$<1.004 + 0.004f_{GHz}$ to 8.5 GHz. 	1000 V, 7 kW.	0900-9711	65.00
	900-QNP		N Plug			0900-9811	60.00
TNC	900-QTNJ		TNC Jack	to 1 GHz: $<1.005 + 0.015f_{GHz}$, 1-8.5 GHz: $<1.015 + 0.005f_{GHz}$. 	500 V, 3 kW.	0900-9717	75.00
	900-QTNP		TNC Plug			0900-9817	75.00
OSM*/ BRM	900-QMMJ		OSM/BRM Jack	to 1 GHz: $<1.005 + 0.025f_{GHz}$, 1-8.5 GHz: $<1.022 + 0.008f_{GHz}$. 		0900-9723	75.00
	900-QMMP		OSM/BRM Plug			0900-9823	80.00
SC	900-QSCJ		SC Jack	to 1 GHz: $<1.005 + 0.015f_{GHz}$, 1-8.5 GHz: $<1.015 + 0.005f_{GHz}$. 	1000 V, 7 kW.	0900-9713	75.00
	900-QSCP		SC Plug			0900-9813	85.00
Amphenol APC-7	900-QAP7		7-mm Precision Connector	$<1.003 + 0.002f_{GHz}$ to 8.5 GHz. 	1000 V, 6 kW.	0900-9791	110.00
Rohde and Schwarz Precifix & Dezifix A	900-QPF7		7-mm Precision Connector	$<1.003 + 0.002f_{GHz}$ to 8.5 GHz. 	1000 V, 6 kW.	0900-9793	110.00
GR874	900-Q874		GR 874-BBL	to 1 GHz: $<1.000 + 0.015f_{GHz}$, 1-8.5 GHz: $<1.010 + 0.005f_{GHz}$. 	1500 V, 10 kW.	0900-9883	60.00
Binding Posts (¾- to 1-in. spacing)	900-Q9		Includes adaptor and hardware to adapt GR900® connector to ¼-in. x 28 tapped hole or threaded stud, such as exposed top of GR 938 Binding Post.			0900-9874	50.00

[1] At frequencies above 1 MHz, max power varies inversely with the square root of frequency.
Flange adaptor to flat surfaces on page 163.

* Registered trademark of Omni Spectra, Inc.

File Courtesy of GRWiki.org

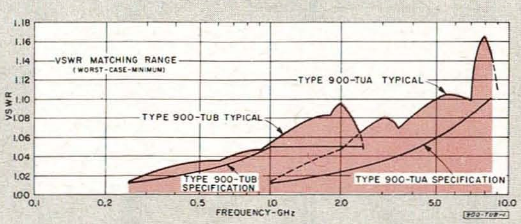
GR900® TUNERS

	Catalog Number	Price in USA

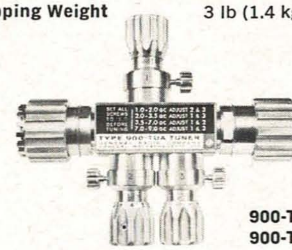
Types 900-TUA and 900-TUB TUNERS

The 900-TUA and -TUB Tuners are compact, broadband tuners useful in matching out small residual reflections in low-VSWR measuring instruments and devices.

Each tuner has three smoothly adjustable tuning screws, used in pairs to tune out reflections of any phase throughout the tuner's frequency range. Each screw has a "neutral" setting, independent of frequency, at which it is effectively out of circuit. Screws can be locked at any setting, permitting excellent VSWR resettability, protection against accidental disturbance, and friction driving (with screws partially locked) if desired.



	900-TUA	900-TUB
Frequency Range	1 to 8.5 GHz	0.25 to 2.5 GHz
Characteristic Impedance	50 Ω	50 Ω
VSWR Matching Range (worst-case minimum)	$1.00 + 0.012\ f_{GHz}$	$1.00 + 0.05\ f_{GHz}$ to 1 GHz 1.05 from 1 to 2.5 GHz
VSWR Resettability	$<1.0005 + 0.0003\ f_{GHz}$	$<1.0005 + 0.0003\ f_{GHz}$
Insertion Loss	<0.1 dB to 4 GHz <0.3 dB to 8.5 GHz	<0.1 dB
Repeatability of Connection	0.05%	0.05%
Electrical Length	12.0 cm	18.5 cm
Dimensions	4½ × 3½ × 1 in. (115 × 88 × 25 mm)	6½ × 4¾ × 1 in. (165 × 120 × 25 mm)
Net Weight	1 lb (0.5 kg)	1¼ lb (0.6 kg)
Shipping Weight	3 lb (1.4 kg)	4 lb (1.9 kg)



	Catalog Number	Price in USA
900-TUA Tuner (1.0 to 8.5 GHz)	0900-9635	**$250.00**
900-TUB Tuner (0.25 to 2.5 GHz)	0900-9637	**295.00**

GR900® TERMINATIONS

RESISTIVE TERMINATIONS

50-OHM STANDARD TERMINATION

Type 900-W50

A precision, low-VSWR, 50-ohm standard for calibration of bridges, slotted lines, admittance bridges, and reflectometers. Can also be used as a precision dummy load or as a termination in measurements of networks with more than one port. With appropriate GR900 precision adaptor, can be used as a low-VSWR, precision type N, BNC, C, etc, termination. A VSWR calibration chart is supplied with each unit.

VSWR: $1.005 + 0.005\ f_{GHz}$ to 8.5 GHz.

Dc Resistance: 50 Ω ±0.3%.

Max Power: 1 W with negligible change; 5 W without damage.

Temperature Coefficient: Less than 150 ppm/°C.

Over-all Length: 2 in. (51 mm). **Net Weight:** 3½ oz (100 g).

STANDARD TERMINATIONS

Type 900-W100 (100-OHM) **AND Type 900-W200** (200-OHM)

These known resistive terminations are especially useful in the calibration of bridges, reflectometers, etc. Position of pure resistance nominally 4 cm from the 900-BT reference plane. Short- and open-circuit terminations with a corresponding 4-cm offset are available (900-WN4 and -WO4; see below). A calibration chart is supplied with each unit.

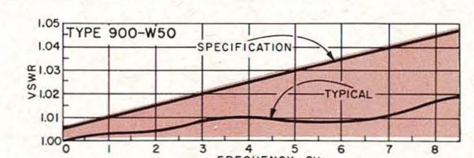
Magnitude of Mismatch: See curves.

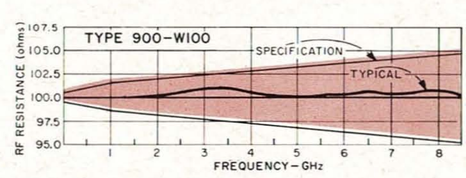
Dc Resistance: 900-W100, 100 Ω ±0.5%.
900-W200, 200 Ω ±0.5%.

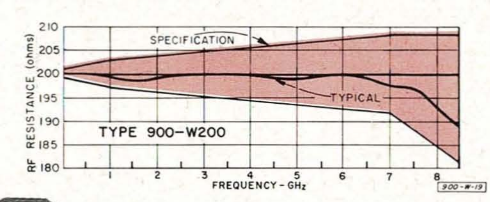
Max Power: 1 W with negligible change; 5 W without damage.

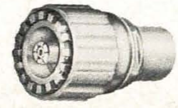
Temperature Coefficient: Less than 150 ppm/°C.

Over-all Length: 2 in. (51 mm). **Net Weight:** 3½ oz (100 g).









	Catalog Number	Price in USA
900-W50 50-Ohm Standard Termination	0900-9953	**60.00**
900-W100 100-Ohm Standard Termination	0900-9957	**70.00**
900-W200 200-Ohm Standard Termination	0900-9959	**70.00**

File Courtesy of GRWiki.org

GR900® TERMINATIONS (cont'd)

RESISTIVE TERMINATIONS (cont'd)

STANDARD MISMATCHES
Types 900-WR110, -WR120, -WR150

Introduce reflections of known VSWR value (1.1, 1.2, and 1.5) into a 50-ohm transmission line. Useful in calibration of reflectometers and other VSWR-measuring instruments. Mismatch calibration data (in VSWR) are provided with each unit.

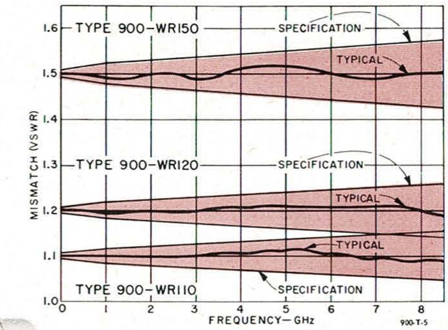
Magnitude of Mismatch: See curves.

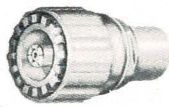
Dc Resistance: 900-WR110, 45.45 Ω ±0.5%.
900-WR120, 41.67 Ω ±0.5%.
900-WR150, 33.33 Ω ±0.5%.

Max Power: 1 W with negligible change; 5 W without damage.

Temperature Coefficient: Less than 150 ppm/°C.

Over-all Length: 2 in. (51 mm). **Net Weight:** 3½ oz (100 g).



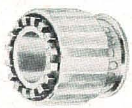


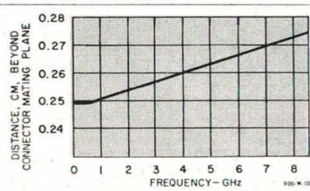
	Catalog Number	Price in USA
900-WR110 Standard Mismatch	0900-9961	**$60.00**
900-WR120 Standard Mismatch	0900-9963	**60.00**
900-WR150 Standard Mismatch	0900-9965	**60.00**

PRECISION OPEN-CIRCUIT TERMINATIONS

Type 900-WO

Establishes a well-shielded open circuit 0.26 cm (±0.02 cm) from the mating plane of the GR900® connector. (For short-circuit termination with corresponding 0.26-cm offset, see 900-WNE below.) Useful in establishing reference plane and in loss measurements. Reflection coefficient is greater than 0.999 at 8.5 GHz.

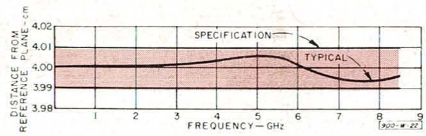




	Catalog Number	Price in USA
900-WO Precision Open-Circuit Termination	0900-9981	**13.00**

Type 900-WO4

This termination is similar to the 900-WO, except that the open is displaced 4 cm (±0.01 cm) to correspond to the 4-cm offset of the 900-W100 and -W200 Standard Terminations.

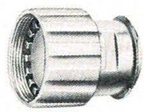


	Catalog Number	Price in USA
900-WO4 Precision Open-Circuit Termination	0900-9985	**60.00**

PRECISION SHORT-CIRCUIT TERMINATIONS

Type 900-WN

A precision-machined, silver-plated disk, mounted in a centering gear ring and locking-nut assembly, which short-circuits the face of a 900-BT connector. For establishing reference planes and for use in loss measurements. Reflection coefficient >0.999 to 8.5 GHz.



	Catalog Number	Price in USA
900-WN Precision Short-Circuit Termination	0900-9971	**13.00**

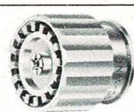
Type 900-WNC

Similar to 900-WN Termination, except that it includes a center contact to support the inner conductor of a 900-LZ Reference Air Line. The reference plane of the termination is exactly at the mating plane of the GR900 connector. Reflection coefficient is greater than 0.999 to 8.5 GHz.

	Catalog Number	Price in USA
900-WNC Precision Short-Circuit Termination	0900-9977	**20.00**

Type 900-WNE

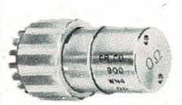
Short circuit is displaced 0.26 ±0.005 cm to correspond to nominal position of open in 900-WO. Center contact will support center conductor of 900-LZ Reference Air Line. Reflection coefficient is >0.998 at 8.5 GHz.

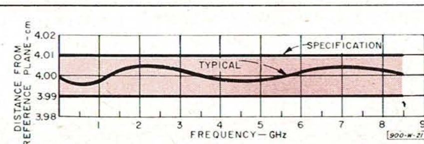


	Catalog Number	Price in USA
900-WNE Precision Short-Circuit Termination	0900-9979	**21.00**

Type 900-WN4

Similar to the 900-WNC except that the short is 4.00 ±0.01 cm from the connector mating plane. Reflection coefficient is >0.996 at 8.5 GHz.





	Catalog Number	Price in USA
900-WN4 Precision Short-Circuit Termination	0900-9975	**60.00**

File Courtesy of GRWiki.org

	Catalog Number	Price in USA

PRECISION AIR LINES — 900-L

Short sections of precision 50-ohm air line with a 900-BT Connector on each end. Useful as low-VSWR line extenders, as aids in checking the VSWR of precision connectors, and as 50-ohm impedance standards at frequencies at which the electrical length is an odd multiple of a quarter wavelength. Also useful as absolute impedance standards in time-domain-reflectometer systems and as capacitance and time-delay standards.

VSWR: $<1.0013 + 0.0013\ f_{GHz}$ up to 8.5 GHz.

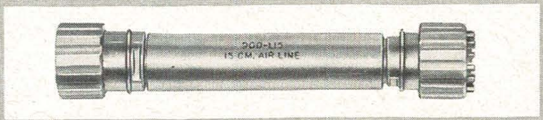
Characteristic Impedance (in air-line section): 50 Ω ± 0.065%

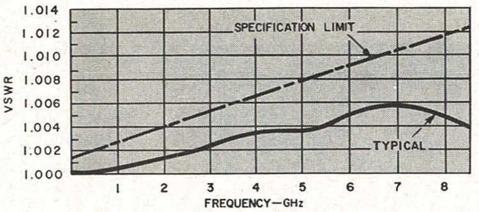
Accuracy of Electrical Length: Within ±0.02 cm.

Max Voltage: 3000 V pk.

Max Power: 20 kW up to 1 MHz, 20 kW/$\sqrt{f_{MHz}}$ above 1 MHz.

Dc Contact Resistance (each end): Inner conductor, <0.5 mΩ; outer conductor, <0.07 mΩ.





Electrical Length	C (pF)	Time Delay-ps (±1 ps)	Insertion Loss (dB)	Type	Catalog Number	Price in USA
3 cm	2.0000	100	$<0.005\sqrt{f_{GHz}}$	**900-L3**	0900-9608	**$ 98.00**
10 cm	6.6667	333	$<0.012\sqrt{f_{GHz}}$	**900-L10**	0900-9605	**105.00**
15 cm	10.000	500	$<0.016\sqrt{f_{GHz}}$	**900-L15**	0900-9607	**110.00**
30 cm	20.000	1000	$<0.028\sqrt{f_{GHz}}$	**900-L30**	0900-9613	**125.00**

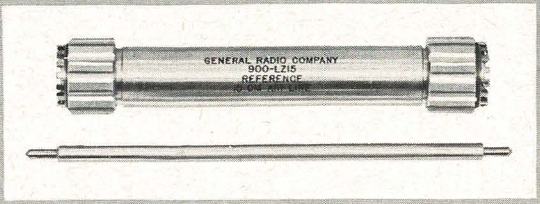
REFERENCE AIR LINES — 900-LZ

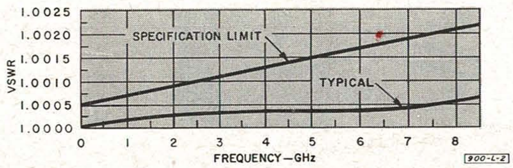
Beadless, virtually reflectionless coaxial air lines, with spring-loaded supporting tips on the ends of the inner conductor to mate with GR900 connectors; microfinished outer-conductor ends butt-contact the mating connectors. VSWR is held to $1.0005 + 0.0002\ f_{GHz}$. Such near-perfect specifications make these air lines most useful in calibration applications, and especially in substitution measurements. The lines can also be used as precision capacitance or time-delay standards, as well defined reactance standards, and as dielectric sample holders for dielectric-constant and loss measurements with the slotted line. Also useful as absolute impedance references in time-domain reflectometry.

Frequency Range: Dc to 9 GHz.

Characteristic Impedance: 50 Ω ±0.05%. Additional skin-effect error is calculable[1].

[1] J. Zorzy, "Skin-Effect Corrections in Standards," IEEE Transactions on Instrumentation and Measurement, Vol IM-15 No. 4, December 1966, p 358 (GR Reprint A-134).





VSWR: $<1.0005 + 0.0002\ f_{GHz}$; calibration data supplied.

Repeatability: Within $(0.010 + 0.003\ f_{GHz})$%.

Leakage: Better than 130 dB below signal.

Insertion Loss: Less than $0.0008\sqrt{f_{GHz}}$ dB/cm.

Max Voltage: 3000 V peak.

Max Power: 20 kW/$\sqrt{f_{MHz}}$.

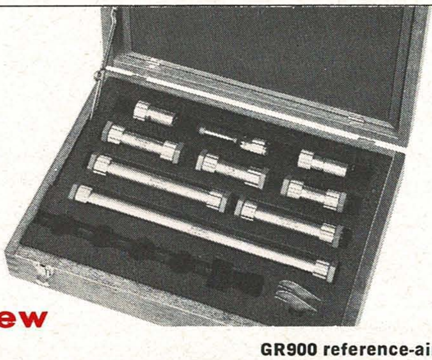
Dc Contact Resistance (each end, mated with GR900): Inner conductor, <0.5 mΩ; outer conductor, <0.07 mΩ.

Electrical Length - cm (±0.002 cm)	Capacitance - pF (±0.07%)	Time Delay - ps (±0.1 ps)	Odd λ/4 Frequencies * - GHz	Type	Catalog Number	Price in USA
2.998	2.0000	100.0	(2n+1)2.50	**900-LZ3**	0900-9603	**76.00**
4.997	3.3333	166.7	(2n+1)1.50	**900-LZ5**	0900-9600	**80.00**
5.996	4.0000	200.0	(2n+1)1.25	**900-LZ6**	0900-9601	**82.00**
7.495	5.0000	250.0	(2n+1)1.00	**900-LZ7H**	0900-9602	**85.00**
9.993	6.6667	333.3	(2n+1)0.75	**900-LZ10**	0900-9604	**90.00**
14.990	10.000	500.0	(2n+1)0.50	**900-LZ15**	0900-9606	**100.00**
29.979	20.000	1000.0	(2n+1)0.25	**900-LZ30**	0900-9612	**130.00**

* Frequencies at which air-line section is an odd multiple of a quarter wavelength, where n is zero or any integer.

REFERENCE-AIR-LINE SET

A set consisting of one each of the seven lengths of 900-LZ Reference Air Lines supplied in an attractive mahogany storage case. Also included are two terminations ordinarily used with the Reference Air Lines, a 900-WN4 short circuit and a 900-WO4 open circuit. The storage case with recessed foam inserts can be supplied separately for use with an individually selected assortment of air lines and/or terminations. Shipping weight of set is 12½ lb (6 kg), of case alone is 8 lb (3.7 kg).



new

	Catalog Number	Price in USA
GR900 reference-air-line set	0900-9452	**722.00**
GR900 storage case, only	0900-9450	**35.00**

File Courtesy of GRWiki.org

coaxial

GR900® CONNECTORS

The GR900® precision coaxial connector is available in 6 models: the 900-BT for use with the 14-mm rigid air line, the 900-C9 and 900-C58 for use with coaxial cable, and three connector kits to permit custom fabrication of GR900 air lines, terminations, and panel connectors. All GR900 connectors have the same basic mechanical features and mate with one another.

Type 900-BT PRECISION COAXIAL CONNECTOR

This is the basic GR900 connector, for use on rigid air-dielectric 50-ohm coaxial lines (principal dimensions: 0.5625 inch and 0.24425 inch). The 900-TOK Tool Kit is recommended for proper assembly.

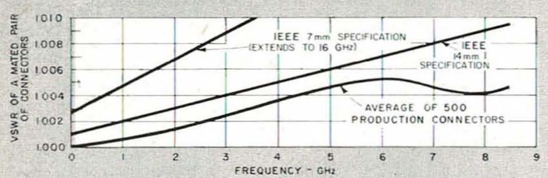
The 900-BT Connectors are available as single connectors or as a pair of connectors with calibration certificate. The same VSWR specification ($<1.001 + 0.001\ f_{GHz}$) applies to either. These limits are those approved in the IEEE Recommended Practice for Precision Coaxial Connectors in the 14-mm general precision connector class.

900-BT Connectors are 100% tested at six frequencies.

Frequency Range: Dc to 8.5 GHz.

Characteristic Impedance: 50 Ω ±0.1% at frequencies where skin effect is negligible.

VSWR: $1.001 + 0.001\ f_{GHz}$; applies to single connectors and 0900-9407 pairs.



Typical and specified VSWR of single and certified pairs of 900-BT Precision Coaxial Connectors. Specified VSWR is identical to that given as IEEE Recommended Practice.

Repeatability of VSWR: Within 0.05%.

Repeatability of Phase: Within 0.008° at 1 GHz, 0.015° at 2 GHz, 0.05° at 6 GHz.

Leakage: Better than 130 dB below signal.

Insertion Loss: Less than $0.03\sqrt{f_{GHz}}$ dB per pair.

Insertion-Loss Repeatability: 0.002 dB, typical.

Max Voltage: 3000 V peak.

Max Power: 20 kW up to 1 MHz; 20 kW/$\sqrt{f_{MHz}}$ above 1 MHz.

Electrical Length: 3.500 ±0.005 cm per pair; 1.750 ±0.0025 cm for single connector.

Dc Contact Resistance: Inner conductor, less than 0.5 mΩ; outer conductor, less than 0.07 mΩ.

Dimensions: Length of one connector, 1³⁄₁₆ in. (31 mm); max diameter, 1¹⁄₁₆ in. (27 mm).

Net Weight: 2 oz (60 g).

	Catalog Number	Price in USA
900-BT Precision Coaxial Connector	0900-9405	**$35.00**
900-BT Precision Coaxial Connectors, (pair) with Calibration Certificate	0900-9407	**72.00**

GR900® Laboratory Precision Connector Kits

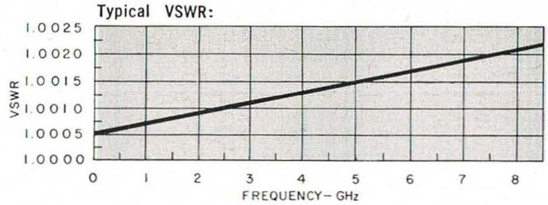
Three kits are available for custom fabrication of air lines and terminations compatible with the GR900® connector. Rigid air-lines can be made from GR900 Precision Rod (0900-9507) and Tube (0900-9509) to serve as precision capacitance or time-delay standards, as well defined reactance standards, and as dielectric sample holders for dielectric-constant and loss measurements with the slotted line.

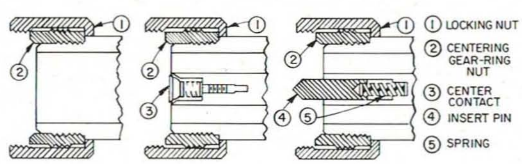
Type 900-AP is for use on elements having unsupported inner conductors. A reference air line can be assembled from a pair of these kits and appropriate lengths of precision rod and tube. The kit consists of coupling nut, centering gear ring, and a spring-loaded centering pin, which allows the inner conductor of a beadless air line to derive its support from the mating 900-BT Connector. Air lines can be machined from the GR precision rod and tube described elsewhere.

Type 900-AC contains the locking nut, centering gear ring, and center contact of a standard GR900® connector. It can be used in place of the 900-BT on any component whose inner conductor is supported within the component itself. Since it includes only those parts necessary in such applications, this kit offers the user superior electrical performance at a considerable saving in cost.

Type 900-AB is like the 900-AC Kit in appearance and function, except that it does not contain the center contact. Thus it can be used to fabricate an air line to be mated with a 900-BT Connector, but it cannot mate with a 900-LZ Reference Air Line or with another 900-AB or 900-AP Connector.

Typical VSWR:





900-AB 900-AC 900-AP

	Catalog Number	Price in USA
900-AP Laboratory Precision Connector Kit **Repeatability:** Within ($0.010 + 0.003\ f_{GHz}$)%.	0900-9406	**$ 5.90**
900-AC Laboratory Precision Connector Kit **Repeatability:** Within 0.05% (0.0005 in VSWR).	0900-9404	**7.60**
900-AB Laboratory Precision Connector Kit **Repeatability:** Within ($0.010 + 0.003\ f_{GHz}$)%.	0900-9402	**4.80**

File Courtesy of GRWiki.org

GR900® CONNECTORS
(cont'd)

Precision Coaxial Cable Connectors —

900-C9, 900-C58

Cable-connector counterparts of the 900-BT. The VSWR of these connectors is much lower than that of even the best-made cables.

The braid-retention system does not compress the cable, yet has good pull and torque resistance. The usual distortion and flow of cable dielectric during inner-conductor soldering have been virtually eliminated by means of a Teflon spacer and a special, low-temperature solder supplied with every connector. All inner-conductor parts are captive.

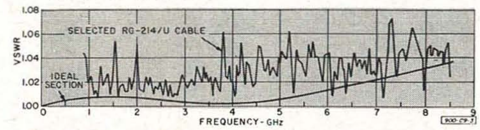
The **900-C9,** although designed for RG-9B/U and RG-214/U, can be used with the following cables with some sacrifice in performance or mechanical reliability: RG-8/U, -8A/U, -10A/U, -87A/U, -116/U, -156/U, -165/U, -166/U, -213/U, -215/U, -225/U, and -222/U.

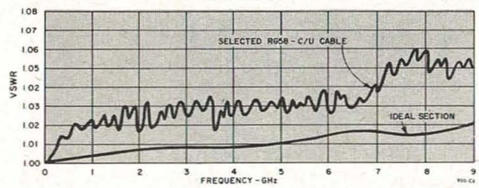
The **900-C58** connector, primarily for use with GR 874-A3 and RG-58/U series cables, will also find limited application with RG-29/U, -55/U series, -141A/U, -142A/U, -159/U, and -223/U.

The 900-TOK Tool Kit is recommended for assembling these connectors.

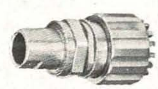
Frequency Range: Dc to 8.5 GHz.
Characteristic Impedance: 50 Ω.
Insertion Loss (approx): $<0.006\sqrt{f_{GHz}}$ dB per pair for 900-C9; $<0.010\sqrt{f_{GHz}}$ dB per pair for 900-C58.
Max Voltage: 1500 V pk (-C9), 500 V pk (-C58).

Typical VSWR performance of a single Type 900-C9 Connector on an "infinite" length of RG-214/U cable and on an "ideal" section with the same diameters.





Similar data for 900-C58 Connector.



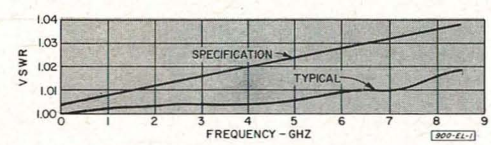
	Catalog Number	Price in USA
900-C9 Precision Coaxial Cable Connector	0900-9421	**$50.00**
900-C58 Precision Coaxial Cable Connector	0900-9431	**58.00**

GR900® PRECISION COAXIAL ELEMENTS

PRECISION 90° ELL — 900-EL

A coaxial right-angle bend with small reflections, the 900-EL permits coaxial devices, such as vertical liquid-dielectric sample holders, to be physically oriented as required without the use of flexible cable with poor electrical performance.

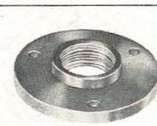
Frequency Range: Dc to 8.5 GHz.
Characteristic Impedance: 50 Ω ±0.4% at frequencies where skin effect is small.
VSWR: $<1.004 + 0.004\ f_{GHz}$.
Electrical Length: $(10.00 + 0.0014\ f^2_{GHz} \pm 0.02)$ cm.
Insertion Loss: $<0.017\sqrt{f_{GHz}}$ dB.
Max Voltage: 1500 V peak.
Max Power: 10 kW to 1 MHz; 10 kW/$\sqrt{f_{MHz}}$ over 1 MHz.
Mating Dimensions: 2.066 in. (5.246 cm) from center line of one connector to reference plane of second connector.
Over-all Dimensions: 2$^{11}/_{16}$ x 2$^{11}/_{16}$ x 7/8 in. (68 x 68 x 22 mm).
Net Weight: 10 oz (280 g).



Gear rings rotatable for proper mating in any orientation.

ADAPTOR FLANGE

Threads onto a 900-BT Connector in place of the center-ing gear ring and locking nut to connect GR900® components to bridges and other instruments that terminate in a flat-plane surface or to other flange-type connectors.



PANEL MOUNTING KIT 900-PKM is used to equip standard 900-BT and 900-C9 Connectors for panel mounting. The kit includes a threaded flange, which accepts the outer conductor and mounting hardware. The 900-PKMR has a rotatable gear ring that permits proper mating to another GR900® connector in any orientation.

	Catalog Number	Price in USA
900-EL Precision 90° Ell	0900-9527	**$180.00**
Adaptor Flange	0900-9782	**10.00**
900-PKM Panel Mounting Kit	0900-9498	**10.00**
900-PKMR Panel Mounting Kit, Rotatable	0900-9500	**20.00**

File Courtesy of GRWiki.org

coaxial

GR900® PRECISION COAXIAL ELEMENTS (cont'd)

PRECISION ROD AND TUBE

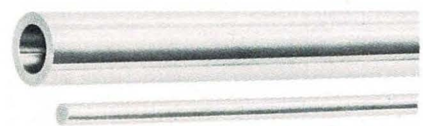
Used in fabrication of custom-length air lines and components, in conjunction with GR900® connectors and connector kits. Diameters are specified at 23°C. Both rod and tube have been stress-relieved to minimize dimensional changes during machining.

PRECISION INNER-CONDUCTOR ROD (supplied in pairs). Centerless-ground, silver-layered brass rod stock with a nominal 0.24425-in. diameter.

Length: 13 ± 1/32 in. (330 mm). **Straightness:** 0.0015 in./ft.
Diameter Accuracy: ±65 microinches. **Uniformity:** ±25 microinches.
Surface Finish: 20 microinches, max.

PRECISION OUTER-CONDUCTOR TUBE. Precision-forged, silver-lined brass tubing with a nominal OD of 0.830 in. and a nominal ID of 0.5625 (9/16) in. Nominal wall thickness is 0.134 in.

Length: 27 in. (690 mm). **Straightness of ID:** 0.005 in./ft.
Inner-Diameter Accuracy: ±140 microinches.
Inner-Surface Finish: 30 microinches, max.



	Catalog Number	Price in USA
Precision Inner-Conductor Rod	0900-9507	$20.00
Precision Outer-Conductor Tube	0900-9509	39.00

ROTATABLE CENTERING RING

A direct replacement for the centering gear ring on the GR 900-BT Precision Coaxial Connector, the rotatable gear ring will thread onto the connector wherever it is used, to permit proper mating with other GR900® connectors in any orientation.

	Catalog Number	Price in USA
Centering Ring, Rotatable	0900-9499	15.00

COMPONENT MOUNT — 900-M

A shielded enclosure for mounting small components, the 900-M permits more accurate measurement of resistors, capacitors, etc, by minimizing connection capacitance and inductance. Contains GR900® connector and low-VSWR coaxial-line section.

Electrical Length: 4.0 cm ±0.04 cm to ideal short-circuit at terminals.
Residual Impedances (at low frequencies): 2.93 pF, typical, with screw.
Accessories Required: 900-WN4 Precision Short Circuit, 900-WO4 Precision Open Circuit for establishing reference plane.
Weight: Net, 8 oz (230 g); shipping, 11 oz (315 g).

new

	Catalog Number	Price in USA
900-M Component Mount	0900-9540	70.00

CLEANING KIT — 900-TOC

Use for cleaning GR874 and GR900® connectors. Solvent supplied in 16-oz aerosol can will not affect polystyrene or Teflon* insulators nor any metal surfaces in these connectors. Also includes two brushes and 24 wiping pads.

*Trademark of E. I. du Pont de Nemours Co., Inc.

new

	Catalog Number	Price in USA
900-TOC Cleaning Kit	0900-9610	7.50

TOOL KIT — 900-TOK

Nine-piece tool kit in fitted case for convenient installation of Types 900-BT, 900-C58, and 900-C9 Precision Coaxial Connectors on suitable air line or component. Complete instructions for use of tools are supplied with each connector to simplify assembly and to ensure precision results.

Shipping Weight: 7 lb (3.2 kg).

	Catalog Number	Price in USA
900-TOK Tool Kit	0900-9902	115.00

STORAGE CASE

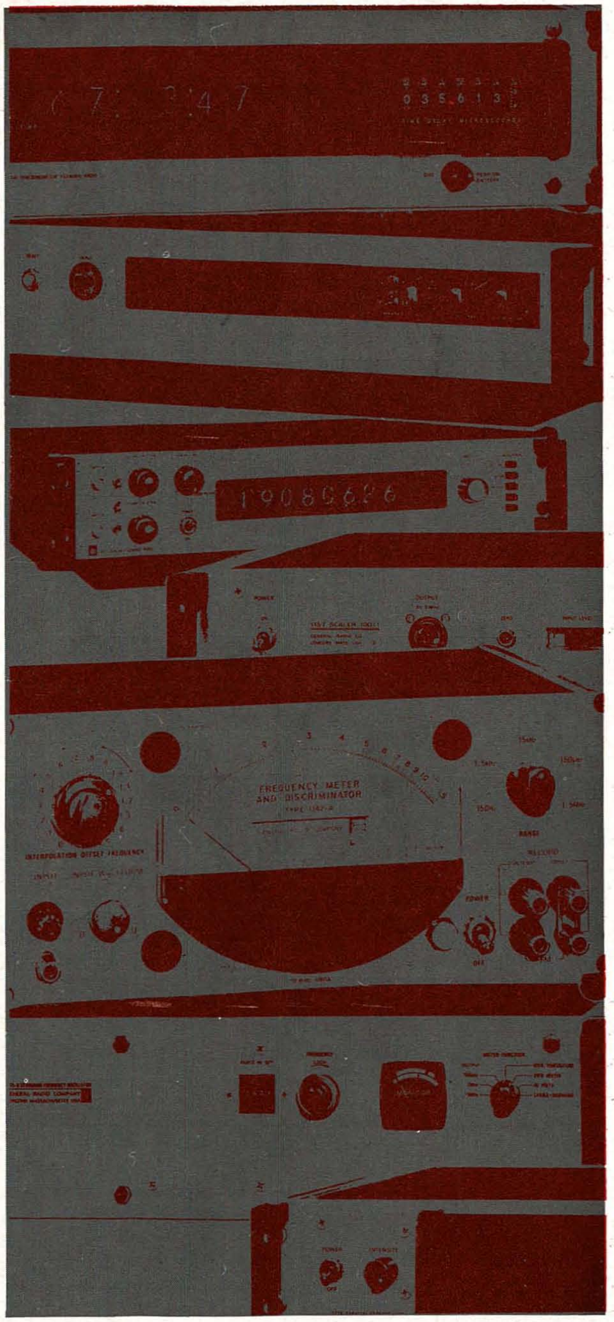
An attractive mahogany case with firm, foamed-plastic inserts having molded recesses designed to hold various types of GR900® precision coaxial components. The ideal way to keep together a set of adaptors, air lines, terminations or the like and to carry and to store them with minimum exposure to dirt or damage to precision machined surfaces.

Shipping Weight: 8 lb (3.7 kg).

new

	Catalog Number	Price in USA
GR900 storage case	0900-9450	35.00

File Courtesy of GRWiki.org



FREQUENCY

FREQUENCY STANDARDS
FREQUENCY METERS AND COUNTERS

File Courtesy of GRWiki.org

FREQUENCY STANDARDS

Time is one of the three fundamental physical dimensions. Since frequency is specified in terms of events per unit time (cycles per second, or hertz), the production of an accurate frequency is directly related to the establishment of an exact time interval.[1] Although formerly determined by astronomical observations, exact time intervals are now derived from the atomic frequency standard. International agreement has defined the second as 9,192,631,770 cycles of the resonance-frequency transition of the cesium atom under zero-field conditions. This uniform time scale is called Atomic Time (A-1). The ephemeris second is the fraction 1/31,556,925.975 of the tropical year 1900. Measurements using the atomic scale indicate agreement with this constant astronomical time scale, Ephemeris Time, which is based on the orbital period of the earth about the sun (the time between vernal equinoxes). For everyday living, Mean Solar Time, also known as Universal Time (UT) or Greenwich Mean Time, which is based on the mean rotational period of the earth, must be used. For example, for navigation and the tracking of artificial satellites with the earth used as a platform, a precise knowledge of the earth's rotational period is required. Mean Solar Time is now defined in terms of atomic time, the predicted average rate being for this century 150×10^{-10} lower than A-1 time with some variations occurring that may modify this estimate.

Standard frequencies and time intervals for measurement purposes are usually derived from a secondary frequency standard, such as a quartz-crystal oscillator, which is periodically calibrated in terms of a primary standard by means of standard-frequency or standard-time radio transmissions. Depending upon the accuracy required, local frequency can be established by either frequency or time measurement. In order to eliminate confusion with respect to the time scale in use (atomic or UT, for example), it is important to obtain information directly from the government agency concerned about the transmitting stations, frequencies and time scales in use.

Atomic clocks establish a perfectly uniform time. By international agreement, the time intervals broadcast are related to this uniform atomic time with step corrections not exceeding 100 milliseconds to agree with astronomical observations of the earth's rotation. Astronomical time observations are carried out by national observatories throughout the world. Their measurements are made available to users by radio time-signal transmissions and by telegraph in their respective countries. Many nations have adopted a "coordinated Universal Time" scale (designated UTC), which is supervised by the Bureau International de l'Heure, Observatoire de Paris, Paris, France. Adoption of this scale has facilitated measurements of time and frequency on an international basis. The UTC offset from atomic time has been designated as -300×10^{-10} for 1968.

The user of a frequency standard equipped with means for measurement of the time of arrival of a radio time signal can then calibrate the standard directly in terms of time. For a precise calibration, the errors of the transmitted time signal must be taken into account. Correction data for time-signal transmissions should be obtained from the agency responsible for their emission.

In the United States, standard frequency and time broadcasts are made by the standard-frequency transmitters operated by the National Bureau of Standards, Radio Standards Laboratory, Boulder, Colorado, and by the U. S. Naval Radio Service monitored by the U. S. Naval Observatory, Washington, D. C. In Canada, standard time signals are broadcast by station CHU, a service of the Dominion Observatory at Ottawa.

Calibration accuracy using a standard-time transmission depends upon the characteristics of the transmitted signal and of the propagation path. The variations in the time of reception of high-frequency sky-wave time signals are seldom less than 100 microseconds, due to propagation-path variations. A low-frequency signal, known to be propagated via a ground-wave, should have variations of less than 2 microseconds over a 1500-mile path.[2]

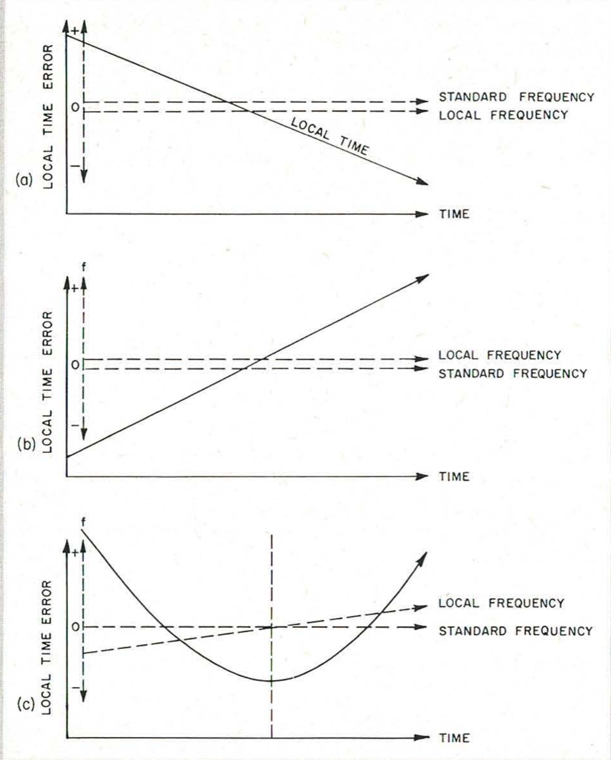


Figure 1.

CALIBRATION METHODS

The basic methods of intercomparing the frequencies of two sources are the same whether the primary standard is local or remote. The techniques employed will differ because of the propagation characteristics of radio transmissions and noise on the radio signal, which do not exist with local calibration. The principal techniques are: zero-beat — direct phase comparison; direct time comparison; frequency difference measurement — usually digital.

A. ZERO-BEAT TECHNIQUES

The basic method for frequency intercomparison is a direct comparison of the phase difference of two signals nearly equal in frequency. If not nearly equal, they must be nearly harmonically related. A change in relative phase between two signals may be determined by measurement of their beat frequency, by observation of a Lissajous figure on an oscilloscope, by measurement with a voltmeter of their common amplitude, by use of a phase-difference detector circuit, or by phase-recording systems.

The precision of the zero-beat method is limited by the ability to detect the zero-beat condition. Suppose, for example, one has a "zero-beat" detector capable of 1-hertz resolution and it is desired to set two standard frequencies equal to one another as closely as possible. If the two frequencies are 1 MHz, then the error will be 1 ppm. Greater resolution can only be attained by multiplication of the two frequencies or by increased resolution of the zero-beat detector. As a practical example of the zero-beat technique, consider the comparison of the 5-MHz carrier of WWV against a local 5-MHz signal. By use of either the receiver S meter or the beat-frequency oscillator, about 1-hertz resolution is available, and the local standard can be set to about 1 part in 10^7.

VLF phase-tracking receivers take advantage of the more stable propagation characteristics of VLF transmissions.[3] Because the frequency is low, a very high degree of phase resolution is required. VLF trackers are capable of resolving approximately ± 1 microsecond of phase delay; this provides a calibration precision of about $\pm 1 \times 10^{-10}$ in three hours, under undisturbed conditions. If a very narrow bandwidth is used, a phase tracker can extract the desired data under very adverse signal-to-noise ratio conditions.

B. DIRECT TIME INTERCOMPARISON.

Frequency may be established to a high degree of precision by direct comparison of time intervals derived from the frequency

[1] F. D. Lewis, "Frequency and Time Standards," Proceedings of the IRE, September 1955, pp 1046-1069.

[2] Doherty, R. N. et al, "Timing Potentials of Loran-C," Proceedings of the IRE, November 1961, p 1659.

[3] Pierce, J. A. "The Diurnal Carrier Phase Variation of a 16-kilocycle Transatlantic Signal," Proceedings of the IRE, May 1955, p 584.

File Courtesy of GRWiki.org

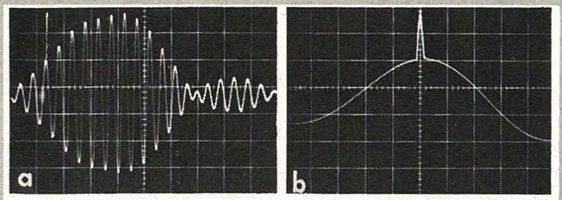


Figure 2. Time comparison of marker pulse and Loran-C 100-kHz pulses.
a. Sweep rate 20 μs/cm. (Note marker pulse on third cycle.)
b. Sweep rate 1 μs/cm, pulse centered.

to be calibrated and from the standard. The time interval compared is usually one second, derived from the standard to be calibrated by a precision electronic clock such as the GR Type 1123 Digital Syncronometer® time comparator. An example of this method is the comparison of locally produced one-second pulses with the one-second timing pulses transmitted by Radio Station WWV. There are two distinct advantages of this method of comparison over others: (1) Individual measurements do not have to have great accuracy since the accuracy is increased by taking longer and longer time intervals between measurements. (2) The measurement results in an accurately set local clock. Local time is known to the extent that the propagation time of the radio signal is known.

The basic principle of the measurement lies in the integrating character of the clock. If the frequency driving the clock is low, the time between successive zero crossings of the driving frequency is a little longer than standard, and at each cycle the clock will lose a fixed increment of time. Obviously, the longer the measurement interval, the larger the time error (Figure 1a). The case of a clock driven by too high a frequency is shown in Figure 1b; the clock steadily gains time with respect to standard time.

The assumption of an absolutely constant frequency with a fixed error with respect to the primary standard leading to a linear change in local time is not the situation usually encountered in practice. The local standard will generally have some drift, which will cause the time error to depart from linear as shown in Figure 1. If the drift in frequency is constant with time, for example $f = (f_o + kt)$, and the initial frequency setting, f_o, is low, it is obvious that at some future instant of time f will become equal to the standard frequency, and the time intervals will be precisely correct. The curves of time error are now parabolic. Figure 1c shows the shape of time error when the local frequency has a positive drift.

As an example of the use of this method of frequency calibration, assume that in your locality WWV can be received with a reproducibility of one millisecond. (This figure must be established by experiment.) Then, in a one day interval, a change in the local frequency of $10^{-3}/86{,}400$ or approximately $1{:}10^8$ can be established.

This method of calibration is limited in accuracy only by one's ability to establish time simultaneity in the measurement. If the local time is, for example, marked by a brief pulse like that produced by a Type 1123 Digital Syncronometer and a cycle of a burst from a Loran C transmitter can be observed, then time can be compared to a fraction of a microsecond,[4] and the local frequency can be established to within a few parts in 10^{10} in a time interval of only a few minutes (Figure 2).

[4] D. O. Fisher and R. W. Frank, "A New Approach to Precision Time Measurements," General Radio Experimenter, February-March 1965.

C. DIGITAL FREQUENCY MEASUREMENT

The introduction to the section on frequency meters describes the application of digital frequency meters to frequency measurement problems in general. Counters can obviously be used for precision frequency intercomparison. The accuracy is limited only by the maximum counting time from one source and the maximum counting rate of the counter. Thus, a 20-MHz counter such as the General Radio Type 1191 with its ten-second time base controlled by the standard can be used to calibrate another frequency source at 10 MHz to an accuracy of $1{:}10^8$. The counter is particularly convenient when the oscillator to be calibrated is not harmonically related to the standard frequency.

THE STANDARD-FREQUENCY LABORATORY

Figure 3 shows equipment that might be encountered in a typical Frequency Standard Laboratory. The requirements of any specific application will dictate how elaborate the system must be. If time information is not required, a master oscillator combined with a VLF Phase Tracker to monitor its performance may suffice as reference frequency source. Alternatively, one can use time signals to monitor the oscillator performance. A cesium beam (primary) standard can be used to check the frequency of a master oscillator but does not provide time calibration, and reference to time signals is still required. In the system shown in Figure 3, the master oscillator is monitored against WWVB (60 kHz, A-1 scale) by a phase tracker and provides exact reference frequencies while the two other (working standard) oscillators are offset by the proper ratio to provide time signals on the UTC scale. A frequency-intercomparison system permits the working standards to be compared with the reference and plots continuous records of their stability.

Multipliers, dividers, and synthesizers make other frequencies available for distribution for calibration and test purposes. These frequencies can be derived either from the master oscillator on the exact frequencies or from the working standards with UTC offset. Distribution amplifiers provide isolation between the various users.

The frequency comparison system can consist of a 20-MHz counter using the master oscillator as time base. If the other oscillators are measured at 5 MHz, a 1000-second gate time in the counter will provide $\pm 2 \times 10^{-10}$ resolution. Higher resolution requires the use of multipliers or error-multipliers. Multiplication to 100 MHz and the use of a 100-MHz counter provides a resolution of $\pm 1 \times 10^{-11}$ for a 1000-second count. Error-multipliers can increase the basic resolution up to 1000 times and do not require a 100-MHz counter. In either case, the digital data from the counter can be printed in numerical form or a digital-analog converter can be used for continuous strip-chart recording. The same frequency intercomparison system can also be used to measure the frequencies of oscillators in other locations if the signals are fed through the distribution lines to the frequency standard equipment.

FREQUENCY SYNTHESIZERS

A new class of instrument, the frequency synthesizer, is both a frequency standard and a variable-frequency signal source. All output frequencies are synthesized coherently from a single-frequency source, usually a quartz crystal oscillator. In General Radio synthesizers, the output frequency is adjustable in decade steps, plus a continuous control. Modular construction permits synthesizers to be assembled with any desired resolution from 3 to 9 significant figures.

GR synthesizers use a room-temperature quartz-crystal oscillator as the standard source, which can be locked to an external standard, such as the Type 1115 Standard-Frequency Oscillator, when extreme stability is required.

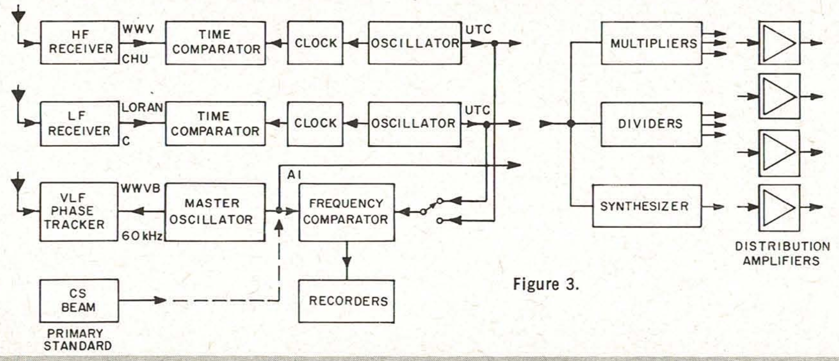


Figure 3.

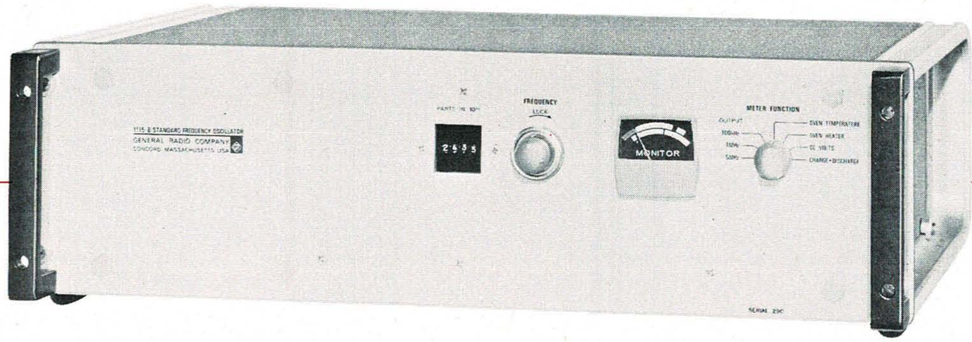
File Courtesy of GRWiki.org

STANDARD-FREQUENCY OSCILLATOR

Type 1115-C

- fast-stabilizing crystal
- <5 x 10^{-10} per day after 3 days
- very high spectral purity
- 35-hour internal battery
- meets MIL E16400D (vibration), MIL-I-26600 (RFI)

new



This highly stable piezoelectric oscillator is suitable for exacting scientific and military uses — in both laboratories and manufacturing plants and on shipboard — wherever a rugged, high stability standard of frequency is required.

Exceptional spectral purity of the 5-MHz output permits multiplication to microwave frequencies for such applications as microwave spectroscopy and phase-coherent radar. Typical noise pedestal at X band is -80 dB per $\sqrt{Hz}$.

When combined with the 1123-A Digital Syncronometer® time comparator this oscillator becomes a highly accurate time standard, which can be precisely compared with, and transferred to, other clocks, either remote or local.

The quartz crystal is a 5-MHz, 5th-overtone unit. It is mounted in a single stage, proportional-control oven, which also contains the oscillator and agc circuits.

The frequency of the oscillator is adjusted by a panel control, direct reading in parts in 10^{10}, to allow correction of crystal aging.

A nickel-cadmium battery is floated across the dc supply. In the event of power-line failure, operation for about 35 hours is ensured at room temperature.

— See **GR Experimenter** for June 1964.

specifications

Output: 5 and 1 MHz, 100 kHz; 1 V rms +50 −10% into 50 Ω at each frequency.

Frequency Adjustment: 2700 × 10^{-10} (1 × 10^{-10} per dial division).

External Frequency Control: Dc voltage from +0.5 to +12 V can be applied. Range is at least 5 × 10^{-7}, total.

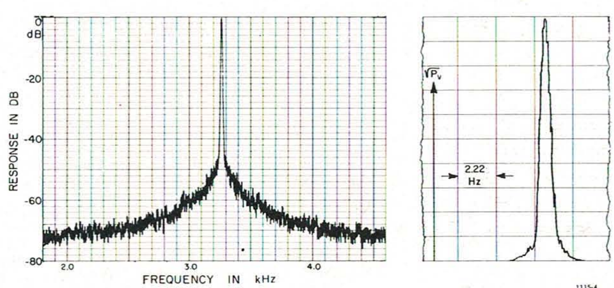
Frequency Stability

Temperature Effects: <±1 × 10^{-11} per degree C between 0°C and 50°C.

Loading of Output: <±2 × 10^{-11} open circuit to short circuit.

Supply Voltage: <±1 × 10^{-11} for ±10% ac line-voltage changes.
<±2 × 10^{-11} for 22 to 35 V, external dc.

Aging: <5 × 10^{-10} per day after 3 days of operation.
<1 × 10^{-10} per day is typical after 6 months.



(Left) X-band power spectrum of two 1115-C Standard-Frequency Oscillators. Analyzer bandwidth is 10 Hz. (Right) Center portion of spectrum measured with 0.54-hertz bandwidth. Vertical scale is linear ($\sqrt{power}$).

Short-Term Stability (5 MHz): Standard Deviation (sigma) is less than stated below (95% confidence):

Averaging Time	Frequency Deviation (Sigma)	Phase Deviation (Radians)
300 μs	100 × 10^{-11}	1 × 10^{-5}
1 ms	50 × 10^{-11}	1.5 × 10^{-5}
10 ms	10 × 10^{-11}	3 × 10^{-5}
100 ms	1.5 × 10^{-11}	4.5 × 10^{-5}
1 s	1 × 10^{-11}	3 × 10^{-4}
10 s	1 × 10^{-11}	3 × 10^{-3}

Spectral Purity: Line width of 5-MHz output multiplied by 2000 times (10 GHz or X band) is less than 0.25 Hz.

Noise Pedestal: Less than −145 dB per $\sqrt{Hz}$ at 5 MHz.

Power Required (ac or dc)

Ac: 90 to 130 or 180 to 260 V, 40 to 2000 Hz, 8 W at 115 V.

Dc: 22 to 35 V, 4 W at 24 V.

Emergency Power: Internal battery provides 24- to 35-hour operation depending on ambient temperature.

Terminals: Locking GR874, 5 MHz, 1 MHz, 100 kHz; type BNC, 1 MHz and 100 kHz for connection to 1123-A Digital Syncronometer.

Accessories Supplied: Power cord, spare fuses.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench model, 19 x 5⅝ x 14½ in. (485 x 145 x 370 mm); rack model, 19 x 5¼ x 14½ in. (485 x 135 x 370 mm).

Weight: Net, 37½ lb (17.5 kg); shipping, 52 lb (24 kg).

Catalog Number	Description	Price in USA
	1115-C Standard-Frequency Oscillator	
1115-9803	Bench Model	**$1800.00**
1115-9813	Rack Model	**1800.00**

File Courtesy of GRWiki.org

DIGITAL SYNCRONOMETER

Type 1123

- bright readout, hours/minutes/seconds
- BCD time output — 10-μs resolution
- time comparisons to 20 ns
- 24-hour internal battery
- timing pulses at 100, 10, 1 kHz, 100, 10, 1, and 0.1 Hz

The 1123 Digital Syncronometer® time comparator is a solid-state digital clock. It provides precise time-of-day information, visually, and in BCD-output form for logging time-of-event and time-interval data to 10-microsecond resolution. By making accurate comparisons between its own time and transmitted standard time (WWV, Loran C, etc), the 1123 can be used to rate local standard-frequency oscillators.

Portable Standard Time

Any number of remote clocks can be started from and synchronized to a master clock without interruption of the master. Precise time can be transported; one sets the clock at a master station and actually carries the standard time to remote locations.

DESCRIPTION: (see diagram)

Functions of the Syncronometer may be divided into four general parts: starting, timekeeping, synchronizing, and readout.

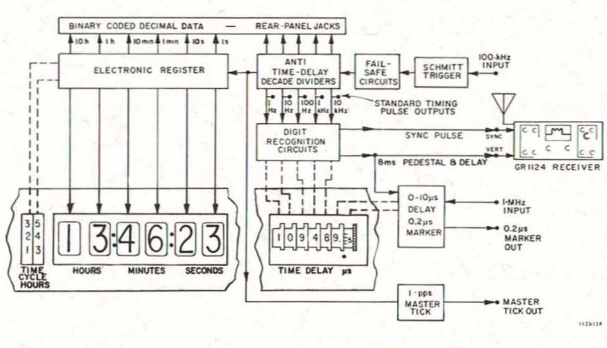
Starting is accomplished either by a front-panel push-button or by a pulse (from an external source or another Syncronometer). With either method any number of clocks can be started simultaneously and in synchronism with an operating master clock.

Timekeeping. A pulse train derived from the 100-kHz input is fed through fail-safe circuits, which stop the clock if input fails for even one cycle. The pulse train is then divided down to produce a 1-pulse-per-second master tick.

Time Comparison and Synchronization. The decade dividers of the timekeeping circuits provide, at output jacks, low-jitter, timing pulses at 100 kHz, 10 kHz, 1 kHz, 100 Hz, 10 Hz, 1 Hz, and 0.1 Hz. These signals also operate a five-digit recognition circuit to produce an 8-millisecond pedestal, occurring at 1 pps. This pedestal can be delayed a precise amount of time with respect to the master tick (delay time of 0.00000 through 0.99999 second is selected by front-panel thumbwheels). Pedestal and a sync pulse are provided for comparisons of the master tick with WWV-type transmissions on a CRO screen.

For intercomparisons where greater time resolution is possible (e.g., Loran C), a 1-MHz input is used to drive a delay circuit (0 to 9 microseconds in 1-microsecond steps, 0 to 1 microsecond continuously), which produces a 0.2-microsecond marker controlled by the last two front-panel thumbwheels.

The thumbwheels used in measuring the time interval between the master tick of the Syncronometer and the standard transmissions serve in **synchronizing** the master tick as well.

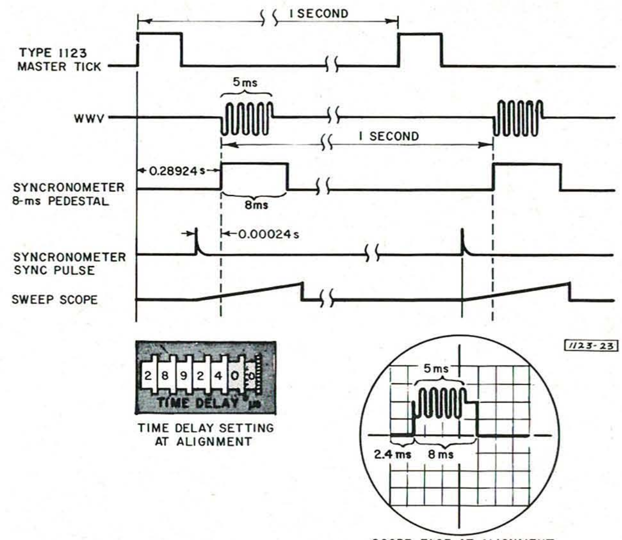


Timekeeping, readout, and comparison circuits of the 1123 Digital Syncronometer.

File Courtesy of GRWiki.org

To determine the precise time relationship of the Digital Syncronometer's master tick to WWV standard timing bursts, both the time transmission and the clock's 8-millisecond pedestal are displayed on a CRO screen. By means of front-panel thumbwheels, successive amounts of delay are introduced until the pedestal is exactly aligned with the WWV bursts. When the delay is determined, the 1123 need only be switched to self-sync operation, and the master tick will be shifted to synchronism with the transmission. The sync pulse retains oscilloscope synchronism and keeps the pedestal in view throughout the operation.

Where the characteristics of the standard-time transmission permit greater resolution than that provided by the 8-ms pedestal, the 0.2-μs marker can be used. With this marker, time comparisons with a precision of better than ±20 ns are possible.



Readout is both visual and electrical. The clock's 1-pps master ticks are accumulated and displayed in a six-digit bank of illuminated indicators, which can be preset to re-cycle at any number of hours from 1 to 99. The indication of each digit may be changed without carrying to the next digit or interrupting the master tick. Output BCD data from each digit of the visual bank and from each of the five decade dividers (0.1 second through 10 microseconds) are in parallel form, an invaluable aid in providing real-time information for time-dependent measurements.

— See **GR Experimenter** for February-March 1965.

specifications

Input: BNC connectors. 0.5 V at 100 kHz (sinusoid or square wave). 0.5 V at 1 MHz (sinusoid or square wave). Normally provided from 1115-C Standard-Frequency Oscillator (1 V into 50 Ω).

Outputs

Time of Day: From all decades, parallel 1-2-4-2 or 1-2-4-8 BCD, depending on model.

	1-2-4-2 Models	1-2-4-8 Models
Logical 0	Approx +0.5 V behind 100 kΩ	Approx +0.5 V behind 1 kΩ, (buffered)
Logical 1	Approx +15 V behind 100 kΩ	Approx +15 V behind 11 kΩ, (buffered)

Timing Pulses: 10 and 1 kHz, 100, 10, 1, and 0.1 Hz are available at output fittings on rear. These outputs are +15-V pulses with approx 100-Ω source impedance and a duty ratio of 0.2. In addition, a 100-kHz pulse signal is available.

Oscilloscope Sync Pulse: Settable in 1-ms steps 0.000 to 0.999 s.
Positive pulse, 13 V, Z approx 2.2 kΩ.
Duration, approx 7 μs.

Time-Comparison Pedestal: Follows oscilloscope sync by 000 to 990 μs (100- and 10-μs steps).
Positive pulse, 10 V from emitter follower.
Duration, approx 8 ms.
T_r <0.5 μs, T_f <0.5 μs.

Parallel Storage Unit page 172

0.2-μs Marker: 10-V positive pulse, 0.2-μs duration, with approx 20-ns rise and fall times, and 100-Ω source impedance. This marker is variable in 1-μs steps and a continuous 0- to 1-μs range from 0 to 10 μs after the 8-ms pedestal.

1-s Master Tick Output: Positive pulse from emitter follower.
Amplitude: 10 V. Duration, approx 5 ms. T_r <2 μs, T_f <2 μs.

Input Start Pulse: Logical 0 (0 V) to 1 (+15 V) holding for >10 μs. May come from second clock or external system.

Output Start Pulse: 11 μs, 0 to +15 V, from emitter follower.

Inhibit Pulse Output: Logical 1 (+15 V) to 0 (0 V); lasting approx 9 to 11 time units at lower frequencies, established by setting internal links for desired inhibit rate (no print on carry).

Visual Indication: 6 dimmable digital indicators for h, m, s.

Delay Setting for Time Measurement: 6 digital thumbwheel switches and 1 continuous (0-1 μs) control calibrated in 20-ns increments.

Visual Register Setting: Direct access to all six visual decades, carries inhibited.

Clock Functions: All control and setting functions are operated by a single pushbutton and are normally locked out and covered.

1. **Operate:** All program controls locked out.
2. **Start:** Clock will be started by 11-μs start pulse from pushbutton or from external source (BNC connector on rear). Start pulse produced and fed from instrument.
3. **Stop:** Clock will be stopped and all counting decades from 100 kHz to 1 Hz will be set to zero by pushbutton. Zero will hold until start command is received.
4. **Set:** Permits setting visual register. All visual-register carries interrupted; 100-kHz to 1-Hz dividers not affected. Selected decade is advanced by 1 count for each push of the initiate pushbutton.
5. **Self Sync:** Permits synchronizing master tick to within 10 μs of a measured time in another time system, as WWV on UT-2.
6. **Start-Slave:** Permits setting a second clock from the first. After the initiate button is pushed, a start pulse will be produced when the count reaches the setting of the time-delay switches of the first clock.

Measurement Rate: Switch permits oscilloscope sync at 10-Hz rate rather than the standard 1-Hz rate.

Power Required: 90 to 130 or 180 to 260 V, 50 to 60 Hz, 32 W approx or 24 to 32 V dc, 1 A approx. Self-contained nickel-cadmium battery for about 24-hour operation is supplied.

Accessories Supplied: Digital-output plug assembly, connector for external batteries, power cord, two 2-foot BNC cables, 3 board extenders, spare fuses.

Accessories Available: 1115-C Standard-Frequency Oscillator as source of 100-kHz and 1-MHz standard frequencies.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench model, 19 x 5⅝ x 14½ in. (485 x 145 x 370 mm); rack model, 19 x 5¼ x 12 in. (485 x 135 x 305 mm).

Weight: Net, 40 lb (18.5 kg); shipping, 54 lb (24.5 kg).

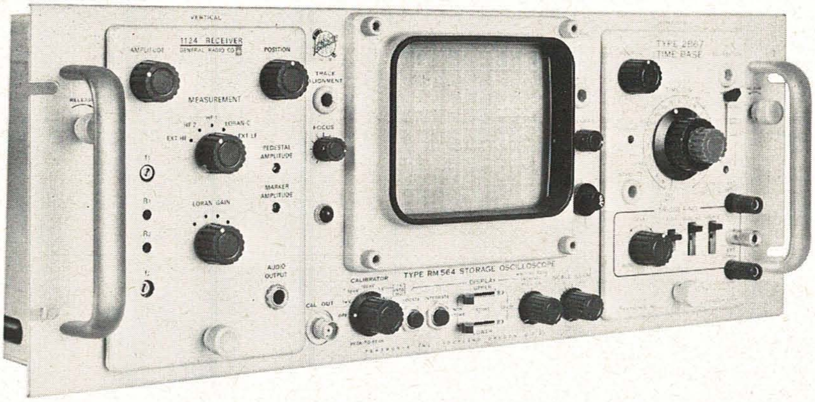
Catalog Number	Description	Price in USA
	1123 Digital Syncronometer	
	BCD Output Code 1-2-4-8	
1123-9760	115 V, Bench Model	**$3650.00**
1123-9763	115 V, Rack Model	**3650.00**
1123-9762	230 V, Bench Model	**3650.00**
1123-9765	230 V, Rack Model	**3650.00**
	BCD Output Code 1-2-4-2	
1123-9801	115 V, Bench Model	**3450.00**
1123-9811	115 V, Rack Model	**3450.00**
1123-9881	230 V, Bench Model	**3450.00**
1123-9891	230 V, Rack Model	**3450.00**

File Courtesy of GRWiki.org

frequency

RECEIVER

Type 1124



new

- for time-signal reception from Loran-C, WWV, or CHU
- oscilloscope display for precise comparisons
- Loran-C antenna supplied

The GR 1124 is a time-signal receiver for Loran-C and high-frequency operation consisting of a storage oscilloscope (Tektronix RM564 and 2B67 time-base unit) and a receiver plug-in. It displays the timing signals from either of two (of five available) high-frequency channels, Loran-C, or an external receiver, and from the GR 1123 Digital Syncronometer® time comparator.

The 1124 Receiver permits frequency standards equipped with time comparators (clocks) to be rated quickly and conveniently from any of several sources of timing signals. In a single instrument it combines many receivers, the necessary oscilloscope-display circuits, and automatic synchronization of the display sweep to the particular timing signal being used. All connections to the receiver are made at rear-panel terminals.

ANTENNA

A 100-kHz loop antenna is supplied with the 1124 Receiver for reception of Loran-C. The antenna is electrostatically shielded to reduce interference and is equipped with a versatile mount for easy installation.

specifications

HIGH-FREQUENCY RECEIVERS

Rf Frequencies: 2.5, 3.33, 5.0, 7.335, and 10 MHz. Any two are selected by a front-panel switch.

Sensitivity: Better than 3 μV.

Input Impedance: Approx 50 Ω.

Max Input Signal: >100 mV.

Bandwidth: I-f 3-dB bandwidth approx 3 kHz; 3.0 MHz center frequency of i-f amplifier and crystal filter.

Automatic Gain Control: Receiver output is within 3 dB for signal change of 10 μV to 100 mV.

Image and I-f Rejection: >80 dB; all other spurious responses at least 70 dB down.

LORAN-C RECEIVER

Center Frequency: 100 kHz; 3-dB bandwidth approx 20 kHz.

Sensitivity: 3 μV for S/N >2.

Input Impedance: Approx 50 Ω.

Max Input Signal: >100 mV.

Gain Control: 4 fixed steps, 60-dB total range.

Notch Filters: Two, front-panel screwdriver-control, 80 to 95 kHz and 105 to 125 kHz (other ranges with internal-capacitor change). Rejection >40 dB; 6-dB bandwidth <3 kHz.

EXTERNAL INPUT Intended for comparing other timing signals with the GR 1123 comparator.

Sensitivity: Approx 0.5 V for full-screen deflection.

GENERAL

Front-Panel Controls: Amplitude (20-dB range), vertical position, input-channel selector, gain; screwdriver controls: notch-filter tuning (2), 1123 pedestal amplitude, and 1123 marker amplitude.

Connections: Front panel: audio output, approx 1 V, for monitoring hf receiver. Rear panel (BNC connectors): Loran antenna, hf antenna, ext-signal input, and pedestal, sync, and marker pulses from 1123.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz, 240 W.

Accessories Supplied: Storage-oscilloscope accessories, shielded-cable set, 1124-P1 Antenna.

Mounting: 19-inch rack-mount.

Dimensions (width x height x depth): 19 x 7 x 18½ in. (485 x 180 x 470 mm).

Weight: Net, 42 lb (19.5 kg); shipping, c 70 lb (32 kg).

specifications — 1124-P1 Antenna

Center Frequency: 100 kHz.

Bandwidth: Approx 20 kHz at 3-dB points, with 50-Ω load.

Dimensions (width x height x depth): 58 x 86 x 3¾ in. (1480 x 2200 x 96 mm).

Catalog Number	Description	Price in USA
1124-9701	**1124 Receiver**	**$3250.00**

File Courtesy of GRWiki.org

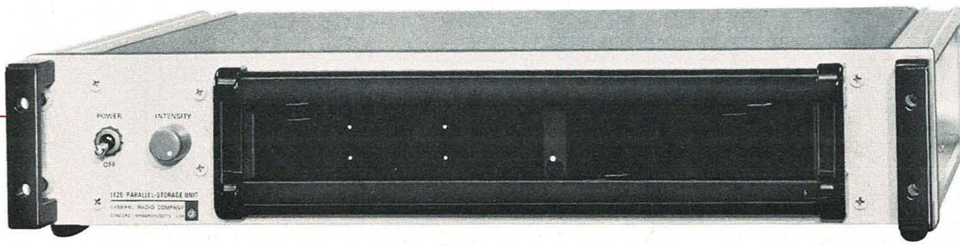
frequency

PARALLEL-STORAGE UNIT

Type 1125

- accessory for 1123 Digital Syncronometer
- 2-μs jam-transfer for BCD data
- 11-digit capacity

new



1123 Syncronometer page 169

The 1125 Parallel-Storage Unit will accept eleven BCD digits of time-of-day information from the GR 1123 Digital Syncronometer® time comparator* in 2 microseconds. This permits time data to be read on command to the nearest 10 microseconds and stored for transfer to slower-reading devices such as card and tape punches, printers, etc. While stored in the 1125, the time in hours, minutes, and seconds (to 10^{-5} s) is displayed on eleven in-line indicators and is available as electrical data in 1-2-4-8 BCD format. The 1125 will accept inhibit signals from both its input and output devices to prevent transfer of data while input is changing or while output is being read.

Although intended for use primarily with the GR digital time comparator, the 1125 Parallel-Storage Unit will serve well in other systems where high-speed parallel jam-transfer is needed. Positive logic is required, but a reference terminal is provided to set the data-zero level at a voltage other than chassis ground.

* Must be used with 1123 models with 1-2-4-8 buffered output.

specifications

TRANSFER CHARACTERISTICS

Capacity: 11 decimal digits (44 bits) parallel-entry jam-transfer; 10 μs resolution.

Transfer Time: 2 μs approx, for up to 8-ft data cables.

Mode: Data are stored until next store command.

INPUT

Data: 4-line BCD, 1-2-4-8; fully compatible with output of 1-2-4-8 versions of GR 1123 time comparator.

Store Command: Positive or negative transition (switch-selected) between 0 and at least +5 V. Input impedance >100 kΩ, dc coupled.

Digital Data Instruments page 60 ff

Inhibit Signal (from 1123): Inhibits transfer while input data are changing.

Inhibit Signal (internal or external): Inhibits transfer while stored data are read by output equipment. Internal inhibit is equal in duration to print command (see below). External inhibit signal can be presence of either 0 or at least +5 V (switch-selected); input impedance >100 kΩ, dc coupled.

OUTPUT

Data: 4-line BCD, 1-2-4-8 with GR 1123.

Logic Levels:
"1" = +10 V
"0" = 0 V

Output Impedance: Approx 6.8 kΩ at logic "1," approx 12 kΩ at logic "0."

Print Command: Pulse of +5 V behind 15 kΩ, duration adjustable 20 ms to 0.5 s; set initially for use with GR 1137 Data Printer.

Data-Ready Signal: Pulse of +15V behind 5 kΩ, 50-μs duration, occurs 10 μs after transfer is completed.

Readout: 11 in-line digital indicators. Indicates 10's of hours through 10 μ.

GENERAL

Power Required: 90 to 130 or 180 to 260 V, 50 to 60 Hz, 15 W.

Accessories Supplied: Data and inhibit signal cables for connection to GR 1123, output data connector, power cord, spare fuses, mounting hardware with rack models.

Accessories Available: GR 1137 Data Printer and other digital-data acquisition instruments.

Mounting: Rack-bench cabinet.

Dimensions (width x height x depth): Bench, 19 x 3⅞ x 17 in. (485 x 99 x 435 mm); rack, 19 x 3½ x 16¾ in. (485 x 89 x 425 mm).

Weight: Net, 23½ lb (11 kg); shipping, 45 lb (20 kg).

Catalog Number	Description	Price in USA
	1125 Parallel-Storage Unit	
1125-9801	Bench Model	**$2600.00**
1125-9811	Rack Model	**2600.00**

File Courtesy of GRWiki.org

FREQUENCY-MEASURING INSTRUMENTS

An unknown frequency is measured by comparison with a standard frequency. The comparison may be direct, as with a digital frequency meter that includes a quartz-crystal-oscillator time base, or indirect, as with a calibrated, analog-type frequency meter.

The digital frequency meter, or counter, measures frequencies up to about 100 MHz directly and economically. The scaler is an economical means of extending the range, by direct-counting techniques, upward by a factor of 10 or 100 up to 500 MHz. The block diagram of Figure 1 illustrates the several possible frequency-measuring combinations.

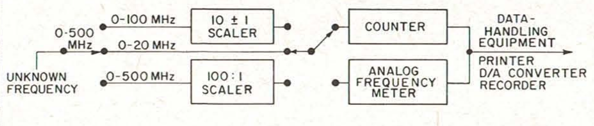


Figure 1. Frequency measurement techniques. Frequencies shown are approximate upper limits for the various systems.

Frequency can also be measured in terms of period or period multiples. A computing counter such as the GR 1159 measures all frequencies in its range in terms of their periods, computing and displaying the result in frequency terms. It is programmed to change ranges automatically to fill the readout registers with significant digits providing 6-place readout at all frequencies. It offers the advantages of fast, automatic, high-resolution measurement over its entire frequency range.

There are many measurements where the high resolution of the counter is not required, and, for these, the direct-reading analog frequency meter is satisfactory and is less expensive than the digital type. See GR 1142-A.

DIGITAL FREQUENCY METERS

The elements of a digital frequency meter (commonly called a counter) are shown in Figure 2. The reference standard, usually called the time base, is a quartz-crystal oscillator. For period measurement, the counter totals the number of standard pulses from the time base for one or more periods of the unknown frequency. For direct frequency measurement, it counts the number of cycles of the unknown in a standard time interval, usually one second. In either type of measurement, the result is displayed as a series of illuminated digits.

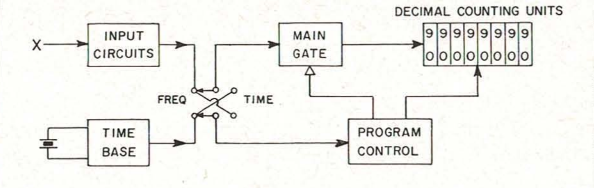


Figure 2. Elementary block diagram of a digital counter.

In addition to its basic function of measuring frequency (or period), the counter can also count events (pulses), whether uniform in rate or random, and display the total. It can also be made to measure the ratio of two input frequencies.

The GR 1191 Counter employs integrated circuits and is designed for maximum performance at low cost. All models include a precise quartz oscillator as the measurement reference. Input controls are provided to permit reliable counting, regardless of input waveform. Counting-time controls vary the resolution of the readout over a 10^7:1 range so that any digits of interest are displayed — coarse digits for coarse measurements, fine digits for fine measurements.

RANGE EXTENSION — to 100 MHz or 500 MHz

Higher frequencies are measured by a combination of the 1191 Counter and the Type 1156-A Decade Scaler (up to 100 MHz) or the 1157 Scaler (100-to-1, up to 500 MHz). These scalers have been designed as independent, self-contained instruments based on the "add-a-unit" philosophy pioneered by General Radio. They may be used with other counters or other types of instruments for a variety of measurements.

PRESET OPERATION

The GR 1191 Counter can be operated in either of two preset modes by the addition of the GR 1399 Digital Divider/Period and Delay Generator, which can produce a time base for the counter of arbitrary frequency for normalized-unit readout or can count events and gate the counter to read time interval for a predetermined number of events.

1399 Divider/ Generator page 227

ANALOG FREQUENCY METER

The 1142-A Frequency Meter and Discriminator is a pulse-count-discriminator type of frequency meter with an over-all accuracy of 0.2% and a range of 3 Hz to 1.5 MHz. With the 1156-A Decade Scaler, its range is increased to 15 MHz; with the 1157 100-to-1 scaler it can be used to 150 MHz.

In addition to its use as a frequency meter, the 1142 operates as a highly linear discriminator for measurements of fm deviation, either the wide swings characteristic of fm systems or the very small swings encountered in measurements of incidental fm and of short-term frequency stability of oscillators.

ACCESSORY EQUIPMENT

Data-handling equipment — D/A converter, data printer, and graphic recorder — is available for use with GR digital frequency meters and is described elsewhere in this catalog. Combinations of frequency meter and auxiliary equipment can be assembled to meet the user's requirements.

Data Instr page 60 ff

We shall be glad to quote on combinations to meet your needs.

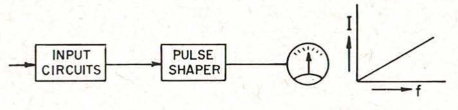


Figure 3. Elementary block diagram of an analog frequency meter.

File Courtesy of GRWiki.org

frequency measuring

COUNTER

Type 1191

- frequency to 20, 100, 500 MHz
- programmable, all functions dc controlled
- economical, modern IC design
- 10-mV sensitivity

new

The 1191 is a general-purpose counter-timer for measuring frequency, period, period average, frequency ratio, and time interval. Extensive use of integrated circuits in the 1191 has resulted in an economical counter with full features and top performance.

AUTOMATIC OPERATION

Scalers page 178

Remote programmability of measurement functions, ranges, and most of the secondary controls, such as display time, makes the 1191 unexcelled as a component in automatic measuring systems. The counter functions are dc controlled, most by simple contact closures to ground. Models are available with high-speed, buffered BCD outputs from internal storage to drive auxiliary data-handling equipment.

OPERATOR CONVENIENCE

The readout of the 1191 is 8 digits of high-intensity neon indicators, with automatic display of decimal point and measurement dimensions. The internal storage gives continuous, flicker-free display of rapidly corrected data. The operator has control of all input trigger circuit characteristics.

INPUT CIRCUITS

The counter has two high-sensitivity input channels, each consisting of a high-impedance, low-noise FET circuit preceded by a 3-position step attenuator and including controls for trigger level, slope and polarity. The 1-megohm input impedance is independent of control settings to permit use of general-purpose low-capacitance oscilloscope probes. One such probe is offered as an accessory to the 1191.

TIME BASE

Model options allow a choice of time base to match needs and budgets. An inexpensive room-temperature-crystal oscillator affords adequate stability for many applications. Or, the counter can be ordered with a more stable crystal-oscillator time base with proportional temperature control. For the greatest possible stability, either oscillator can be phase locked to an external standard frequency of 10 MHz or any submultiple down to 100 kHz. A front-panel monitor is included for this purpose. Oscillator frequency can be set with an easily accessible, rear-panel dc-voltage adjustment.

specifications

MEASUREMENT RANGES AND ACCURACY

Frequency: Dc to 20 MHz; 1-μs to 10-s counting gate times. Accuracy, ± 1 count ± time-base accuracy.

Single Period: 1 to 10^9 s measured by counting 0.1-μs to 10-s intervals derived from internal 10-MHz clock. Accuracy (see note) is dependent on the signal-to-noise ratio of the input signal, the counter input noise, and the ± 1-count error.

Multiple Period: 1 to 10^8 periods measured by counting internal 10-MHz clock. Accuracy, (see note).

Time Interval: 0.1 μs to 10^9 s measured by counting 0.1-μs to 10-s intervals derived from internal 10-MHz clock. Accuracy (see note), ± 1 clock pulse ± trigger error ± time-base stability. Interval is measured between "start" and "stop" signals driving the input channels independently, or from a single signal with common connection between channels, as for pulse-duration measurements.

Frequency Ratio: 1 to 10^8. Frequency "A", dc to 20 MHz, is measured over 1 to 10^8 periods of frequency "B", dc to 10 MHz. Accuracy, ± 1 count of "A" ± trigger error divided by number of "B" periods.

Count: Register capacity, 10^8. Events are accumulated between "start" and "stop" commands from manual panel buttons or, externally, from contact closures or solid-state switches. In "count", storage is automatically disabled.

INPUT

Frequency: Channel "A", dc to 20 MHz (3 Hz to 20 MHz ac-coupled); channel "B", dc to 10 MHz (3 Hz to 10 MHz ac-coupled).

Sensitivity: 10 mV rms sine wave, 30 mV pk-pk pulse; trigger level variable ±100 mV.

Attenuator: x1, x10, x100 (0, 20, 40 dB); low-capacitance 10:1 probe available.

Voltage Rating: Input voltage should not exceed 150 V on x1 or 300 V on x10 or x100.

Impedance (all attenuator settings): Approx 1 MΩ shunted by 35 pF. At rear connectors (supplied mounted, unwired), shunt C increases to approx 70 pF.

Signal Polarity: Front-panel control permits selection of positive- or negative-going signal sense for triggering.

File Courtesy of GRWiki.org

10-MHz TIME-BASE OPTIONS

Room-Temperature Oscillator

Stability: $<2 \times 10^{-7}/°C$ from 0° to 50°C. Drift less than $\pm 2 \times 10^{-6}$ per month. With ±10% line-voltage variation, $<2 \times 10^{-8}$.

Manual Adjustment Range: $\pm 1 \times 10^{-5}$ at rear-panel control.

High-Precision Oscillator (in proportional-control oven)

Stability: $<2 \times 10^{-10}/°C$ from 0° to 50°C when operated continuously. Drift $\pm 1 \times 10^{-8}$ per week, approx 2×10^{-9} per day after 1 month of continuous operation. With ±10% line-voltage variation, $<2 \times 10^{-10}$.

Manual Adjustment Range: $\pm 1 \times 10^{-6}$ at rear-panel control.

Time-Base Output: 10-MHz square wave, 2 V pk-pk behind 50 Ω at rear-panel BNC connector.

External Phase-Lock: Both time-base oscillators can be locked to external standard frequency at 0.1, 1, 2.5, 5, or 10 MHz, of at least 1 V rms into 1 kΩ. A front-panel phase-lock indicator lamp is provided.

NOTE — Trigger error in time measurements: ±0.3% of one period ÷ number of periods averaged, for a 40-dB input signal-to-noise ratio. This assumes no noise internal to the counter. For input signals of extremely high signal-to-noise ratio, the trigger error in μs will be <0.0005 ÷ the signal slope in V/μs.

DATA PRESENTATION

Display: 8-digit display with automatically positioned decimal point and measurement dimensions. High-intensity neon readout tubes.

Storage: Display can be either stored or not. Operator can select from approx 100 μs or 10 s or infinity for display time (in normal mode) and for data holdoff time (in storage mode).

Data Output (in some models): Fully buffered 1-2-4-8 BCD output at standard DTL levels; data zero is 0.5 V max and data 1 approx 5 V behind 6 kΩ.

PROGRAMMING

Input: All instrument functions controllable by closure to ground within capabilities of DTL micrologic (2- to 6-mA sink current required), except:

PERIOD and TIME INTERVAL require approx 50-mA-capacity external closures for added load of dimension-display lamps.

Functions controlled by other than contact closure:

Input Threshold: Requires dc voltage of ±100 mV corresponding to desired threshold level.

Display Time: Requires RC circuit to ground. Display/hold-off interval is approx one RC time constant.

Nonprogrammable functions: Input attenuator, input ac/dc coupling, separate/common switch, self-test, internal/external control of time-base oscillator, and frequency adjustment of time-base oscillator.

GENERAL

Environmental: 0° to 50°C operating range.

Power Required: 100 to 125 or 200 to 250 V, 50 to 400 Hz, 32 W.

Accessories Supplied: Rack-mounting hardware set, power cord, spare fuses.

Accessories Available: Input probe, 1156 Decade Scaler for measurement to 100 MHz; 1157 Scaler (100-to-1) for measurement to 500 MHz; 1137 Data Printer, and other GR digital-data acquisition equipment.

Dimensions (width x height x depth): Bench model, 19 x 3⅞ x 12¾ in. (485 x 99 x 325 mm); rack model, 19 x 3½ x 11 in. (485 x 89 x 280 mm).

Net Weight (approx): 22 lb (10 kg).

specifications — FOR INPUT PROBE — 1158-9600

Input Impedance: 10 MΩ shunted by approx 7 pF when used with 1191 counter.

Attenuation: ×10 (20 dB).

Voltage: 600 V dc or ac pk-pk, max up to 5.7 MHz; less at higher frequencies.

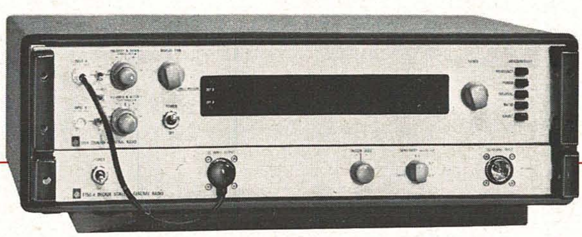
Length: 3½ ft.

Catalog Number	Description	Price in USA
	1191 Counter	
1191-9700	Bench Model	**$1340.00**
1191-9701	Rack Model	**1340.00**
1191-9702	Bench Model with Data Output Option	**1390.00**
1191-9703	Rack Model with Data Output Option	**1390.00**
1191-9704	Bench Model with High-Precision Time-Base Option	**1490.00**
1191-9705	Rack Model with High-Precision Time-Base Option	**1490.00**
1191-9706	Bench Model with both Options	**1540.00**
1191-9707	Rack Model with both Options	**1540.00**
1158-9600	**P6006 Probe,** Tektronix Catalog No. 010-0127-00 (not sold separately)	**22.00**

COUNTER

Type 1191-Z

- measure frequency to 100 MHz, 500 MHz



The 1191 counter-timer is available in combination with either of two GR scalers that extend the frequency-measuring range to 100 or 500 MHz by dividing the input frequency by a factor of 10 or 100, respectively.

The counter and scaler are offered in rack-mount or bench versions, the latter supplied with the two instruments mounted in a single cabinet.

In combination, the 1191 Counter and a scaler are economical and provide all the features of the counter alone, full counter-timer functions, programmability, high-speed data access, with the extra benefits of high-frequency operation.

Scalers page 178

specifications

Dimensions (width x height x depth): Bench, 19½ x 6½ x 12¾ in. (495 x 170 x 325 mm); rack, 19 x 5¼ x 11 in. (485 x 135 x 280 mm.

Net Weight (est): Bench, 30 lb (14 kg); rack, 15 lb (7 kg).

Shipping Weight (est): Bench, 50 lb (23 kg); rack, 30 lb (14 kg).

Catalog Number	Description	Price in USA
	1191-Z Counter (100 MHz)	
1191-9900	Bench Model	**$2040.00**
1191-9901	Rack Model	**2040.00**
	1191-Z Counter (500 MHz)	
1191-9902	Bench Model	**2190.00**
1191-9903	Rack Model	**2190.00**

File Courtesy of GRWiki.org

frequency measuring

RECIPROMATIC COUNTER

Type 1159

- 0.6 Hz to 20 MHz; to 500 MHz with scaler
- 6-digit resolution
- 0.1 second per measurement
- fully automatic ranging; programmable controls
- integrated-circuit design

new

Scalers
page 178

The Type 1159 Reciprοmatic Counter uses a built-in computer to combine the resolution and speed of a period measurement with the convenience of direct frequency readout. The computer also selects the measurement range automatically so that the result is always displayed as a 6-digit number with the measurement units correctly labeled and the decimal point correctly positioned.

In measuring several widely spaced frequencies with previous counters, it was necessary either to change range or to accept less-than-maximum resolution at the lower frequencies. Furthermore, in measuring low frequencies, high-resolution readings required either long measurement intervals or the need to make period measurements and then to calculate frequency. In manual measurement systems, these considerations slow down accurate measurements and increase the likelihood of operator error, while in automatic systems they lead to greater system complexity and often to poorer system performance.

By contrast, the 1159 measures the period of the unknown signal and computes the reciprocal for display in units of frequency. A full six-digit reading is always displayed, regardless of frequency, because the counter automatically selects the appropriate period multiples and clock frequency to ensure maximum resolution.

SIMPLICITY OF OPERATION

In using the 1159, the operator simply applies the unknown frequency to the counter input and reads the result. The front panel contains only the power switch and reset button. The display-time controls and a few controls useful in accommodating adverse input-signal conditions are concealed behind a hinged panel.

PROGRAMMED OPERATION

When the 1159 is used as a system component, its essentially automatic operation minimizes the need for external programming. The few manual controls are fully programmable and BCD data output is provided for operation of a printer or other data-handling equipment. An additional feature is the ability to control the readout dimensions so that correct data will be obtained when the 1159 is preceded by a 10-to-1 or 100-to-1 scaler.

TIME BASE

The time base of the 1159 is controlled by a stable 10-MHz crystal in a proportional-controlled oven. Its rapid warmup and high-stability characteristics ensure that the full accuracy of the 1159 is available promptly and will be maintained for long periods between recalibrations. The oscillator can also be phase-locked to an external 100-kHz or 1-MHz reference.

APPLICATIONS

The 1159 can be used in any frequency measurement where both speed and accuracy are needed. It is especially useful in accelerating the test and calibration of frequency sources such as oscillators, signal generators, and voltage-to-frequency converters, particularly at low frequencies. The 1159's automatic ranging capability can be used at frequencies up to 500 MHz by use of GR 1156 or 1157 Scalers.

File Courtesy of GRWiki.org

specifications

Frequency-Measurement Range: 0.6 Hz to 20 MHz. In the fast mode, 6 Hz to 20 MHz; in the slow mode, 0.6 Hz to 9.99999 MHz. Extend range to 100 or 500 MHz without loss of accuracy with GR 1156 (10:1) or 1157 (100:1) Scaler.

Frequency-Measurement Accuracy: $\pm 1 \times 10^{-6} \pm$ clock accuracy $\pm$ noise (see note).

Measurement Rate: Sum of adjustable display time, 0.02 to 10 s and ∞, and measurement time of about 100 ms in fast mode or 1 s in slow mode.

INPUT

Sensitivity: Typically 20 mV rms at 20 MHz; 10 mV rms from 1 Hz to 10 MHz.

Bandwidth: Ac-coupled input, −3 dB at approx 1 Hz. Bandwidth switch sets −3 dB points at approx 10 or 1 MHz, 100, 10, or 1 kHz.

Impedance: 1 MΩ∥27 pF for up to 5-V pk-pk input; 0.67 MΩ∥30 pF for up to 200 V pk-pk. Input capacitance can be reduced by disconnecting either unused front- or rear-panel input connector. Front only, 20 pF; rear only, 17 pF.

Trigger Threshold: ±20 mV, adjustable.

Slope: Positive- or negative-going, switch-selected.

CLOCK

Internal: 10-MHz, third-overtone quartz-crystal oscillator in proportional-controlled oven.

Temperature Effects: $<1 \times 10^{-6}$ from 0 to 50°C ambient.

Warmup: Within 1×10^{-6} in 10 minutes at 25°C ambient.

Stability: Better than 3×10^{-9} per day after 1 month of operation; better than 1×10^{-6} per year.

External Control: Internal clock oscillator can be phase-locked to external 100-kHz or 1-MHz signal of at least 1 V rms.

GENERAL

Programmability: All control functions can be programmed by contact closures to ground (2- to 4-mA sink current required) except display time, which requires an external resistance of 0 to 100 kΩ, and trigger level, which requires 0 to ±5 V dc.

Data Output: 1-2-4-8 BCD-DTL output for 6 digits of data, decimal point, and measurement units. Data zero is 0.5 V max (12-mA current sinking capability); data one is approx 5 V behind 6 kΩ.

Display: Six neon readout tubes, automatically positioned decimal point, and measurement units. Dimensions can be multiplied by 1, 10, or 100 with rear-panel switch for use with 10:1 or 100:1 prescaler.

Power Required: 100 to 125 or 200 to 250 V, 50 to 400 Hz, 60 W.

Accessories Supplied: Power cord, spare fuses, mounting hardware with rack models.

Accessories Available: GR 1156 (10:1) and 1157 (100:1) Scalers, 1137 Data Printer, 1136 Digital-to-Analog Converter, other GR data-handling equipment.

Scalers page 178

Mounting: Rack-bench cabinet.

Dimensions (width x height x depth): Bench, 19½ x 4⅞ x 15 in. (495 x 125 x 385 mm); rack, 19 x 3½ x 12 in. (485 x 89 x 305 mm).

Net Weight (est): Bench, 28 lb (13 kg); rack, 21 lb (10 kg).

Shipping Weight (est): Bench, 43 lb (20 kg); rack, 36 lb (16.5 kg).

Note — Noise affects precision of frequency measurement. For additive noise on signal measured, the error in measurement will be $\epsilon = \frac{N}{\pi S n}$ where N is the noise level and S the signal level in the same units; n is the number of periods averaged. Internally produced noise in the counter will determine the limiting error level. For the 1159, this internal noise is approx 50 μV rms.

Catalog Number	Description	Price in USA
	1159 Recipromatic Counter	
1159-9700	Bench Model	**$2235.00**
1159-9701	Rack Model	**2235.00**

Automatic Frequency-Measuring Systems

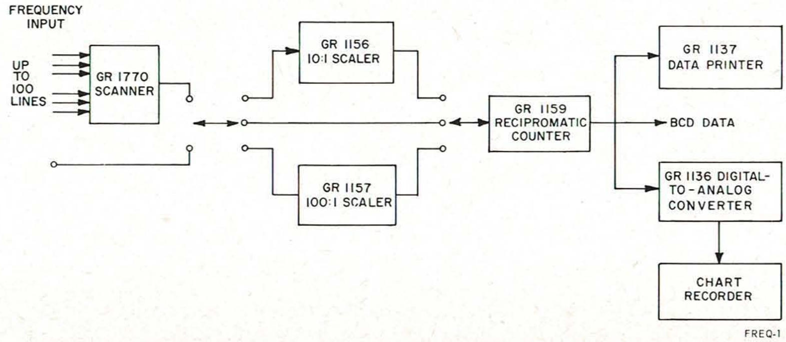
The 1159 Recipromatic Counter is excellent for use in automatic frequency-measuring systems. Its ability to change range automatically means that external instructions to the counter are minimal and infrequent as they concern only secondary functions. Thus, frequency-measuring systems that include the 1159 can be greatly simplified.

Automatic ranging facilitates use of an input scanner to measure many widely diverse frequencies with full readout resolution, an impossible task with most counters unless an operator or external ranging program is employed. As many as 100 signal lines can be scanned by the GR 1770 Scanner System.

The BCD data output can be used to plot, record, or compute from the measurement results. The GR 1137 Data Printer will produce a permanent printed record of up to 12 digits, enough capacity for counter data as well as such corrolary information as channel numbers from an input scanner. The 1136 Digital-to-Analog Converter will provide the frequency data to a recorder in suitable analog form to plot, for example, frequency as a function of temperature.

System Components page 60 ff

We are interested in discussing any specialized requirements you may have; custom measurement systems can be supplied designed to meet your particular needs.



Some possible frequency-measuring-system combinations using the 1159 Recipromatic Counter.

File Courtesy of GRWiki.org

DECADE SCALER

Type 1156-A

- dc to 100 MHz
- input: 30 mV rms into 50 Ω
- output: 5 V pk-pk behind 250 Ω

The 1156 will extend the frequency range of any counter by 10-to-1 up to 100 MHz. It can be used with any GR counter, counters of other makes, oscilloscope trigger circuits, analog frequency meters, or in any application calling for 10-to-1 frequency division.

The 1156 input circuitry consists of a sensitive amplifier, which also serves to isolate the input from switching circuit noise, preceded by an attenuator with one 500-ohm and four 50-ohm positions. A level control permits optimum triggering with a variety of inputs including sine waves, pulses, and noisy signals. The input and output connectors can be attached to either the front or the rear of the instrument.

— See **GR Experimenter** for September 1965.

specifications

INPUT

Frequency: Dc to 100 MHz (to 125 MHz with reduced sensitivity).

Sensitivity: 0.1, 0.2, 0.5, and 1 V, pk-pk, at 50 Ω; 1 V pk-pk, at 500 Ω. Maximum input is 20 times sensitivity or ½ W, whichever is smaller.

Impedance: 50 or 500 Ω. VSWR into 50 Ω is <1.1 at 100 MHz; reflection <10% with 0.4-ns step.

OUTPUT

Frequency: Dc to 10 MHz. Approx square-wave output, 20 mA pk-pk; >5 V pk-pk open-circuit, 1 V pk-pk into 50 Ω.

Impedance: 250 Ω.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz, 15 W.

Terminals: GR874 Locking Connectors. For connection to other types of coaxial connectors, use a locking adaptor.

Accessories Supplied: Power cord, spare fuses, 874-to-BNC patch cord.

Accessories Available: 874-K Coupling Capacitor for ac coupling to input or output connectors.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench, 19 x 2⅛ x 12¼ in. (485 x 54 x 315 mm); rack, 19 x 1¾ x 11¼ in. (485 x 45 x 290 mm).

Weight: Net, 10¾ lb (4.9 kg); shipping, 25 lb (11.5 kg).

Catalog Number	Description	Price in USA
	1156-A Decade Scaler	
1156-9801	Bench Model	**$500.00**
1156-9811	Rack Model	**500.00**

SCALER 100:1

Type 1157

- 1 to 500 MHz

new

Similar to the 1156 10:1 Scaler, the 1157 100:1 Scaler will extend the range of any frequency-measuring instrument to a maximum of 500 MHz. Thus, it too is a valuable accessory to the GR 1191 and 1159 Counters and 1142 analog frequency meter giving them 500-, 500-, and 150-MHz capabilities respectively.

The 1157 is completely self-contained. It can be used with virtually any frequency meter or counter and in many other applications, such as oscilloscope triggering. It has an input attenuator, front- or rear-panel input and output connectors, and a panel meter to aid in setting proper input level.

specifications

INPUT

Frequency: 1 to 500 MHz.

Sensitivity: Better than 0.1 V rms (0.3 V pk-pk) over entire range.

Impedance: 50Ω.

Attenuator: 1-2-5 sequence for signals up to 5 V rms.

Max Input: 5 V rms.

OUTPUT

Frequency: 0.01 to 5 MHz. Approx square-wave output, 20 mA pk-pk; >5 V pk-pk open-circuit, 1 V pk-pk into 50Ω.

Impedance: 250Ω.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz, 25 W.

Terminals: GR874 locking connectors; can be attached to either front or rear panel. Adaptors to other connector types available.

Accessories Supplied: 874-C58A Cable Connector, power cord, spare fuses, rack- or bench-mount hardware, 874-to-BNC patch cord.

Accessories Available: 874-K Coupling Capacitor for ac-coupling to input.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench, 19 x 3⅞ x 14¾ in. (485 x 99 x 375 mm); rack, 19 x 3½ x 13¼ in. (485 x 89 x 340 mm).

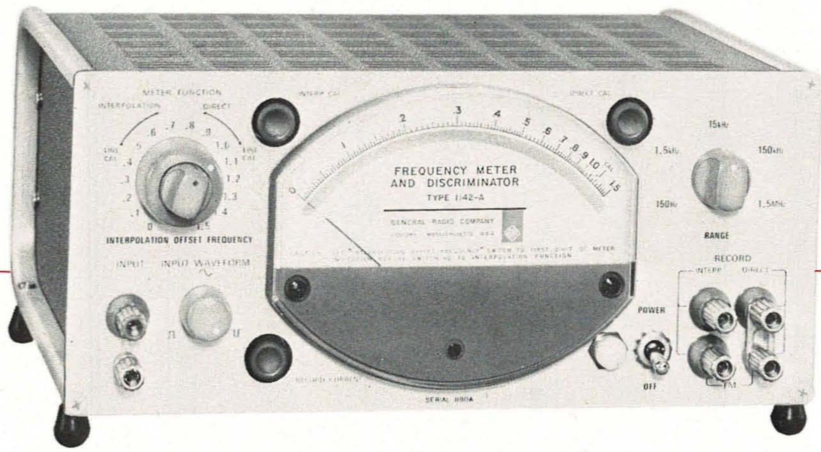
Catalog Number	Description	Price in USA
	1157 Scaler 100:1	
1157-9801	Bench Model	**$650.00**
1157-9811	Rack Model	**650.00**

File Courtesy of GRWiki.org

FREQUENCY METER AND DISCRIMINATOR

Type 1142-A

- 3 Hz to 1.5 MHz; to 15 MHz with 1156-A Decade Scaler to 150 MHz with 1157 Scaler
- 0.2% accuracy
- 0.1% resolution through scale expansion
- as an fm discriminator: linear, low-noise, high-level output



For making frequency measurements, the 1142-A can be used in several ways: direct-reading for speed and ease; with built-in scale expansion for greater accuracy and high resolution; with 1156-A Decade Scaler for measurements to 15 MHz; and with an oscillator to heterodyne the unknown frequency. By this means even higher frequencies can be measured, and resolution is increased in proportion. At 100 MHz, drift and incidental fm can be measured to better than one part in 10^9.

Dc and fm outputs permit frequency changes to be recorded and the 1142 to be used as an fm discriminator.

USES

- Measure fm deviation and spectra
- Record oscillator drift or aging
- Measure doppler shift
- Analyze tape recorder dynamics
- Convert frequency to dc for X-Y plotters
- Linearize voltage-controlled oscillators

Scalers page 178

OPERATION

The 1142-A is a pulse-count discriminator. The ac input signal is converted to a train of fixed amplitude and duration pulses, one pulse for each cycle of the input signal. The meter responds to the average dc component of the pulse train, which is proportional to pulse rate, hence to input frequency. An fm input signal adds to the dc an ac component that reproduces the modulating signal and whose amplitude is a measure of deviation.

specifications

INPUT

Frequency: 3 Hz to 1.5 MHz in 5 ranges; full scale values of 150 Hz to 1.5 MHz. A calibrated interpolation feature expands meter scale by a factor of 10 so that 1/10 of any range covers the full scale, providing a readout precision of 0.1%.
Sensitivity: 20 mV rms, 20 to 150 Hz; rising to 200 mV at 3 Hz and 1.5 MHz. Up to 5 V for narrow pulses (1 ns) required.
Max Input: 300 V pk-pk up to 150 kHz; 70 V pk-pk above 150 kHz.
Impedance: 100 kΩ, dropping to no less than 5 kΩ above 500 kHz.

ACCURACY

Over-all: 0.2%, nominal. Internal calibration at twice line frequency to standardize output current. Over-all accuracy is the sum of recorder output current accuracy and any of the other errors that are applicable.
Recorder Output Current: Below 15 kHz, 0.05% of full scale +0.05% of reading; above 15 kHz, 0.1% of full scale +0.1% of reading.
Meter: Direct reading, 1% of reading above 10% of full scale (0.1% of full scale below 10% of full scale). Interpolating, 0.1% of full scale (range switch setting).
Line-Voltage Effect: ±10% change produces approximately ±0.2% change in reading (±0.5% on 1.5-MHz range).
Warmup Drift: Less than 0.2% of reading after a few minutes, substantially complete within 30 minutes.
Ambient-Temperature Effect: Output current changes less than 0.01%/°C (0.02%/°C on 1.5-MHz range).

DISCRIMINATOR CHARACTERISTICS

Output Voltage: 15 V dc full scale (1.5) on all ranges.
Residual FM Noise: Below 1 MHz, more than 100 dB below full output. (With 400-Hz power, 90 dB down.) Narrow-band residual noise at frequencies other than 60 or 120 Hz is more than 120 dB down from full output.
Linearity: Below 15 kHz, 0.05% of full scale (15 V) ±0.05% of output voltage; above 15 kHz, 0.1% of full scale (15 V) ±0.1% of output voltage.

RECORDER OUTPUT

Direct: Output current adjustable to drive recorders from 1 mA (2.7 kΩ max) to 5 mA (190 Ω max).
Interpolate: Full scale, 0.64 V behind 4.8 kΩ.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 85 W.
Accessories Supplied: CAP-22 Power Cord, spare fuses.
Accessories Available: 1156-A Decade Scaler, 1157 Scaler 100-to-1; 1952 Universal Filter; 480-P312 Relay-Rack Adaptor Set, panel height 5¼ in.
Mounting: Convertible-Bench Cabinet.
Dimensions (width x height x depth): 12 x 5⅞ x 12 in. (305 x 150 x 305 mm).
Weight: Net, 16 lb (7.5 kg); shipping, 23 lb (10.5 kg).

Catalog Number	Description	Price in USA
1142-9701	**1142-A Frequency Meter and Discriminator**	**$595.00**
0480-9832	**480-P312 Relay-Rack Adaptor Set**	**6.50**

PATENT NOTICE. See Notes 15 and 16.

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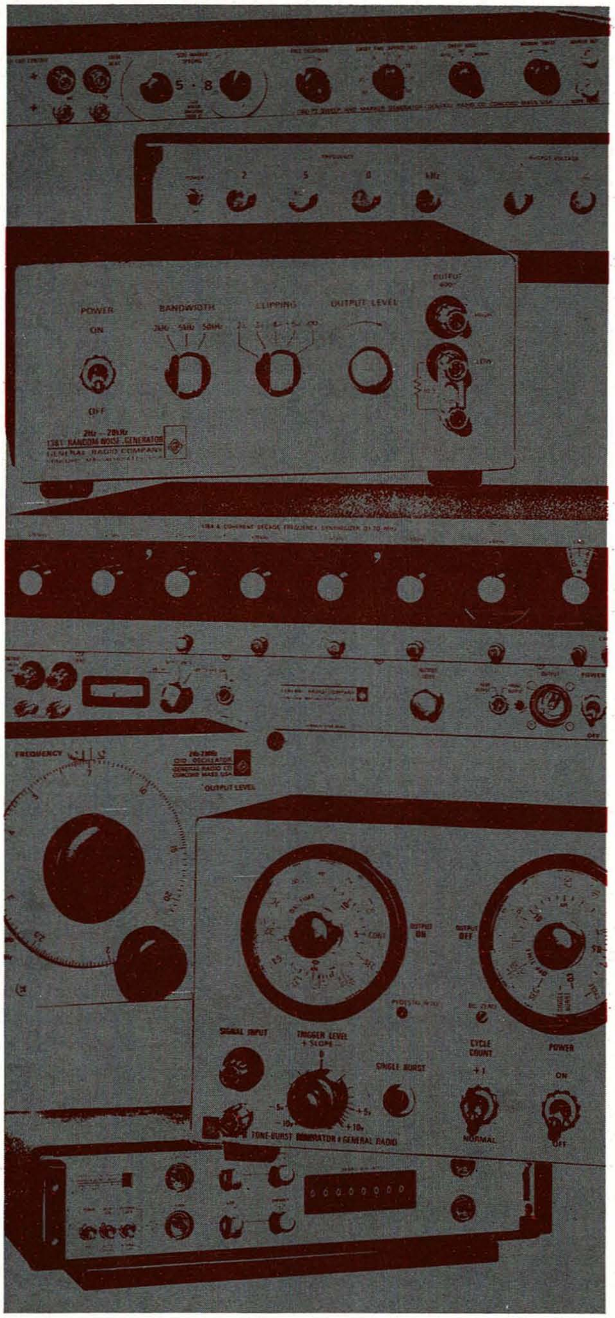


GENERATORS

FREQUENCY SYNTHESIZERS
STANDARD-SIGNAL GENERATORS
LOW-FREQUENCY OSCILLATORS
HIGH-FREQUENCY OSCILLATORS
PULSE GENERATORS
NOISE GENERATORS

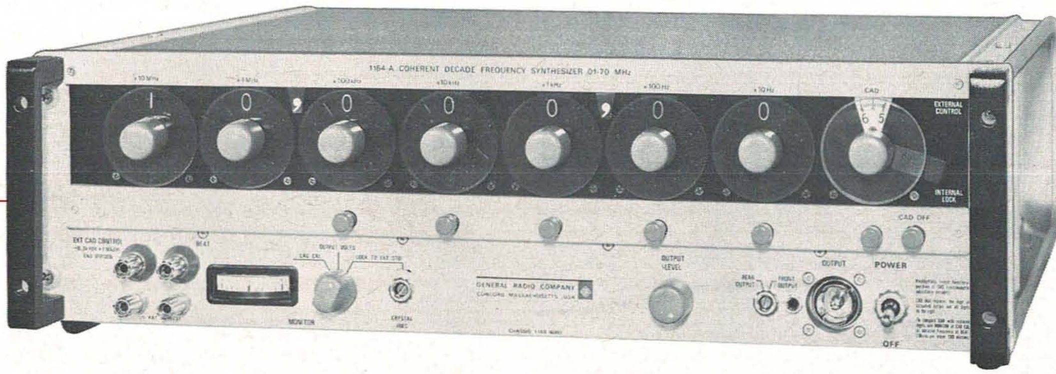
File Courtesy of GRWiki.org

COHERENT DECADE FREQUENCY SYNTHESIZERS

1160 Series

- sine-wave outputs to 70 MHz
- single-crystal frequency control
- unlimited frequency selection
- resolution to at least 9 significant figures
- calibrated sweep/search, manual and electrical
- programmed or manual digit selection
- low cost — all-solid-state — 80-model choice
- ac or battery operation

new



1164-A7C

The frequency synthesizer is, in essence, a sine-wave oscillator that has the stability characteristic of a crystal-controlled oscillator (which it is) yet is tunable over a wide frequency range with high resolution. Or, it can be considered a tunable frequency standard.

MANUAL AND ELECTRICAL TUNING

Like a decade box, the synthesizer has its output frequency set on decimal-digit switches ensuring precise resettability. Owing to its unique method of generating frequency, the synthesizer has great versatility. A calibrated, continuously adjustable decade can be substituted for any of the step decades, giving the instrument manual-search and electrical-sweep capabilities with any desired degree of fineness. GR synthesizers equipped with this continuously adjustable decade (CAD) can be manually or electrically swept over a span of from 1.2 MHz to as little as a part in 10^9 of the instrument's top frequency, a minimum sweep of 0.0001 Hz in some models. With the accessory Sweep and Marker Generator 1160-P2, the sweep rate and width, marker positions, and marker spacing are controllable and calibrated. No guessing is required to operate or to interpret results

The frequency dial of the CAD is calibrated and can be read to 2 places directly; the step decades in positions less-significant than the CAD-replaced digit are disabled and have no effect on the output frequency. However, their output is diverted to an internal comparison circuit by which the CAD setting can be calibrated readily to 4 significant places against the settings of the replaced step decades.

PROGRAMMABILITY

Each synthesizer model is available in either a manual or manual/programmable version. With the latter, as many as 7 digits of a frequency can be preprogrammed and set precisely, quickly and automatically from a remote controller. With the accessory Preset-Frequency-Program Unit 1160-P1, 20 or 40 frequencies can be preset to 7 digits and each selected by a single external switch closure. The sweep capability of GR synthesizers is, of course, also a remote-control function. The broad pro-

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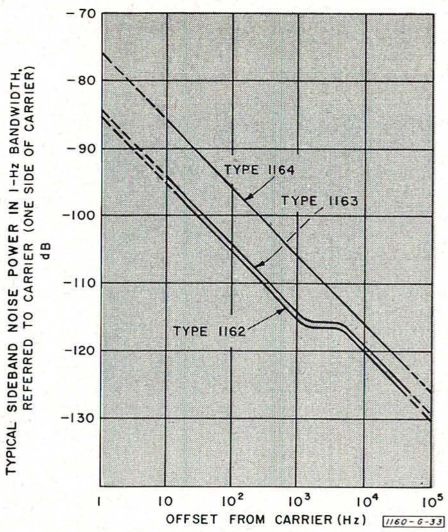


Typical phase-noise power-density distribution in GR 1160-series synthesizers. See **GR Experimenter** for January 1967 for full discussion of phase noise in synthesizers.

grammability of these instruments makes them a boon to fully automatic testing of a host of frequency-sensitive instruments and components.

OPTIONS

Modular construction of the GR synthesizers, besides simplifying servicing, permits GR to offer a wide choice of options to satisfy budgets and performance requirements for resolution, sweepability, and programmability. You can buy to suit initial needs; add modules later for augmented capability with no price penalty.

All step-decade modules in the 0.01-Hz to 100-kHz-per-step positions are identical and interchangeable (regardless of synthesizer model) and are readily replaceable with the programmable step-decade modules. The 1-MHz- and 10-MHz-per-step modules are peculiar to specific synthesizer models and are available in interchangeable manual or manual/programmable versions.

QUARTZ-CRYSTAL FREQUENCY SOURCE

All frequencies are synthesized, coherently, from a primary oscillator employing a hermetically sealed AT-cut crystal, without oven. Temperature coefficient is low at normal operating range. In many applications where extreme precision is not required, substantial savings in cost, space, and weight are achieved.

A more stable standard-frequency source, the 1160-P3, is available as an accessory to the GR synthesizers. Moderately priced, the 1160-P3 mounts inconspicuously on the rear of any model and generates a 5-MHz signal to which the synthesizer's internal oscillator locks, thereby improving the synthesizer's long-term stability and temperature dependence.

When maximum stability is required, the synthesizer's internal standard oscillator can be readily phase-locked to an external standard frequency such as that available from the GR 1115 Standard-Frequency Oscillator.

— See **GR Experimenters** for January 1967, September 1966, November-December 1965, May 1965, and September 1964. Or request GR reprint E119.

WHY BUY A SYNTHESIZER?

Almost daily, the synthesizer is being "discovered" by people who need something better from an oscillator. Why? Because the synthesizer will do nearly everything better.

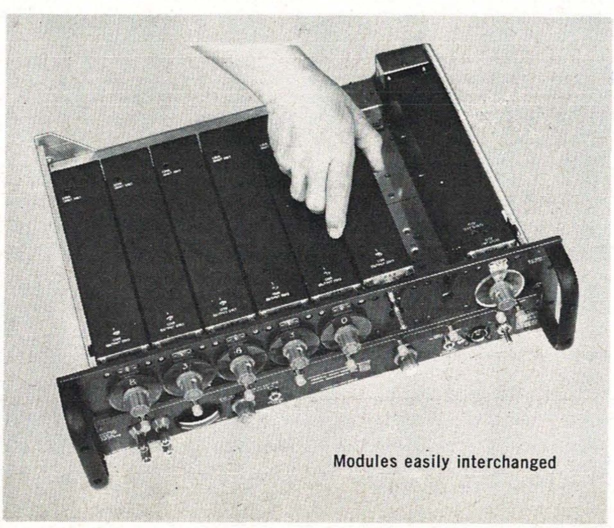
It is fully tunable yet, once set to a desired frequency, is rock-solid — virtually a frequency standard supplying your choice of frequency. Your frequency can be set to 7 significant figures on decade-box-like dials or can be continuously tuned with a single control that can have megahertz to millihertz resolution. It's a sweep oscillator with stable markers and center frequency, with sweep width adjustable from over a megahertz to less than a millihertz. For automated measurements and computer control, any GR synthesizer can be remotely controlled — tuned to any frequency from a preset program control or as directed by a computor. In short, there are few jobs for an oscillator that a synthesizer can't do better.

RECEIVER AND HIGH-Q-FILTER TESTING

For measurements on sharply tuned devices, the stability and resolution provided by a synthesizer are absolutely necessary; the half-power points are only 50-ppm away from the resonant frequency in a crystal filter with a Q of 10,000. The dial calibration of the continuously adjustable decade obviates the need for a companion frequency counter. In sweep operation, crystal-controlled markers are available. In addition, the ability to select or to scan preset frequencies and to search or to sweep regions around them, all automatically, means faster production and acceptance testing at more frequencies than ever before possible.

RESONANCE PHYSICS

The growing areas in physical research that are coming to depend upon high-precision frequency determination for studying physical events (nuclear magnetic resonance, electron paramagnetic resonance, etc) will find great value in the synthesizer's unique combination of virtues: wide frequency range with extremely narrow-band sweeps, high-resolution frequency settability, and the ability of the synthesizer to be locked to an external signal either by a dc voltage applied to the CAD or by a 5-MHz (or a submultiple) signal applied directly to phase-lock the internal crystal oscillator.



Modules easily interchanged

File Courtesy of GRWiki.org

specifications

Type	1161	1162	1163	1164
Output Frequency:	0 to 100 kHz	0 to 1 MHz	30 Hz to 12 MHz	10 kHz to 70 MHz
Digital Frequency Selection (per step):	0.01 Hz to 10 kHz	0.1 Hz to 100 kHz	1 Hz to 1 MHz	10 Hz to 10 MHz
Smallest Directly Indicated Frequency Increments on CAD* Dial:	0.0001 Hz	0.001 Hz	0.01 Hz	0.1 Hz
Incremental Frequency Range of CAD: (manually tuned)	−10 to +100 kHz down to −0.001 to +0.011 Hz	−0.1 to +1.1 MHz down to −0.01 to +0.11 Hz	−0.1 to +1.1 MHz down to −0.1 to +1.1 Hz	−0.1 to +1.1 MHz down to −1 to +11 Hz
RMS Phase-Noise Modulation re 1 Radian:**	−70 dB	−52 dB	−52 dB	+52 dB
RMS Amplitude-Noise Modulation re 100% Carrier:**	−70 dB	−70 dB	−60 dB	−60 dB
Reference-Frequency Source:	Internal, room-temperature, quartz-crystal oscillator with temperature coefficient typically <2 × 10^{-7}/°C from 20 to 50°C. Frequency control on front panel provides adjustment range of ±7 to ±10 ppm. For better accuracy and stability the internal oscillator can be phase-locked to an external standard-frequency source supplying 0.25 to 5 V rms (into 1 kΩ at lowest levels, dropping to 50 Ω at high) at 5 MHz or any submultiple down to 100 kHz.			

RMS Fractional Frequency Deviation:†

Output Frequency	1161 Averaging Time 1 s	1161 Averaging Time 10 ms	1162 Averaging Time 1 s	1162 Averaging Time 10 ms	1163 Averaging Time 1 s	1163 Averaging Time 10 ms	1164 Averaging Time 1 s	1164 Averaging Time 10 ms
70 MHz							3×10^{-11}	7×10^{-10}
50 MHz							3×10^{-11}	1×10^{-9}
10 MHz					3×10^{-11}	3×10^{-9}	5×10^{-11}	5×10^{-9}
5 MHz					6×10^{-11}	6×10^{-9}	1×10^{-10}	1×10^{-8}
1 MHz			3×10^{-10}	3×10^{-8}	3×10^{-10}	3×10^{-8}	5×10^{-10}	5×10^{-8}
0.1 MHz	3×10^{-10}	3×10^{-8}	3×10^{-9}	3×10^{-7}	3×10^{-9}	3×10^{-7}	5×10^{-9}	5×10^{-7}

Type	1161	1162	1163	1164
Spurious Signals (discrete nonharmonic):	<−80 dB	<−60 dB	<−60 dB	<−60 dB
Harmonic Signals (at max output):	<−40 dB	<−40 dB	<−30 dB	<−30 dB
Output Voltage: Monitoring Accuracy: ±0.2 V (±0.1 V above 100 kHz for 1164)	**Coupling Switch at ac:** 0 to 2 V rms, metered at output connector. 50-Ω load or higher flat to within ±1 dB above 50 Hz. **Coupling Switch at dc:** 0 to 0.8 rms, not metered, into high impedance (>100 kΩ) flat to within ±0.2 dB from 0 to 10 kHz.		**Output Impedance Switch at 50 Ω:** 0 to 2 V rms, metered behind 50 Ω ±10%. **Output Impedance Switch at 0:** 0 to 2 V rms, metered at output connector. Flat to within ±1.5 dB above 50 Hz, 50-Ω load.	0.2 to 2 V rms, metered and leveled behind 50 Ω ±5%. Output switch selects front-panel or rear connector. Leveling ±3% ±0.02 V above 100 kHz, ±5% ±0.02 V from 10 kHz to 100 kHz. Level is externally programmable.
Operating Temperature Range:	0 to 50°C, ambient temperature			
Power Required:	100 to 125 or 200 to 250 V, 50 to 400 Hz; or 20 to 28 V dc, 1.8 A approx			
	55 watts			60 watts
Dimensions (width x height x depth): Bench	19 x 5½ x 15½ in. (485 x 145 x 395 mm)			19¼ in. (490 mm) deep
Dimensions (width x height x depth): Rack	19 x 5¼ x 13 in. (485 x 135 x 330 mm)			17 in. (435 mm) deep
Weight: Net	38 lb (17.5 kg)			45 lb (20.5 kg)
Weight: Shipping	45 lb (20.5 kg)			52 lb (24 kg)

* The CAD (Continuously Adjustable Digit) provides a frequency indication on its dial accurate to two significant figures in the internal locked mode. In the external control mode ±1½ V, approx, into 6 kΩ from an external source provides frequency control over at least ±5 major divisions centered on any manual digit setting (except that in highest rank position of CAD, sweep should not exceed limits of manual tuning). Approx −0.3 V produces a + frequency change equal to one step of digit unit at pushbutton selected position of the CAD. An internal calibrating mixer produces a beat frequency proportional to the frequency difference between the CAD and the digit units it replaces (10 kHz per Δf = digit step of selected position). This beat frequency covers 0 to 110 kHz, and a level of at least 0.5 V behind 3 kΩ is provided at the BEAT terminals. The panel meter can be switched to monitor the beat frequency, providing a self-contained calibration system that can be used to set the CAD frequency to at least four significant figures.

** Phase- and amplitude-modulation noise measured in a 0.5-Hz to 15-kHz band, after the detector, without predetection filtering. These measurements are commonly expressed by signal-to-noise ratios in a 30-kHz band centered on the signal, excluding a 1-Hz band in the center. The absolute values of the figures given are identical to these ratios (in dB).

† Period measurements on low beat frequencies between the synthesizer and a low-noise standard-freqency oscillator. Beat frequency filtered by 15-kHz low-pass filter ahead of counter. Synthesizer locked to external GR 1115-B Standard-Frequency Oscillator. Signal from unlocked synthesizer may be poorer for 1-s averaging time unless in a perfectly stabilized ambient temperature, but figures given for 10 ms apply.

Programmability: Programmable models (-AR) contain digit-selection units that can be remotely programmed as well as locally set.

Digit Unit	Programming Speed	Life
RDI-1 (100-kHz steps and lower)	<2 ms to establish new frequency	$>10^8$ operations
RDI-2 (1-MHz steps in 1164)	<200 μs	unlimited
RDI-3 (10-MHz steps in 1164)	<200 μs	unlimited
RDI-4 (1-MHz steps in 1163)	<200 μs	unlimited

Programming accomplished by circuit closure to common (at ground potential) for each digit selected. Max circuit resistance, 50 Ω, or max drop, 0.5 V. Connections made by multiple-contact filter plugs at rear of instruments.

Output level of 1164 is externally programmable over a range of up to 20 dB by resistance or voltage, 5 to 25 kΩ or 6 to 10 V dc into 5 kΩ. A level change is 95% completed in 10 ms after a programmed step. Connection is provided by a type BNC connector at rear of instrument.

Auxiliary Outputs

Primary Outputs (GR874 connectors at rear of instrument — all four models): 100 kHz and 5 MHz (0.5 V rms, min into 50 Ω).

File Courtesy of GRWiki.org

Secondary Outputs (submin connectors at rear panel):

All Types			1162			1163			1164		
Freq	Level	Load	Freq	Level	Load	Freq	Level	Load	Freq	Level	Load
1 MHz	0.4 V	1 kΩ	50 MHz	0.1 V	1 kΩ	39/50 MHz 1-MHz steps	0.1 V	1 kΩ	40/49 MHz 1-MHz steps	0.1 V	1 kΩ
5 MHz	0.1 V	1 kΩ	50/51 MHz	0.1 V	1 kΩ	50/51 MHz	0.1 V	1 kΩ	30 MHz	50 mV	50 Ω
5/5.1 MHz reference	0.1 V	1 kΩ							50/51 MHz	25 mV	50 Ω
5/5.1 MHz*	0.1 V	1 kΩ							90 MHz	50 mV	50 Ω
42 MHz	0.1 V	1 kΩ							ALC (input)	0-15 mA	1 kΩ (input)
dc	+18 V	0.2 A									

*Output of replaced DI modules.

Main Output and Input Connectors

Front Panel: Main output connector, recessed locking GR874; external CAD control, ¾-in.-spacing binding posts; beat output, ¾-in.-spacing binding posts.

Rear Panel: Type BNC connectors duplicating front-panel connections.

Accessories Supplied: 874-R22LA Patch Cord, bridging unit (substitute for DI-1 during maintenance) with panel insert, power cord, spare dial lamp and fuses.

Cabinet: Rack-bench; end frames for bench mounting and fittings for rack mounting are included.

COHERENT DECADE FREQUENCY SYNTHESIZERS

		with MANUAL/PROGRAMMABLE STEP DECADES — OUTPUT FREQUENCY RANGE				with MANUAL STEP DECADES — OUTPUT FREQUENCY RANGE				
	Smallest Step	0-100 kHz	0-1 MHz	30 Hz-12 MHz	10 kHz-70 MHz	0-100 kHz	0-1 MHz	30 Hz-12 MHz	10 kHz-70 MHz	
Continuously Adjustable Search/Sweep Decade (CAD) Included	0.01 Hz	1161-AR7C 1161-9527 $6590.00				1161-A7C 1161-9597 $5960.00				Type Catalog No. Price
	0.1 Hz	1161-AR6C 1161-9526 $6055.00	1162-AR7C 1162-9527 $6725.00			1161-A6C 1161-9596 $5515.00	1162-A7C 1162-9597 $6095.00			Type Catalog No. Price
	1.0 Hz	1161-AR5C 1161-9525 $5520.00	1162-AR6C 1162-9526 $6190.00	1163-AR7C 1163-9527 $6755.00		1161-A5C 1161-9595 $5070.00	1162-A6C 1162-9596 $5650.00	1163-A7C 1163-9597 $6215.00		Type Catalog No. Price
	10 Hz	1161-AR4C 1161-9524 $4985.00	1162-AR5C 1162-9525 $5655.00	1163-AR6C 1163-9526 $6220.00	1164-AR7C 1164-9527 $7515.00	1161-A4C 1161-9594 $4625.00	1162-A5C 1162-9595 $5205.00	1163-A6C 1163-9596 $5770.00	1164-A7C 1164-9597 $7065.00	Type Catalog No. Price
	100 Hz	1161-AR3C 1161-9523 $4450.00	1162-AR4C 1162-9524 $5120.00	1163-AR5C 1163-9525 $5685.00	1164-AR6C 1164-9526 $6980.00	1161-A3C 1161-9593 $4180.00	1162-A4C 1162-9594 $4760.00	1163-A5C 1163-9595 $5325.00	1164-A6C 1164-9596 $6620.00	Type Catalog No. Price
	1 kHz		1162-AR3C 1162-9523 $4585.00	1163-AR4C 1163-9524 $5150.00	1164-AR5C 1164-9525 $6445.00		1162-A3C 1162-9593 $4315.00	1163-A4C 1163-9594 $4880.00	1164-A5C 1164-9595 $6175.00	Type Catalog No. Price
	10 kHz			1163-AR3C 1163-9523 $4615.00	1164-AR4C 1164-9524 $5910.00			1163-A3C 1163-9593 $4435.00	1164-A4C 1164-9594 $5730.00	Type Catalog No. Price
	100 kHz				1164-AR3C 1164-9523 $5375.00				1164-A3C 1164-9593 $5285.00	Type Catalog No. Price
Step Decades Only	0.01 Hz	1161-AR7 1161-9507 $6050.00				1161-A7 1161-9417 $5420.00				Type Catalog No. Price
	0.1 Hz	1161-AR6 1161-9506 $5515.00	1162-AR7 1162-9507 $6185.00			1161-A6 1161-9416 $4975.00	1162-A7 1162-9417 $5555.00			Type Catalog No. Price
	1.0 Hz	1161-AR5 1161-9505 $4980.00	1162-AR6 1162-9506 $5650.00	1163-AR7 1163-9507 $6215.00		1161-A5 1161-9415 $4530.00	1162-A6 1162-9416 $5110.00	1163-A7 1163-9417 $5675.00		Type Catalog No. Price
	10 Hz	1161-AR4 1161-9504 $4445.00	1162-AR5 1162-9505 $5115.00	1163-AR6 1163-9506 $5680.00	1164-AR7 1164-9507 $6975.00	1161-A4 1161-9414 $4085.00	1162-A5 1162-9415 $4665.00	1163-A6 1163-9416 $5230.00	1164-A7 1164-9417 $6525.00	Type Catalog No. Price
	100 Hz	1161-AR3 1161-9503 $3910.00	1162-AR4 1162-9504 $4580.00	1163-AR5 1163-9505 $5145.00	1164-AR6 1164-9506 $6440.00	1161-A3 1161-9413 $3640.00	1162-A4 1162-9414 $4220.00	1163-A5 1163-9415 $4785.00	1164-A6 1164-9416 $6080.00	Type Catalog No. Price
	1 kHz		1162-AR3 1162-9503 $4045.00	1163-AR4 1163-9504 $4610.00	1164-AR5 1164-9505 $5905.00		1162-A3 1162-9413 $3775.00	1163-A4 1163-9414 $4340.00	1164-A5 1164-9415 $5635.00	Type Catalog No. Price
	10 kHz			1163-AR3 1163-9503 $4075.00	1164-AR4 1164-9504 $5370.00			1163-A3 1163-9413 $3895.00	1164-A4 1164-9414 $5190.00	Type Catalog No. Price
	100 kHz				1164-AR3 1164-9503 $4835.00				1164-A3 1164-9413 $4745.00	Type Catalog No. Price

PATENT NOTICE. See Note 28.

Prices in USA only.

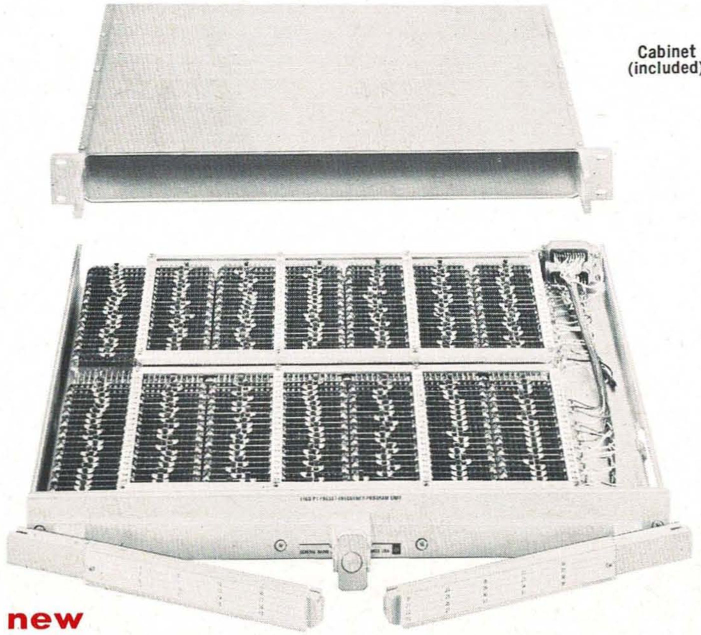
1163-AR4C
- C — CAD Included
- 4 — Number of Step Decades Included
- R — All Step Decades Programmable
- 1163 — Basic Synthesizer type number

File Courtesy of GRWiki.org

PRESET-FREQUENCY-PROGRAM UNIT

1160-P1

- synthesizer accessory
- preprogram up to 40 frequencies, 7 digits each
- select any frequency with simple switch closure
- use with any programmable synthesizer



Cabinet (included)

new

Used with any programmable GR synthesizer, the 1160-P1 permits fast, repetitive, and error-free selection of preset frequencies by an operator, mechanical selector, or electronic programmer. It converts the single-contact closure of a mechanical or solid-state switch into the multiple closures needed to set up all 7 digits of any preset frequency. It will operate all the RDI programmable step decades used in the four basic GR synthesizer models. (It programs 10 of the possible 12 settings of the 1163-RDI-4 1-MHz-per-step decade). Connecting cables, one to each programmable decade in the synthesizer, must be ordered separately to suit the types of RDI in use.

The programmer consists of a tray containing a matrix of selector switches and a cabinet into which the tray slides and engages electrically. With a simple hand tool (supplied) it is easy to set up each 7-digit channel frequency in a few seconds with the 7 slide switches associated with each channel. Trays are supplied with a capacity of either 20 or 40 channels; effective total capacity is unlimited, as any number of trays can be set up in advance and quickly inserted into the active cabinet in sequence. A spare, empty cabinet is available for convenience in storing trays during a change-over.

External channel-selecting switches are not presently catalogued. GR will make recommendations or quote on a special-order basis to suit individual requirements.

— See **GR Experimenter** for September 1967.

specifications

Capacity: Stores 20 or 40 preset 7-digit frequencies (depending upon model).

Frequency-Selection Input: Mechanical or solid-state switch closure to ground required for each channel. Each closure must be capable of carrying 70 mA with <0.5-V drop.

Frequency-Selection Output: Circuit closure on 10-line connection to each controlled digit.

Switching Time: <2 ms, depends only on speed of programmable modules.

Accessory Supplied: 40-pin-connector assembly for connection of external selector switches to 1160-P1.

Accessories Required: Cables from 1160-P1 to synthesizer, one per controlled digit; select to suit RDI modules to be controlled.

Accessories Available: Empty instrument cabinet, for convenient storage in interchanging trays in systems using more than one tray (similar to cabinet supplied with 1160-P1).

Mounting: Relay-rack cabinet.

Dimensions (width x height x depth): 19 x 1¾ x 15 in. (485 x 45 x 385 mm).

Weight: 20 channel, net, 9 lb (4.1 kg), shipping 20 lb (9.5 kg); 40 channel, net, 11 lb (5 kg), shipping, 22 lb (10 kg).

Catalog Number	Description	Price in USA
	1160-P1 Preset-Frequency-Program Unit	
1160-9620	20 channels	**$1000.00**
1160-9640	40 channels	**1825.00**
1160-9701	**Cable Assembly** (2-ft) to any programmable module (1160-RDI-1) up to 100 kHz/step	**75.00**
1160-9702	**Cable Assembly** (2-ft) to 1 MHz/step programmable module (1164-RDI-2) and 10 MHz/step module (1164-RDI-3) in 1164 models	**75.00**
1160-9704	**Cable Assembly** (2-ft) to 1 MHz/step programmable module (1163-RDI-4) in 1163 models	**75.00**
1160-9500	**Cabinet**, empty	**50.00**

File Courtesy of GRWiki.org

- synthesizer accessory
- sweep width: <1 Hz to 1.2 MHz
- variable sweep rate
- built-in, accurate markers

SWEEP AND MARKER GENERATOR

Type 1160-P2

new

This instrument permits advantage to be taken of the sweep capability of any GR synthesizer that contains the CAD continuously adjustable decade. The 1160-P2 sweeps the CAD frequency over a width adjustable from ±1 to ±5 CAD divisions (up to ±10 divisions with CAD at center of dial). The actual sweep width can range from 1.2 MHz to $\pm1/10$ the frequency interval-per-step of the least significant decade and, except for widest sweeps, can be centered on any frequency in the synthesizer's normal operating range. The oscilloscope-horizontal sweep voltage provided is independent of the frequency sweep width selected. Slow automatic and manual sweep speeds, very narrow sweep widths, and stable center frequency and markers make this system particularly useful for testing high-Q devices.

The 1160-P2 generates a synthesized marker that occurs at the frequency to which the step decades are set. Side markers can be located symmetrically 1.0 to 5.9 CAD divisions from the center marker. Actual frequency spacing of these markers depends upon the functional position of the CAD unit.

— See **GR Experimenter** for January 1967.

specifications

AUTOMATIC SWEEP

Sweep Voltages: Symmetrical triangular waveforms centered on 0 V dc.

Time for One-Way Sweep: 0.02 s to 60 s, automatic, selectable in 9 steps.

Sweep-Time Accuracy: $\pm10\%$.

Outputs: CAD sweep is continuously adjustable from ±1 to ±10 major CAD divisions (±0.3 to ±3 V approx). The SCOPE HORIZ output is nonadjustable (12 V pk-pk behind approx 10 kΩ).

MANUAL SWEEP

Outputs: Sweep excursions are the same as in automatic mode, with continuous manual control.

MARKERS

Location: Center marker occurs at the frequency set on synthesizer digit dials. Side markers are displaced symmetrically from the center marker by the amount set on the MARKER SPACING dials.

Side Marker: Spacing from center marker can be from 1.0 to 5.9 CAD divisions in 0.1 steps. **Accuracy:** $\pm1\%$ of dial setting.

GENERAL

Power Required: 100 to 125 or 200 to 250 V, 50 to 400 Hz, 3 W.

Ambient Temperature: 0 to 50°C.

Accessories Supplied: Two 2-foot and two 4-foot BNC coaxial patch cords, power cord, spare fuse.

Terminals: Connections to synthesizer, MARKER OUT, and SCOPE HORIZ output available front and rear.

Cabinet: Rack-bench. End frames for bench mount and fittings for rack mount are included.

Dimensions (width x height x depth): Bench, 19 x 2 x 14½ in. (485 x 52 x 370 mm); rack, 19 x 1¾ x 13¼ in. (485 x 45 x 330 mm).

Weight: Net, 12 lb (5.5 kg); shipping, 23 lb (10.5 kg).

Catalog Number	Description	Price in USA
1160-9600	**1160-P2 Sweep and Marker Generator**	**$495.00**

STANDARD-FREQUENCY OSCILLATOR

Type 1160-P3

As an accessory for use with any GR synthesizer, the 1160-P3 is a stable source of 5-MHz signal to which a synthesizer's internal oscillator can be locked for improved long-term stability and reduced temperature dependence. In all other regards, the operation and performance of the synthesizer are unchanged.

The 1160-P3 contains a temperature-controlled crystal oven, buffer amplifier, and power supply and operates directly from the ac line independent of the synthesizer power switch. It mounts inconspicuously on the rear of any model, adding only a few inches to its depth.

File Courtesy of GRWiki.org

specifications — 1160-P3

Crystal Frequency: 5.0 MHz. Internal adjustment range of at least $\pm 1 \times 10^{-6}$, initially. Deviation $<24 \times 10^{-8}$ per turn of the control.

STABILITY

Ambient Temperature: After stabilization at any temperature between 0° and +50° C, fractional frequency deviation from the stabilized frequency at 25° C will not exceed 1×10^{-8}. Frequency will be within 2×10^{-8} of stabilized frequency within one hour of turn-on at 20° C ambient.

Line Voltage: Fractional frequency deviation will be $<\pm 2 \times 10^{-9}$ for line-voltage changes of ±10%.

Aging: Absolute fractional frequency deviation will not exceed 3×10^{-9} per day after 72 hours.

OUTPUT VOLTAGE: Sufficient to permit locking of synthesizer oscillator.

GENERAL

Power Required: 105 to 125 or 195 to 235 V (210 to 250 V also available), 50 to 400 Hz, 8 W max.

Accessories Supplied: Spare fuse, mounting hardware.

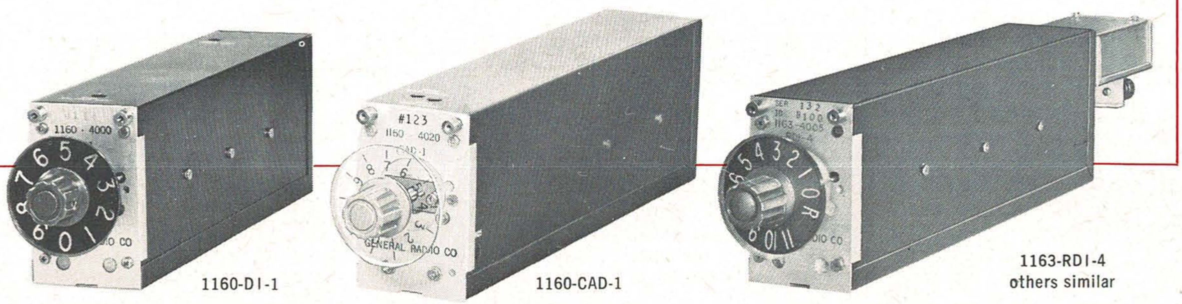
Dimensions (width x height x depth): 16½ x 3 x 5 in. (420 x 80 x 130 mm). Mounted, the 1160-P3 adds about 4½ inches to the over-all depth of the synthesizer.

Weight: Net, 3¼ lb (1.5 kg); shipping, (est) 7 lb (3.2 kg).

Catalog Number	Description	Price in USA
1160-9603	**1160-P3 Standard-Frequency Oscillator**	**$525.00**

SYNTHESIZER MODULES

Sold only as replacements or to fill out partially equipped synthesizers.



1160-DI-1 1160-CAD-1 1163-RDI-4 others similar

1160-DI-1 — MANUAL STEP-DECADE MODULE

Digit-Insertion Units, 1160-DI-1, are available to expand the resolution capability of less-than-fully equipped synthesizers, or as spares. The modules are complete and ready to plug in. The change takes only minutes and requires no special tools. The DI-1 module works in any step-decade station of any synthesizer, except for the X1-MHz and X10-MHz stations on the 1163 and 1164 models. All ancillary controls are preinstalled for every station, even in minimally equipped synthesizers.

Net Weight: 1½ lb (0.7 kg).

1160-CAD-1 — CONTINUOUSLY ADJUSTABLE DECADE MODULE

The 1160-CAD-1 Continuously Adjustable Decade module is available to add increased versatility and extended resolution to **any** synthesizer purchased without this decade. The CAD adds two calibrated digits to the readout directly and three or more if it is first calibrated against the step decades. It can convert any step decade (and all to its right) to continuously adjustable operation at the push of a button. The capability of instantaneous self-check is another advantage furnished a synthesizer to which the CAD is added. The module is complete and ready to plug into the decade station at the right-hand end of any of the synthesizers. The change takes only minutes and requires no special tools.

Net Weight: 1¾ lb (0.8 kg).

1160-RDI — PROGRAMMABLE STEP-DECADE MODULES

The 1160-RDI Digit-Insertion Units (remote or manual control) are offered to permit programmed frequency selection in the step decades of **any** of the synthesizers. They can fill out partially complete synthesizers or convert manual instruments, partially or fully, to programmed operation. The modules are complete and ready to plug in. The change takes only minutes and requires no special tools. A filter-plug at the rear can be cabled to a programmer for fast, automatic operation. Control-cable filtering circuits are included in the plug.

FOUR MODELS

The 1160-RDI-1 unit will operate in any station of any synthesizer up to the X1-MHz position from a 10-line command input. The 1163-RDI-4 operates in the X1-MHz position of an 1163 synthesizer, controlled from a 12-line input. The 1164-RDI-2 replaces the manual step-decade module in the X1-MHz position of an 1164-series synthesizer. The 1164-RDI-3 operates in the X10-MHz position in the 1164 model synthesizers with a 7-line command input for full programmability to 70 MHz.

Net Weight: 1½ lb (0.7 kg).

HOOK-UP CABLE FOR RDI

A special, 12-conductor, shielded cable is recommended for connection of the 12-pin filter-plug to remote equipment. One 50-foot roll of cable is furnished with each synthesizer containing an RDI unit but is not supplied with an individually purchased RDI. Additional 50-foot lengths can be ordered.

Net Weight: 2½ lb (1.2 kg).

Catalog Number	Description	Price in USA
1160-9439	**1160-DI-1 Digit-Insertion Unit** (Manual Control)	**$455.00**
1160-9432	**1160-CAD-1 Continuously Adjustable Decade** (includes Calibrating Mixer Unit)	**550.00**
	Programmable Digit-Insertion Units	
1160-9479	**1160-RDI-1,** up to 100 kHz/step, all synthesizer models	**545.00**
1163-9479	**1163-RDI-4,** 1 MHz/step, in 1163 models	**575.00**
1164-9479	**1164-RDI-2,** 1 MHz/step, in 1164 models	**555.00**
1164-9489	**1164-RDI-3,** 10 MHz/step, in 1164 models	**575.00**
1160-9650	**Hook-Up Cable** for all RDI's, 50-ft, 12-conductor, shielded	**15.00**

File Courtesy of GRWiki.org

STANDARD-SIGNAL GENERATORS

A standard-signal generator is a source of alternating-current energy of accurately known characteristics. The carrier, or center, frequency is indicated by a dial setting, the output voltage by a meter reading and associated attenuator setting, and the modulation by a meter reading set by appropriate control knobs. Common types of modulation signals are sine-wave, square-wave, and pulse; the output signal may be either frequency- or amplitude-modulated by these signals. When the frequency-modulation system produces a considerable excursion in frequency at a relatively low-cyclical rate, the instrument is known as a sweep-frequency generator and is particularly useful for automatic data display. Standard-signal generators are used for testing radio receivers, as voltage standards over the range from a few microvolts to about a volt, and generally as power sources in measurement of gain, bandwidth, signal-to-noise ratio, standing-wave ratio, and other circuit properties.

For use as a standard-signal generator, the oscillator must be stable, have reasonably constant output over any one frequency range, have good waveform, and have no appreciable hum or noise modulation. Careful over-all shielding of the generator is essential in order to minimize stray fields.

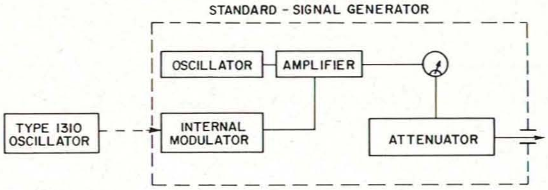


Figure 1. Elements of a standard-signal generator.

The elements of a typical amplitude-modulated standard-signal generator are shown in Figure 1. A new type of standard-signal generator, which is capable of unusual frequency stability, is shown in Figure 2. The elements of a standard sweep-frequency generator are shown in Figure 3.

AMPLITUDE-MODULATED SIGNAL GENERATORS

The three General Radio amplitude-modulated standard-signal generators are general-purpose, wide-tuning-range instruments covering the range from 5 kHz to 500 MHz.

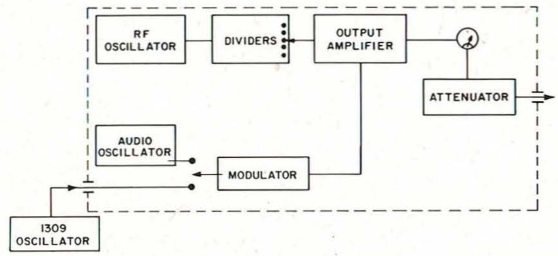


Figure 2. High-stability standard-signal generator.

Amplitude modulation is provided from an internal, fixed-frequency, sine-wave generator or from an external audio-frequency source. This provision is omitted for sweep-frequency generators. In addition to a choice of frequency ranges, the GR generators offer a wide selection of performance features: high output, excellent shielding for accurate low-level output, levelling, modulation versatility, and unusually good stability. Each instrument offers a well balanced combination of features that allow the user to make fast and accurate measurements over a wide range of test conditions.

SWEEP-FREQUENCY GENERATOR

The 1025-A Standard Sweep-Frequency Generator covers the range from 700 kHz to 230 MHz in ten octave bands and has in addition bandspread ranges at 450 kHz and 10.7 MHz. This instrument employs a rotating tuning capacitor to bring the precision and stability of conventional manually tuned signal generators to the field of sweep measurement. It sweeps 20 times per second over complete octave ranges and is fast enough to eliminate flicker. This generator includes a very effective automatic level control so that the full advantage may be taken of the use of sweep techniques.

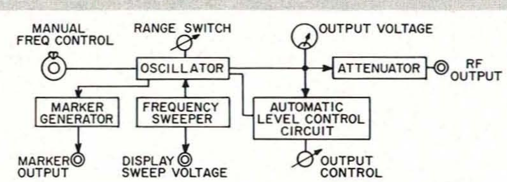


Figure 3. Elements of a standard sweep-frequency generator.

	Type	Frequency Range	Open-Circuit Voltage	Output Impedance	Modulation
Standard-Signal Generators	**1001-A** **1003** **1026**	5 kHz to 50 MHz 67 kHz to 80 MHz 9.5 to 500 MHz	0.1 μV to 200 mV 0.1 μV to 6 V 0.1 μV to 10 V	10 Ω, 50 Ω 50 Ω 50 Ω	0-80% 0-95% 0-95%
Standard Sweep-Frequency Generator	**1025-A**	0.7 to 230 MHz 0.45 and 10.7 MHz	0.3 μV to 1 V	50 Ω	Sweep, all bands
Accessories	**1000-P4** **1000-P5** **1000-P10**	Dummy Antenna VHF Transformer (50 ohms grounded to 300 ohms balanced) Test Loop			

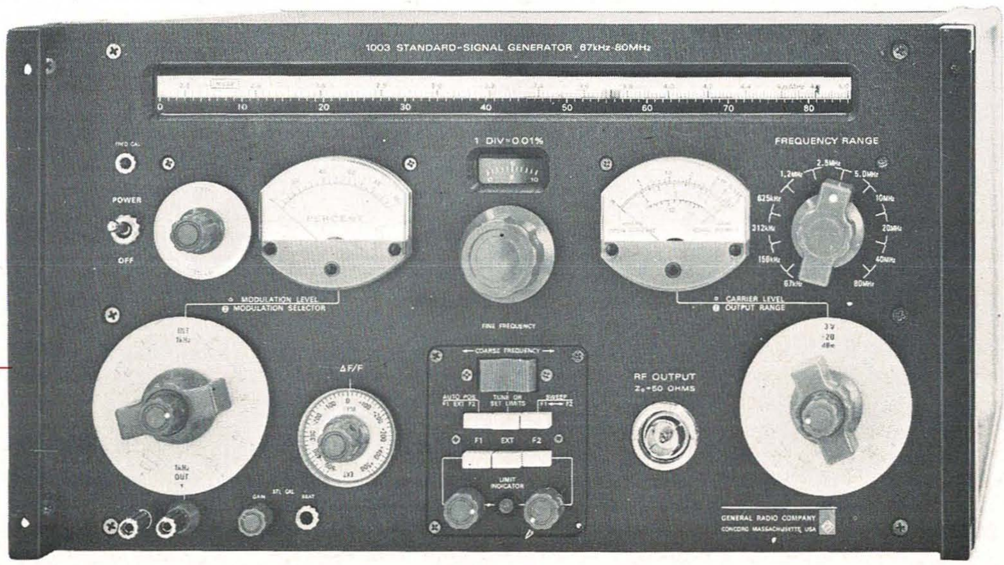
File Courtesy of GRWiki.org

STANDARD-SIGNAL GENERATOR

- 67 kHz to 80 MHz
- 1 ppm typical over-all stability
- optional programmability and crystal calibrator
- 6 V behind 50-Ω cw output
- 0 to 95% a-m

Type 1003

new



An innovation in signal-generator-circuit concepts in the GR 1003 brings about a 10-to-1 improvement in frequency stability without sacrificing the other performance features expected in a fine signal generator. The frequency-generating system is a single-range, highly stable oscillator followed by frequency dividers to provide the successively lower ranges. Thus the high stability of one range is the stability of all, and range switching is accomplished without any transient instability.

All-solid-state design ensures both low-drift warmup to the 1003's ultimate stability and high reliability expected from cool-running components.

APPLICATIONS

Important in the testing of devices with steep-slope frequency characteristics are the stability, residual fm, and settability of the signal source. Noise, drift, or poor resolution can make it impossible to determine the test frequency accurately enough. The 1003 eliminates these obstacles without introducing spurious outputs, tuning complications, and potential signal leakage.

CONFIDENCE AND CONVENIENCE

Beyond the traditional electrical virtues of low leakage, calibrated output, flat frequency characteristic, minimal distortion, and low spurious outputs that ensure confidence in the measured results, the 1003 has many features that simplify the measurement techniques, thereby lowering cost per measurement.

Motorized high-speed tuning with very fine manual vernier tuning justifies the use of a long, high-resolution frequency scale. The programmable model uses this motor drive as a "homing" device, permitting frequency to be set on command to within 0.1% of preselected values; two can be preset internally, any number externally. Output amplitude can also be programmed externally over a 40-dB span.

FREQUENCY CONTROL

Vital to the use of a standard-signal generator is the accuracy with which frequency can be determined, both absolute and relative. The long slide-rule scale of the 1003 is calibrated to within 0.25% for absolute frequency readings; this main tuning control also has a vernier scale that permits small changes and interpolation between crystal-calibrator frequencies to be made to a resolution of 0.01%.

A separate front-panel Δf control, calibrated in ppm, tunes electronically over a ±500-ppm range with a resolution of 2 ppm. External control of this electronic tuning

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facilitates phase locking the generator frequency and gives a limited fm capability.

With external counters, for which outputs are provided, these high-resolution capabilities can be further extended to absolute frequency settability.

Thus, the excellent stability and control of the 1003 ensures that its frequency will change only when, and by the exact amount, desired by the operator.

MODULATION

Internal 400- and 1000-Hz a-m is adjustable and metered 0 to 95% and has very low incidental fm and distortion controlled by envelope feedback. External a-m is provided for with a 20-kHz ac mode and a direct-coupled mode for remote level control and low-frequency square-wave modulation.

— See **GR Experimenter** for July-August 1967.

specifications

FREQUENCY

Range: 67 kHz to 80 MHz in 10 ranges: 67 to 156, 135 to 312, 270 to 625, 540 to 1250 kHz, 1.08 to 2.5, 2.16 to 5, 4.32 to 10, 8.64 to 20, 17.28 to 40, and 34.56 to 80 MHz.

Calibration Accuracy: ±0.25%, typically ±0.1%; scale logarithmic, 140 in. total length. Logging scale with vernier, 8500 div, 0.01%/div.

Crystal Calibrator (in 1003-9704 model): Markers at 50-kHz, 200-kHz, and 1-MHz intervals, accurate to 20 ppm.

Mechanical Tuning: Fast motor drive, manually or externally controlled: manual fine tuning, 1% per revolution, calibrated in 0.01% increments.

Auto-Control Tuning (in 1003-9704 model): 0.1% positioning accuracy. Motor drive sweeps between preset limits or tunes on command to preset frequencies (two internal, additional from external dc voltages or voltage dividers). Sweep rate approx 7%/s.

Electronic Tuning: Internal, ±500 ppm, calibrated, settable to better than 2 ppm; external, approx 60 ppm/volt up to ±1000 ppm typical, limited fm capability. Max input ±15 V into 15 kΩ (+ volts increase frequency).

Stability: After warmup <5 ppm per 10 min, typically 1 ppm. Frequency will vary less than 1 ppm as a result of ±10% line-voltage changes, range switching (instant restabilization), rf-level adjustments, or load variations. Warmup drift typically 150 ppm in 3 h at 20°C.

Carrier Distortion: <5% typical.

Noise: A-M, hum and noise within 15 kHz down at least 80 dB relative to carrier. Residual fm, <3 Hz pk at high-frequency end, <1 Hz pk at low-frequency end.

RF OUTPUT

Range: CW, 0.1 μV to 6 V behind 50 Ω, 180 mV into 50 Ω (−133 to +22.6 dBm); modulated, 0.1 μV to 3 V behind 50 Ω, 45 mW into 50 Ω (−133 to +16.6 dBm).

Source Impedance: 50 Ω. SWR is <1.02 with attenuator set for 0 dBm or less, <1.05 for +10 dBm, <1.20 for +20 dBm.

Level Control: Total range, 155 dB. Step attenuator, 140 dB in 10-dB steps; continuously adjustable level control, >10 dB additional.

Accuracy of Leveled Output Power: ±1 dB at any frequency and termination. Attenuator, ±0.1 dB per 10-dB step, max accumulated error, ±0.5 dB.

Level Stability: Warmup drift <0.3 dB, temperature effects <0.01 dB/°C, line-voltage variations <0.02 dB.

Meter: Reads open-circuit volts and dBm.

MODULATION

Level: 0 to 95%, continuously adjustable. Stable within ±1 dB independent of carrier or modulation frequency (within modulation bandwidth) and output level.

Modulation Bandwidth: At 100-kHz carrier, max modulation frequency is 500 Hz for 95% a-m and 2 kHz for 30% a-m. Above 1-MHz carrier, max is 3 kHz for 95% and 10 kHz for 30%.

Meter: Reads 0 to 100%. Accuracy ±5% fs with int mod, ±10% fs with ext mod, 0 to 95% within modulation bandwidth.

Incidental Angle Modulation: <0.1 radian pk at 30% a-m.

Internal

Frequency: 400 and 1000 Hz, ±0.5%. Output of 2 V behind 100 kΩ available at panel connector.

Envelope Distortion: <1% at 50% a-m, <2% at 70% a-m.

External

AC-Coupled: 20 Hz to 20 kHz, 2 V into 2.5 kΩ for 95% modulation within modulation bandwidth.

Direct-Coupled: Dc to 20 kHz. Carrier off with 0-volt input; 3-V rf output with +5 V into 10 kΩ. Max input 10 V peak.

AUXILIARY MONITORING OUTPUTS

Main-Output Frequency: At least 0.5 V pk-pk into 50 Ω (cw) at output carrier frequency.

Subharmonic Frequency: At least 0.3 V pk-pk (approx square wave) behind 150 Ω. Frequency (between 67 and 156 kHz) is coherent with and integrally related to carrier frequency by factor N shown on main dial.

Tuning-Shaft Position (in 1003-9704 model): Analog dc voltage proportional to shaft position and logging number. Approx −7.5 V max behind 7500 Ω, or 90 mV for 1% frequency change.

Range Indicator: Contact closure through rear connector.

GENERAL

Leakage: Effects negligible on measurements of receiver sensitivity down to 0.1 μV.

Environment: 10 to 50°C ambient for specified performance.

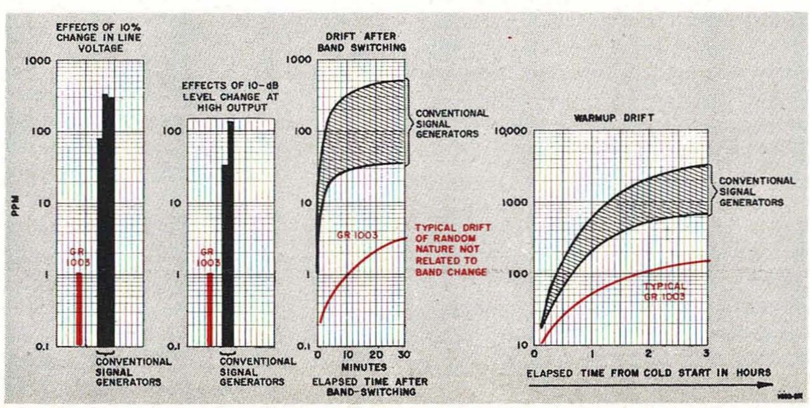
Accessories Supplied: 874-R22LA Patch Cord, power cord, two 12-terminal connectors for external controls, spare fuses, hardware for both bench and rack mounting.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 Hz, 20 W (33 W with motor operating).

Dimensions (width x height x depth): Bench, 19 x 11 x 15¼ in. (485 x 280 x 390 mm); rack, 19 x 10½ x 12¾ in. (485 x 270 x 325 mm).

Weight (approx): Net, 64 lb (30 kg); shipping, 87 lb (40 kg).

Catalog Number	Description	Price in USA
1003-9701	**1003 Standard-Signal Generator**	**$2795.00**
1003-9704	**1003 Standard-Signal Generator** Complete with Auto-Control Unit and Crystal Calibrator	**2995.00**



The stability of the 1003 compared with that of other signal generators.

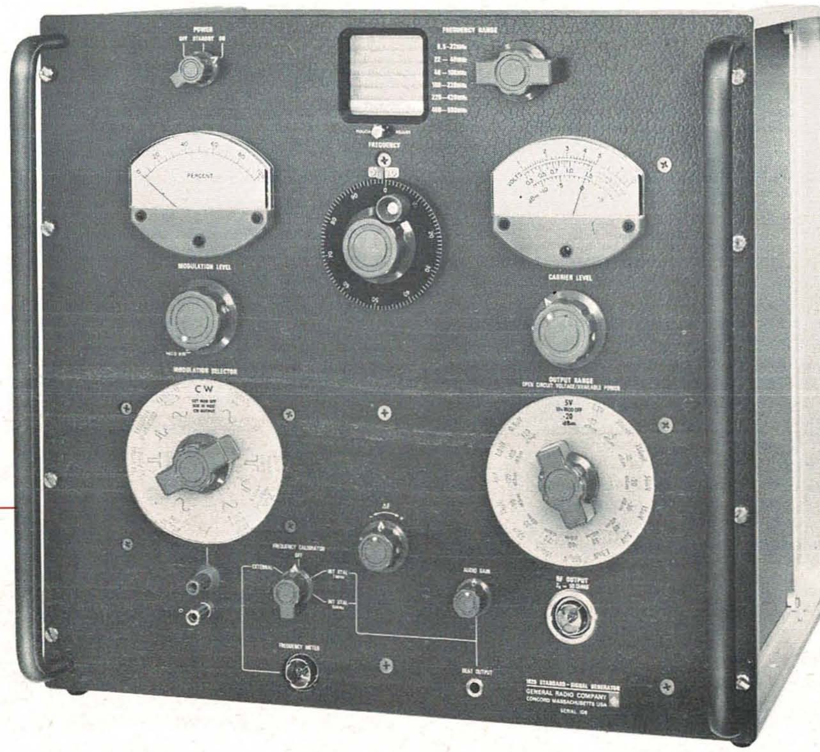
File Courtesy of GRWiki.org

STANDARD-SIGNAL GENERATOR

Type 1026

- 9.5 to 500 MHz, single-dial tuning
- 10-volt output behind 50 ohms, leveled
- crystal calibrator
- incidental fm <1 ppm $+$ 100 Hz
- audio, video, and pulse a-m
- fm and phase-lock capability

new



This vhf signal generator was designed to meet the most exacting requirements for measurements on a-m receivers, filters, attenuators, and other components and incorporates many convenience features to let the operator give his full attention to the measurement rather than the instrumentation. The ease of operation and outstanding performance of the 1026 in the most critical applications must be experienced to be appreciated.

Unusually high-level output signals are available for antenna-pattern and impedance measurements, receiver overload and cross-modulation tests, and measurements of large insertion losses without auxiliary amplifiers and the attendant setup and tuning problems. Similarly, precision attenuation and excellent shielding make possible tests with the very low signal levels required in other receiver measurements. Carrier distortion, residual a-m and fm, and incidental fm are all kept to very low levels.

LEVELING

High-gain feedback of the detected carrier to the modulation amplifier provides very precise leveling in all modes of operation, modulated and unmodulated. With audio modulation, envelope feedback ensures low envelope distortion; with pulse modulation, the peak of the pulsed carrier is leveled.

MODULATION VERSATILITY

Amplitude modulation up to 95% can be imposed on the carrier from a highly stable internal 1-kHz oscillator or from an external audio source. In addition, the generator has provisions for wide-band external modulation to 1.5 MHz and for pulse modulation with an on-off ratio typically greater than 40 dB at full output. An accurate panel meter monitors modulation levels.

HIGH ACCURACY

The main frequency drum scales are accurate to $\pm0.5\%$ direct reading and can be calibrated even more closely over small spans through use of the internal 1 and 5 MHz crystal frequencies, both of which are usable to 500 MHz and are accurate to $\pm0.001\%$. The fiducial mark is adjustable to permit easy scale calibration. Also provided is an auxiliary output sufficient to drive a frequency counter for extreme precision in the setting and measuring of generator frequency. This output can be disabled at will and isolated by $>$ 100 dB. An external signal applied to this same terminal will beat with the generator frequency and generate a difference frequency that is available at the BEAT output jack; thus the 1026 will serve as a heterodyne frequency meter as well.

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FM AND PHASE-LOCKED OPERATION

The generator frequency can be electrically controlled by an external dc or audio frequency signal. Good linearity is attained for narrow-band fm throughout the carrier frequency range; in the important 88-108 MHz range, peak deviations up to 100 kHz are readily obtainable. Using an external phase detector and dc amplifier, one can phase-lock the generator frequency to an external frequency standard for stability.

CONVENIENT

Many features are included which not only mean convenience for the operator but will also reduce potential errors and permit operation by less-skilled personnel. True single-dial frequency control speeds frequency setting and eliminates the misadjustments possible with signal generators in which the amplifier tracking depends upon auxiliary-trimmer adjustment by the operator. A parallax-free fiducial mark and illumination of only the scale in use reduce possible error in frequency readings. All controls and indicators are grouped by function, and their use is self-evident, obviating frequent reference to operating instructions. Output connectors are easily convertible to practically any common coaxial connectors with GR874 adaptors.

specifications

FREQUENCY

Range: 9.5 to 500 MHz in 6 ranges: 9.5 to 22, 22 to 48, 48 to 108, 108 to 220, 220 to 420, and 400 to 500 MHz.

Manual Control: Main frequency control, spinner knob with 100-division vernier dial (25 turns per range) drives main drum-type dial. Illuminated scale indicates selected range. Parallax-free fiducial mark is adjustable for fine calibration. Scales to 108 MHz are linear. An uncalibrated Δf control spans typically ±0.003% at low end of range to ±0.015% at high end (actual spans may vary 2:1 depending on frequency range).

Scale Characteristics:

Frequency Range (MHz)	Main Scale Interval	kHz per Vernier Division	Scale Length (in.)
9.5-22	100 kHz	5	14¼
21.2-49.6	200 kHz	11	14¼
47.4-111	500 kHz	25	14¼
100-220	1.0 MHz	45-60	13
216-430	2.0 MHz	80-150	10½
400-500	2.0 MHz	150	4

External Electrical Fine Frequency Control: Applied voltage of ±20 V dc varies frequency typically ±0.04% at low end of range to ±0.2% at high end (actual variation may differ by 2:1 depending on frequency range).

Stability: After 1-h warmup, drift rate is typically <50 ppm per 10 min for carrier frequencies <400 MHz; from 400 to 500 MHz, rate is typically <100 ppm per 10 min. Following frequency change <10 min is required for restabilization.

Calibration Accuracy: ±0.5% direct reading, after initial adjustment of fiducial. With internal crystal calibrator, ±0.01% at 1.0-MHz intervals, typically ±0.05% by interpolation.

Calibration Provisions: Internal crystal frequency, accurate to ±0.001%, provides calibration at intervals of 1 and 5 MHz over entire frequency range. Calibration by external counter provided for by output of about 0.1 to 1 V behind 50 Ω. When not needed, this output can be disabled with > 100-dB isolation; external counter can be simultaneously disabled by a contact closure provided to eliminate interference from the counter's internal signals.

Harmonic Output: At least 30 dB below carrier.

RF OUTPUT

Range: CW, 0.1 μV to 10 V behind 50 Ω, ½ W into 50 Ω (−133 to + 27 dBm); modulated, 0.1 μV to 5 V behind 50 Ω (−133 to + 21 dBm). Load VSWR > 2.0 may restrict the max output available at some frequencies.

Control: Step attenuator, 140 dB in 10-dB steps, voltage and dBm calibration. Continuous interpolation with metered level control.

Meter Scales: 0.3 to 1.5 V, 1.0 to 5.0 V, and −13 to +1 dBm. Scale extensions (in red), for cw use only, to 10 V and to +7 dBm.

Accuracy: Metering, ±5% to 108 MHz; above 108 MHz, harmonics can add ±3% and rectifier characteristic can add ±2%. Attenuator, ±1% (±0.1 dB) per step to −110 dBm; ±2% (±0.2 dB) from −110 to −120 dBm; max accumulated error ±0.5 dB.

RF Interference: Leakage has negligible effect on measurements of receiver sensitivity down to 0.1 μV.

Leveling: CW output is held at preset level to within ±3% (0.3 dB) up to 108 MHz and to within ±5% (0.5 dB) to 500 MHz as frequency is varied, including effects due to range switching. Effectiveness of leveling under modulated operation is a function of modulation mode and frequency.

Stability: At any given frequency, in cw operation or internal 1-kHz modulation mode, and after 2-hour warmup, output will typically remain constant within ±0.0025 dB per minute, or ±0.01 dB over any 15-min period. Also under these conditions, variation due to ±10% line-voltage fluctuation is < ±0.005 dB.

Effective Generator Impedance (at panel jack): 50 Ω resistive; VSWR is < 1.05 with output attenuator set for 0 dBm or less. At higher outputs, source impedance viewed as Thévenin generator has a VSWR < 1.2.

MODULATION

Modes: Amplitude Modulation is provided in four modes:

1. Internal 1 kHz. Modulation level adjustable 0 to > 95% and metered to within ±3% of reading ±2% of full scale. Envelope feedback provides leveling and holds distortion to < 1% at 30% modulation and < 3% at 80% modulation. Modulating frequency, 1 kHz ±0.5%; after 2-hour warmup stable to better than 0.1% over 8-hour period or for line-voltage variations of ±10%. 1-kHz signal available at MOD binding posts, about 2.5 V behind 100 kΩ.

2. External Audio. Response flat to dc, down < 0.5 dB at 10 kHz. Square-wave response 0 to 10 kHz; rise and fall time < 10 μs; overshoot < 10%; rampoff negligible. Modulation is adjustable 0 to > 95% for dc to 5-kHz input, to > 70% at 10 kHz, and is metered to within ±5% of reading ±5% of full scale for sine-wave inputs from 20 Hz to 10 kHz. For 95% modulation < 3 V, peak required into 3 kΩ. Envelope feedback provides leveling and holds distortion at 30% modulation to < 1% up to 1 kHz, < 5% up to 10 kHz.

3. External Wide Band. Modulation level adjustable 0 to > 80%. Response flat to ±3 dB for 50-Hz to 1.5-MHz inputs at carrier frequencies above 108 MHz. Average carrier is leveled and metered, but modulation depth and linearity should be monitored externally. For full modulation, about 0.6 to 3.5 V (depending on carrier frequency) is required into 3 kΩ.

4. External Pulse. Required input pulses, at least 10 V peak, positive going (max 30 V); repetition rate 500 Hz to 150 kHz; duration 1 to 300 μs (min 3 μs on 9.5- to 22-MHz range); max 50% duty ratio. Input impedance 3 kΩ. Output pulse, duration within ±0.5 μs of input; rise and fall times < 1 μs each on all ranges but 9.5 to 22 MHz (up to 3 μs); rampoff < 5%. On-off ratio > 30 dB and at max output setting of attenuator is typically > 40 dB. Peak amplitude of pulses is leveled and metered to within ± 1 dB added to accuracy specified for cw leveling.

Incidental FM (accompanying a-m); < 1 ppm + 100 Hz, peak, at 1 kHz, 50% a-m.

Residual FM: < 0.05 ppm, peak.

Residual A-M: A-m due to hum and noise in 15-kHz bandwidth is at least 70 dB below carrier level in cw, internal 1-kHz, and external audio modes.

GENERAL

Power Required: 105 to 125 or 200 to 250 V, 50 to 60 Hz, 90 W.

Terminals: RF and counter outputs are GR874 coaxial connectors, recessed and locking; for rapid conversion to other common types, use locking GR874 adaptors. Modulation connection is to front-panel binding posts and rear-panel multiterminal connector. Audio (BEAT) output from front-panel telephone jack. Electrical frequency control is through rear-mounted 12-pin connector.

Accessories Supplied: 874-R22LA Patch Cord (GR874-to-GR874), phone plug, 12-pin connector plug, power cord, spare fuses, hardware for bench and rack mounting.

Mounting: Rack-bench cabinet.

Dimensions (width x height x depth): Bench, 19 x 17¾ x 15¼ in. (485 x 450 x 390 mm); rack, 19 x 17½ x 13 in. (485 x 445 x 330 mm).

Weight: Net, 96 lb (44 kg); shipping, 156 lb (72 kg).

Catalog Number	Description	Price in USA
1026-9701	**1026 Standard-Signal Generator**	**$6500.00**

File Courtesy of GRWiki.org

STANDARD-SIGNAL GENERATOR

Type 1001-A

- 5 kHz to 50 MHz
- 0 - 80% a-m

The 1001-A is a laboratory instrument for use in determining the performance of receivers and other equipment at ultrasonic and radio frequencies. Its sturdy construction and simplicity of operation make it suitable for production testing. Because of its small size, light weight, and low power consumption, it can be adapted for use in field-strength measurements.

The oscillator frequency varies logarithmically with dial rotation, so that the precision of frequency setting is constant; the vernier dial is calibrated directly in percentage frequency increments.

A buffer amplifier between the oscillator and the low-impedance output circuits can be amplitude modulated from zero to 80%. Loose coupling between the oscillator and the amplifier minimizes incidental frequency modulation. The output circuit is coupled to the amplifier through a high-pass filter, to reduce modulation-frequency voltages in the output.

A 400-Hz RC oscillator supplies internal modulation voltage. The panel meter can be switched to monitor either carrier-level input to the attenuator or modulation percentage.

specifications

CARRIER FREQUENCY

Range: 5 kHz to 50 MHz in 8 ranges: 5 to 15 kHz, 15 to 50 kHz, 50 to 150 kHz, 150 to 500 kHz, 0.5 to 1.5 MHz, 1.5 to 5 MHz, 5 to 15 MHz, and 15 to 50 MHz. Logarithmic scale up to 15 MHz, departs slightly from logarithmic at higher frequencies. Vernier-dial frequency increment is 0.1% per dial division up to 15 MHz.

Accuracy: ±1% of reading.

Stability: Warmup drift is of the order of 0.25%. Half the maximum drift is reached in approx 1½ hours.

Leakage: Stray fields at 1 MHz are less than one microvolt per meter two feet from the generator.

Distortion and Noise Level:

Envelope Distortion: Less than 8% at 80% amplitude modulation.

Carrier Noise Level: Corresponds to about 0.1% modulation.

Carrier Distortion: Of the order of 7% on all except 5 to 15 kHz range, where it may increase to about 15%.

MODULATION

Amplitude Modulation: 0 to 80%, continuously variable, indicated on the panel meter to ±10% of reading with possible additional error of 2% modulation.

Internal Modulation Frequency: 400 Hz ±5%.

External Modulation Characteristic: For carrier frequencies above 400 kHz, modulation is flat within ±1 dB from 20 Hz to 15 kHz; for those below 400 kHz, modulation is flat within ±1 dB from 20 Hz to 1 kHz; 12 V into 4 kΩ for 80% modulation.

Incidental Frequency Modulation: 30 to 300 ppm at 80% amplitude modulation, over all ranges except 15 to 50 MHz where it may be 3 times as great; approximately proportional to modulation percentage at low modulation percentages.

OUTPUT

Voltage Range: At ATTEN terminal, 0.1 μV to 200 mV, open circuit; 0.05 μV to 100 mV with output cable terminated at both ends. Output continuously variable. At 2 VOLTS terminal, 2 V, open circuit, up to at least 15 MHz, with output meter set to reference mark.

Voltage Accuracy: At ATTEN terminal, ±(6% + 0.1 μV), 150 kHz to 10 MHz with output dial near full scale or 1/10 full scale (error may be 4% greater with output dial set to mid-scale region); ±(10% + 0.3 μV) above 10 MHz with output dial near full scale (error may be 10% larger or smaller at other output dial settings). At 2 VOLTS terminal, ±3% at mid-frequencies.

Impedance: At ATTEN terminal, 10 Ω; 50 Ω when series unit is used; 50 Ω at highest output position of attenuator; 25 Ω at end of terminated cable. At 2 VOLTS terminal, 300 Ω. Type 1000-P4 Dummy Antenna provides a standard (IEEE) test impedance. A known induction field is obtainable with the Type 1000-P10 Test Loop (for testing loop receivers).

File Courtesy of GRWiki.org

GENERAL

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 40 to 60 Hz, 65 W; 115 to 125 V up to 400 Hz.

Terminals: GR874 coaxial connectors. For connection to type N, BNC, TNC, SC, C, or UHF connector, use a GR874 locking adaptor.

Accessories Supplied: 874-R22LA Coaxial Cable, 1000-P1 50-Ohm Termination Unit, 1000-P2 40-Ohm Series Unit, 874-Q2 Adaptor, TO-44 Adjustment Tool (stored in cabinet), 274-MB Plug, CAP-22 Power Cord, spare fuses.

Accessories Available: 1000-P4 Standard Dummy Antenna, the 1000-P10 Test Loop.

Mounting: Lab-Bench Cabinet.

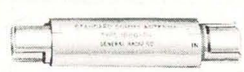
Dimensions (width x height x depth): 20¼ x 13¾ x 11 in. (515 x 350 x 280 mm).

Weight: Net, 54 lb (25 kg); shipping, 67 lb (31 kg).

Catalog Number	Description	Price in USA
1001-9701	**1001-A Standard-Signal Generator**	**$1295.00**

SIGNAL-GENERATOR ACCESSORIES

	Description	Catalog Number	Price in USA



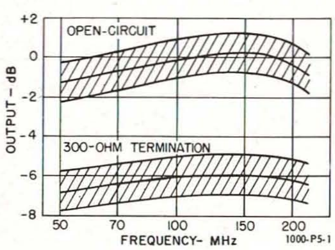
Type 1000-P4 DUMMY ANTENNA

Connected to the terminated output of a 50-ohm generator, this dummy antenna provides the output characteristics specified by the IEEE in "Standards on Radio Receivers, Methods of Testing Amplitude-Modulation Broadcast Receivers," 1948 (now USASI Standard C16.19-1951).

Dimensions: Diameter ⅞, length 4⅜ in. (23, 115 mm).

Weight: Net, 3¼ oz (0.1 kg); shipping, 1 lb (0.5 kg).

Description	Catalog Number	Price in USA
1000-P4 Dummy Antenna	1000-9604	**$25.00**



Type 1000-P5 VHF TRANSFORMER

50 to 220 MHz

The 1000-P5 plugs into a 50-ohm standard-signal generator to produce an equal, balanced, open-circuit voltage behind a 300-ohm balanced impedance for measurements of fm and TV receivers.

One terminal fits the Alden HA902P Connector for standard 300-ohm line, the other a GR874 Coaxial Connector.

Dimensions: Diameter, ⅞, length 4⅜ in. (23, 115 mm).

Weight: Net, 3½ oz (0.1 kg); shipping, 1 lb (0.5 kg).

Description	Catalog Number	Price in USA
1000-P5 VHF Transformer	1000-9605	**45.00**

Type 1000-P10 TEST LOOP

For testing radio receivers with loop antennas by the preferred method of the 1948 "Standards on Radio Receivers, Methods of Testing Amplitude-Modulation Broadcast Receivers," published by the IEEE (now USASI Standard C16.19-1951). The 3-turn loop is enclosed in aluminum tubing for electrostatic shielding. The field strength in volts per meter, 19 inches from the loop, is one-tenth the generator output in volts, with a 50-ohm generator.

Frequency: 3 MHz, max.

Accuracy: ±10% (±5% is typical); with 1001-A Standard-Signal Generator, ±15% (±10% is typical).

Dimensions: Width 11¾, height 16½, depth 3½ in. (300, 420, 89 mm), over-all.

Weight: Net, 4½ lb (2.1 kg); shipping, 6 lb (2.8 kg).

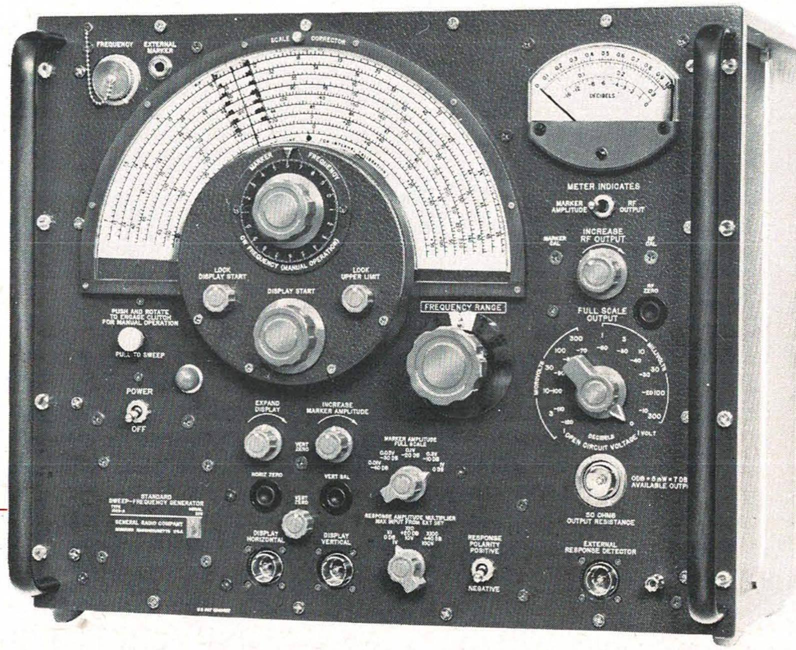
Description	Catalog Number	Price in USA
1000-P10 Test Loop	1000-9610	**85.00**

File Courtesy of GRWiki.org

STANDARD SWEEP-FREQUENCY GENERATOR

Type 1025-A

- 400 kHz to 230 MHz
- calibrated, adjustable marker
- cw as well as sweep operation
- 1 μV to 1 V, calibrated output



The 1025-A is a standard-signal generator, an accurately calibrated source for cw and sweep-frequency measurements on tuned circuits, filters, i-f amplifiers, and other networks. Amplitude and frequency data can be taken directly from the oscilloscope display by use of the calibrated marker. The instrument can be easily switched between cw and swept operation with no change in test setup, for the output voltage and impedance levels are unchanged, the horizontal deflection voltage is generated in both modes, and the main frequency control sets marker position or cw frequency with equal accuracy, ±0.5%. Thus, a response can be displayed swept or investigated point-by-point, also displayed, with no change-over fuss or degraded performance.

SWEEP OPERATION

The frequency of the sinusoidal output is varied smoothly and continuously over a frequency band in repetitive cycles by a motor-driven tuning capacitor. Thus, the amplitude response of a device as a function of frequency can be displayed automatically on an oscilloscope. A synchronously varying horizontal-deflection voltage is provided. The large dial indicates the frequency of a manually positioned marker on the display. The amplitude of the marker is adjustable and is monitored by a panel meter, thus providing frequency and amplitude calibration of the displayed response. Distortion of the response curve is eliminated; the marker is added to the baseline of the oscilloscope trace during alternate sweeps appearing superimposed on the response curve.

The frequency range is covered in 10 step-switched, octave bands plus two bandspread ranges for 450 kHz and 10.7 MHz. Other ranges can be supplied on special order.

The entire selected range is swept, but, by means of EXPAND DISPLAY and DISPLAY START controls, as little as one-tenth of any range can be set to occupy the full width of the oscilloscope screen.

Manual sweep operation is also possible; a dc horizontal-deflection voltage is produced for a manually swept CRO display or X-Y recording. A detector probe is supplied, but dc output of devices with built-in detectors can also be used.

— See **GR Experimenter** for January 1963 or write for **GR Reprint A-109,** "Sweep-Frequency Measurement Techniques."

File Courtesy of GRWiki.org

specifications

FREQUENCY

Range: 0.7 to 230 MHz in 10 ranges (0.7 to 1.4, 1.3 to 2.6, 2.4 to 4.8, 4 to 8, 7 to 14, 13 to 26, 24 to 48, 40 to 80, 65 to 140, and 100 to 230 MHz) and bandspread ranges of 400 to 500 kHz and 10.7 ± 0.3 MHz.

Alternate range* sectors can be substituted in the range-selector turret. Those presently available are:

0.4 to 0.8 MHz	4.0 to 5.0 MHz	14.25 ± 0.3 MHz
2.0 ± 0.1 MHz	4.0 ± 0.1 MHz	16 ± 0.3 MHz
2.8 ± 0.1 MHz	5.0 ± 0.3 MHz	19 ± 1 MHz
		40 to 50 MHz

Other special bandspread ranges (prices on request) can be supplied as follows:

Specified Center Frequency	Bandwidth
Between 0.4 and 0.5 MHz	±0.01 MHz
0.45 and 1.6 MHz	±0.03 MHz
1.4 and 5 MHz	±0.1 MHz
4.5 and 16 MHz	±0.3 MHz

Control: 11-in. semicircular dial, logarithmic scales for octave bands up to 80 MHz, quasilogarithmic between 65 and 230 MHz, essentially linear for all bandspread ranges. One division on the slow-motion dial represents approximately 0.1% frequency difference on the octave frequency bands.

Calibration Accuracy: ±0.5% of reading at output voltages less than 0.3 V when scale corrector is set to bring dial to index line. Frequency changes up to ±0.5% can be caused by load changes at output voltages over 0.3 V. With an external frequency meter, scale corrector can be used to bring dial into agreement, for frequency resolution within ±0.1%.

Drift: 0.3%, or less, per 3 h after 1-h warmup.

Sweeping Rate: 20 times per second, 22.2 ms from low- to high-frequency end; output blanked for return sweep.

Sawtooth Sweep Voltage: 100 V pk-pk max; amplitude and starting point in frequency band both adjustable.

Marker: 3 mV to 1 V, adjustable, internally generated, half-sinusoidal waveform, at any frequency within sweep range; response amplitude multiplier effectively extends range up to 100 V; amplitude is indicated to an accuracy of ±10%.

External Marker Input Voltage: 1 V pk-pk into 50 kΩ. Birdie-type markers can be applied, which are controlled in amplitude and added to the response displayed.

RF OUTPUT

Voltage: 0.3 μV to 1 V behind 50 Ω (−123 to 7 dBm power), adjustable.

Accuracy: ±14% of reading, over-all, up to 100 MHz; harmonics may add additional ±3% error above 100 MHz. Over-all accuracy is sum of voltmeter error of ±2% of reading +2% of full scale and attenuator error of 1% per step up to a maximum of 6%.

Stability: Output constant within ±1% (0.1 dB) up to 100 MHz, ±3% (0.25 dB) up to 230 MHz. Output variations due to band switching and line-voltage changes will not exceed ±3% (0.25 dB) max. Type 874-R22LA Patch Cord reduces output 5% (0.4 dB) at 230 MHz.

Effective Generator Impedance: 50 Ω resistive, VSWR less than 1.01 at panel jack; less than 1.1 at output of Type 874-R22LA Patch Cord, over the frequency range of the active generator.

Leakage: External rf field produces negligible interference with measurements down to lowest output levels.

RESPONSE AMPLIFIER

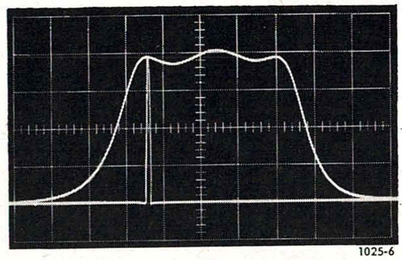
Input Voltage: 1, 10, or 100 V max, as selected by response-amplifier switch. Noise level (with 100-kΩ source) varies with multiplier-switch setting — 1 mV max pk-pk at ×1 (1 V), 10 mV at ×10 (10 V), and 100 mV at ×100 (100 V) referred to input.

Input Impedance: 1 MΩ in parallel with 30 to 45 pF.

Gain: Dc amplification between external response input and vertical display output varies with multiplier switch setting — approx 18 dB at ×1 setting, −2 dB at ×10, and −22 dB at ×100.

Bandwidth: 10 kHz or greater; sufficient to pass all details of any response that can be resolved at maximum sweep rate.

* Prices on request.



Marker is accurately calibrated in frequency and amplitude.

Polarity: Switch provided to give positive display output voltage with either positive or negative inputs from external response detector.

OTHER OUTPUT VOLTAGES

Display, Vertical: Up to +8 V into 100-kΩ load, consisting of marker plus response to be displayed.

Display, Horizontal: Up to +100 V dc or sawtooth peak into 100-kΩ load.

Frequency Output Voltage: 0.1 to 0.3 V into 50 Ω for operating external frequency counter or external marker generator.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 60 Hz, 145 W. 50-Hz model available.

Terminals: GR874 Coaxial Connector, recessed, locking, except EXTERNAL MARKER input connector, which is a standard telephone jack. For simple conversion to type N, BNC, TNC, SC, C, or UHF connector, use a locking adaptor, which locks securely in place, yet is easily removed. Panel connector is recessed, and adaptor projects only about an inch from panel.

Accessories Supplied: 1025-P1 Detector Probe, 2 Type 874-R22A Patch Cords, 874-R22LA Patch Cord, 3 Type 874-R33 Patch Cords, 2 Type 874-C58A Cable Connectors, 6 alligator clips, power cord, phone plug, spare fuses.

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Accessories Available: 874-VQ Voltmeter Detector, 874-W50B 50-ohm Termination.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench, 19 x 16 x 13¾ in. (485 x 410 x 350 mm); rack, 19 x 15¾ x 11¼ in. (485 x 400 x 290 mm).

Weight: Net, 73 lb (34 kg); shipping, 152 lb (70 kg).

Type 1025-P1 DETECTOR PROBE

(supplied with instrument)

Frequency: 0.4 to 250 MHz, flat within 5% (0.4 dB).

Fall Time: 150 μs, or less, sufficiently short to follow all details of any response that can be resolved at maximum sweep of generator.

Max RF Voltage: 3 V rms.

Input Impedance: 25 kΩ in parallel with 3 pF up to 10 MHz, decreases to 2 kΩ at 250 MHz.

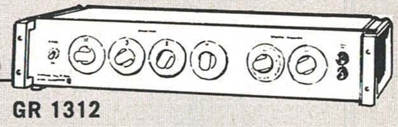
Transfer Characteristic: Positive polarity; dc output voltage equals rms rf voltage above 0.5-V input; essentially square-law characteristic below 50-mV input.

Catalog Number	Description	Price in USA
	1025-A Standard Sweep-Frequency Generator	
1025-9801	Bench Model, for 60-Hz supply	**$3950.00**
1025-9811	Rack Model, for 60-Hz supply	**3950.00**
1025-9495	Bench Model, for 50-Hz supply	**on request**
1025-9496	Rack Model, for 50-Hz supply	**on request**

File Courtesy of GRWiki.org

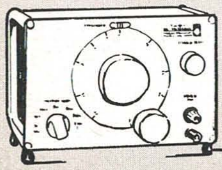
LOW-FREQUENCY OSCILLATORS

2 Hz - 2 MHz



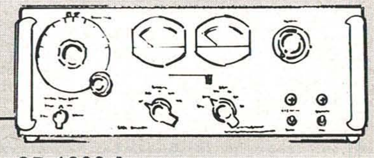
GR 1312

- In-line frequency readout ■ 10 Hz to 1 MHz
- 20 V ■ 80-dB step attenuator



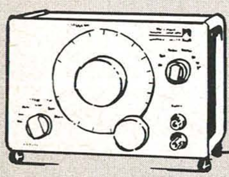
GR 1310-A

- 2 Hz to 2 MHz
- 20 V ■ 0.25% distortion



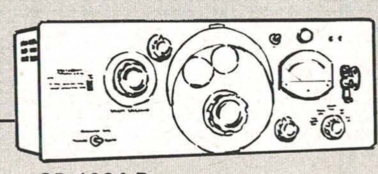
GR 1308-A

- 200 VA ■ 400 V or 5 A
- 20 Hz to 20 kHz ■ transformer output



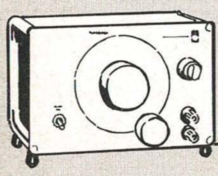
GR 1309-A

- 0.05% distortion ■ sine and square waves
- 10 Hz to 100 kHz ■ 5 V ■ 60-dB step attenuator



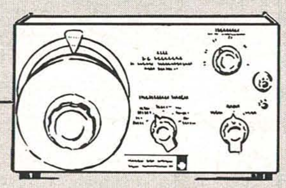
GR 1304-B

- 20 Hz to 20 kHz in one logarithmic sweep
- 1 watt ■ transformer output



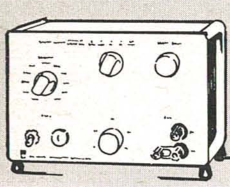
GR 1313-A

- 10 Hz to 50 kHz in one range
- sine and square waves



GR 1210-C

- 20 Hz to 500 kHz ■ sine and square waves
- 45 V



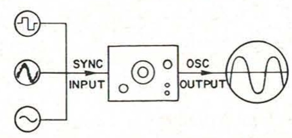
GR 1311-A

- 1 watt ■ 100 V or 4 A ■ transformer output
- 50 Hz to 10 kHz ■ discrete frequencies

General Radio's low-frequency oscillators are of the RC Wien-bridge type, which, when designed using modern solid-state devices, can provide a combination of wide frequency range, low noise distortion, and stable output in a reliable and inexpensive instrument. The Type 1304-B Beat-Frequency Audio Oscillator is the single exception to RC design.

In the Wien-bridge oscillator the frequency is determined by passive resistors and capacitors; both can be made very stable with time and temperature. Tuning is accomplished with a variable air capacitor, which provides continuous adjustment without jumps, or with switched resistances that vary frequency in discrete steps. Both offer advantages, depending upon the application: infinite resolution or fast, repeatable frequency selection.

For greater frequency stability, the oscillator can have its frequency locked to an external signal by means of a synchronization input. All the oscillator's output characteristics are maintained and the long-term frequency stability is the same as the external signal.[1] By this means, also, the oscillator can filter out noise and distortion in an applied signal, while providing the output amplitude and shortability of the normal oscillator. Short-term frequency instability or jitter can be reduced also.



Oscillator filters, amplifies, isolates, multiplies frequency

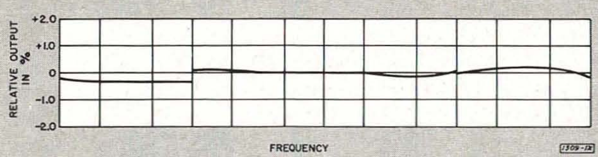
With a new type of amplitude regulator circuit,[2] the output of an RC oscillator is held very constant, regardless

[1] See GR Instrument Note IN-109, "Principles and Applications of RC Oscillator Synchronization," 1966.

[2] R. E. Owen, "Solid State RC Oscillator Design for Audio Use", Journal of the Audio Engineering Society, January 1966, available from GR as reprint A-125.

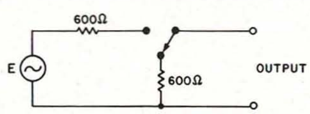
File Courtesy of GRWiki.org

of changes in the output frequency. This new regulator circuit operates without increasing distortion, and the output is so constant that an analog voltmeter will not move as the frequency is changed, providing that the oscillator is properly terminated so reactive loading effects are insignificant.



Constant output voltage vs frequency change

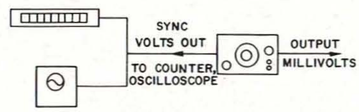
The oscillator output may be made available through a constant-impedance attenuator, a tapped transformer, or a combination. The constant-impedance attenuator is most common because of its convenience in controlling loading effects — cable-capacitance shunting or low-impedance loads, for example. Also convenient is an attenuator position that removes the oscillator voltage yet maintains the output impedance. Thus one can set the output to zero without changing the variable control setting or shorting shielded connections. Since the impedances all remain the same, the effects of ground loops and other noise sources are unchanged, yet they are easier to locate with the oscillator output removed.



Zero-output position on attenuator

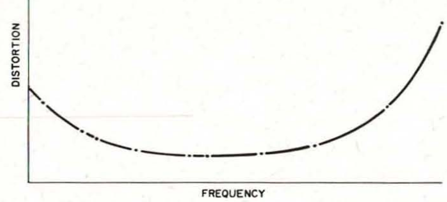
Transformer outputs offer a selection of output impedances for maximizing power into a load or for maintaining a sinusoidal current or voltage with nonlinear loads. Further, they provide isolation of the output for ungrounded or balanced operation and are a low-impedance direct-current path through the source.

The synchronization jack also provides an output of the order of one volt, a convenience for triggering a counter or an oscilloscope as it is independent of a varying or low output level.



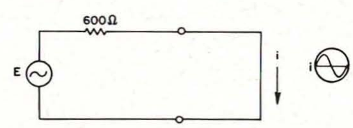
Using sync output

The distortion in the output of a solid-state RC oscillator can be quite low with a properly designed amplitude regulator. It will be lowest in the middle of its frequency range and increase at the extremes in a manner similar to many devices apt to be tested.



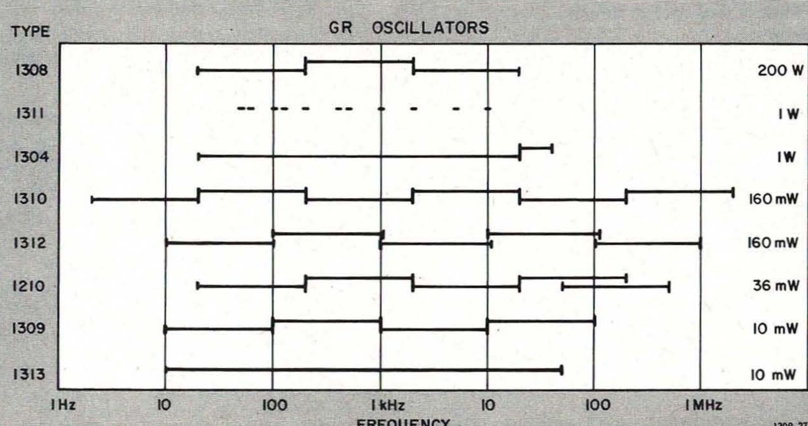
Distortion is lowest at frequencies that matter most

Maintaining low distortion under all load conditions is desirable and is made practical with solid-state design. Output waveform will not be clipped even when short-circuited at maximum output.



No clipping of output current, even into a short circuit

These many features have been combined in the eight oscillators described in the following pages. The combination in each case attempts to satisfy the requirements of broad application areas. As the chart below reveals, frequency range alone is not the greatest distinction between them.



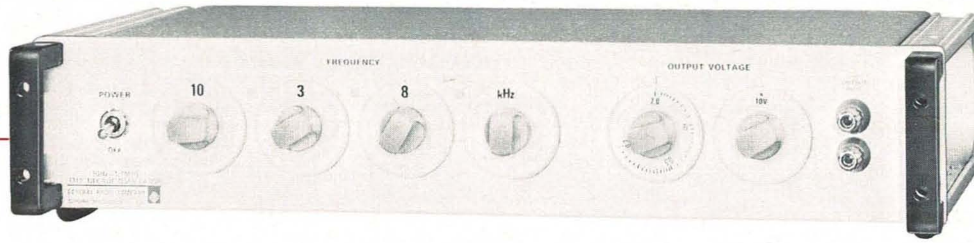
File Courtesy of GRWiki.org

DECADE OSCILLATOR

Type 1312

- 10 Hz to 1 MHz
- 20-V output, 80-dB step attenuator
- low distortion and hum
- decade controls, in-line readout

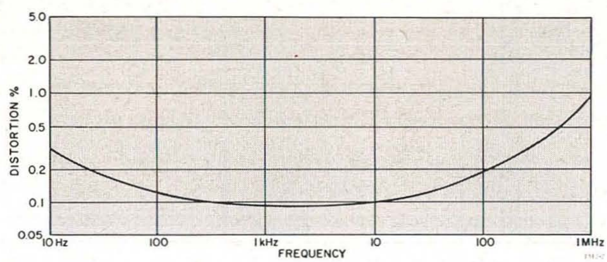
new

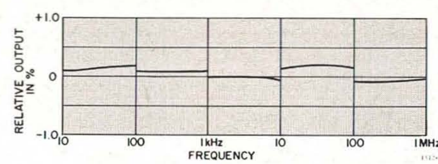


The 1312 permits frequency to be set fast, yet accurately, and with little chance of operator error. Thus it is the ideal oscillator for the many production and quality-control tests that demand laboratory performance and easy operation. Like a decade resistor or capacitor, the 1312 can be set to the desired frequency with two step decades and one continuously adjustable dial; selected frequency is displayed digitally in line, with decimal point and frequency units.

Although the 1312 is economical, it represents no performance compromises. The 20-volt output is held constant to within ±2%, without degrading the low distortion. For measurements of attenuation and gain, output level can be changed in precise increments with the precision 80-dB step attenuator, while a continuous control permits setting to any desired level. Output impedance of 600 ohms is maintained at all voltage levels, including the zero-volt setting of the attenuator provided for ease in locating sources of hum and noise in a measurement setup. The output of the 1312 is isolated from the chassis to reduce the effects of ground loops.

— See **GR Experimenter** for January 1968.





Typical low distortion (left) and uniform output level (above), shown as functions of frequency.

specifications

FREQUENCY

Range: 10 Hz to 1 MHz in five decade ranges.

Accuracy: ±1% of setting.

Stability (typical at 1 kHz): Warmup drift, 0.1%. After warmup: 0.001% short term (10 min), 0.005% long term (12 h). Resettable within 0.005%.

Control: Step control of two most significant digits, continuously adjustable third digit with detented zero position. In-line readout with positioned decimal point and frequency units.

Synchronization: Frequency can be locked to external signal. Lock range ±3% per volt rms input up to 10 V. Frequency controls function as phase adjustment.

OUTPUT

Voltage: >20 V open circuit.

Power: >160 mW into 600 Ω.

Impedance: 600 Ω. Isolated from chassis by 10 Ω across 0.1 μF.

Attenuation: Continuously adjustable attenuator with >20-dB range, and 80-dB step attenuator with 20 dB per step. Intermediate steps reduce output to zero while maintaining 600-Ω output impedance.

Distortion: <0.25%, 50 Hz to 50 kHz with any linear load. Oscillator will drive a short circuit without clipping.

Hum: <0.04% of max output or 4 μV, whichever is greater.

Amplitude vs Frequency: ±2%, 10 Hz to 100 kHz with ≥600-Ω load; ±4%, 100 kHz to 1 MHz with ≤600-Ω load.

Synchronization: Constant-amplitude (0.8-V) high-impedance (27-kΩ) output to drive counter or oscilloscope.

GENERAL

Power Required: 100 to 125, 200 to 250 V, 50 to 400 Hz, 13 W.

Terminals: Front-panel output, GR 938 Binding Posts; rear-panel output, female BNC connector. Sync, rear-panel, female BNC.

Accessories Supplied: Power cord, spare fuses.

Accessories Available: 776-A Patch Cord (BNC to shielded double plug).

Mounting: Rack-bench cabinet.

Dimensions (width x height x depth): Bench, 19 x 3⅞ x 11 in. (485 x 99 x 330 mm); rack, 19 x 3½ x 8⅞ in. (485 x 89 x 225 mm).

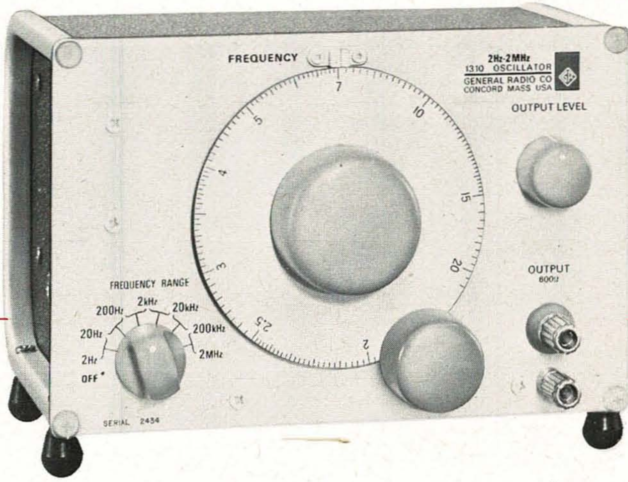
Weight: Net, 13¼ lb (6.5 kg); shipping, 17 lb (8 kg).

Catalog Number	Description	Price in USA
	1312 Decade Oscillator	
1312-9700	Bench Model	**$415.00**
1312-9701	Rack Model	**415.00**

File Courtesy of GRWiki.org

OSCILLATOR

Type 1310-A



- 2 Hz to 2 MHz
- 20-V, constant output, ±2%
- 0.25% distortion

The superior characteristics of this oscillator make it an exceptionally useful laboratory signal source.

Constant output over a very wide frequency range facilitates frequency-response measurements.

High-resolution dial and exceptional amplitude and frequency stability are important for measurements of filters and narrow-band devices.

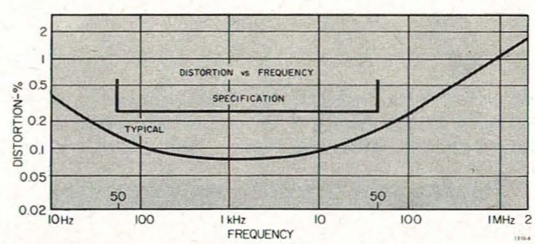
Equally useful in 600-ohm and 50-ohm circuits, since distortion is independent of load, even a short circuit.

When phase-locked to a frequency standard, the oscillator can deliver a high-level standard-frequency output with adjustable amplitude and low distortion.

DESCRIPTION

A capacitance-tuned, RC Wien-bridge oscillator drives a low-distortion output amplifier, which isolates the oscillator from the load and delivers a constant voltage behind 600 ohms.

A jack is provided for introduction of a synchronizing



signal for phase locking or to furnish a signal, independent of the output attenuator setting, to operate a counter, or to synchronize an oscilloscope or another oscillator.

Seven transistors, one nuvistor, and ingenious design make the 1310-A Oscillator not only rugged, reliable, and insensitive to mechanical vibration but also compact and light in weight.

— See **GR Experimenter** for August 1965.

specifications

FREQUENCY

Range: 2 Hz to 2 MHz in 6 decade ranges. Overlap between ranges, 5%.

Accuracy: ±2% of setting.

Stability (typical at 1 kHz): Warmup drift, 0.1%. After warmup: 0.003% short term (10 min), 0.03% long term (12 h).

Controls: Continuously adjustable main dial covers decade range in 305°, vernier in 4 turns.

Synchronization: Frequency can be locked to external signal. Lock range ±3% per volt rms input up to 10 V. Frequency dial functions as phase adjustment.

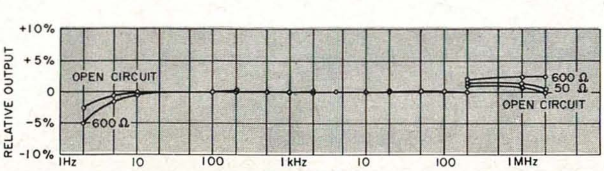
OUTPUT

Voltage: >20 V open circuit.

Power: >160 mW into 600 Ω.

Impedance: 600 Ω. One terminal grounded.

Attenuation: Continuously adjustable attenuator with >46-dB range.



Distortion: <0.25%, 50 Hz to 50 kHz with any linear load. Oscillator will drive a short circuit without clipping.

Hum: <0.02%, independent of attenuator setting.

Amplitude vs Frequency: ±2%, 20 Hz to 200 kHz, into open circuit or 600-Ω load.

Synchronization: Constant-amplitude (0.8-V), high-impedance (27-kΩ) output to drive counter or oscilloscope.

GENERAL

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 400 Hz, 12 W.

Terminals: Output, GR 938 Binding Posts; sync, side-panel telephone jack.

Accessories Supplied: Power cord, spare fuses.

Accessories Available: Adaptor cable 1560-P95 (telephone plug to double plug); rack-adaptor set.

Mounting: Convertible-bench cabinet.

Dimensions (width x height x depth): 8 x 6 x 8⅛ in. (205 x 155 x 210 mm).

Weight: Net, 7¾ lb (3.6 kg); shipping, 10 lb (4.6 kg).

Catalog Number	Description	Price in USA
1310-9701	**1310-A Oscillator**	**$325.00**
1560-9695	**1560-P95 Adaptor Cable**	**3.00**
0480-9838	**480-P308 Rack-Adaptor Set**	**7.00**

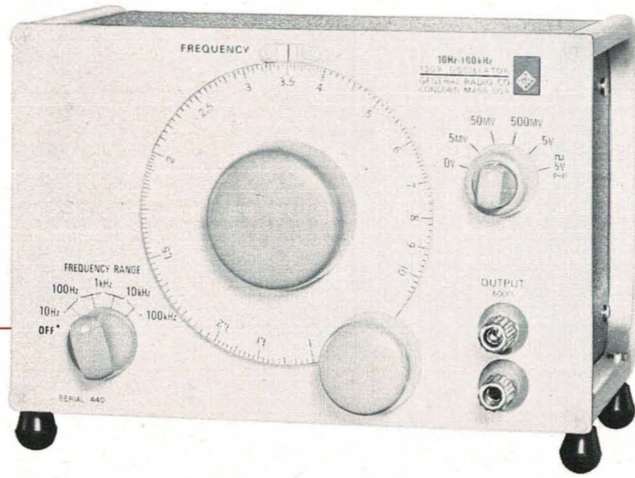
File Courtesy of GRWiki.org

OSCILLATOR

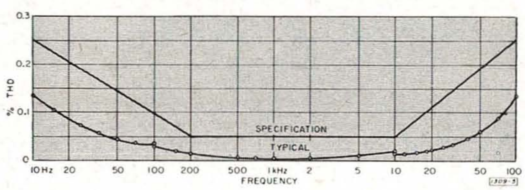
Type 1309-A

- 10 Hz to 100 kHz
- 0.05% distortion
- 5-V output, 60-dB step attenuator
- sine- or square-wave output

new



The 1309-A is particularly well suited for distortion measurements, in addition to its obvious value as a general-purpose laboratory oscillator. Distortion, noise, and hum are exceptionally low, and output is flat over the entire frequency range.



The output attenuator can be set for zero volts behind 600 ohms, a useful condition for measuring low-level noise and extraneous signals.

A square wave with 40-ns rise time is also available for transient-response tests. It has good symmetry at all frequencies and no low-frequency tilt.

— See **GR Experimenter** for March 1966.

specifications

FREQUENCY

Range: 10 Hz to 100 kHz in 4 decade ranges. Overlap between ranges, 5%.

Accuracy: ±2% of setting.

Stability (typical at 1 kHz): Warmup drift, 0.3%. After warmup: 0.001% short term (10 min), 0.01% long term (12 h).

Controls: Continuously adjustable main dial covers decade range in 305°, vernier in 4 turns.

Synchronization: Frequency can be locked to external signal. Lock range ±3% per volt rms input up to 10 V. Frequency dial functions as phase adjustment.

OUTPUT

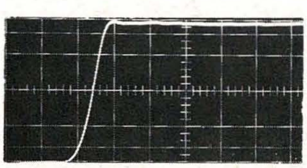
Sine Wave

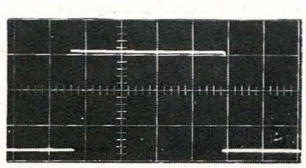
Voltage: 5.0 V ±5% open circuit.

Power: >10 mW into 600 Ω.

Impedance: 600 Ω. One terminal grounded.

Attenuation: Continuously adjustable attenuator with >20-dB range, and 60-dB step attenuator with 20 ±0.2 dB per step and a zero-volt position with 600-Ω output impedance maintained.





(Left) 10 kHz square-wave into 50 ohms. 50 ns/div, horiz. (Right) Direct-coupled 10-Hz, square-wave. Note flat top. 10 ms/div, horiz.

Distortion: <0.05%, 200 Hz to 10 kHz, increasing to <0.25% at 10 Hz and 100 kHz, into open circuit or 600-Ω load.

Hum: <50 μV independent of attenuator setting (<0.001% of full output).

Amplitude vs Frequency: ±2% for loads of ≥600 Ω.

Synchronization: Constant-amplitude (1.5-V), high-impedance (12-kΩ) output to drive counter or oscilloscope.

Square Wave

Voltage: >+5.0 V pk-pk open circuit. Dc-coupled output.

Impedance: 600 Ω. One terminal grounded.

Rise Time: <100 ns into 50-Ω load. Typically 40 ns at full output.

Symmetry: ±2% (48 to 52% duty ratio).

Attenuation: Continuously adjustable attenuator with >20-dB range.

GENERAL

Power Required: 100 to 125 or 200 to 250 V, 50 to 400 Hz, 6 W.

Terminals: Output, GR 938 Binding Posts; sync, side-panel telephone jack.

Accessories Supplied: Power cord, spare fuses.

Accessories Available: Adaptor cable 1560-P95 (telephone plug to double plug), rack-adaptor set.

Mounting: Convertible-bench cabinet.

Dimensions (width x height x depth): 8 x 6 x 8⅛ in. (205 x 155 x 210 mm).

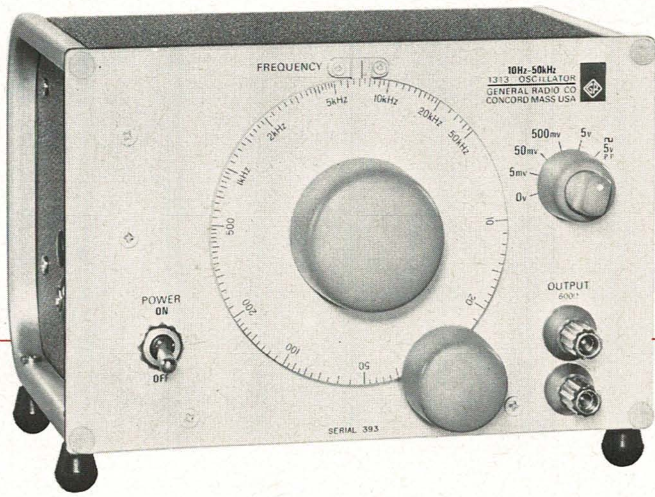
Weight: Net, 6¾ lb (3.1 kg); shipping, 9 lb (4.1 kg).

Catalog Number	Description	Price in USA
1309-9701	**1309-A Oscillator**	**$325.00**
1560-9695	**1560-P95 Adaptor Cable**	**3.00**
0480-9838	**480-P308 Rack-Adaptor Set**	**7.00**

File Courtesy of GRWiki.org

OSCILLATOR

Type 1313-A



new

- 10 Hz to 50 kHz in one range
- 5-V output, 60-dB step attenuator
- sine- or square-wave output

The single-range tuning of the 1313-A permits fast, transient-free, unambiguous frequency selection, all of which are highly desirable features in production-type testing of many devices. Amplifiers, loudspeakers, and other audio, acoustic, and ultrasonic equipment must be response- and distortion-tested quickly, surely, and without overdriving. The 1313-A is the ideal source for such applications.

The 1313 can be manually swept with ease for quick checks, in addition to detailed analyses, of cross-over and resonance frequencies, of equalization and other filter performance, and of mechanical and acoustical transducers and systems.

— See **GR Experimenter** for February 1967.

specifications

FREQUENCY

Range: 10 Hz to 50 kHz in one range.

Accuracy: ±4% of setting or ±1 Hz, whichever is greater.

Controls: Continuously adjustable main dial covers range in 322.5°, vernier in 4 turns. Vernier can be disengaged for rapid setting of main dial.

Synchronization: Frequency can be locked to external signal. Lock range ±1% to ±40% per volt rms input, depending on frequency.

OUTPUT

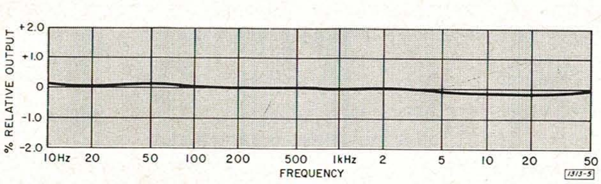
Sine Wave

Voltage: 5.0 V ±5% open circuit.

Power: >10 mW into 600 Ω.

Impedance: 600 Ω. One terminal grounded.

Attenuation: Continuously adjustable attenuator with >20-dB range, and 60-dB step attenuator with 20 ±0.2 dB per step and a zero-volt position with 600-Ω output impedance maintained.



Typical uniformity of output level as 1313-A is tuned through entire frequency range.

Distortion: <0.5%, 100 Hz to 10 kHz, into open circuit or 600-Ω load.

Hum: <0.05% of max output at 1 kHz.

Amplitude vs Frequency: ±2% for ≧600-Ω loads.

Square Wave

Voltage: >+5.0 V pk-pk open circuit. Dc-coupled output.

Impedance: 600 Ω. One terminal grounded.

Rise Time: <100 ns into 50-Ω load. Typically 40 ns at full output.

Symmetry: ±2% (48 to 52% duty ratio).

Attenuation: Continuously adjustable with >20-dB range.

GENERAL

Power Required: 100 to 125 or 200 to 250 V, 50 to 400 Hz, 6 W.

Terminals: Output, GR 938 Binding Posts; sync, side-panel telephone jack.

Accessories Supplied: Power cord, spare fuses.

Accessories Available: Adaptor cable 1560-P95 (telephone plug to double plug), rack-adaptor set.

Mounting: Convertible-bench cabinet.

Dimensions (width x height x depth): 8 x 6 x 8⅛ in. (205 x 155 x 210 mm).

Weight: Net, 7 lb (3.2 kg); shipping, 9¼ lb (4.2 kg).

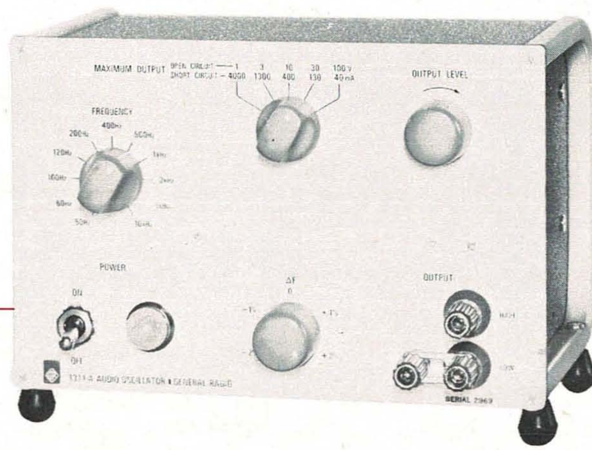
Catalog Number	Description	Price in USA
1313-9701	**1313-A Oscillator**	**$325.00**
1560-9695	**1560-P95 Adaptor Cable**	**3.00**
0480-9838	**480-P308 Rack-Adaptor Set**	**7.00**

File Courtesy of GRWiki.org

AUDIO OSCILLATOR

Type 1311

- 50 Hz to 10 kHz, discrete frequencies
- 1 W, 100-V or 4-A output
- transformer output

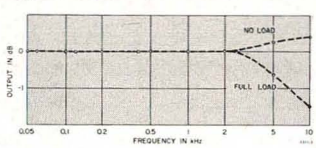


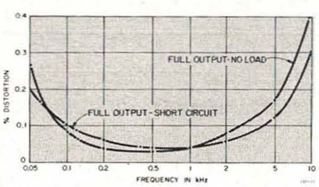
The 1311 oscillators offer high-power output and load-matching through a multitap output transformer that ensures at least ½ watt into any load from 0.08 to 8000 ohms. Thus, it is ideal for driving impedance bridges where high sensitivity is required at extreme measurement limits and for driving directly such low-impedance devices as acoustic transducers. For bridge measurements, the shielded output-transformer secondary minimizes circulating ground currents. The 1311-A is supplied in an assembly with the 1232 Tuned Amplifier and Null Detector as the 1240 Bridge Oscillator-Detector. The 1311-A is also included in many GR impedance-measuring systems.

AUDIOMETRY

The high output and low distortion of the 1311 recommend its use in the calibration of audiometric equipment. For this application, the 1311-AU is available with 12 frequencies commonly used in audiometry, including the octave series based on 125 Hz specified by the USA Standards Institute for "general diagnostic purposes" in Z24.5-1951. All other specifications are the same as the 1311-A.

Typical output characteristics





specifications

FREQUENCY

Range: 1311-A, 50 Hz to 10 kHz. Eleven fixed frequencies, 50, 60, 100, 120, 200, 400, and 500 Hz, 1, 2, 5, and 10 kHz. One other frequency can be added at an unused switch position. 1311-AU, 50 Hz to 10 kHz. Twelve fixed frequencies, 125. 250, 400, 500, and 750 Hz, 1, 1.5, 2, 3, 4, 6, and 8 kHz. Both models, a Δf control provides ±2% continuous adjustment.

Accuracy: ±1% of setting with Δf control at zero.

Stability (typical at 1 kHz): Warmup drift, 0.3%. After warmup: 0.008% short term (10 min), 0.02% long term (12 h).

Synchronization: Frequency can be locked to external signal. Lock range ±3% per volt rms up to 10 V. The Δf control functions as phase adjustment.

OUTPUT

Voltage: Continuously adjustable from 0 to 1, 3, 10, 30, or 100 V open circuit (E_{oc}).

Power: >1.0 W into matched load, >0.5 W into any resistive load between 80 mΩ and 8 kΩ.

Current: Continuously adjustable from 0 to 40, 130, 400, 1300, or 4000 mA, into approx short circuit (I_{sc}).

Impedance: One to three times $\frac{E_{oc}}{I_{sc}}$, depending on output amplitude. Output isolated from ground.

Distortion: <0.5% with any linear load. Oscillator will drive a short circuit without clipping.

Hum: <0.01%, independent of output setting.

Synchronization: Constant-amplitude (1-V), high-impedance (4.7-kΩ) output to drive counter or oscilloscope.

GENERAL

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

Terminals: Output, GR 938 Binding Posts and ground terminal with shorting link; sync, side-panel telephone jack.

Accessories Supplied: Power cord, spare fuses.

Accessories Available: Adaptor cable 1560-P95 (telephone plug to double plug), rack-adaptor set.

Mounting: Convertible-bench cabinet.

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

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

Catalog Number	Description	Price In USA
1311-9701	**1311-A Audio Oscillator**	**$260.00**
	1311-AU Audiometric Oscillator,	
1311-9703	for 115-V	**270.00**
1311-9704	for 230-V	**280.00**
1560-9695	**1560-P95 Adaptor Cable**	**3.00**
0480-9838	**480-P308 Rack-Adaptor Set**	**7.00**

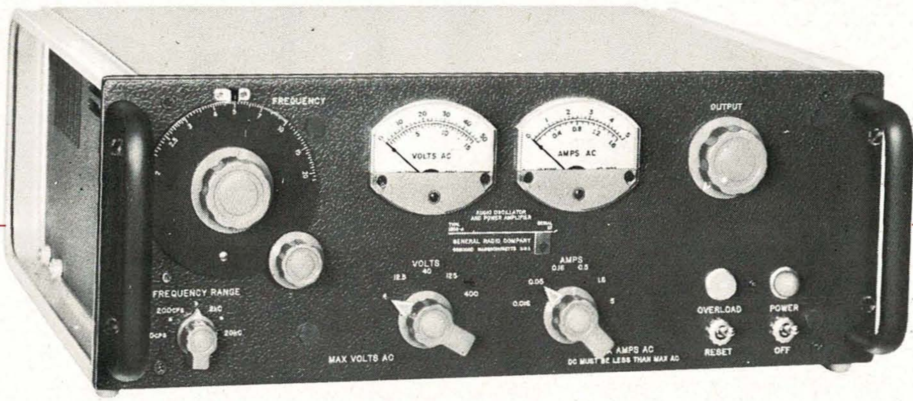
PATENT NOTICE. See Note 1.

File Courtesy of GRWiki.org

AUDIO OSCILLATOR AND POWER AMPLIFIER

Type 1308-A

- 200-VA, 400-V or 5-A output
- 20 Hz to 20 kHz
- transformer output

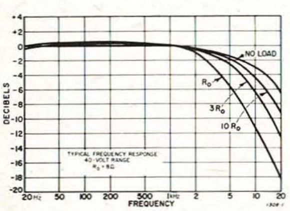


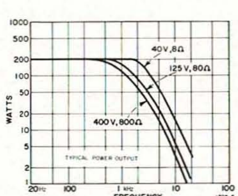
The 1308-A Audio Oscillator and Power Amplifier is an ac power source covering the audio range. It is an excellent power source for the 1633-A Incremental-Inductance Bridge. Its low dynamic output impedance enhances its usefulness as a power source for testing other devices over a wide range of supply frequencies. This instrument will provide a low-distortion signal (not clipped) to non-linear loads, such as capacitor-input rectifier systems. It can also be used to drive small shake tables and to isolate sensitive equipment from power-line transients.

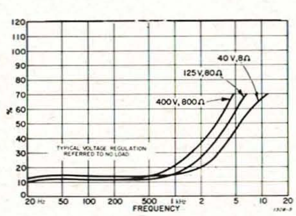
This instrument also finds many uses as an audio-frequency power amplifier. When it is used with the 1396 Tone-Burst Generator, high-power tone bursts are provided for testing sonar projectors, amplifiers, etc.

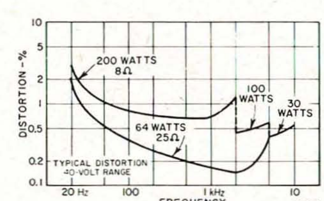
This instrument combines a capacitor-tuned, Wien-bridge oscillator, a low-distortion power amplifier, and a tapped output transformer. The output is monitored by an overload circuit, which turns off the output when it exceeds safe limits.

— See **GR Experimenter** for January 1964.









specifications

FREQUENCY

Range: 20 Hz to 20 kHz in 3 ranges.

Accuracy: ±3% of setting or ±1 Hz, whichever is greater.

Stability (typical at 1 kHz): Warmup drift at full load, 0.3%. After warmup: 0.003% short term (10 min), 0.03% long term (12 h), 0.04% from no load to full load.

Controls: Continuously adjustable main dial covers decade range in 157.5°, vernier in 2 turns.

OUTPUT

Voltage Ranges: Max of 4, 12.5, 40, 125, and 400 V open circuit, continuously adjustable from 0 to max.

Power: 200 VA max, 50 Hz to 1 kHz.

Current Ranges: Max of 0.016, 0.05, 0.16, 0.5, 1.6, and 5.0 A.

Regulation: <20%, no load to full load, 20 Hz to 1 kHz. Output impedance is typically 0.3, 0.8, 1.6, 19, and 220 Ω, depending on voltage range, 20 Hz to 1 kHz. Output transformer can pass dc current equal to max of ac current range. Output isolated from ground.

Load Impedances: Will drive short circuit or non-linear loads. Load impedances of 0.8, 2.5, 8, 80, or 800 Ω, depending on voltage range, are optimum for max available power.

Load Power Factor: Continuous operation at max VA for any power factor 0 to 1 with ambient up to 25°C. Power factor of 0.7 to 1.0 for continuous operation to 40°C ambient. Intermittent operation to 50°C.

Distortion (linear load): <1%, 100 Hz to 10 kHz; <2%, 50 Hz to 100 Hz at max power and 115-V supply.

Hum: <0.3% of max output.

Meters: Indicate output terminal voltage and current.
Voltmeter: 5, 15, 50, 150, and 500 V ±3% full scale.
Ammeter: 0.016, 0.05, 0.16, 0.5, 1.6, and 5 A ±3% full scale.

Overload Protection: Electronic overload trips at approx 1.5 × max of current range (manual reset), thermal cut-out on transistor heat sink (automatic reset).

AMPLIFIER

Sensitivity: <2.0 V for full output.

Input Impedance: 10 kΩ.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 60 Hz, 70 to 500 W, depending on load.

Terminals: Output, GR 938 Binding Posts and four-terminal socket on rear panel; input, GR 938 Binding Posts on rear panel.

Accessories Supplied: Power cord, spare fuses, and four-terminal plug.

Mounting: Rack-bench cabinet.

Dimensions (width x height x depth): Bench, 19 x 7 x 16¼ in. (485 x 180 x 414 mm); rack, 19 x 7 x 15 in. (485 x 180 x 385 mm).

Weight: Net, 91 lb (42 kg); shipping, 145 lb (67 kg).

Catalog Number	Description	Price in USA
	1308-A Audio Oscillator and Power Amplifier	
1308-9801	Bench Model	**$1395.00**
1308-9811	Rack Model	**1395.00**

PATENT NOTICE. See Note 1.

File Courtesy of GRWiki.org

UNIT R-C OSCILLATOR

Type 1210-C

- 20 Hz to 500 kHz
- 45-V output
- sine or square wave

Oscillator and power supply can be rigidly clamped together.

This popular oscillator generating high output voltage at audio, ultrasonic, and radio frequencies has found application in many areas:

- as a sine- or square-wave modulator for rf generators,
- as a source for both steady-state and transient network analysis with its choice of output waveform,
- as a square-wave trigger for pulse generators,

and many others.

An RC network determines the frequency and drives three different switch-selected output circuits for added usefulness:

1. A cathode-follower amplifier for a low-impedance, low-voltage output.
2. A high-voltage amplifier with an output whose high impedance is independent of attenuator setting.
3. A Schmitt circuit that generates a square-wave output of 30 volts pk-pk (open circuit) with ½-μs rise time.

specifications

FREQUENCY

Range: 20 Hz to 500 kHz in 5 decade ranges.
Accuracy: ±3% of setting.
Control: Vernier covers decade in 4½ turns.

OUTPUT (no load condition)

Sine Wave — 0 to 7-V range
Impedance: 1250 Ω max, varies with attenuator setting.
Distortion: <1.5%.
Hum: <0.1%, independent of attenuator setting.
Amplitude vs Frequency: ±1 dB, 20 Hz to 200 kHz.

Sine Wave — 0 to 45-V range
Impedance: 14 kΩ.
Distortion: <5%, 200 Hz to 200 kHz.
Hum: <0.3 of max output.
Amplitude vs Frequency: ±1 dB, 200 Hz to 150 kHz.

Square Wave — 0 to 30-V pk-pk range
Rise Time: <0.35 μs into 1 kΩ with max output at 500 kHz.
Impedance: 2.5 kΩ max, decreases with attenuator setting.

GENERAL

Power Required: 50- to 400-Hz power into either Unit Power Supply 1203-B (115 to 125 V) or 1203-BQ18 (230 to 250 V) or Unit Regulated Power Supply 1201-C (105 to 125 V) or 1201-CQ18 (195 to 250 V).
Terminals: Output, GR 938 Binding Posts. One terminal grounded.
Accessory Required: Power supply, see above.
Accessory Available: Rack-adaptor panel.
Mounting: Unit-Instrument Cabinet.
Dimensions (width x height x depth): 15 x 5¾ x 7 in. (385 x 150 x 180 mm); with power supply.
Weight: Net, 10½ lb (4.8 kg); shipping, 18 lb (8.3 kg).

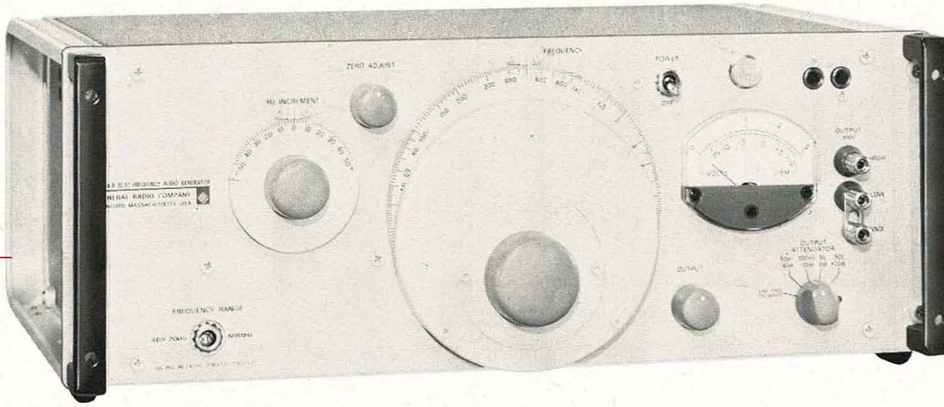
Catalog Number	Description	Price in USA
1210-9703	**1210-C Unit R-C Oscillator**	**$235.00**
	Unit Power Supply, unreg.	
1203-9702	**1203-B,** 115-125 V	**75.00**
1203-9818	**1203-BQ18,** 230-250 V	**on request**
	Unit Regulated Power Supply	
1201-9703	**1201-C,** 105-125 V	**105.00**
1201-9824	**1201-BQ18,** 195-250 V	**on request**
0480-9986	**480-P4U3 Rack-Adaptor Panel**	**12.00**

File Courtesy of GRWiki.org

BEAT-FREQUENCY AUDIO GENERATOR

Type 1304-B

- 20 Hz to 20 kHz, one logarithmic range
- 1 W into 600 Ω; 80-dB metered output
- automatic frequency tests with 1521 Recorder



The many features of this generator make it especially well suited for amplitude-frequency tests on audio-frequency equipment — lines, amplifiers, filters, equalizers, transducers, and other networks. It finds constant use in the electronics laboratory as a power source for acoustical tests, as a power source for bridge measurements, and as a modulator for rf signal generators.

Frequency-response characteristics of circuits and devices can be recorded by the Type 1521-B Graphic Level Recorder. The graphic level recorder drives the generator dial through a chain-and-gear system, and the response is plotted on chart paper whose frequency scale matches that of the oscillator.

An assembly of generator and graphic level recorder is listed on the next page.

DESCRIPTION

This instrument has a number of unusual design features that contribute to superior performance and ease of operation. Two rf oscillators, one fixed and one variable, feed a converter through buffer amplifiers. The resulting difference frequency, after passing through a low-pass filter, is amplified; the output stage of the amplifier is the unique, low-distortion, single-ended, push-pull circuit.[1]

The oscillator output level is continuously adjustable, and the output can be either balanced or grounded. The unbalanced circuit contains a three-step calibrated attenuator. The output voltmeter is calibrated in dBm and open-circuit output volts.

The frequency dial carries a logarithmic frequency scale for the range 20 Hz to 20 kHz and is driven by a gear-reduction drive, essentially free from backlash.

Rotation is continuous over 360°, to facilitate automatic recording. A hertz-incremental dial varies the frequency over a range of ±50 Hz at any setting of the main dial and can be swept by the Type 1750-A Sweep Drive.

The 20- to 40-kHz range is selected by a single panel switch.

1304-P1 MUTING SWITCH

The muting switch short circuits the generator output during rotation through the blank portion of the dial and thus eliminates any low-frequency signals that might damage the recorder or the device under test when the recorder is swept continuously. The switch can be adjusted to mute the blank portion of the dial plus any range of frequencies from 0 Hz to 1.5 kHz.

The switch mounts on the main-dial assembly of the generator and connects to the generator output terminals by means of a cable and plug.

[1] A. P. G. Peterson and D. B. Sinclair, "A Single-Ended Push-Pull Audio Amplifier," Proceedings of the IRE, Vol 40, pp 7-11, January 1952.

File Courtesy of GRWiki.org

specifications

FREQUENCY

Range: 20 Hz to 40 kHz in two ranges, 20 Hz to 20 kHz and 20 kHz to 40 kHz.

Accuracy: ±(1% + 0.5 Hz) after standardization by zero-beat or line frequency. The 20-kHz increment for high range, ±0.5%. Frequency increment dial, ±1 Hz.

Stability: Warmup drift, <7 Hz in first hour at zero beat.

Controls: Main dial with logarithmic scale from 20 Hz to 20 kHz, 80° per decade with 360° continuous rotation, driven with 10:1 vernier. Toggle switch adds 20 kHz to main dial. Linear frequency-increment dial covers −50 Hz to +50 Hz.

OUTPUT

Voltage: >50 V open circuit.

Power: >1 W into 600-Ω load.

Impedance: 600 Ω ±2%. One side grounded, or balanced with respect to ground at max output setting of step attenuator.

Attenuation: Continuously adjustable attenuator from zero to max output, 60-dB step attenuator wth 20 ± 0.2 dB per step with one side of output grounded.

Distortion: <0.25%, 100 Hz to 10 kHz; <1.0%, 10 to 40 kHz.

Hum: <0.1% for meter readings above 10% of full scale.

Recorder page 40

Amplitude vs Frequency: ±0.25 dB, 20 Hz to 20 kHz; ±0.5 dB, 20 to 30 kHz; ±1.0 dB, 30 to 40 kHz; all with 600-Ω load.

Voltmeter: Measures voltage into step attenuator. Calibrated in dBm and open-circuit output voltage. Accuracy is ±5% of reading above 10% of full scale.

GENERAL

Power Required: 105 to 120 or 210 to 250 V, 50 to 60 Hz, 90 W.

Terminals: Output, GR 938 Binding Posts and Western Electric double jack on front panel, four-terminal socket on rear.

Accessories Supplied: Power cord, four-terminal plug, spare fuses.

Accessories Available: 1521 Graphic Level Recorder, Muting Switch Type 1304-P1.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): 19 x 7½ x 15¼ in. (485 x 190 x 390 mm); rack, 19 x 7 x 13¼ in. (485 x 180 x 340 mm).

Weight: Net, 39 lb. (18 kg); shipping, 43 lb (20 kg).

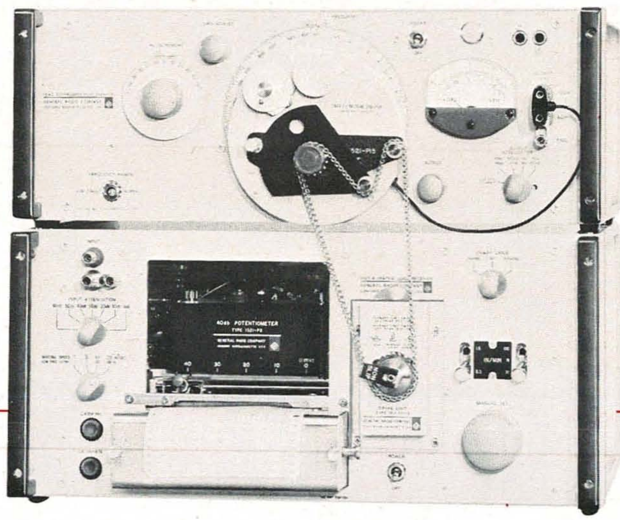
Catalog Number	Description	Price in USA
	1304-B Beat-Frequency Audio Generator	
1304-9802	Bench Model	**$1075.00**
1304-9812	Rack Model	**1075.00**
1304-9601	**1304-P1 Muting Switch**	**55.00**

PATENT NOTICE. See Notes 5, 9, 14, and 15.

GENERATOR-RECORDER ASSEMBLY

Type 1350-A

- automatic frequency-response plotting
- 20 Hz to 20 kHz
- combines 1304-B with 1521 Graphic Level Recorder



Constant generator output and uniform recorder response make this an excellent assembly for measuring the response of filters, attenuators, networks, loud-speakers, amplifiers, microphones, transducers, and complete acoustic systems.

The complete assembly includes the following:

1304-B Beat-Frequency Audio Generator with accessories, end frames and rack supports.

1521-B Graphic Level Recorder with accessories (including a 40-dB potentiometer), 1521-P19 motor, end frames and rack supports.

1521-9427 Chart Paper, 10 rolls
274-NP Patch Cord
1521-P10B Drive Unit
1521-P15 Link Unit
1521-P16 Sprocket Kit
1560-P95 Adaptor Cable
1304-P1 Muting Switch

The blank parts on the chart paper correspond to the length of the blank portion on the generator dial so that many charts can be recorded with complete synchronization of the chart and the dial frequency.

— See **GR Experimenter** for September 1964.

specifications

Power Required: 105 to 125 or 210 to 250 V, 60 or 50 Hz, 135 W.

Dimensions (width x height x depth): 19 x 16½ x 15¼ in. (485 x 420 x 390 mm).

Weight: Net, 89 lb (41 kg); shipping, 165 lb (76 kg).

Catalog Number	Description	Price in USA
	Generator-Recorder Assembly	
1350-9701	**1350-A,** for 60-Hz supply	**$2570.00**
1350-9494	**1350-AQ1,** for 50-Hz supply	**on request**

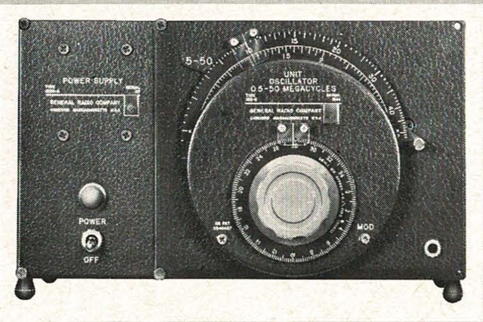
File Courtesy of GRWiki.org

HIGH-FREQUENCY OSCILLATORS
0.5 to 4100 MHz

See following pages for individual oscillator listings.

These compact, low-priced oscillators provide continuous coverage from 500 kHz to 4.1 GHz, with single-dial control and output in the order of several hundred milliwatts. By appropriate choice of power supply the user can secure from these oscillators (1) maximum power, (2) optimum frequency stability with minimum residual fm and a-m, (3) pulse and square-wave modulated output, (4) amplitude-regulated output for sweeping applications, or use them as local oscillators in heterodyne detector systems.

Power supplies and oscillators are designed for semi-permanent attachment for bench use or relay-rack mounting. Accessories suitable for use with these oscillators are also listed.



Oscillator with 1269 or 1267 power supply.

specifications for 500-kHz—2000-MHz Oscillators
(Types 1211, 1215, 1218, 1361, 1362, and 1363)

Frequency Control: Gear-driven precision dials.

Output Power: Output power obtainable with 1269, 1264 or 1267 Power Supplies is shown in the figure accompanying the description of each oscillator.

With the 1263-C Amplitude-Regulating Power Supply, the max useful power output is 20 mW. The available power is adequate for practically all laboratory measurements with bridges, slotted lines, admittance and transfer-function meters, tuned circuits, etc.

Output System: A short coaxial line brings the output from an adjustable coupling loop (in the 1211-C and 1363 from a fixed loop and potentiometer) to a locking GR874 coaxial connector. The output connector is located at the rear of the oscillator except on the 1361, 1362, and 1363, which have it on the front panel. Max power can be delivered to load impedances normally encountered in coaxial systems. Adaptors are available to convert the GR874 connector to any other common type. These adaptors lock securely in place, yet are easily removed.

Power Supply: The external power supply should be chosen from the group listed in the Summary of Power-Supply Characteristics. Operation from 400-Hz lines is possible with many of these power supplies with all oscillators.

Modulation: For amplitude modulation over the audio range, a modulating voltage is imposed on the plate supply. A jack is provided for this purpose. The audio source must be capable of carrying the dc plate current of the oscillator. The 1311 Audio Oscillator is recommended as a modulator. For 30% a-m, incidental fm in this system is of the order of 0.01% at the lower part of the tuning range, and increases to about 0.05% at the high-frequency end.

Square-wave or pulse modulation can be obtained on all oscillators, except the 1211-C, by use of the 1264-B Modulating Power Supply. All oscillators except the 1211-C and 1363 can be square-wave modulated at 1 kHz supplied by the 1263-C Amplitude-Regulating Power Supply.

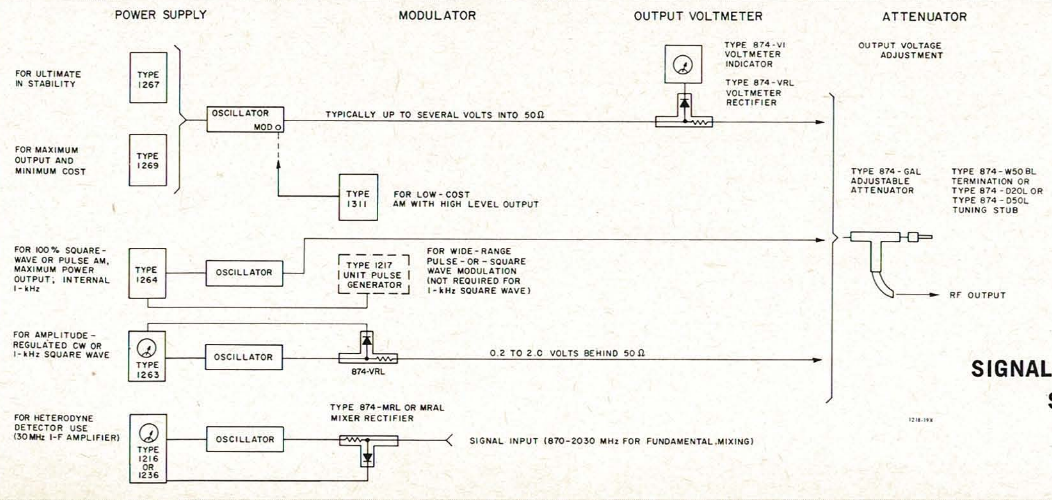
Sweep Applications: Mechanical sweep at speeds suitable for oscilloscope display can be obtained by use of the 1750 Sweep Drive with the 1211-C, 1215-C, 1361, and 1362. The 1363 and 1218-B are not recommended for this service because of the sliding contacts in the tuned circuits.

The 1263-C Amplitude-Regulating Power Supply is recommended (except with 1363) to hold the oscillator output constant as the frequency is varied, particularly when mechanical sweep is employed.

Mounting:

Bench Use — Any of the oscillators can be used on the bench with any of the recommended power supplies; interconnecting cables are supplied. All oscillators and all power supplies are 7 in. high and can be attached to each other with the hardware supplied to form a rigid assembly.

Relay-Rack Use — Any oscillator except the 1218-B can be relay-rack mounted together with a 1263, 1264, 1267, or 1269 Power Supply in 7 inches of rack height. The 1218-B requires 7 inches of rack height when mounted with a 1267 or 1269 Power Supply, or 14 inches of rack height when used with 1263 or 1264 Power Supply. Accessories required for rack mounting are listed elsewhere in this section. For complete assemblies of oscillator and power supply for either rack mount or bench mount, see following pages.



TYPICAL SIGNAL-SOURCE SYSTEMS

File Courtesy of GRWiki.org

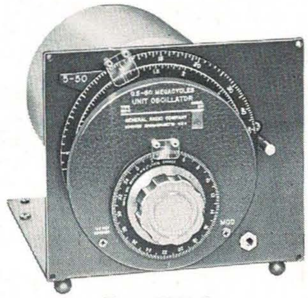
HF, VHF, UHF, Microwave Oscillators

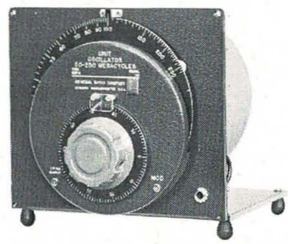
See preceding page for general specifications

Supplied with each oscillator, except as noted under "Remarks":

Type 874-R22LA Patch Cord

Telephone Plug





new

	Type 1211-C Unit Oscillator	Type 1215-C Unit Oscillator	Type 1363 VHF Oscillator
Catalog Number	1211-9703	1215-9703	1363-9701
Frequency	0.5 to 50 MHz	50 to 250 MHz	56 to 500 MHz
Tuned Circuit	Variable L and C	Semi-Butterfly	Variable L and C
Calibration Accuracy	±2%	±1%	±2%
Warmup Frequency Drift (Typical)	0.4%	0.2%	0.8%

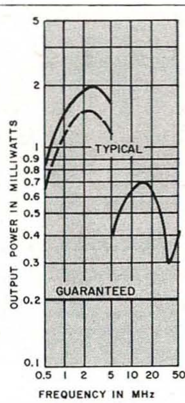
Power Output into 50 ohms using Power Supply:

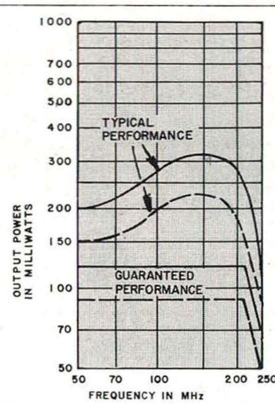
— Type 1269

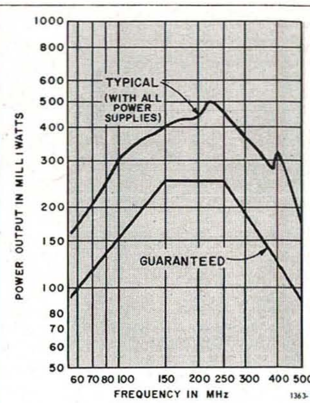
- - - Type 1264 or 1267

[Types 1203 and 1201 Power Supplies can also be used.]

1360-B has internal power supply.







	Type 1211-C	Type 1215-C	Type 1363
Cabinet[1]	Unit	Unit	Convertible Bench
Panel Dimensions	8 × 7 in. (205 x 180 mm)	8 × 7 in. (205 x 180 mm)	8 × 7 in. (205 x 180 mm)
Depth Behind Panel	9¾ in. (250 mm)	7½ in. (190 mm)	8¼ in. (210 mm)
Net Weight	11½ lb (5.5 kg)	7¼ lb (3.3 kg)	7½ lb (3.4 kg)
Shipping Weight	19 lb (9 kg)	10 lb (4.6 kg)	10 lb (4.6 kg)
Price in USA	**$460.00**	**$295.00**	**$395.00**

ACCESSORIES AVAILABLE

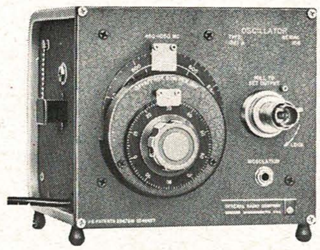
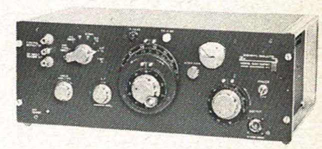
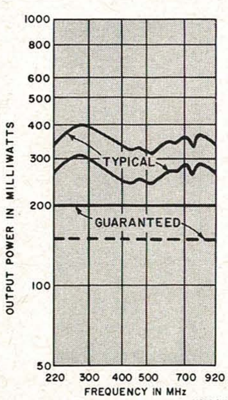
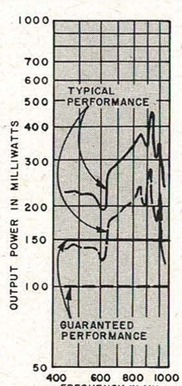
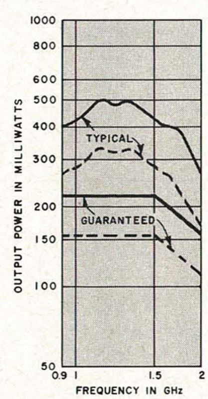
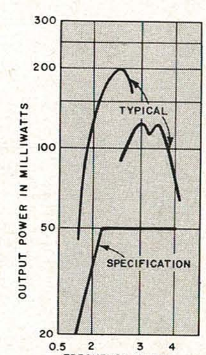
	Type 1211-C	Type 1215-C	Type 1363
Modulating Power Supply **Type 1264-B**	No	Yes[2]	Yes
Amplitude-Regulating Power Supply **Type 1263-C**	Yes	Yes	Not Recommended
Sweep Drive Type 1750-A	Yes	Yes	Not Recommended
Remarks	874-Q2 Adaptor supplied	No Sliding Contact	Sliding Contact

[1] Relay-rack mount, see page 216.   [2] Requires Adaptor Cable 1264-P1 (see page 214).

File Courtesy of GRWiki.org

HF, VHF, UHF, Microwave Oscillators

See next page for complete combinations of oscillators and power supplies.

 new			See p 217 for full specs. 
Type 1362 UHF Oscillator	**Type 1361-A UHF Oscillator**	**Type 1218-B Unit Oscillator**	**Type 1360-B Microwave Oscillator**
1362-9701	1361-9701	1218-9702	1360-9802
220 to 920 MHz	450 to 1050 MHz	900 to 2000 MHz	1.7 to 4.1 GHz
Butterfly	Butterfly	Adjustable Lines	Coaxial Cavity
±1%	±1%	±1%	±1%
0.2%	0.2%	0.1%	0.15%
			
Convertible Bench	Convertible Bench	Unit	Rack-Bench
8 × 7 in. (205 x 180 mm)	8 × 7 in. (205 x 180 mm)	12 × 7 in. (305 x 180 mm)	19 × 7 in. (485 x 180 mm)
8¼ in. (210 mm)	8¼ in. (210 mm)	7½ in. (190 mm)	13 in. (330 mm)
8 lb (3.6 kg)	7 lb (3.2 kg)	14 lb (6.5 kg)	38 lb (17.5 kg)
11 lb (5 kg)	11 lb (5 kg)	26 lb (12 kg)	75 lb (35 kg)
$395.00	**$395.00**	**$695.00**	**$1500.00**

ACCESSORIES AVAILABLE

Yes	Yes	Yes	Not required
Yes	Yes	Yes	Not required
Yes	Yes	No	Yes
No Sliding Contacts	Logarithmic frequency scale. Low external field. Calibrated attenuator. No sliding contact.	Sliding contacts. Fine frequency control. Low external field.	Full specifications given on page 217

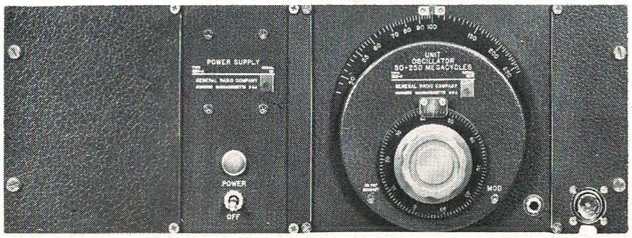
File Courtesy of GRWiki.org

OSCILLATOR-POWER-SUPPLY COMBINATIONS

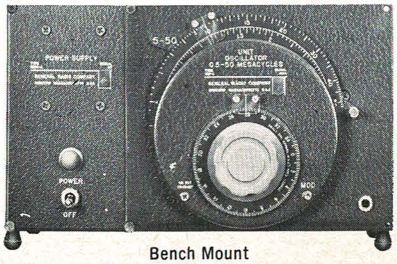
Rack-mount versions supplied assembled; bench models separately for easy interchangeability.

Frequency Range and (Oscillator Type)	Mount	Performance → (Power Supply Type)	Maximum power; lowest cost (1269-A)	Best cw stability; very low residual fm (1267-B)	Stable cw; 100% square-wave & pulse modulation; stable internal 1-kHz square-wave (1264-B)	Amplitude-leveled output behind 50-Ω source impedance; metered output level; 1-kHz square-wave modulation, or cw (1263-C)
		Input Line Voltage	105 to 125 V or 195 to 250 V	105 to 125 V or 195 to 250 V	105 to 125 V or 210 to 250 V	105 to 125 V or 210 to 250 V
0.5-50 MHz (Type 1211-C)	Bench	Catalog No.	1211-9439	1211-9437	Not Available	1211-9433
		Price in USA	**$555.00**	**$655.00**		**$1010.00**
	Rack	Catalog No.	1211-9579	1211-9577		1211-9573
		Price in USA	**$580.00**	**$680.00**		**$1036.00**
50-250 MHz (Type 1215-C)	Bench	Catalog No.	1215-9439	1215-9437	1215-9434	1215-9433
		Price in USA	**$390.00**	**$490.00**	**$735.00**	**$845.00**
	Rack	Catalog No.	1215-9579	1215-9577	1215-9574	1215-9573
		Price in USA	**$415.00**	**$515.00**	**$761.00**	**$871.00**
56-500 MHz (Type 1363)	Bench	Catalog No.	1363-9419	1363-9417	1363-9414	Not Available
		Price in USA	**$490.00**	**$590.00**	**$810.00**	
	Rack	Catalog No.	1363-9509	1363-9507	1363-9504	
		Price in USA	**$515.00**	**$615.00**	**$836.00**	
220-920 MHz (Type 1362)	Bench	Catalog No.	1362-9419	1362-9417	1362-9414	1362-9413
		Price in USA	**$490.00**	**$590.00**	**$810.00**	**$945.00**
	Rack	Catalog No.	1362-9509	1362-9507	1362-9504	1362-9503
		Price in USA	**$515.00**	**$615.00**	**$836.00**	**$971.00**
450-1050 MHz (Type 1361-A)	Bench	Catalog No.	1361-9419	1361-9417	1361-9414	1361-9413
		Price in USA	**$490.00**	**$590.00**	**$810.00**	**$945.00**
	Rack	Catalog No.	1361-9509	1361-9507	1361-9504	1361-9503
		Price in USA	**$515.00**	**$615.00**	**$836.00**	**$971.00**
900-2000 MHz (Type 1218-B)	Bench	Catalog No.	1218-9429	1218-9427	1218-9424	1218-9423
		Price in USA	**$790.00**	**$890.00**	**$1110.00**	**$1245.00**
	Rack	Catalog No.	1218-9549	1218-9547	1218-9544	1218-9543
		Price in USA	**$816.00**	**$916.00**	**$1139.00**	**$1274.00**

Power Supply characteristics presented on following pages.



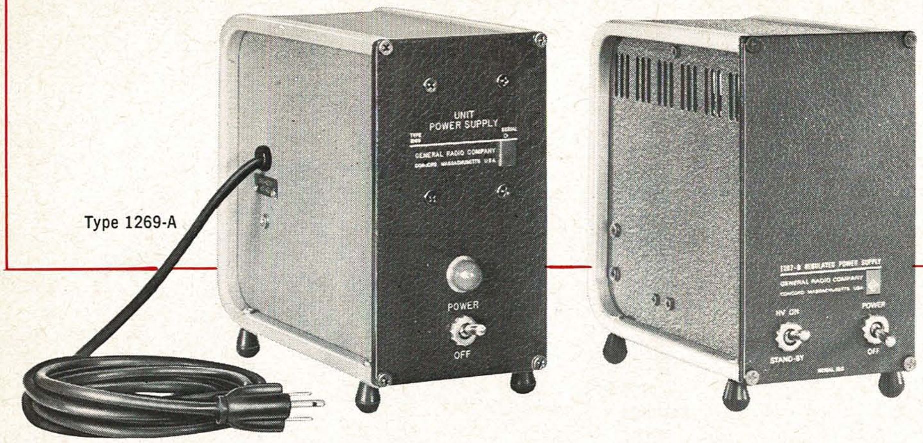
Rack Mount



Bench Mount

File Courtesy of GRWiki.org

OSCILLATOR POWER SUPPLIES



Type 1269-A

Type 1267-B

Power-supply characteristics are frequently a determining factor in the performance of an oscillator. For such applications as parametric-amplifier pumps, oscillators must be stable against all power-line variations and free of modulation from power-supply ripple. For these extreme requirements, both plate and heater supplies should be regulated, well-filtered dc, as in the 1263, 1264, and 1267 power supplies. In any application, use of these power supplies is desirable as they ensure conservative operating conditions resulting in long oscillator-tube life.

For noncritical applications, unregulated dc plate and ac heater supplies are adequate and represent a saving. The 1269 Power Supply is of this type.

AMPLITUDE MODULATION

Other applications require power supplies in which the plate-supply voltage is controllable to modulate or to regulate the oscillator output. The 1264-B Modulating Power Supply provides 100% amplitude modulation at high level by square-waves or pulses as well as cw operation. The 1-kHz modulation frequency is highly stable. Both plate and heater supplies are electronically regulated.

RF LEVEL AND MODULATION

The 1263-C Amplitude-Regulating Power Supply includes a feedback loop to maintain constant oscillator output as the oscillator frequency is varied. Constant output not only speeds and simplifies measurements where the oscillator is tuned manually but is essential when making sweep measurements. The 1263-C Amplitude-Regulating Power Supply has an internal 1-kHz oscillator for square-wave modulation. The heater supply is electronically regulated.

SUMMARY OF OSCILLATOR POWER-SUPPLY CHARACTERISTICS

Type	Applications	Panel Width	Price in USA
1267-B	Ultimate stability for cw	4″	**$195.00**
1269-A	Max output and low cost for cw	4″	**95.00**
1264-B[1]	100% square wave and pulse a-m	8″	**415.00**
1263-C	Amplitude-regulated cw or 1-kHz square-wave output	8″	**550.00**
1236	Heterodyne detector	8″	**735.00**

[1] Requires Type 1264-P1 Adaptor Cable when used with 1215-C Unit Oscillator.

For complete combinations of Oscillator and Power Supply, see page 212.

Type 1267 REGULATED POWER SUPPLY
Type 1269-A POWER SUPPLY

The 1269 is a general-purpose, unregulated 300-volt dc and 6.3-volt ac supply. In the 1267, both heater and plate supplies are regulated to provide complete freedom from line-voltage variations, minimum residual modulation and frequency drift, and long oscillator-tube life.

specifications

		TYPE 1269-A	TYPE 1267-B
Output	Dc	At nominal input line voltage, 300 V ±5% at 50 mA; approx 410 V at no load; 50 mA, max.	300 V, 70 mA max; can be disconnected by standby switch. Regulation, ±0.25% for line and load changes.
	Ripple	Less than 80 mV rms at full load	Less than 1 mV rms at full load
	Low Voltage	6.3 V ac, unregulated, at 3 A	6.5 V dc at 1 A; regulation, ±0.25 % for line-voltage changes. Output resistance 35 mΩ, approx.
Input	V	105 to 125, 195 to 235, or 210 to 250	105 to 125, 195 to 235 or 210 to 250
	Hz	50 to 60 or 400*	50 to 60 or 400*
	W	50	75
Connectors		Permanently attached 3-wire line cord, 4-terminal output socket	4-terminal output socket
Accessories Supplied		Mating plug for output, spare fuses	3-wire line cord, mating plug for output, spare fuses
Convertible-Bench Cabinet	Dimensions	Width 4¼, height 7⅝, depth 9¼ in. (110, 195, 235 mm)	
	Weight	Net, 5¾ lb (2.7 kg); shipping, 8 lb (3.7 kg)	Net, 7¾ lb (3.6 kg); shipping, 10 lb (4.6 kg)
Catalog Number		1269-9701	1267-9702
Price in USA		**$95.00**	**$195.00**

* At 400 Hz, minimum input line-voltage requirements are increased 5%.

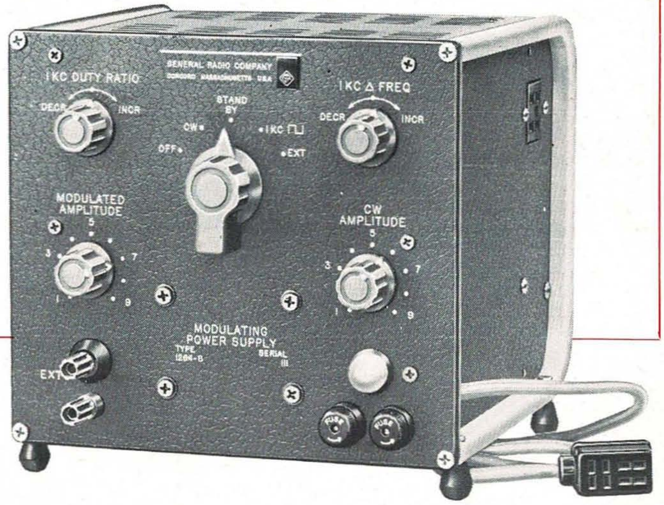
File Courtesy of GRWiki.org

MODULATING POWER SUPPLY

Type 1264-B

- for use with GR high-frequency oscillators
- stable 1-kHz square-wave modulation
- 20-Hz to 100-kHz pulse mod from external source
- adjustable, regulated dc supply

new



The 1264-B produces 100% pulse and square-wave modulation of vhf and uhf oscillators, 1361-A, 1362, 1363, 1215-C, and 1218-B. In addition, it can be used as an adjustable regulated power supply for the oscillator plate and as a source of regulated heater power.

Oscillators page 209 ff

It is available in combination with the above oscillators.

The 1264-B comprises an electronically regulated, adjustable-output, high-voltage, dc supply; a dc-coupled, series-type power modulator driven by a Schmitt trigger circuit; and a 1-kHz multivibrator. A switch permits selection of cw, standby (only heaters energized), 1-kHz square-wave modulated (internally generated), or externally modulated operation. Independent panel controls vary the regulated supply voltage for cw operation and the modulator amplitude for square-wave and pulse operation. Controls are also provided to adjust the frequency of the internal 1-kHz multivibrator and the duty ratio to produce a true square wave.

The input trigger circuit accepts single or multiple positive pulses, which are reproduced at the modulator output. It also accepts square waves at rates up to 100 kHz, or sine waves up to 50 kHz, from any 20-volt source such as the 1217-C Unit Pulse Generator or the 1310 Oscillator and produces square waves at the modulator output. No adjustment of triggering is necessary. The stable 1-kHz multivibrator provides ideal square-wave modulation for use with sharply selective amplifiers following the signal detector.

specifications

REGULATED DC OUTPUT (Unmodulated)

Output: Adjustable 200 to 300 V; 50 mA, max.

Regulation: Output voltage at any rated load will change <0.5 V for 10-V line-voltage change. Dc output resistance, $<5\ \Omega$ (typically 2 Ω).

Ripple: <1 mV rms with B— grounded; <5 mV rms with B+ grounded.

HEATER POWER OUTPUT

Output: 6.5 V dc, regulated; adjustable, ±0.3 V, 1 A, max.

Regulation: For 6.2- to 6.5-V output, voltage will change <5 mV for 10-V line-voltage change. Dc output resistance, <40 mΩ (typically 20 mΩ).

Ripple: <5 mV rms at full load.

MODULATED OUPUT (Internally or Externally Driven)

Transition Times.(10 to 90% points): $<1.5\ \mu$s when driving 300 pF across 15 kΩ or less.

Ramp-off: None.

SQUARE-WAVE OUTPUT (Internally Generated)

Amplitude: Adjustable, approx 160 to 210 V.

Frequency: Adjustable, 850 to 1150 Hz. Can be set to within 0.3 Hz of desired value.

Stability: Frequency will change $<0.1\%$ (typically 0.04%) for 10-V line-voltage change.

Duty Ratio: 0.5, adjustable ±5%.

SQUARE-WAVE OUTPUT (Driven by External Sine-Wave Source)

Amplitude: Adjustable, approx 160 to 210 V.

Driver Requirement: 20 to 50 V rms, 20 Hz to 50 kHz.

PULSE OUTPUT (Driven by External Pulse Generator)

Amplitude: Adjustable, approx 160 to 210 V.

Duration (between half-amplitude points): 1.5 μs to square waves, determined by external source.

Driver Requirement: +20 to +50 V, 100,000 pps, max.

Synchronization: Internal square-wave generator can be synchronized to a sine- or square-wave signal applied to the EXTERNAL INPUT/1 KHZ OUTPUT binding posts. Sync range is $>\pm1\%$ for a 5-V-rms, 1-kHz sine wave. A sync output of >2 V pk-pk behind 18 kΩ is delivered to these binding posts in internal 1-kHz square-wave mode of operation.

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 85 W.

Accessories Supplied: Power cord, connector plug ,spare fuses.

Recommended Oscillators: 1361-A (450-1050 MHz); 1215-C (50-250 MHz); 1362 (220-920 MHz); 1363 (56-500 MHz); and 1218-B (900-2000 MHz). An adaptor cable is required for use with 1215-C.

Accessories Available: 1264-P1 Adaptor Cable to connect to 1215-C Oscillator; rack-adaptor sets for 19-in. relay-rack mounting, panel height 7 in.

Mounting: Convertible-Bench Cabinet.

Dimensions (width x height x depth): 8 x 7 x 9¼ in. (205 x 180 x 235 mm).

Weight: Net, 12 lb (5.5 kg); shipping, 15 lb (7 kg).

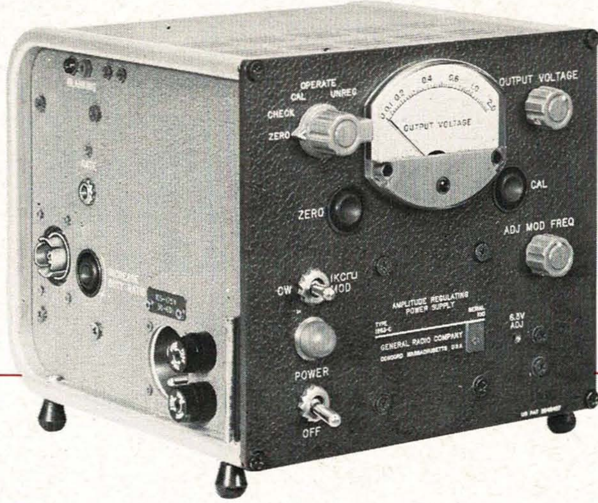
Catalog Number	Description	Price in USA
	1264-B Modulating Power Supply	
1264-9702	115-V Model	**$415.00**
1264-9703	230-V Model	**415.00**
1264-9601	**1264-P1 Adaptor Cable** for 1215-C	**25.00**

File Courtesy of GRWiki.org

- for use with GR high-frequency oscillators
- levels output within ±0.5 dB
- supplies 1-kHz square-wave modulation
- meters rms output voltage of oscillator

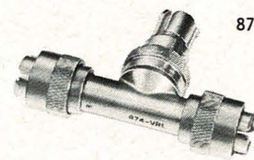
AMPLITUDE-REGULATING POWER SUPPLY

Type 1263-C



new

874-R22LA



874-VRL

Rectifier and patch cord are included

USES: The 1263-C automatically maintains the output of vhf and uhf oscillators at a preset value in spite of incidental amplitude variations that may occur both with supply-voltage variations and with changes in oscillator frequency.

Its very-high-speed response is particularly useful when the oscillator dial is mechanically driven by a 1750-A Sweep Drive.

This power supply will modulate an oscillator with 1-kHz square waves, thus eliminating incidental frequency modulation and permitting the use of an untuned detector with a sensitive audio amplifier. Regulation of average output level is maintained in this mode of operation so that swept measurements at very low rf detector levels can be made.

The dc potential developed by the oscillator output rectifier (874-VRL) is compared with an adjustable dc reference in a feedback system. A rapid correction is applied to the plate current to hold the oscillator output to a preset level. Rf blanking can be accomplished by external shorting of the reference potential.

For 1-kHz modulation, the voltage regulated is the average value of the square-wave envelope. An external synchronous detector can be gated from a voltage provided, to maintain a high signal-to-noise ratio in low-level measurements.

Oscillators page 209 ff

specifications

Rf Output Voltage: 0.2 to 2.0 V behind 50 Ω for any recommended oscillator (see below). With 1-kHz square-wave modulation, 0.2 to 1.0 V (average value of rms carrier level) behind 50 Ω.

Rf Output Regulation: Below 500 MHz, rf output of 1211, 1215, and 1362 oscillators is held to within ±5% including the effects of harmonics. This regulation can be attained up to 2000 MHz if proper low-pass rf filters are used and a correction applied for the rectifier frequency characteristic.

Modulation

Frequency: 1-kHz square-wave, adjustable ±5%, stable within 5 Hz over the rated range of line voltage.

Duty Ratio: 0.5 to 0.53, adjustable to compensate for oscillator-starting delay.

Rise and Decay Times: 50 μs each.

Overshoot: None. **Ramp-off:** Less than 0.5%.

Gate Voltage: Synchronized with "off" interval of modulation, exceeds 1 V into the recommended load of 30 kΩ shunted by 300 pF. Rise and decay times are less than 50 μs. Gate output during "on" interval of modulation is less than 0.01 V.

Plate Supply Output: 0 to 30 V at 30 mA.

Heater Supply Output: 6.5 V dc at 1 A, regulated. **Ripple:** <1 mV rms (120 Hz) at full load. **Dc Output Impedance:** Approx 35 mΩ. **Response Time:** For a 2-to-1 step variation in oscillator output, correction is completed within 0.5 ms with cw operation, 50 ms with 1-kHz modulation. Recovery time after blanking is less than 2 ms with cw operation, 200 ms with 1-kHz square-wave modulation.

Hum and Noise: Peak residual hum and noise modulation, less than ±0.3% on cw, ±3% with 1-kHz square-wave modulation.

Output Voltmeter: With 1-kHz square-wave modulation, meter reads average value of rms carrier level. Internal standardizing circuit is provided. Accuracy after standardization is better than ±10% of indication when a correction is applied for rectifier characteristic at extremely high frequencies.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz, 55 W.

Accessories Supplied: 874-VRL Voltmeter Rectifier, 874-R22LA Patch Cord for connecting output rectifier, power cord, connector cable for modulation jack on oscillator, spare fuses.

Accessories Required: 874-T Tee for oscilloscope connection in sweeping applications.

Recommended Oscillators: 1215-C (50 to 250 MHz), 1362 (220 to 920 MHz), 1361-A (450 to 1050 MHz), 1218-B (900 to 2000 MHz); for cw operation only, 1211-C (0.5 to 50 MHz).

Accessories Available: The 1750-A Sweep Drive for automatic operation; GR874 coaxial accessories. Panel adaptor plate sets for 19-in. relay-rack mounting, panel height 7 in.

Mounting: Convertible-Bench Cabinet.

Dimensions (width x height x depth): 8 x 7 x 9¼ in. (205 x 180 x 235 mm).

Weight: Net, 14½ lb (7 kg); shipping, 18 lb (8.5 kg).

Catalog Number	Description	Price in USA
1263-9703	**1263-C Amplitude-Regulating Power Supply**	**$550.00**

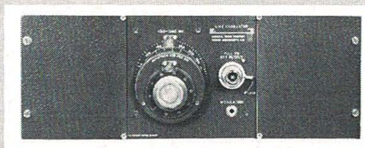
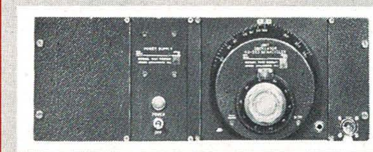
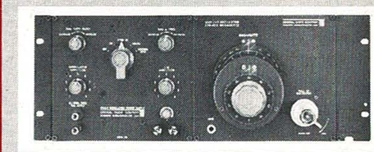
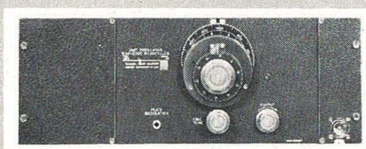
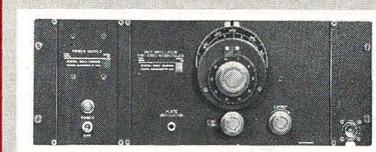
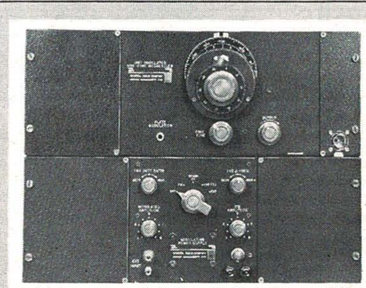
PATENT NOTICE. See Note 15.

File Courtesy of GRWiki.org

OSCILLATOR ACCESSORIES

RACK-ADAPTOR SETS For mounting oscillators and power supplies in a 19-inch rack

These adaptor sets include the necessary flanges and hardware for combining oscillator and power supply into a rigid assembly and for extending the panel width to rack size. A coaxial cable with panel connector is supplied for mounting on the right-hand adaptor panel to provide alternate front or rear output connections.*

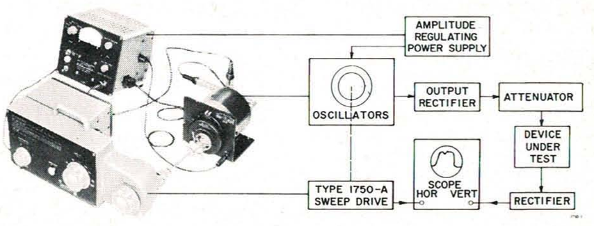
Oscillator Type	Adaptor Set for Oscillator Only	Adaptor Set for Oscillator and either 1267 or 1269 Power Supply	Adaptor Set for Oscillator and either 1263 or 1264 Power Supply
1211-C **1215-C** **1361-A** **1362** **1363**	 Catalog No. 0480-9648 Type 480-P408 **Price in USA: $10.00**	 Catalog No. 0481-9642 Type 481-P412 **Price in USA: $20.00**	 Catalog No. 0481-9646 Type 481-P416 **Price in USA: $21.00**
1218-B	 Catalog No. 0481-9642 Type 481-P412 **Price in USA: $20.00**	 Catalog No. 0481-9646 Type 481-P416 **Price in USA: $21.00**	 Catalog No. 0482-9642 Type 482-P412† **Price in USA: $24.00**

*Not supplied with Type 480-P408.

†Consists of one set for oscillator and one for power supply.

SWEEP DRIVE—Type 1750-A A mechanical hand for automatic sweeping.

The 1750-A adapts manually operated equipment to sweep operation. In conjunction with GR oscillators, it makes available an extremely versatile system of swept signal sources covering a frequency span from 20 Hz to 2000 MHz. For constant output over the entire frequency range of any one of the rf oscillators, the 1263-C Amplitude-Regulating Power Supply is used. Sweep frequency, arc, and center position are all adjustable while the drive is in motion. An adjustable limit switch can be set to stop the drive when predetermined limits of motion of the driven shaft are exceeded.



A constant-amplitude sweeping system consisting of Type 1750-A Sweep Drive, a Unit oscillator, an amplitude-regulating power supply, and GR874 coaxial accessories.

specifications

Output Shaft

Center Position: Adjustable over 9-turn range.

Sweep Arc: Adjustable 30 to 300 degrees.

Sweep Rate: Adjustable 0.5 to 5 per second. Moment of inertia of driven device determines upper limit.

Torque: 24 ounce-inches, max. Will drive 1211-C, 1215-C Unit Oscillators, 1361, 1362 oscillator, 1360-B Microwave Oscillator, 1304-B Beat-Frequency Audio Generator, 1308 Audio Oscillator and Power Amplifier, 1330 Oscillator, 1564 Sound and Vibration Analyzer, 1001-A and 1003 Standard-Signal Generators.

Height of Shaft: Adjustable, 2½ to 4⅞ in. over bench.

Flexible Coupling: 5¾ in. long. Couples to ¼- and ⅜-in. shafts; knobs and dials 1 to 4 in. in diameter.

Limit Switch: Adjustable within 9 turns.

Sweep Voltage: 2.5 V, pk-pk, ungrounded.

Blanking: Shorting contact closed during clockwise rotation of driven shaft, ungrounded.

Power Required: 105 to 125 volts, 50 to 60 Hz, 60 W. On 400-Hz supply, max sweep speed is reduced 25%. A 210- to 250-volt model, 1750-AQ18, is also available.

Accessories Supplied: Couplings, lubricant, spare fuses.

Dimensions (width x height x depth): 17½ x 9 x 8¼ in. (445 x 230 x 210 mm).

Weight: Net, 22½ lb (10.5 kg); shipping, 33 lb (15 kg).

For a discussion of sweep measurements, ask for a copy of "Sweep-Frequency Measurement Techniques" (GR Reprint A-109), free on request.

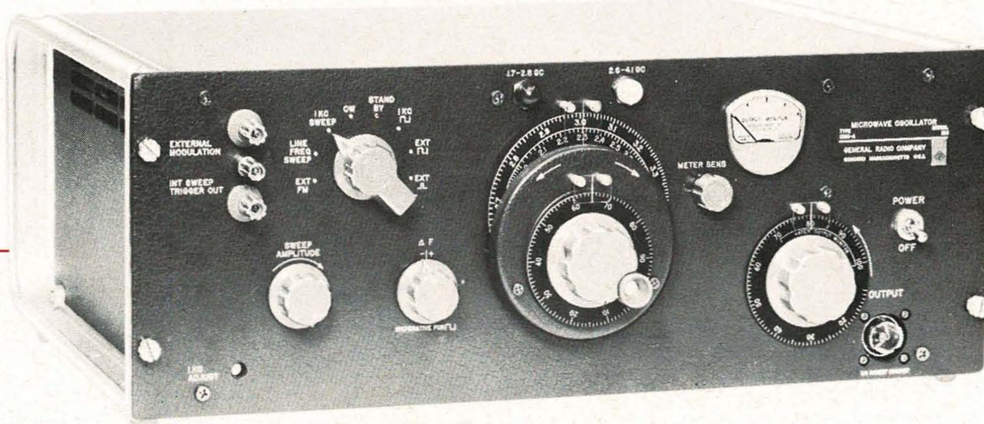
Catalog Number	Description	Price in USA
1750-9701	**1750-A Sweep Drive,** for 115 volts	**$895.00**
1750-9911	**1750-AQ18 Sweep Drive,** for 230 volts	**on request**

File Courtesy of GRWiki.org

MICROWAVE OSCILLATOR

Type 1360-B

- 1.7 to 4.1 GHz
- output >100 mW, most of range
- stability 5 ppm over 10 min
- internal 1-kHz square-wave mod and sweep



The many modulation capabilities of this oscillator make it a most useful power source for microwave measurements. It is a suitable driver for slotted lines and a stable local oscillator for heterodyne detectors.

The oscillator is a reflex klystron in a coaxial cavity with a noncontacting plunger. The two frequency ranges, 1.7 to 2.8 GHz and 2.6 to 4.1 GHz, are selected automatically by the main frequency dial. The scales are in different colors; a pilot light indicates the scale in use.

The output is adjustable and monitored against overcoupling.

Cathode, repeller, and bias voltages are well regulated, and the klystron heater supply is dc. Tube replacements, including the klystron, require no tools. Long-life Teflon* bearings are used for the plunger.

— See **GR Experimenter** for Jan-Feb 1962 and Aug 1964.

* Registered trademark of the E. I. duPont de Nemours and Company.

specifications

FREQUENCY

Range: 1.7 to 4.1 GHz in two ranges, 1.7 to 2.8 GHz, covered in 5½ turns of tuning control, and 2.6 to 4.1 GHz, covered in 9 turns; 100-division interpolation of scale.

Fine Frequency Control (ΔF): Order of 1 MHz, but not functioning for square-wave modulation.

Accuracy: ±1%.

Stability: Warmup drift under laboratory conditions is approx 0.15% during the first hour, total drift approx 0.25%. After warm-up, average frequency observed in a 1-s measurement interval is stable within approx 5 ppm over a 10-minute period.

Residual FM: Approx 3 ppm pk with 115-V, 60-Hz power; 6 ppm pk with 230 V, 50 Hz. Peak deviation increases substantially at high line voltage.

OUTPUT

Power: At least 20 mW from 1.7 to 2.1 GHz; at least 50 mW from 2.1 to 4.1 GHz. Individual instruments may vary 2:1 from typical curve.

Attenuator: Relative calibration only.

Terminal: GR874 coaxial connector, recessed, locking. For connection to other type connectors, use a GR874 locking adaptor.

INTERNAL MODULATION

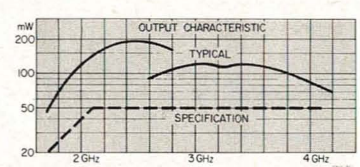
Narrow-Band Sweep: At least 0 to 1 MHz at either 1 kHz or line-frequency rate. Max sweep width up to 3 MHz depends on carrier frequency. Negative pulse for oscilloscope sync provided.

Square-Wave: 1 kHz, adjustable ±5%.

EXTERNAL MODULATION

FM: Sensitivity approx 0.2 MHz per V; input impedance, 400 kΩ and 70 pF (ac only).

Square-Wave: 50 Hz to 200 kHz, 12 V rms sine wave or 20 V pk-pk, square wave; 20% min duty cycle from external source. Impedance >100 kΩ.



Output-power characteristic.

Pulse: Rise and fall times approx 0.2 μs, min length approx 0.5 μs. Input impedance 100 kΩ; driving-pulse amplitude, 20 V pk-pk; max duty cycle 20%.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz, 85 W. Instrument will operate satisfactorily (except for line-frequency sweep) at power-line frequencies up to 400 Hz.

Accessories Supplied: 874-R22LA Patch Cord, power cord, spare fuses.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench model, 19 x 7½ x 15½ in. (485 x 195 x 395 mm); rack model, 19 x 7 x 13 in. (485 x 180 x 330 mm).

Weight: Net, 38 lb (17.5 kg); shipping, 75 lb (35 kg).

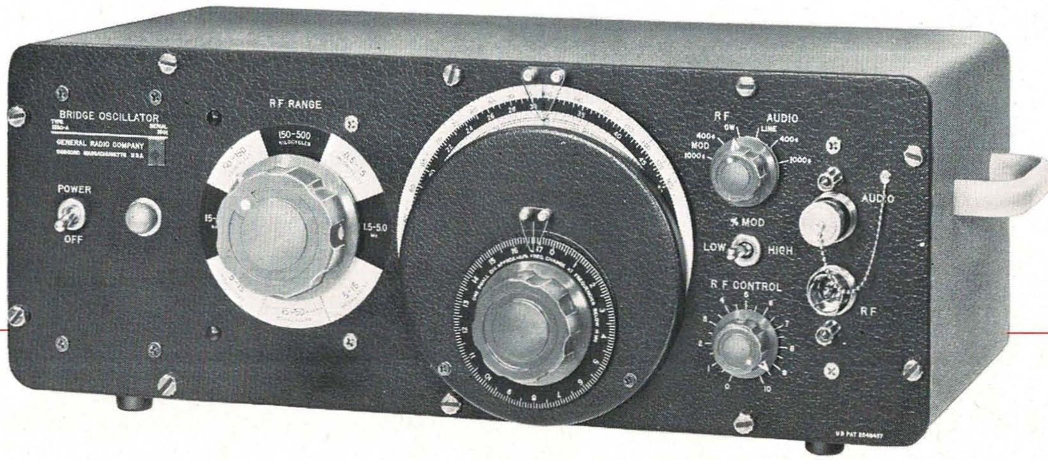
Catalog Number	Description	Price in USA
	1360-B Microwave Oscillator	
1360-9802	Bench Model	**$1500.00**
1360-9812	Rack Model	**1500.00**

File Courtesy of GRWiki.org

BRIDGE OSCILLATOR

Type 1330-A

- 400 Hz to 50 MHz
- 1-watt output over most of rf range
- excellent shielding



The 1330-A is an economical, general-purpose laboratory source of audio and radio frequencies. It covers the major part of the frequency range of the 1606-B and 916-AL Radio-Frequency Bridges and also supplies 400 and 1000 Hz. Its power output is adequate for most direct-deflection-type measurements with resonant circuits.

The circuit and the mechanical construction are similar to those of the 1001-A Standard-Signal Generator. Tuning capacitor and inductors are ruggedly constructed to assure frequency stability, the oscillator circuits are doubly shielded to minimize stray fields, and a modulating circuit of unusual design provides excellent modulation characteristics over the radio-frequency range.

Modulation is available at two audio frequencies and at two levels, selected by switches.

specifications

FREQUENCY

Range: 5 kHz to 50 MHz, continuous, plus 1000 Hz, 400 Hz, and the power-line frequency.

Calibration: Direct reading for eight 3:1 ranges. Calibration is logarithmic, and vernier dial indicates increments of 0.1% per division from 5 kHz to 15 MHz.

Accuracy: 400 and 1000 Hz, ±5%; frequencies below 150 kHz, ±3%; above 150 kHz, ±2%, all at no load. Frequency shift with 50-Ω load, 5% at low carrier frequencies; <1% above 150 kHz.

OUTPUT

Voltage: Open-circuit audio, 12 V; rf, adjustable, approx 10 V over the mid-frequency range, less at ends of range.

Power (Into 50-Ω load): Audio, approx ¾ W; rf, 1 W, over most of range.

Impedance: Audio jack, 50 Ω; rf, 20 to 80 Ω, depending upon frequency, when output control is at max setting.

Distortion: Rf, with max output into 50 Ω, about 3.5%, except at the lower frequencies, where it reaches 7%. Audio, 5%.

Leakage: Stray fields are <50 μV/m at 2 ft from oscillator.

Modulation: Internal only, at 400 and 1000 Hz, 25% and 50%.

Envelope Distortion: Less than 6% at 50% modulation; less than 4% at 25% modulation.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 Hz; 30 W.

Terminals: GR874 Coaxial Connectors, locking. For connection to other popular types, use a GR874 locking adaptor, which locks securely in place yet is easily removed.

Accessories Supplied: 874-R22LA Coaxial Cable, 874-Q2 Adaptor, TO-44 Adjustment Tool (mounted on rf shield cover), CAP-22 Power Cord, and spare fuses.

Mounting: Lab-Bench Cabinet. Cabinet can be removed for rack mounting (panel 19 x 7 in.).

Dimensions (width x height x depth): 21¾ x 7½ x 11¼ in. (560 x 190 x 290 mm).

Weight: Net, 38 lb (17 kg); shipping, 50 lb (23 kg).

Catalog Number	Description	Price in USA
1330-9701	**1330-A Bridge Oscillator**	**$995.00**

File Courtesy of GRWiki.org

PULSE GENERATORS

Much of today's electronic engineering effort is devoted to the development of circuits and systems operating in the time domain. Switching, pulse, and digital circuits predominate in modern computing, navigation, and data-communication systems. In the laboratory, the oscilloscope and pulse generator replace the voltmeter and sinusoidal oscillator of yesterday as detector and source.

A pulse generator is, in essence, a highly versatile and controllable switch. Two parameters of interest that must be controlled are the pulse repetition frequency, or switching rate, and the pulse duration, or length of time the switch is closed (or open). The rise time, or speed of switching, is also an important parameter. In addition to the characteristics of the switch, specific applications will require particular characteristics for the energy source switched. The output impedance, open-circuit voltage, and available current must all be known and specified to fit a given pulse generator to a specific application.

Computational and data rates rise as rapidly as device development will permit. Pulse repetition rates can now range from nearly dc to over 100 MHz, and durations from seconds to less than 1 nanosecond. For computation and data-transmission systems, most of the applications can be served by relatively low power outputs, while radar and certain magnetic data-storage systems may require pulses of extremely high energy. It appears that a pulse generator that will meet all requirements, even in the laboratory, is out of the question.

The series of pulse generators offered in this catalog are pulse-signal sources of as general a type as economics will permit. The 1217-C produces pulses ranging from 0.1 µs to 1 s over a repetition rate range from dc to 2 MHz. It, like all the General Radio pulse-generator line, contains an internal prf oscillator with continuous range from 3 Hz to 1.2 MHz. Both pulse polarities are simultaneously available, and output circuits are dc coupled, an absolutely necessary characteristic when pulses of long duration must be produced. This high level of performance is achieved at nominal cost because the output power level is low. The 1397-A Pulse Amplifier can be used to translate this performance to 1-ampere output levels.

The 1398-A Pulse Generator is very similar in electrical characteristics to the 1217-C but produces faster pulses (5-ns rise time) at high current (60 mA).

The 1394 High-Rate Pulse Generator will produce fast-transition pulses with controllable, stable delay and duration at repetition rates up to 100 MHz.

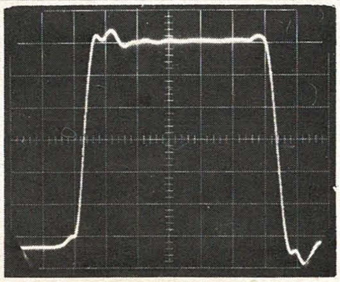
For the utmost in flexibility we offer the 1395-A Modular Pulse Generator. This hybrid system has duration ranges, rise times, and prf ranges similar to the 1217-C but permits, in one package, interconnection of various modules to produce a pulse generator of almost infinite variety. An input circuit module either serves as a prf oscillator or processes an external driving signal from dc to 2 MHz to produce a standardized system-synchronizing pulse. A second module produces pulses or delayed 0.1-µs synchronizing pulses in the range from 0.1 to 1 s with rise times of 15 ns. A single input module and three pulse/delay modules will form an excellent double-pulse generator, while 5 pulse/delay modules will provide a triple-pulse. A third module, timed from a pulse/delay module, will produce pulses with linear and independently variable rise and fall times over a range from 0.1 µs to 1 s. A fourth module produces up to 16-bit pulse words. A power amplifier with up to 0.4-ampere output at limited duty-ratio is the fifth module. Another module will convert the pulse words to NRZ (non-return-to-zero) form and act as a sampler.

The dual role of frequency divider and delay generator is performed digitally by the GR 1399. Its 8 thumb wheels permit precise divider ratios to be set up to divide either an external signal or, for the precision-delay function, the 10-MHz output from the internal time-base crystal oscillator. For use in automatic systems, the 1399 is fully programmable.

The 1396-A Tone-Burst Generator, a new type of pulse instrument, operates as a coherent gate for an externally introduced signal. It has many applications in sonar, the design and test of amplifiers, transducers, filters, meters, as well as in acoustical measurements.

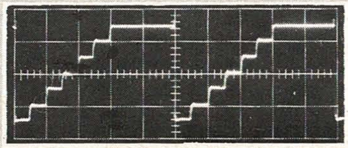
PULSE GENERATORS

Type	Name	Remarks
1217-C	Unit Pulse Generator	Low cost — high performance
1398-A	Pulse Generator	60-mA pulse output
1395-A	Modular Pulse Generator	Generates complex pulse waveforms — ultimate in flexibility
1397-A	Pulse Amplifier	1-A output pulses into 50 Ω
1396-A	Tone-Burst Generator	Coherent gate — adjustable on and off intervals
1394	High-Rate Pulse Generator	2-ns pulses, dc to 100 MHz
1399	Digital Divider/Period and Delay Generator	Delays to 10 s or more, division by up to 10^8

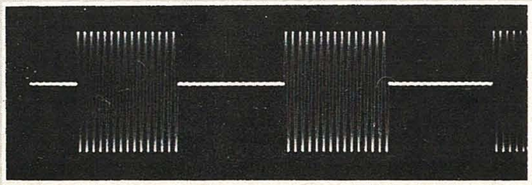


0.12-µs pulse from 1217-C Unit Pulse Generator.

Staircase waveform generated by 1395-A Modular Pulse Generator.



Tone-burst pattern from 1396-B Tone-Burst Generator. Input: 3 kHz; 16 cycles on; 16 cycles off.



File Courtesy of GRWiki.org

PULSE GENERATOR

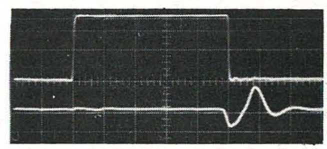
Type 1398-A

- <5 ns rise and fall
- 60-mA output pulses
- 0.1-μs to 1.1-s duration
- dc to 2.4 MHz

Pulse generator shown with accessory 1398-P1 Dc Component Control

The 1398-A Pulse Generator is basically a 1217-C Unit Pulse Generator with a self-contained power supply, higher output, and improved output-pulse characteristics. Rise and fall times are less than 5 nanoseconds, one-half those of the 1217-C. Power output has been increased to provide positive and negative 60-mA current pulses, producing 60-V pulses across the 1-kΩ internal load impedance.

With the accessory 1398-P1, the dc level of the output pulse's average value or positive or negative peak can be controlled and will be held independent of duty ratio or repetition rate. Time constant of the regulating circuit can be selected according to output-pulse duration. The 1398-P1 attaches to the side of, and derives its power from, the pulse generator.



1-μs pulse into 50 ohms with delayed sync pulse.

specifications (1398-A alone)

PULSE REPETITION FREQUENCY

Internally Generated: 2.5 Hz to 1.2 MHz, with calibrated points in a 1-3 sequence from 10 Hz to 300 kHz, and 1.2 MHz, all ±5%. Continuous coverage with an uncalibrated control.

Externally Controlled: Aperiodic, dc to 2.4 MHz with 1-V rms input (0.5 V at 1 MHz and lower); input impedance at 0.5 V rms, approx 100 kΩ shunted by 50 pF. Output pulse is started by negative-going input transition.

OUTPUT-PULSE CHARACTERISTICS

Duration: 100 ns to 1 s in 7 decade ranges, ±5% of reading or ±2% of full scale or ±35 ns, whichever is greater.

Rise and Fall Times: Less than 5 ns into 50 or 100 Ω; typically 60 ns + 2 ns/pF external load capacitance into 1 kΩ (60 V).

Voltage: Positive and negative 60-mA current pulses available simultaneously. 60-V pk into 1-kΩ internal load impedance for both negative and positive pulses. Output control marked in approx output impedance. Dc coupled; dc component negative with respect to ground, can be controlled with accessory 1398-P1 Dc Component Control; see specifications.

Overshoot: Overshoot and noise in pulse, less than 10% of amplitude with correct termination.

Ramp-off: Less than 1%.

Synchronizing Pulses

Prepulse: Positive and negative 8-V, approx, pulses of 150-ns duration. If positive sync terminal is shorted, negative pulse can be increased to 100 V.

Sync-pulse source impedance:
positive — approx 300 Ω;
negative — approx 1 kΩ.

Delay-Sync Pulse: Consists of a negative-going transition of approx 5 V and 100-ns duration, coincident with the late edge of the main pulse. Duration control reads time between prepulse and delayed sync pulse. This negative transition is immediately followed by a positive transition of approx 5 V and 150 ns to reset the input circuits of a following pulse generator. (See oscillogram.)

Stability: With external-drive terminals short-circuited, prf jitter and pulse-duration jitter are each 0.04%. (Jitter figures may vary somewhat with range switch settings, magnetic fields, etc.)

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 Hz, 90 W.

Accessories Available: Type 1217-P2 Single-Pulse Trigger, rack-adaptor panel, Dc Component Control.

Mounting: Convertible-Bench Cabinet.

Dimensions (width x height x depth): 12 x 5¼ x 8¼ in. (305 x 135 x 210 mm).

Weight: Net, 14½ lb (7 kg); shipping, 18 lb (8.5 kg).

specifications (1398-P1 Dc Component Control)

Parameters: Controls average value, positive peak, or negative peak of either positive or negative output pulse.

Range: ±15 V with 1398-A output unloaded. Generator source impedance not affected. Approx 100 mA translating current available for ext loads; linear control range thereby limited, e.g., into 100 Ω, 10-V range (+2.5 to −7.5 V).

Accuracy: ±3% of full scale, ±3% independent linearity for unloaded generator output.

GENERAL

Time Constant: Effective time constant variable 0.1 to 100 s in four steps; use to control ramp-off and recovery time on average and positive peak (does not apply to negative peak). A 1-s-duration pulse will have <1% ramp-off with a 100-s time constant.

Duty-Ratio Effects: Negligible. Short circuit or other load will not cause damage.

Pulse Aberration: No effect on rise time and duration of output. An additional 300 mV pk-pk of noise and ringing may occur. Asymmetrical external load on output may cause a slight change in prf.

Accessory Available: Rack-adaptor set for combination of generator and dc component control.

Mounting: Attaches mechanically and electrically to right side of 1398-A.

Dimensions: Add 4½ in. to width of 1398-A.

Weight: Net, 3¼ lb (1.5 kg); shipping, 5 lb (2.3 kg).

Catalog Number	Description	Price in USA
1398-9701	**1398-A Pulse Generator**	**$595.00**
1398-9601	**1398-P1 Dc Component Control**	**185.00**
	Rack-Adaptor Sets	
0480-9632	**480-P312,** for 1398 alone	**6.50**
0480-9337	**480-P317,** for combination	**6.00**

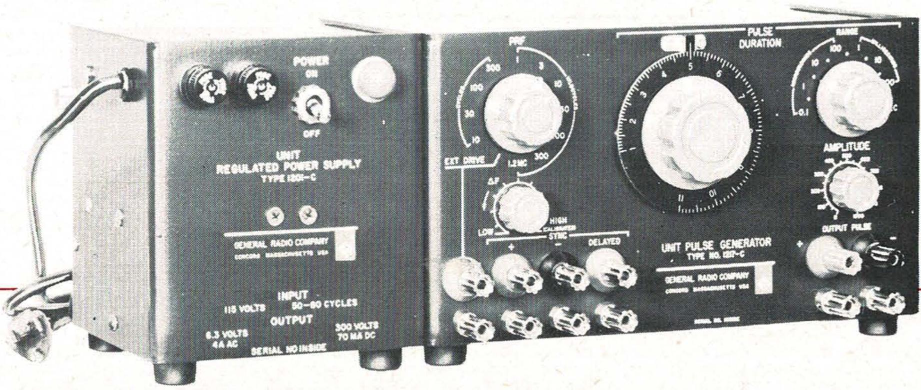
File Courtesy of GRWiki.org

1217-P2
Single-pulse
trigger

- $<$10-ns rise/fall times
- dc to 2.4-MHz repetition frequency
- 40-mA output pulses, positive and negative
- duration adjustable 100 ns to 1.1 s

UNIT PULSE GENERATOR

Type 1217-C



Unit pulse generator
with power supply

This simple, reliable pulse generator has many applications in the laboratory and on the test bench. Its wide ranges of pulse-duration and repetition rate and its excellent output characteristics fit it for many applications ranging from high-speed computing circuits through radar to geophysical and physiological pulse simulation. It is also an excellent, low-cost instrument for the student laboratory.

specifications

PULSE REPETITION FREQUENCY

Internally Generated: 2.5 Hz to 1.2 MHz, with calibrated points in a 1-3 sequence from 10 Hz to 300 kHz, and 1.2 MHz, all $\pm$5%. Continuous coverage with an uncalibrated control.

Externally Controlled: Aperiodic, dc to 2.4 MHz with 1-V-rms input (0.5 V at 1 MHz and lower); input impedance at 0.5 V rms approx 100 kΩ shunted by 50 pF. Output pulse is started by negative-going input transition.

OUTPUT-PULSE CHARACTERISTICS

Duration: 100 ns to 1 s in 7 decade ranges, $\pm$5% of reading or $\pm$2% of full scale or $\pm$35 ns, whichever is greatest.

Voltage: Positive and negative 40-mA current pulses available simultaneously. Dc-coupled; dc component negative with respect to ground. 40 V peak into 1-kΩ internal load impedance for both negative and positive pulses. Output control marked in approx output impedance.

Transitions: At max output into 50- or 100-Ω resistive load, transitions are typically $<$10 ns; no transition is ever $>$15 ns. Overshoot typically $<$10% (worst case 15%). Output control permits reduction of overshoot at slight rise-time penalty. Into high-resistance loads, all transitions are $<$(60 ns + 2 ns/pF load capacitance), with no overshoot.

Ramp-off: Less than 1%.

Synchronizing Pulses:

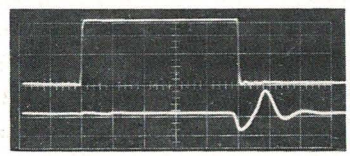
Pre-pulse: Positive and negative 8-V pulses of 150-ns duration. If positive sync terminal is shorted, negative pulse can be increased to 50 V. Sync-pulse source impedance:

positive — approx 300 Ω; negative — approx 1 kΩ.

Delayed Sync Pulse: Consists of a negative-going transition of approx 5 V and 100-ns duration coincident with the late edge of the main pulse. Duration control sets time between prepulse and delayed sync pulse. This negative transition is immediately followed by a positive transition of approx 5 V and 150 ns to reset the input circuits of a following pulse generator. (See oscillogram.)

Stability: Prf and pulse-duration jitter are dependent on power-supply ripple and regulation. With 1201 power supply and external-drive terminals short-circuited, prf jitter and pulse-duration jitter are each 0.01%. With 1203 power supply, they are 0.05% and 0.03%, respectively. (Jitter figures may vary somewhat with range switch settings, magnetic fields, etc.)

1-μs pulse into 50 ohms
with delayed sync pulse.



GENERAL

Power Required: 1203 or 1201 Unit Power Supply is recommended.

Accessories Available: 1217-P2 Single-Pulse Trigger, rack-adaptor panel for both generator and power supply (19 x 7 in.).

Mounting: Unit-Instrument Cabinet.

Dimensions (with power supply) (width x height x depth): 15 x 5¾ x 6½ in. (385 x 150 x 165 mm).

Weight: Net, 9½ lb (4.4 kg); shipping, 12 lb (5.5 kg).

Catalog Number	Description	Price in USA
1217-9703	**1217-C Unit Pulse Generator**	**$275.00**
1201-9703	**1201-C Unit Regulated Power Supply** (for 115 V)	**105.00**
1201-9824	**1201-CQ18 Unit Regulated Power Supply** (for 230 V)	**on request**
1203-9702	**1203-B Unit Power Supply** (for 115 V)	**75.00**
1203-9818	**1203-BQ18 Unit Power Supply** (for 230 V)	**on request**
1217-9602	**1217-P2 Single-Pulse Trigger**	**30.00**
0480-9986	**480-P4U3 Rack-Adaptor Panel**	**12.00**

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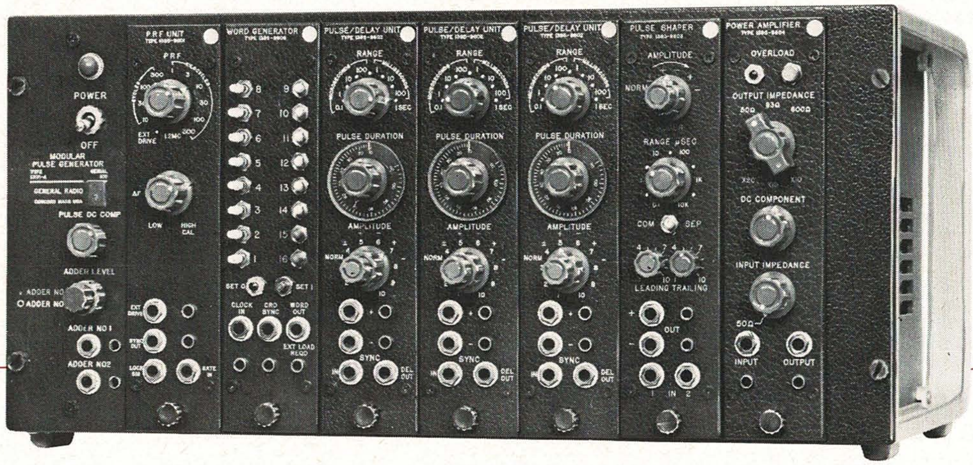
MODULAR PULSE GENERATOR

Type 1395-A

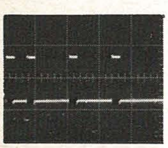
- dc to 2 MHz
- limitless variety of pulses
- flexible, convenient, economical

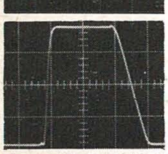


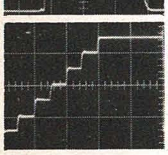
The 1395-A Modular Pulse Generator is a pulse generating system of almost infinite possibilities. With it you can construct, to suit your requirements or your fancy, practically any pulse shapes or combinations thereof, by the appropriate selection and interconnection of a wide variety of available modules.

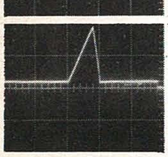
USES

This instrument is used principally as a means for simulating the signals commonly associated with radar, telemetry, and moderate-speed digital-data handling. In addition, those working in the areas of physiological and geophysical testing find use for its low prf's and long time delays and pulse durations. With the pulse shaper module it will serve as a function generator as well.









PULSES TO ORDER

The generator consists of up to seven modules and a frame to hold them. The photograph shows only one of thousands of combinations that can be assembled from currently available modules. By selecting the appropriate number and types of plug-ins, a user actually builds his own special-purpose instrument.

The 1395-A can produce any or all of the following waveshapes:

rectangular pulses
pulse bursts
binary patterns or words
  2 to 112 bits long
single pulses
triangles
trapezoids
doublet pulses
pulses with pedestals
ascending and descending staircases
non-return-to-zero (NRZ) signals

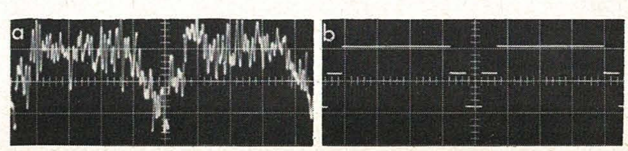
In addition it can

- give independent control over amplitudes, durations, and delays in all parts of complex pulses
- amplify the pulses it produces (up to 400 mA into 50 ohms)
- give both positive and negative polarities simultaneously
- allow noise or sine waves to be added to pulses
- lock on higher frequencies up to ratios of about 15:1
- scale, in true digital fashion, by any quantity that can be expressed as the product of up to 7 numbers between 2 and 16
- generate time delays
- make binary, coincidence decisions

The main frame of the 1395-A Modular Pulse Generator contains the power supply to operate the modules, two ADDER busses with their corresponding output controls and jacks, and a control for varying the level of the output-pulse base line. Selector switches permit the outputs of individual modules to be applied to the busses in desired polarities to generate a complex waveform at the ADDER output jacks.

Six types of modules are available plus a skeleton-frame module in which the user can install his own circuitry. The modules can be used in any combination up

(a) A noisy pulse train, taken with single sweep on the oscilloscope. (b) The same signal without noise.



File Courtesy of GRWiki.org

to a total of seven, of which only one may be a Power Amplifier and a maximum of three may be Pulse Shapers. To satisfy power-supply limitations, Pulse Shaper Units fit only in the three right-hand slots and the Power Amplifier only in the farthest right-hand slot.

— See **GR Experimenter** for May 1965 and write for Instrument Note IN-108, "Generation and Detection of Modulated Pulses."

specifications (MAIN FRAME)

ADDER Output Level: 0 to 1 V or more, depending on number of modules used (continuously adjustable).

ADDER Output Impedance: 100 Ω or less (100-Ω pot).

PULSE DC COMPONENT Range: 0 to +20 V (continuously adjustable).

Power Required: 105 to 125 V, 195 to 235 V, or 210 to 250 V, 50 to 60 Hz; approx 250 W, depending on quantity and type of plug-ins.

Accessories Supplied: CAP-22 Power Cord; spare fuses; six patch cords — one each 274-LMB and 274-LMR, two each 274-LSB and 274-LSR; four blank cover panels; one 14-conductor module extension cable.

Accessories Available: All modules in the 1395 series, 1217-P2 Single-Pulse Trigger.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench, 19 x 9⅛ x 14½ in. (485 x 235 x 370 mm); rack, 19 x 8¾ x 13¼ in. (485 x 225 x 340 mm).

Weight (without modules): Net, 29 lb (13.2 kg); shipping, 42 lb (19.5 kg).

1395-P1 PRF UNIT

This module generates the pulses that trigger the Pulse/Delay Units and provides the synchronization necessary for synthesizing complex waveforms. The maximum repetition rate is 1.2 MHz when generated internally, and at least 2 MHz with external drive. The PRF Unit acts as a synchronous divider when a signal of higher frequency is applied to the LOCK SIG jack, and a stable division of up to about 15:1 is practical. When a positive pulse is applied to the GATE IN jack, the PRF Unit is disabled for the duration of the pulse. Varying the time of occurrence and duration of this gating pulse, which can be generated by other modules, controls when and how long the PRF Unit is inoperative.

specifications

PULSE REPETITION FREQUENCY

Internally Generated: 2.5 Hz to 1.2 MHz with 12-position switch and uncalibrated ΔF control. Accuracy: ±5% of nominal.

Externally Controlled: After adjustment for maximum sensitivity, sine-wave input of 0.5 V rms required for prf from dc to 0.5 MHz, rising to 1.5 V rms at 2 MHz. Input impedance at 0.5 V is approx 100 kΩ shunted by 50 pF. Nonsinousoidal signal requires a negative-going step of 1 V.

INPUT AND OUTPUT SIGNALS

Sync Out Pulses: At least 10 V, positive, with duration between 75 and 150 ns (nominally 100 ns); rise time approx 25 ns and output impedance approx 35 Ω.

Lock Signal: PRF Unit operating at 1 kHz can be locked to a frequency of 10 kHz by 10-V positive pulses with 100-ns duration or with a sine wave of 7 V rms. Required positive-pulse amplitude increases to about 12 V to lock the 1 kHz to a frequency of 2 kHz.

Gate Input: A potential more positive than −1 V at this terminal stops the generation of SYNC OUT pulses.

Stability: Prf jitter is 0.05% when the PRF Unit is operated from the power supply in the 1395-A main frame.

GENERAL

Accessories Supplied: Six patch cords — one each of 274-LMB and 274-LMR, two each 274-LSB and 274-LSR; two insulated plugs, one each 274-DB1 and 274-DB2.

Accessories Available: 1217-P2 Single-Pulse Trigger, other 1395 modules.

Weight: Net, 1½ lb (0.7 kg); shipping, 4½ lb (2.1 kg).

1395-P2 PULSE/DELAY UNIT

Each Pulse/Delay Unit receives its input signal from a PRF Unit, external source, Word Generator module, or another Pulse/Delay Unit. Front-panel controls are provided for output-pulse amplitude and duration and for the timing of a sync pulse, which can be used to trigger other modules. The output pulse in either polarity is available at panel terminals and can be fed to the main frame ADDER busses where it can be combined with other pulses. The dc reference level of all the output pulses can be varied by a main frame control.

1395-P1

specifications

Pulse and Delay Durations: 100 ns to 1 s, accurate to ±5% of reading or ±2% of full scale, or ±35 ns, whichever is greater.

Pulse Repetition Frequency: Determined by input sync signal — range dc to 2.4 MHz. Input signals can be randomly spaced if separated by at least 400 ns.

Rise and Fall Times: Less than 15 ns with 50-Ω load. On high-voltage output (20 V into 1 kΩ), transitions are typically 80 ns + 2 ns/pF of load capacitance.

Output Voltage: ±20 V pulses into 1-kΩ internal load impedance (±1 V into 50-Ω load).

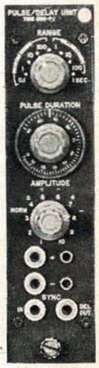
Input Sync Requirements: Positive-going pulse, 10 to 20 V, with 75- to 150-ns duration.

Delayed Output: Positive pulse of at least 10-V amplitude and 75- to 150-ns duration. Output impedance approx 125 Ω. Time between SYNC IN and DEL OUT pulses set by PULSE DURATION control.

Stability: Pulse-duration jitter is 0.05% when Pulse/Delay Unit is operated in the 1395-A main frame.

Accessories Supplied: Five patch cords — two each 274-LSB and 274-LSR, one 274-LMR; two insulated plugs, one each 274-DB1 and 274-DB2.

Weight: Net, 1¾ lb (0.8 kg); shipping, 4¾ lb (2.2 kg).



1395-P2

1395-P3 PULSE SHAPER

This unit produces pulses with straight-line leading and trailing edges whose rise and fall times can be adjusted individually by separate controls or simultaneously by a single control. The leading edge starts with the pulse that is applied to the IN 1 jack; the trailing edge starts with the pulse that is applied to the IN 2 jack. If input pulses are applied only to the IN 1 jack, the leading edge of the output pulse starts with the first input pulse and the trailing edge starts with the second pulse. Both positive and negative output pulses are produced, and the dc reference level can be varied by the PULSE DC COMPONENT control on the main frame. The output can be switched to the ADDER busses.

specifications

INPUT PULSES: 10 V to 20 V in amplitude and 75 ns minimum duration.

OUTPUT PULSES

Duration: Time between pulses at IN 1 and IN 2 plus duration of trailing edge.

Rise and Fall Times: 100 ns to 10 ms in five decade ranges, ±10% of full scale, from the 0 to 100% points. Rise and fall times can be adjusted, independently by separate controls or simultaneously by a single control, within the same decade range. To obtain times less than a few hundred nanoseconds, output must be terminated in 50 to 100 Ω.

Linearity: A leading or trailing edge voltage e(t) making a transition of E volts in time T will not at any time t depart from the equation $e = \frac{Et}{T}$ $(0 \le t \le T)$ by more than 0.1 E (typically better than 0.05 E). The fastest transitions will not yield this performance unless outputs are terminated in 50 to 100 Ω.

Voltage: ±20-V pulses into 1-kΩ internal load impedance (±1 V into 50-Ω load).

GENERAL

Accessories Supplied: Five patch cords — two each 274-LSB and 274-LSR, one 274-LMR; two insulated plugs, one each 274-DB1 and 274-DB2.

Weight: Net, 1¾ lb (0.8 kg); shipping, 4¾ lb (2.2 kg).

1395-P3

File Courtesy of GRWiki.org

1395-P4 POWER AMPLIFIER

1395-P4

This amplifier is designed primarily for pulse amplification in applications where extremely fast rise time is not necessary. It delivers a 20-volt, minimum, pulse of either polarity into a 50-ohm load, and can amplify the signals from the ADDER busses or the output of any 1395 module. As a sine-wave amplifier it is useful for frequencies in the audio range and up to 1.5 MHz, or 5 MHz, depending upon the termination. Output power as a sine-wave amplifier is approximately two watts, and distortion is 5% or less. It is a suitable coupling element between the outputs of the various pulse-forming modules and the most commonly encountered impedances used in radar, video, and telephone practice.

specifications

Output Impedances: 50, 93, and 600 Ω, all ±10%.

Gains: 20, 20, and 26 dB, respectively, at the above impedances and with matched loads, all ±2 dB.

Pulse Output Voltage: ±20-V pulses into 50-Ω load with 10% duty cycle. Larger duty cycles may be used at lower output levels.

Rise and Fall Times: Less than 60 ns on all transitions with a 50-Ω load and selector switch set for 50-Ω impedance.

Sine-Wave Amplifier: Power output into 50- and 93-Ω loads is at least 2.5 W (3% distortion typical); into 600-Ω load, at least 1.5 W (distortion, 1.5% typical).

Frequency Response: Down less than 3 dB at 20 Hz and 5 MHz with 50- and 93-Ω loads; 20 Hz and 1.5 MHz with 600-Ω load.

Dc Level: Dc baseline of pulses and centerline of sine waves can be moved at least ±1.5 V dc with 50-Ω loads, and more with higher impedance loads.

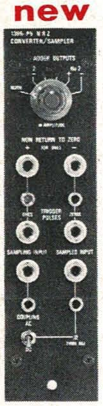
Input Impedance: Adjustable from 50 to 1050 Ω, shunted by approx 45 pF.

Accessories Supplied: Four patch cords — one each 274-LMB, 274-LMR, 274-LSB, and 274-LSR; two insulated plugs, one each 274-DB1 and 274-DB2.

Weight: Net, 2 lb (1.0 kg); shipping, 5 lb (2.3 kg).

1395-P5 NRZ CONVERTER/SAMPLER

new


1395-P5

This module, used with the 1395-P6 Word Generator, can produce non-return-to-zero (NRZ) signals. Or, it can be used for its binary decision-making capability, indicating the binary level of a signal at the SAMPLED input at the time of an interrogating pulse applied to the SAMPLING input. It responds to each interrogation with a trigger pulse from either the ONES or ZEROS output to indicate the state of the SAMPLED input, and with an appropriate transition or nontransition of the NRZ output. It can also be used to generate random pulse trains and diphase pulse signals. Related dipulse and NRZI signals can also be produced by the 1395-A, though they do not require use of the 1395-P5.

specifications

SAMPLING INPUT

Pulses: 10 to 15 V, positive-going, 75- to 150-ns duration, dc to 2.5 MHz.

Sine Wave: At least 17 V rms, 1 to 2.5 MHz. Sine-wave sampling below 1 MHz not recommended.

Input Impedance: Approx 4500 Ω across 40 pF.

SAMPLED INPUT

Sensitivity: 0.2 V pk-pk up to 2.5 MHz, optimized by adjustment of threshold control. Input required increases at other settings.

Coupling: Ac or dc, switch-selected.

Threshold Control: Compensates for dc components between approx ±0.6 V.

Input Impedance: Approx 100 kΩ across 40 pF.

NRZ OUTPUTS Both positive- and negative-going transitions are available simultaneously with the dc component controlled by the 1395-A.

Amplitude: >20 V, open circuit: >1 V across 50 Ω.

Transition Times: <15 ns with 50-Ω load at max input. Typically 80 ns + 2 ns/pF of load capacitance for high-impedance loads.

Output Impedance: 1 kΩ max.

TRIGGER OUTPUTS Two outputs available simultaneously: pulse generated when SAMPLED terminal is in ONE state, another when terminal is in ZERO state.

Amplitude: >+10 V. **Duration:** Approx 70 ns.

Output Impedance: Approx 160 Ω.

Delays: Trigger and NRZ outputs are delayed approx 190 ns from the SAMPLING input.

Accessories Supplied: Eight patch cords — two each Types 274-LMB, 274-LMR, 274-LSB, 274-LSR; two double plugs, four insulated plugs.

1395-P6 WORD GENERATOR

1395-P6

This module produces a pattern of 16 binary digits (BITS) in accordance with the settings of the switches on the module front panel. As many as seven Word Generators can be connected in cascade, utilizing the full capacity of the 1395-A main frame, to provide an 112-bit capability in one binary word. Rear-panel switching provides conversion of the 16-bit-per-generator capacity to 14-bit capacity. Numerous options are provided by the interconnection of two or more Word Generators in cascade, or by a change in the internal wiring of a Word Generator with a patch cord.

The output pulses are trigger signals designed to operate other 1395 modules. In addition, each Word Generator provides a sync pulse coincident with the time when an output pulse would occur from switch #1, whether or not that switch is actually engaged.

specifications

INPUT

Pulse Repetition Frequency: Dc to 2.5 MHz, externally controlled by 1395-P1 PRF Unit (or similar unit).

Trigger-Pulse Requirements: 10- to 20-V positive-going pulses of 75- to 150-ns duration. Square waves can be used above 10 kHz; sine waves, above 500 kHz.

Impedance: 400 to 600 Ω, depending upon trigger amplitude.

OUTPUTS

Oscilloscope Sync: Rectangular pulse of 2-V min amplitude and duration equal to period of driving-signal prf. Occurs approx 50 ns before the switch-#1 output pulse, whether or not the switch is on.

Word Out: 10- to 20-V positive-going pulses of 75- to 150-ns duration. Output impedance approx 150 Ω, but termination in 500 to 1000 Ω is recommended.

Pattern: Set by front-panel switches. Choice of 16-bit or 14-bit capacity by rear-panel switch. One can achieve capacities other than 14 and 16 by modification of internal wiring. Interconnection of up to seven units provided by the 1395-A main frame.

GENERAL

Accessories Supplied: Five patch cords — one each 274-LSB, 274-LSR, 274-LMB, 274-LMR, and 274-LLR; two insulated plugs, one each 274-DB1 and 274-DB2.

Weight: Net, 2½ lb (1.2 kg); shipping, 5½ lb (2.5 kg).

TYPE 1395-P7 SKELETON FRAME

A blank module suitable for mounting the components of a user-designed circuit.

Weight: Net, ½ lb (0.3 kg); shipping, 3½ lb (1.6 kg).

Catalog Number	Description	Price in USA
	1395-A Modular Pulse Generator (main frame only),	
1395-9801	Bench Model	**$650.00**
1395-9811	Rack Model	**650.00**
1395-9601	**1395-P1 PRF Unit**	**160.00**
1395-9602	**1395-P2 Pulse/Delay Unit**	**190.00**
1395-9603	**1395-P3 Pulse Shaper**	**295.00**
1395-9604	**1395-P4 Power Amplifier**	**295.00**
1395-9605	**1395-P5 NRZ Converter/Sampler**	**295.00**
1395-9606	**1395-P6 Word Generator**	**350.00**
1395-9607	**1395-P7 Skeleton Frame**	**15.00**

File Courtesy of GRWiki.org

- output: 60 V into 50 ohms
- rise/fall times: <50 ns, and adjustable

PULSE AMPLIFIER

Type 1397-A

The 1397-A Pulse Amplifier can be used with any pulse generator capable of supplying negative input pulses, particularly the GR 1217, 1395, and 1398 Pulse Generators.

Such combinations are excellent for testing radar circuits, which often require pulses up to 50 volts into 50 ohms, with transitions less than 50 nanoseconds and repetition rates up to one megahertz. The high output is also valuable for testing switching arrays and the thin-film or core memories used in computers. The variable-transition-time feature provides a rapid means for determination of the rise-time ranges over which these devices will operate.

Additional uses include the testing of inductors, semiconductors, and other components. The linearly increasing output current is especially useful for testing pulse transformers.

OUTPUT TRANSITIONS

The 1397-A has two modes of operation: normal and variable transition time. In the normal mode, the input pulses are fed directly to the output amplifier. This mode provides the fastest rise and fall times, typically 30 ns. In the variable-transition-time mode, exponential transitions are obtained by applying the input pulses to an RC network that slows the leading and trailing edges. Linear transitions are obtained by applying a higher-level input pulse to overdrive the RC network. The output of the RC network is followed by a diode circuit, which provides the linear transitions.

— See **GR Experimenter** for February 1966.

specifications

INPUT (conditions depend on output transition-time mode):

Output Mode	Input Impedance	Drive Required
NORMAL	100 Ω or 100 kΩ shunted by approx 50 pF, switch selected	—2 V pk-pk, min
VARIABLE Linear	30 kΩ, approx	—30 V pk-pk, approx, min
Exponential	100 Ω	—2 to —4 V pk-pk, approx

OUTPUT

Amplitude: 1.2 A pk-pk, max (60 V into 50 Ω); 1 A pk-pk with 10% duty ratio. Positive or negative polarity, ground-based, direct coupled. Automatic overload protector with manual reset.

Amplitude Variation: ±10% for duty-ratio changes from minimum to 10%. With ±10% line-voltage changes, positive output variation is ±10%, negative is ±5%.

Impedance (Internal Shunt): Positive output, 50 Ω or open circuit; negative output, 50 Ω, 100 Ω, or open circuit.

Rise and Fall Times: NORMAL mode, <50 ns (30 ns typical) with input rise and fall times <20 ns; VARIABLE LINEAR mode, 0.2 to 100 μs, approx, continuously adjustable; VARIABLE EXPONENTIAL mode, 0.5 to 500 μs, approx, continuously adjustable.

Rampoff: Approx 30% with 5-ms pulse duration.

Overshoot: <15% for 10% duty ratio, full output into 50 Ω.

Max Duty Ratio: 10%.

TRANSFER CHARACTERISTICS

Transfer Function: Approximates linear amplifier in normal mode.

Transconductance: 0.5 ℧ (2 V in produces 1 A out).

Inherent Delay: <50 ns between input and output pulses.

GENERAL

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 Hz, 100 W.

Terminals: Input, binding posts; output, GR874 recessed, locking connector.

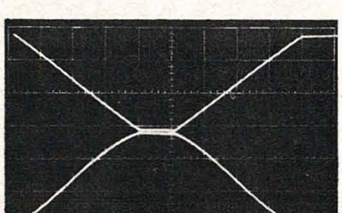
Accessories Supplied: CAP-22 Power Cord, spare fuses.

Accessories Available: Relay-rack adaptor set, panel 19 x 5¼ in. (485 x 135 mm), depth behind panel 9 in. (230 mm).

Mounting: Convertible-Bench Cabinet.

Dimensions (width x height x depth): 14 x 5⅞ x 10¼ in. (355 x 150 x 260 mm).

Weight: Net, 18 lb (8.5 kg); shipping, 24 lb (11 kg).



1397-A Transfer Characteristics. The linear ramp on top is the input to the 1397-A. The lower trace is the output, at full 1.2-A power. Transfer function shows lower gain at very low and very high power level as pulse starts from cut-off and rises into grid-current regions of output stage.

Catalog Number	Description	Price in USA
1397-9701	**1397-A Pulse Amplifier**	**$565.00**
0480-9634	**480-P314 Relay-Rack Adaptor Set**	**6.00**

File Courtesy of GRWiki.org

HIGH-RATE PULSE GENERATOR

Type 1394

- dc to 100 MHz
- 2-nanosecond transitions
- 96% max duty ratio
- 4-volt output into 50 ohms

The twin virtues of high performance and modest cost make this generator desirable for any work with advanced high-frequency digital circuits or components. These rarely paired attributes result from use of standard components in novel yet straightforward circuit designs.

Pulse delay and duration are accomplished by coaxial cables that can be switched into the signal paths to produce intervals of 0 to 99 ns in 1-ns increments. Unlike active networks, this type of delay imposes no duty-ratio restrictions. And, since only cable length and dielectric constant determine delay, a high degree of accuracy and stability is realized.

The versatile input circuits accept virtually any signal of sufficient amplitude, making the instrument useful as a pulse regenerator and permitting precise synchronization to an external signal. Or the pulse rate can be set by an internal LC oscillator of unique design and excellent stability.

EASY TO USE

Calibrated controls free the operator from dependence on an oscilloscope. In addition, he need have no concern for duty-ratio or dissipation limits as they cannot be exceeded by any combination of settings.

Pulses of either polarity can be generated. Amplitude can be controlled by a precision step attenuator, and the offset smoothly adjusted. Thus, there is wide, continuous control of pulse level for threshold tests on level-sensitive circuits.

The 1394-Z is a combination of the 1394-A and the 1394-P1. Output of 1394-A is ac coupled. The 1394-P1 inserts a dc component in the pulse output of the 1394-A so that baseline is regulated to equal a desired dc reference level, adjustable from −2 to +2 volts. For those who don't need a direct-coupled output, the 1394-A is an economical choice; the 1394-P1 can be added later if needed.

— See **GR Experimenter** for July 1966.

specifications

PULSE-REPETITION FREQUENCY

Internally Generated: 1.0 MHz to 100 MHz. Continuous coverage in six ranges. Accuracy, 5% of setting. Jitter, <0.1 ns, pk.

External Control: Dc to 100 MHz. Amplitude, 0.4 to 4.0 V, pk-pk, or 4.0 to 40 V, pk-pk, with 10:1 attenuator switched in. 50-Ω impedance, max avg power 1 W.

Input Controls: Attenuator, trigger level −2 to +2 V, and slope polarity.

SYNCHRONIZING-PULSE OUTPUT

Description: Bipolar pulses. Leading edge of positive pulse is time reference.

Duration: 4 ns.

Amplitude: 250 mV, pk-pk, into 50 Ω.

INCREMENTAL DELAY

Range: 0 to 99 ns in 1-ns steps. (No restriction on ratio: delay/period.)

Accuracy: ±2.5% + 1 ns.

Jitter: <0.1 ns, pk.

Residual Delay: 35 ns, typically.

OUTPUT PULSE (all specifications apply with 50-Ω load)

Duration: 4 to 99 ns in 1-ns steps. Accuracy, ±2.5% +1 ns.

Jitter: <0.1 ns, pk.

Rise and Fall Times: 1.8 to 2.6 ns.

Amplitude: 0 to 4 V, adjustable in 0.5-V steps. Positive or negative pulses.

Baseline: Continuously adjustable −2 to +2 V, regulated, in 1394-Z only.

Accuracy: ±200 mV up to 90% duty ratio.

Duty Ratio: Limited only by rise-plus-fall time.

Droop: <12%.

Overshoot: 12% typically.

GENERAL

Power Required: 100 to 125, 200 to 250 V, 50 to 400 Hz, 28.5 W.

Accessories Supplied: Two power cords, 874-R22A Coaxial Patch Cord, spare fuses.

Mounting: Rack-Bench Cabinet.

Dimensions (width x height x depth): Bench model, 19 x 5⅞ x 16¾ in. (485 x 150 x 425 mm); rack model, 19 x 5¼ x 15 in. (485 x 135 x 380 mm).

Weight: Net, 35½ lb (16.5 kg); shipping, 60 lb (28 kg).

Catalog Number	Description	Price in USA
	1394-Z High-Rate Pulse Generator with Pulse-Offset Control	
1394-9911	Bench Model, 115 volts	**$1250.00**
1394-9912	Rack Model, 115 volts	**1250.00**
1394-9913	Bench Model, 230 volts	**1250.00**
1394-9914	Rack Model, 230 volts	**1250.00**
	1394-A High-Rate Pulse Generator	
1394-9801	Bench Model	**995.00**
1394-9811	Rack Model	**995.00**
	1394-P1 Pulse-Offset Control	
1394-9611	Bench Model	**255.00**
1394-9621	Rack Model	**255.00**

PATENT NOTICE. See Note 29.

File Courtesy of GRWiki.org

- divides frequency continuously by any number from 3 to 99,999,999
- <100-ns recovery for continuous division
- fully programmable
- 100-mV sensitivity

DIGITAL DIVIDER/ PERIOD AND DELAY GENERATOR

Type 1399

new

The 1399 is a high-resolution digital delay generator that also serves as a frequency divider. Its internal 10-MHz clock establishes a 0.1-μs period, which is the basis for delays of from 0.3 μs to 10 s. With an external signal of 100 Hz to 12 MHz replacing the internal clock signal, the 1399 acts as a frequency divider capable of producing, for example, an arbitrary fractional frequency from an integral standard frequency or the reverse. Full control is provided over the input-circuit characteristics of both the external-clock and delay-start channels, permitting the 1399 to accept a variety of signals and to define the reference time in the delay mode.

Full programmability of all controls enables the 1399 to be a flexible component in automatic instrumentation systems operating in either the time or frequency domain. It will serve equally well as a time-interval generator and as the primary component in systems involving digital frequency synthesis.

The 1399 enables a frequency counter to be used in either of two preset modes. Acting as the time base, the 1399 can supply a frequency of any arbitrary value to normalize the counter readout to be direct reading in any desired units. Or the 1399 can count events and gate the counter to read elapsed time, as in rate-table control applications.

As a stable and precise delay generator, the 1399, with an oscilloscope, is an invaluable aid in trouble-shooting complex programs. Locked to a computer's clock, the instrument will act as a coherent, jitter-free, high-resolution sweep delay. The accuracy of delay is independent of the total delay set on the 1399's thumb wheels. The precision possible with this generator also enhances its use as a timing source for the generation of precision pulses and in the measurement of delays and time intervals by substitution methods.

specifications

Frequency Divider Ratio: 3:1 to 99,999,999:1. Delay range, 3 to 99,999,999 clock time-intervals, i.e. 0.3 μs to 9.9999999 s with 10-MHz clock.

Delay Accuracy: Delay interval varies from 0 to 1 clock interval when clock and start signal are not coherent.

INPUT CHARACTERISTICS Clock and delay-start inputs are identical except for max frequency (rate).

Rate: Delay-start input, 100 Hz to 2.5 MHz. Ext clock input, >10 MHz, typically 12 MHz; min, 100 Hz for 1-V pk-pk sensitivity, lower frequency with reduced sensitivity.

Sensitivity: 100 mV rms; will accept waveform of arbitrary shape.

Input Impedance: Approx 100 kΩ //30 pF.

Trigger Threshold: ±1 V dc offset.

Trigger Polarity: Positive or negative, switch-selected.

INTERNAL CLOCK OSCILLATOR

Frequency Control: 10-MHz third-overtone quartz crystal in proportional-control oven.

Temperature: <1 ppm, 0°C to 50°C.

Warmup: Within 1 ppm from room temperature in 10 min.

Short-Term Stability: 1×10^{-7} for 1-s sampling interval.

Long-Term Stability: 1×10^{-6} per year; with oscillator running continuously, $<3 \times 10^{-9}$ per day after one month of operation.

Internal Clock Output: 1 V rms into 50 Ω.

Output Pulse: 5 V behind 50 Ω, positive and negative available simultaneously. Duration approx 15 ns.

PROGRAMMABILITY All functions and control settings, except trigger threshold, controlled by single contact closures to chassis ground. Max current, 2 mA through closed contact; max voltage drop, 150 mV across closed contact.

Divider/Delay Control: 1-2-4-8 BCD; DTL logic levels or contact closures.

Trigger Threshold: 0 to +10 V into approx 100 kΩ produces −1 to +1 V threshold detection

Power Required: 100 to 125 or 200 to 250 V switch selected, 50 to 60 Hz, 20 W.

Accessories Supplied: Power cord, spare fuses, and mounting hardware with the rack model.

Mounting: Bench model (in metal cabinet) or rack model.

Dimensions (width x height x depth): Bench, 19½ x 4⅞ x 17 in. (495 x 125 x 435 mm); rack, 19 x 3½ x 16 in. (485 x 89 x 410 mm).

Net Weight: Bench, 28 lb (13 kg); rack, 21 lb (10 kg).

Shipping Weight (est): Bench, 43 lb (20 kg); rack, 36 lb (16.5 kg).

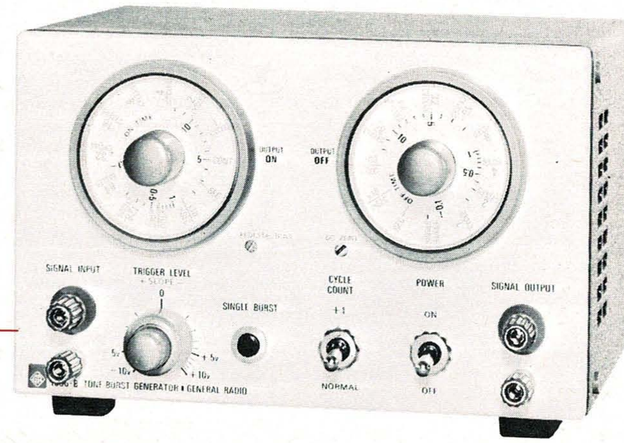
Catalog Number	Description	Price in USA
	1399 Digital Divider/Period and Delay Generator	
1399-9801	Bench Model	**$1775.00**
1399-9811	Rack Model	**1775.00**

File Courtesy of GRWiki.org

TONE-BURST GENERATOR

Type 1396-B

- fast, coherent switch for sine waves
- dc to 2 MHz
- signal attenuated >60 dB between bursts
- on-off times: 10 μs – 10 s or 1 – 129 periods of switched or other signal



new

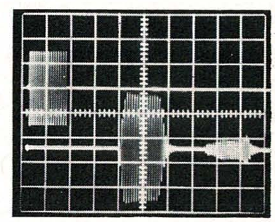
Oscillators page 198 ff

The 1396-B Tone-Burst Generator fills the gap between steady-state cw testing and step-function, or pulse, testing of amplifiers, meters, etc. It is ideally suited for applications such as the test and calibration of sonar transducers and amplifiers, the measurement of distortion and transient response of amplifiers and loudspeakers, and routine testing of filters and ac meters. Still other uses are found in the measurement of room acoustics and automatic-gain-control circuits, in the synthesis of time ticks on standard-time radio transmissions, and in psychoacoustic instrumentation.

For a full discussion of the many uses for tone-burst testing see the May 1964, **General Radio Experimenter** or write for publications A130, IN105, and IN110.

DESCRIPTION

The 1396 acts as a switch that alternately interrupts and passes an input signal, thus chopping into bursts a sine wave, or continuous tone, applied to the input. The instrument times the burst duration and interval between



Typical waveform produced by the Type 1396/Type 1310 oscillator combination with a 15-kHz signal turned on for 16 cycles and off for one-half second. Upper trace shows input to sonar projector; lower trace shows output from projector and subsequent echo return from wall of test tank.

bursts exactly by counting the number of cycles, or periods, of the input signal. Panel controls permit these intervals to be set to a wide range of values. The exact time at which the burst starts and stops can be controlled, thus the burst is phase-coherent with the input signal.

Alternately, timing can be based on a separate signal, the output can be turned on continuously for alignment or calibration, or single bursts can be generated with a front-panel push button. The 1396-B can also operate with nonsinusoidal or aperiodic inputs.

specifications

SIGNAL INPUT (signal to be switched)

Amplitude: >10 V pk (7 V rms) max for proper operation; <1 V pk-pk min for proper triggering.

Frequency Range: Dc to 2 MHz.

Input Impedance: 50 kΩ, approx.

TIMING INPUT (signal that controls switch timing). Same specifications as SIGNAL INPUT except:

Input Impedance: 20 kΩ, approx.

SIGNAL OUTPUT

Output On: Replica of SIGNAL INPUT at approx same voltage level; dc coupled; down 3 dB at >1 MHz. Output current limits at >25 mA pk, decreasing to >15 mA at 2 MHz. Output source impedance typically 25 Ω increasing above 0.2 MHz. Total distortion contribution <0.3% at 1 kHz and 10 kHz.

Output Off: Input-to-output transfer (feedthrough), <–60 dB, dc to 1 MHz, increasing above 1 MHz.

Spurious Outputs: Dc component and change in dc component due to on-off switching (pedestal) can be nulled with front-panel control. Output switching transients are typically 0.2 V pk-pk and 0.2 μs in duration (120-pF load).

ON-OFF TIMING Timing is phase-coherent with, and controlled by, either the signal at the SIGNAL INPUT connector or a different signal applied to the EXT TIMING connector. The on interval (duration of burst) and the off interval (between bursts) can be determined by cycle counting, timing, or direct external control.

Cycle-Count Mode: On and off intervals can be set independently, to be of 1, 2, 4, 8, 16, 32, 64, or 128 cycles (i.e. periods) duration or to be 2, 3, 5, 9, 17, 33, 65, or 129 cycles with +1 switch operated.

Timed Mode: On and off intervals can be set, independently, for durations of 10 μs to 10 s ± 2 periods of timing signal. It is also possible for one interval to be timed and the other counted.

Switching Phase: In above modes, input controls determine phase of timing signal at which on and off switching occurs. SLOPE control selects either positive or negative slope of timing signal; TRIGGER LEVEL control sets voltage level at which switching occurs.

Direct External Control: A 10-V pulse applied to rear-panel connection will directly control switching.

SYNCHRONIZING PULSE: A dc-coupled pulse that alternates between approx +8 V for output on, and –8 V when off. Source resistance approx 0.8 kΩ for positive output and 2 kΩ for negative.

GENERAL

Ambient Operating Temperature: 0 to 55°C.

Power Required: 100 to 125 or 200 to 250 V, 50 to 400 Hz, 16 W.

Accessories Supplied: Power cord.

Mounting: Convertible-Bench Cabinet.

Dimensions (width x height x depth): 8½ x 5⅝ x 10 in. (220 x 145 x 255 mm).

Weight: Net, 8 lb (3.7 kg); shipping (est), 12 lb (5.5 kg).

Catalog Number	Description	Price in USA
	1396-B Tone-Burst Generator	
1396-9702	Bench Model	**$550.00**
1396-9703	Rack Model	**572.00**

File Courtesy of GRWiki.org

RANDOM-NOISE GENERATORS

Electrical noise is, by definition, any unwanted disturbance and its reduction in communications circuits is a constant aim of the engineer. Noise from a controlled source, however, is useful in studying the effectiveness of systems for detecting and recovering signals in noise. Well defined random noise is, moreover, a remarkably useful test signal that has, for many measurements, properties that are more useful than those of a single-frequency signal. Its wide frequency content sometimes permits one test with random noise to replace a series of single-frequency tests. Noise is also useful in simulating speech, music, or communications circuit traffic.

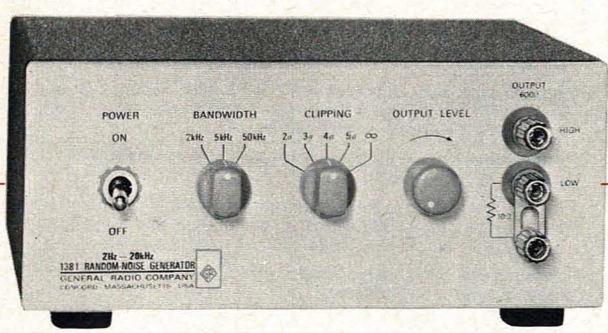
Noise is called random if its instantaneous amplitude at any future instant is unpredictable. Random noise is specified by its amplitude distribution and by its spectrum. Many types of naturally occurring electrical noise have the same distribution of amplitudes as do errors that normally occur in experimental measurements — the normal or Gaussian distribution. In general-purpose noise generators the design objective is random noise that is Gaussian and has a uniform spectrum level over the specified frequency range.

The General Radio random-noise generators produce electrical noise at high output levels, each model having been designed for specific uses. The 1381 is useful for many audio-frequency applications, and also in vibration testing as its spectrum extends well into the subaudio range; the 1382 is intended for audio-frequency electrical, acoustical, and psychoacoustical applications; the 1390-B is useful at higher frequencies because its spectrum extends to 5 MHz.

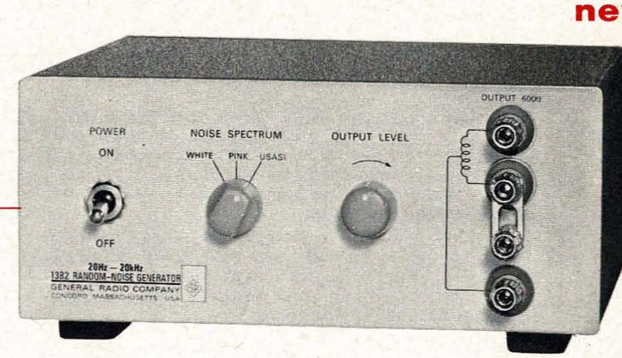
RANDOM-NOISE GENERATORS

Type 1381
Type 1382

new



new



1381

- 2 Hz to 2, 5, or 50 kHz
- Gaussian distribution
- adjustable clipping
- 3-V rms output

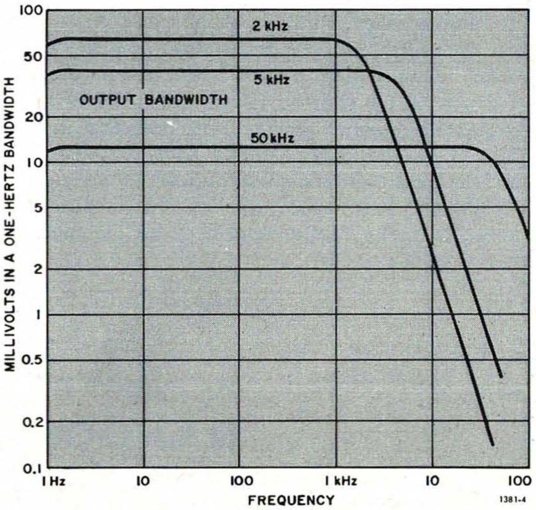
1382

- 20 Hz to 50 kHz
- white, pink, or USASI spectra
- Gaussian distribution
- 3-V rms output, balanced, unbalanced, or floating

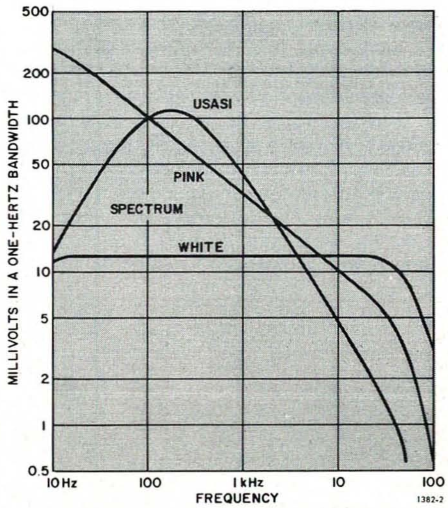
File Courtesy of GRWiki.org

The 1381 and 1382 are companion instruments that generate truly random noise from a semiconductor source. Special precautions are taken to ensure a symmetrical, Gaussian amplitude distribution. Output level is adjustable from below 3 millivolts to 3 volts rms behind a 600-ohm source impedance. Each model is constructed in a 3½-inch-high, half-rack-width cabinet, convenient for bench use and two can be mounted side-by-side in a relay rack.

Either of these noise generators can be used for simulation of noise in signal paths, as test-signal sources, or for demonstrations of statistical and correlation principles. The different features of the two offer a choice to match your needs.



Type 1381



Type 1382

The 1381 generates noise that is flat down to 2 Hz and is intended for random-vibration tests and for general-purpose use in the audio and subaudio range. The upper-frequency limit (at —3 dB) can be switched to 2, 5, or 50 kHz. The output signal can be clipped symmetrically at 2, 3, 4, or 5 times the rms amplitude.

The 1382 generates noise in the 20-Hz to 20-kHz band and is intended for electrical, acoustical, and psycho-acoustical tests. It offers three spectra, white (flat), pink (—3 dB per octave), and USASI (see specifications). The output can be taken balanced or unbalanced, floating or grounded.

specifications

SPECTRUM

1381: Flat (constant energy per hertz of bandwidth) ±1 dB from 2 Hz to 1, 2.5, or 25 kHz; upper-cutoff frequency (3-dB point) can be switched to 2, 5, or 50 kHz. Spectral density at 3-V output and for 1-Hz bandwidth is approx 64, 40, and 13 mV, respectively, for 2-, 5-, and 50-kHz upper cutoff. Upper cutoff slope is 12 dB/octave. See curve.

1382: Either (a) white noise (constant energy per hertz bandwidth) ±1 dB, 20 Hz to 20 kHz. with 3-dB points at approx 10 Hz and 50 kHz; (b) pink noise (constant energy per octave bandwidth) ±1 dB, 20 Hz to 20 kHz; or (c) USASI noise, as specified in USA Standard S1.4-1961. See curve.

Waveform:

Voltage	Gaussian Probability-Density Function	Amplitude-Density Distribution of 1381/1382
0	0.0796	0.0796 ± 0.005
$\pm\sigma$	0.0484	0.0484 ± 0.005
$\pm 2\sigma$	0.0108	0.0108 ± 0.003
$\pm 3\sigma$	0.000898	0.000898 ± 0.0002
$\pm 4\sigma$	0.0000274	0.0000274 ± 0.00002

These data measured in a "window" of 0.2σ, centered on the indicated values; σ is the standard deviation or rms value of the noise voltage.

Clipping: The output of the 1381 can be clipped internally to remove the occasional wide extremes of amplitude. Clipping, if desired, is adjustable to approx 2, 3, 4, or 5σ. Such clipping has negligible effect on the spectrum or the rms amplitude.

Output Voltage: >3 V rms max, open-circuit, for any bandwidth.

Output Impedance: 600 Ω. Can be shorted without causing distortion. 1381 output is unbalanced; 1382 output is floating, can be connected balanced or unbalanced.

Amplitude Control: Continuous adjustment from full output to approx 60 dB below that level.

Terminals: 1381 output at front-panel binding posts and rear-panel BNC connector; 1382 output at front-panel binding posts and rear-panel jacks for double plugs.

Accessories Supplied: Power cord, spare fuses, rack-mounting hardware with rack models.

Power Required: 100 to 125 or 200 to 250 V, 50 to 400 Hz, 6 W.

Mounting: Convertible-Bench Cabinet.

Dimensions (width x height x depth): Bench, 8½ x 3⅞ x 9⅞ in. (220 x 99 x 250 mm); rack, 19 x 3½ x 9 in. (485 x 89 x 230 mm).

Weight: Net, 7 lb (3.2 kg); shipping, 10 lb (4.6 kg).

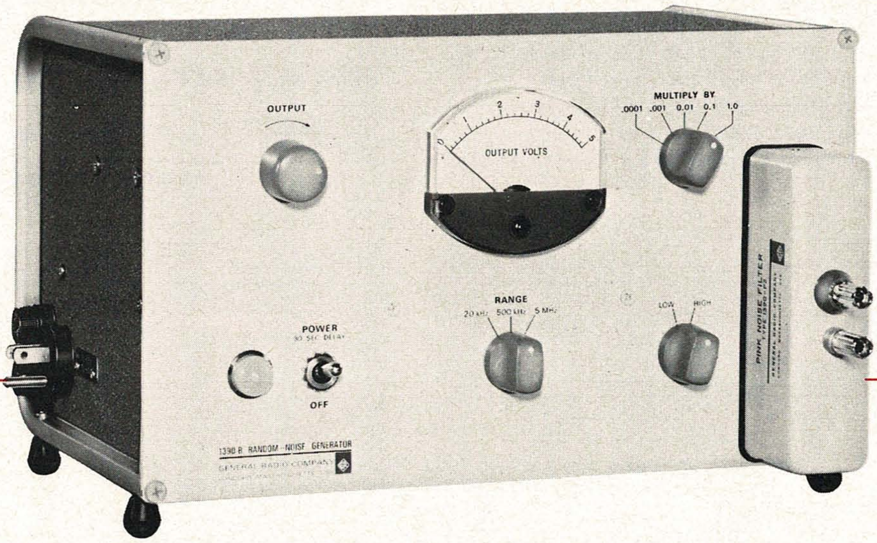
Catalog Number	Description	Price in USA
	Random-Noise Generator	
1381-9700	2 Hz to 20 kHz, Bench Model	**$375.00**
1381-9701	2 Hz to 20 kHz, Rack Model	**398.00**
1382-9700	20 Hz to 20 kHz, Bench Model	**375.00**
1382-9701	20 Hz to 20 kHz, Rack Model	**398.00**

File Courtesy of GRWiki.org

RANDOM-NOISE GENERATOR

Type 1390-B

- 5 Hz to 5 MHz
- 30-μV to 3-V output
- $\pm$1-dB audio-spectrum-level uniformity



This instrument generates wide-band noise of uniform spectrum level, particularly useful for noise and vibration testing in electrical and mechanical systems. The noise output of a gas-discharge tube is amplified and shaped with low-pass filters to provide ranges to 20 kHz, 500 kHz, and 5 MHz.

The output level is controlled by a continuous attenuator followed by a 4-step attenuator of 20-dB per step and is metered from over 3 volts to below 30 microvolts. When the attenuator is used, the output impedance remains essentially constant as the output level is adjusted.

Use the 1390-B as a broad-band signal source for:

- frequency response — drive device under test with 1390-B and analyze output with any of several GR analyzers, manually or with the GR 1521-B Graphic Level Recorder.
- intermodulation and cross-talk tests.
- simulation of telephone-line noise.
- measurements on servo amplifiers.
- noise interference tests on radar.
- determining meter response characteristics.
- setting transmission levels in communication circuits.
- statistical demonstrations in classroom and lab.

acoustic measurements:

- frequency response.
- reverberation — use 1390-B with a GR analyzer as source of narrow-band noise.
- sound attenuation of ducts, walls, panels, or floors.
- acoustical properties of materials.
- room acoustics.

Analyzers page 28 ff

or use with an amplifier to drive:

- a loudspeaker for structural fatigue tests in high-level acoustic fields.
- a vibration shake-table.

— For more information, request GR Reprint E-110.

specifications

Frequency Range: 5 Hz to 5 MHz.

Output Voltage: Max open-circuit output is at least 3 V for 20-kHz range, 2 V for 500-kHz range, and 1 V for 5-MHz range.

Output Impedance: Source impedance for max output is approx 900 Ω. Output is taken from a 2500-Ω potentiometer. Source impedance for attenuated output is 200 Ω. One output terminal is grounded.

Range	Typical Spectrum Level (with 1-V rms output)	Spectrum Level Uniformity *
20 kHz	5 mV for 1-Hz band	within $\pm$1 dB, 20 Hz to 20 kHz
500 kHz	1.2 mV for 1-Hz band	within $\pm$3 dB, 20 Hz to 500 kHz
5 MHz	0.6 mV for 1-Hz band	within $\pm$3 dB, 20 Hz to 500 kHz; within $\pm$8 dB, 500 kHz to 5 MHz

* Noise energy also present beyond these limits. Level is down 3 dB at 5 Hz. See plot.

File Courtesy of GRWiki.org

specifications (cont'd)

Waveform: Noise source has good normal, or Gaussian, distribution of amplitudes for ranges of the frequency spectrum that are narrow compared with the band selected. Over wide ranges the distribution is less symmetrical because of dissymmetry introduced by the gas tube. Some clipping occurs on the 500-kHz and 5-MHz ranges.

Voltmeter: Rectifier-type averaging meter measures output. It is calibrated to read rms value of noise.

Attenuator: Multiplying factors of 1.0, 0.1, 0.01, 0.001, and 0.0001. Accurate to ±3% to 100 kHz, within ±10% to 5 MHz.

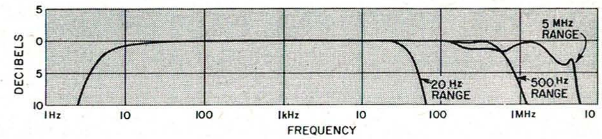
Power Required: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 50 W.

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

Accessories Available: Rack-adaptor set (19 x 7 in.); 1390-P2.

Mounting: Convertible-Bench Cabinet.

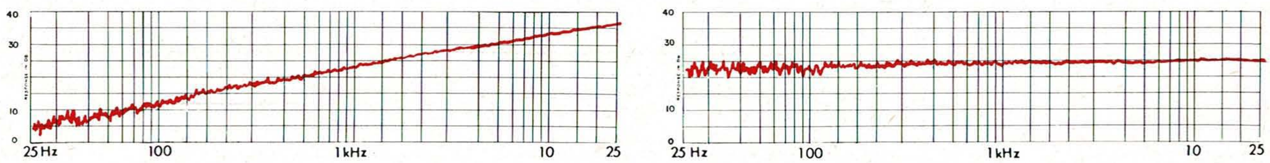
Dimensions (width x height x depth): 12¾ x 7½ x 9¾ in. (325 x 190 x 250 mm).



Typical spectrum-level characteristics.

Weight: Net, 12 lb (5.5 kg); shipping, 16 lb (7.5 kg).

Catalog Number	Description	Price in USA
1390-9702	**1390-B Random-Noise Generator**	**$350.00**



(Left curve) White noise output of the 1390-B Random-Noise Generator as measured by a one-third octave-bandwidth filter and (right curve) pink noise output.

PINK-NOISE FILTER

Type 1390-P2

When white noise is used for frequency-response measurements in conjunction with a constant-percentage bandwidth analyzer (such as the GR 1564-A Sound and Vibration Analyzer or 1568-A Wave Analyzer), the amplitude-frequency characteristic of a flat system appears to slope upward with increasing frequency at a rate of 3 dB per octave, owing to the constantly increasing bandwidth (in hertz) of the analyzer. The 1390-P2 converts the audio-frequency output of the 1390-B from white noise to pink noise, which has constant energy per octave. Thus it flattens the response curves made with a constant-percentage-bandwidth analyzer.

— See **GR Experimenter** for July 1962.

specifications

Frequency Response: Sloping −3 dB per octave from 20 Hz to 20 kHz, −6 dB per octave above 20 kHz. Output voltage is approx −5 dB with respect to the input voltage at 20 Hz and −35 dB at 20 kHz. It lies within 1 dB of the straight line connecting these two points on a graph of output in decibels vs log frequency.

Over-all Output Level: When the filter is used with the random-noise generator set for the 20-kHz range, the output voltage of the filter is approx 30 dB below its input, and the voltage level in each one-third-octave band is approx 17 dB below that. Thus, when the output meter of the generator indicates 3 V, the output of the filter is approx 0.1 V, and the level in each one-third-octave band is approx 15 mV.

Input Impedance: The filter should be driven from a source whose impedance is 1 kΩ or less. Input impedance is variable from 6.5 kΩ + load resistance at zero frequency to 6.7 kΩ at high frequencies.

Output Impedance: The filter should not be operated into a load of less than 20 kΩ. Internal output impedance is variable from 6.5 kΩ + source resistance at low frequencies to approx 200 Ω at high frequencies.

Max Input Voltage: 15 V rms.

Terminals: Input terminals are recessed banana pins on ¾-in. spacing at rear of unit. Output terminals are jack-top binding posts with ¾-in. spacing.

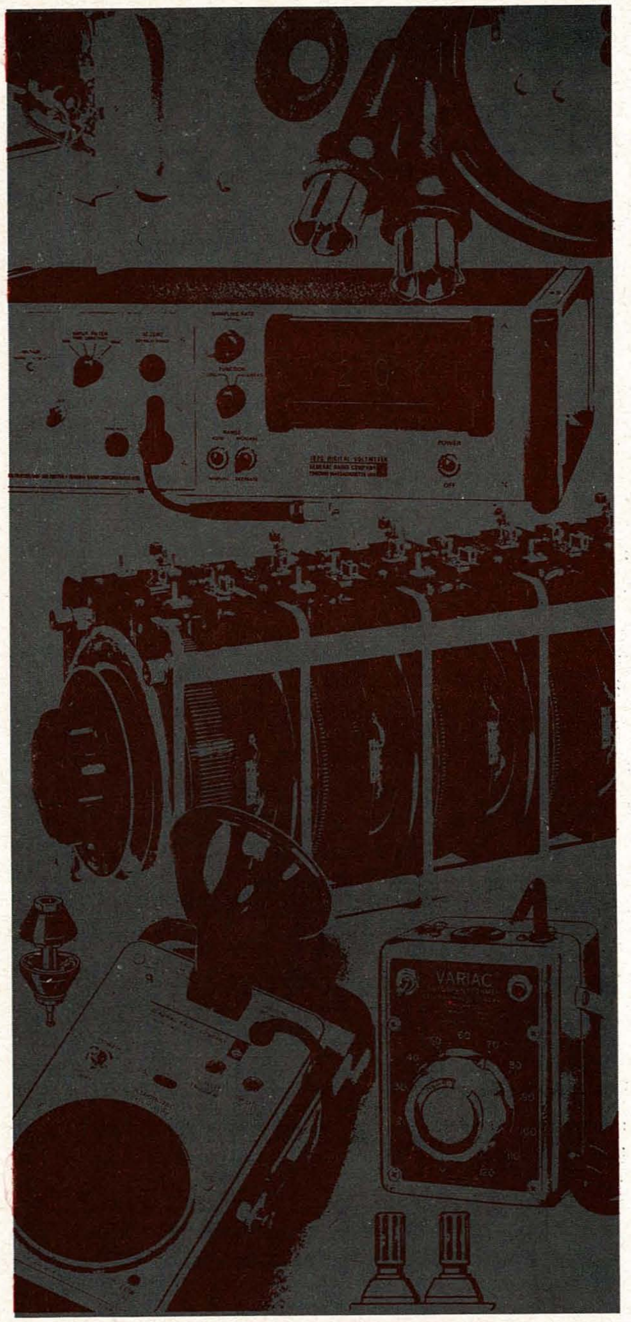
Dimensions (width x height x depth): 1⅜ x 5 x 2⅞ in. (35 x 130 x 73 mm).

Weight: Net, 6 oz (0.2 kg); shipping, 4 lb (1.9 kg).

Catalog Number	Description	Price in USA
1390-9702	**1390-B Random-Noise Generator**	**$350.00**
1390-9602	**1390-P2 Pink-Noise Filter**	**45.00**
0480-9842	**480-P412 Relay-Rack Adaptor Set**	**7.00**

PATENT NOTICE. See Note 15.

File Courtesy of GRWiki.org



MISCELLANY

METERS

STROBOSCOPES

VOLTAGE REGULATORS

VARIAC® AUTOTRANSFORMERS

PARTS

File Courtesy of GRWiki.org

METERS

Described in this section are a digital voltmeter with capabilities from gigahertz voltage measurements to picoamperes of current, with extremely high input impedances, and dB-readout capability, and resistance ranges, a vacuum-tube voltmeter usable up into the gigahertz range, measuring also dc volts and resistance; an electrometer instrument measuring dc millivolts, femtoamperes, and teraohms; and a new output power meter for audio frequencies. The ranges of these instruments, collectively, cover most of the magnitudes usually encountered in the electronics laboratory.

VOLTMETER

The Type 1806-A Electronic Voltmeter surpasses in frequency range and accuracy the best of previously available types. It has also many other features that contribute to operating convenience and over-all utility — high input impedance, logarithmic meter scale, excellent zero stability, and a small high-frequency probe with a variety of connector accessories.

ELECTROMETER

The Type 1230-A Electrometer and DC Amplifier is a high-stability, direct-coupled amplifier, which can be used not only for direct-reading measurements of small voltages and currents and high esistances but also for amplifying weak currents and voltages to operate recorders, relays, and other equipment.

OUTPUT POWER METER

The output power meter, an original General Radio development, is now available for use over wider ranges than ever before. This indispensable laboratory and test-bench device measures power into an adjustable resistive load and thus can determine both the maximum power output and the internal impedance of oscillators and amplifiers.

HIDDEN METERS

Elsewhere throughout the GR Catalog, under the guise of analyzers, resistance bridges, sound-level and vibration meters, detectors, or frequency counters, will be found many other metering instruments. If what you need is not in the following pages, we suggest you look at the disguised meters; any GR sales engineer or representative will be glad to assist.

DIGITAL VOLTMETER

Type 1820-A

- linear or log (dB) readout
- 0.1% basic dc accuracy
- 10^{11}-Ω input impedance up to 220 volts
- plug-in versatility

new

Digital Voltmeter with 1820-P1 plug-in

The 1820-A Digital Voltmeter exhibits broad capability in a single instrument owing to a selection of plug-ins and accessories. Both plug-ins are general-purpose devices, measuring ac and dc voltage and resistance; each, in addition, has special virtues such as high frequency, high sensitivity and the like. Voltage readout is presented in decibels or volts; ranges are selected automatically with decimal point and measurement units displayed. A digital-data output in BCD form is provided with range, polarity, log/linear indication, and other data and timing outputs. Fast 30-Hz sampling rate ensures delay-free readout and permits rapid data acquisition in automatic measuring systems; measurements can also be externally initiated.

File Courtesy of GRWiki.org

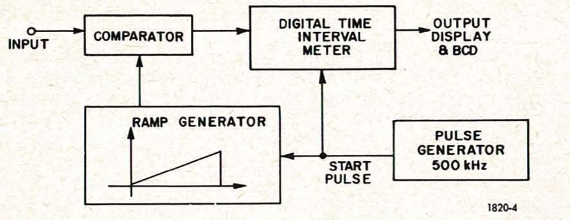


Figure 1. Basic block diagram of Type 1820 Digital Voltmeter. The 1820 is a ramp-type DVM, which gives it the advantages of speed and particular suitability to dB readout as the ramp generated by a simple rc circuit is inherently logarithmic.

with the 1820 you can measure

ac volts to 1.5 GHz
dc volts 5 μV to 1000 V
ac volts 10 μV to 200 V
dc current to picoamperes
ac current to nanoamperes

DC MULTIMETER/UHF VOLTMETER

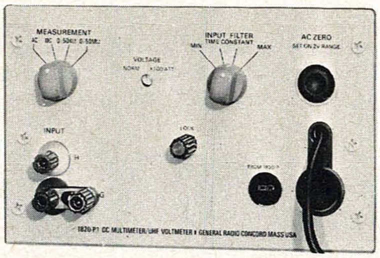
The 1820-P1 plug-in measures ac voltage, dc voltage and current and resistance, to 0.1% accuracy in most cases. It is especially useful for high-frequency voltage measurements to 1.5 GHz and exhibits extremely high input impedance for all ranges of both ac and dc voltage. Voltage-measurement ranges extend from millivolts to 1000 volts, resistance to 50 megohms.

AC/DC MILLIVOLTMETER

The 1820-P2 plug-in measures both ac (average) and dc with microvolt sensitivity. Dc current can be measured with picoampere resolution. With a standard oscilloscope current probe, ac current can be measured with 1-nanoampere resolution. For added convenience, an ohmmeter capability is also included.

DIFFERENTIAL INPUT

An adaptor, the 1820-P3, will convert the dc input of either plug-in to a true differential input, i.e., fully balanced. Common-mode rejection is about 100 dB, even with a source impedance of 100 kΩ.



1820-P1 DC Multimeter/UHF Voltmeter

specifications — with 1820-P1

DC VOLTAGE

Range: 220.0 mV to 220.0 V full scale (positive or negative), in four ranges; 1000 V with attenuator.

Impedance: 10^{11} Ω, all four ranges; 10^7 Ω on 1000-V range.

Accuracy: ±(0.1% of full scale + 100 μV).

AC VOLTAGE

Range: 2.200 to 220.0 V, full scale reading, in three ranges. Max 200 V (1000 V with attenuator); above 200 MHz, max voltage limit varies inversely with frequency.

Effective Impedance: Approx 25 MΩ across 2 pF with probe.

Accuracy: ±(0.4 % of reading +0.1% of full scale), for readings up to 10% of full scale, at 1 kHz.

Detector Response: Operates as peak voltmeter calibrated to read rms value of a sine wave or 0.707 × peak of a complex wave.

Waveform Error: For low voltage, the response gradually shifts from peak above 2 V to essentially rms below 200 mV.

Frequency Response: Within 3 dB at 10 Hz and 1.5 GHz; <1% down at 50 Hz. Probe resonance above 3 GHz.

LOG VOLTAGE FUNCTION

Range: Ac voltage, 6 to 62 dB re 100 mV in 3 ranges. Negative dc voltage, −14 to 62 dB re 100 mV in 4 ranges.

Accuracy: Ac, ±0.15 dB; neg dc, ±0.05 dB.

ISOLATION Low input terminal is by-passed and can be floated up to 400 V from ground.

RESISTANCE

Kilohm Range: 0.220, 2.200, 22.00, and 50.00 kΩ full scale.

Megohm Range: 0.220, 2.200, 22.00, and 50.00 MΩ full scale.

Max Test Voltage: −0.22, −2.2, −22, and −50 V, corresponding to above measurement ranges.

Accuracy: ±(0.1% of reading +0.1% of full scale + 100 mΩ) on 0- to 50-kΩ range; ±(0.3% of reading +0.1% of full scale + 100 Ω) on 0- to 50-MΩ range.

Noise: Less than one-half of least significant digit on most sensitive linear range.

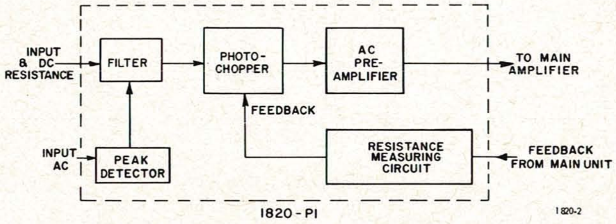
Speed (dc, filter on min): Approx 40 ms for a step of up to 10% full scale; 70 ms for full-scale step; 200 ms per range for greater-than-full-scale step.

Input Filter: Four time constants, switchable, 10, 33, 100, and 300 ms.

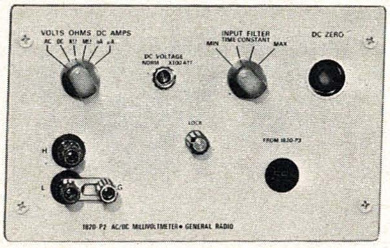
Accessories Supplied: Probe accessories.

Accessories Available: 1806-P1 Tee for high-frequency voltage measurements.

Terminals: Front-panel input, probe and binding posts.



Block diagram of the 1820-P1



Type 1820-P2 plug-in
Available late 1968

1820-P2 AC/DC Millivoltmeter

specifications — with 1820-P2

AC/DC VOLTAGE

Linear Ranges: 2.200 mV to 220.0 V full scale, 6 ranges. With switched ×100 attenuator, 1000 V dc full scale max.

Log Ranges: 6 to 122 dB re 100 μV in six ranges.

Accuracy: Dc, ±(0.1% of full scale + 5 μV). Ac, 50 Hz to 100 kHz, ±(0.2% of reading +0.1% of full scale + 10 μV); 20 Hz to 2 MHz, ±(2% of reading +0.2% of full scale + 50 μV).

Input Impedance: Dc, $>10^9$ Ω all ranges, except $>10^8$ Ω on 2-mV range. Ac, 1 MΩ + 40 pF, all ranges.

Noise: 5 μV at 3σ.

Speed (dc, with filter on min): Approx 40 ms for a step of up to 10% of full scale; 70 ms for full-scale step; 200 ms per range (max 800 ms for 6 ranges) for greater-than-full-scale step.

Speed (ac, with filter on min, at 1 kHz): Approx 800 ms for full-scale step; 1 s per range (max 4 s for 6 ranges) for greater-than-full-scale step.

File Courtesy of GRWiki.org

Input-Filter Time Constant: Dc volts, 2 ms to 0.1 s; ac, 200 ms to 1 s.

RESISTANCE

0-20 kΩ Range: 2.200 Ω to 22.00 kΩ in 5 decade ranges.

0-20 MΩ Range: 2.200 kΩ to 22.00 MΩ in 5 decade ranges.

Accuracy: 0-20 kΩ range, ±(0.1% of full scale + 0.1% of reading + 5 mΩ); 0-20 MΩ range, ±(0.1% of full scale + 0.4% of reading + 5 Ω).

CURRENT

Dc: 2.200 nA to 220.0 μA full scale, in 6 ranges, (1 MΩ). 2.200 μA to 2.200 mA full scale, in 4 ranges, (1 kΩ). Extendable with external shunts.

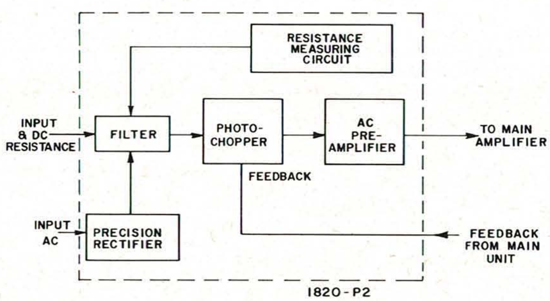
Accuracy: Microampere range, ±(0.1% of full scale, +0.1% of reading + 5 nA); nanoampere range, ±(0.1% of full scale +0.1% of reading + 5 pA).

Ac: Measured with any Tektronix current probe; with type 6020 and termination, 1 mA corresponds to 1 mV or 0.1 mV.

Accuracy: ±(1% of reading + 0.2% of full scale + 10 nA) at 100 kHz. For low-frequency limit, see probe specifications; high-frequency limit, 2 MHz.

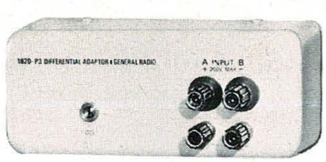
Accessories Supplied: Adaptor, binding post to BNC.

Accessories Available: Tektronix current probe for ac measurements.



Block diagram of the 1820-P2.

1820-P3 Differential Adaptor



specifications — 1820-P3

Input: Floating, symmetrical configuration.

Common-Mode Rejection: >100 dB at dc; >120 dB at 60 Hz with 1-kΩ source impedance; 10 dB less with 100-kΩ source impedance.

Noise: 5 μV at 3σ.

Drift: Approx 0.1 μV/°C.

Mounting: Plugs into front-panel input terminals of either 1820-P1 or 1820-P2 plug-in.

general specifications — 1820-A

Ranging: Manual or automatic, switch selected.

Display: Four numerals (max reading 2200 on linear ranges, 62.00 on log ranges) with decimal point and units.

Sampling Rate: 0.5 to 30 Hz, adjustable. In HOLD mode, measurement can be externally initiated by positive pulse of >2 V.

Digital Data Instruments page 60 ff

DATA OUTPUT

Numerical Data: Four digits BCD 1-2-4-2 code (1-2-4-8 with slight modification).

Other Data (all 1-2-4-2 BCD): Range, 2 digits; polarity, 1 digit; log/linear, 1 digit.

Print Command (at completion of measurement): Transition from "1" level to "0" level, approx 15 ms duration, impedance 2 kΩ.

Signal Levels: Logical "one" is 0 V, logical "zero" —10 V, both with respect to reference line at +10 V above ground. Impedance 57 kΩ.

Accessories Supplied: Power cord, spare fuses, bench- or rack-mounting hardware.

Accessories Available: Plug-ins and adaptor as listed, 1806-P1 Tee Connector for high-frequency voltage measurements in coax, input scanner and other GR digital-data handling equipment. Order 1137 Data Printer and two extra modules for 8-digit capacity.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 Hz, 40 W.

Terminals: At rear panel, data output, ext sampling rate, and aux input terminals.

Mounting: Rack-Bench Cabinet.

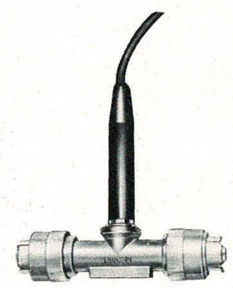
Dimensions (width x height x depth): Bench, 19 x 5⅝ x 18¾ in. (485 x 145 x 480 mm); rack, 19 x 5¼ x 15½ in. (485 x 135 x 395 mm). Plug-ins approx 8 x 5 x 9 in. (200 x 130 x 230 mm).

Weight: Net, 30 lb (13.6 kg); shipping, 74 lb (33.6 kg). Plug-in (approx), net 4 lb (2 kg); shipping, 10 lb (4½ kg).

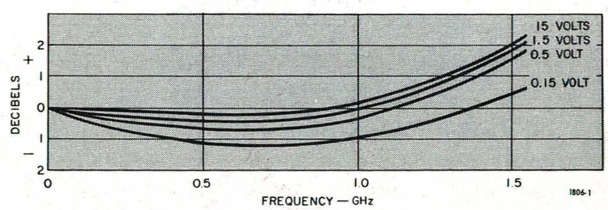
Catalog Number	Description	Price in USA
	1820-A Digital Voltmeter (no plug-in)	
1820-9700	Bench Model	**$1985.00**
1820-9701	Rack Model	**1985.00**
	Plug-Ins and Accessories	
1820-9601	**1820-P1 DC Multimeter/UHF Voltmeter**	**525.00**
1820-9602	**1820-P2 AC/DC Millivoltmeter**	**550.00**
1820-9603	**1820-P3 Differential Adaptor** (for use with 1820-P1 or -P2 Plug-ins)	**90.00**

Type 1806-P1

TEE CONNECTOR



A necessary attachment to the ac probe to realize the full 1500-MHz frequency range of the voltmeter with 1820-P1 plug-in. Screws onto the probe tip in place of the probe tip.



Typical high-frequency response characteristics of the probe and tee connector operating in a 50-ohm system.

VSWR: The VSWR of the tee connector and probe is less than 1.1 below 1000 MHz.

Connectors: Locking GR874 Connectors are used. Adaptors to other coaxial systems are available.

Dimensions: 4 x 1 x 1⅛ in. (102 x 25 x 28 mm).

Weight: Net, 3½ oz (100 g); shipping, 1 lb (0.5 kg).

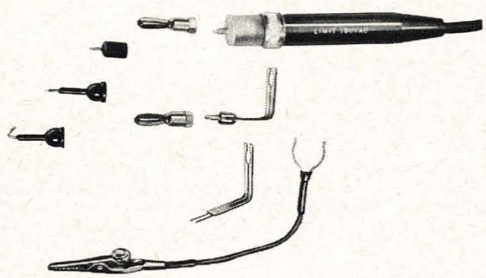
Catalog Number	Description	Price in USA
1806-9601	**1806-P1 Tee Connector**	**$40.00**

File Courtesy of GRWiki.org

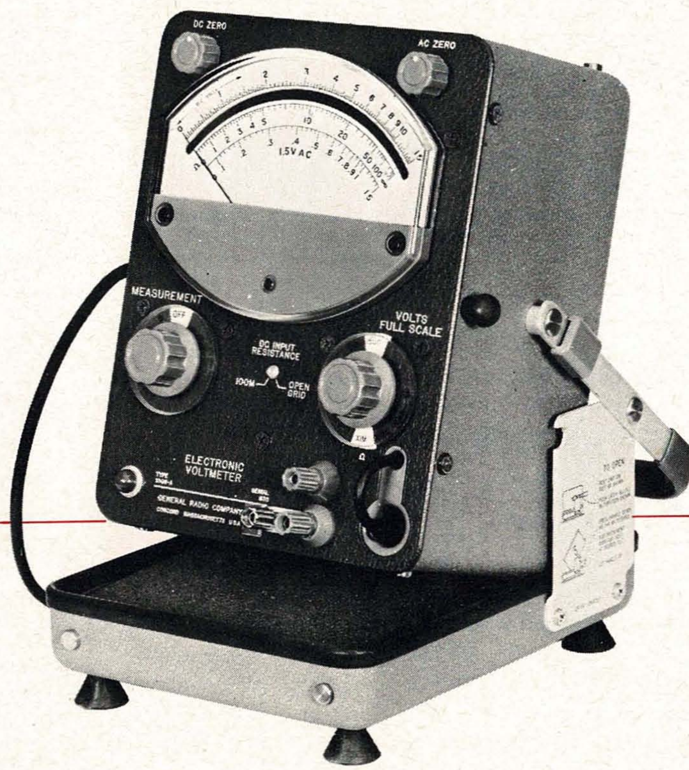
ELECTRONIC VOLTMETER

Type 1806-A

- accuracy: ±2% of reading
- 20 Hz to 1.5 GHz
- dc voltage and resistance
- up to 1500 V in four 10:1 ranges



The ac probe and its accessory tips and ground clips.



This versatile voltmeter is an asset in the modern electronics laboratory. Its logarithmic meter scale ensures undiminished accuracy for less-than-full-scale readings and minimizes range changing as each range is useful over a more than 10:1 span of values with no reduction in accuracy. DC voltage measurements can be made to 150 volts with the "open grid" drawing less than 10^{-10} ampere.

A small probe allows convenient connection to circuit points for high-frequency measurements. Its use can be extended to 1500 volts with the 1806-P2 Range Multiplier or to 1500 MHz with the 1806-P1 Tee Connector. As an ohmmeter, the 1806-A will measure resistance from 0.2 ohm to 1000 megohms.

The heart of this instrument is a new, highly stable, tube-and-transistor dc amplifier. Its balanced circuit and regulated heater voltages ensure stability of meter zero. Calibration stability is excellent owing to the use of ample feedback to compensate for changes in tube or transistor characteristics.

For ac voltage measurements, a ceramic thermionic diode is used in the probe. Its small size and close electrode spacing give it a high resonant frequency and low transit time, both essential to excellent high-frequency performance.

— See also **GR Experimenter** for July 1963.

File Courtesy of GRWiki.org

specifications

DC VOLTMETER

Voltage Range: Four ranges, 1.5, 15, 150, and 1500 V, full scale, positive or negative. Min reading is 0.005 V.

Input Resistance: 100 MΩ, ±5%. Also "open grid" on all but the 1500-V range; grid current is less than 10^{-10} A.

Accuracy: ±2% of indicated value from one-tenth of full scale to full scale; ±0.2% of full scale from one-tenth of full scale to zero. Scale is logarithmic from one-tenth of full scale to full scale, permitting constant-percentage readability over that range.

AC VOLTMETER

Voltage Range: Four ranges, 1.5, 15, 150, and 1500 V, full scale. Min reading on most sensitive range is 0.1 V.

Input Impedance: Probe, approx 25 MΩ in parallel with 2 pF; with 1806-P2 Range Multiplier, 2500 MΩ in parallel with 2 pF; at binding post on panel, 25 MΩ in parallel with 30 pF.

Accuracy: At 400 Hz, ±2% of indicated value from 1.5 V to 1500 V; ±3% of indicated value from 0.1 V to 1.5 V.

Waveform Error: On the higher ac-voltage ranges, the instrument operates as a peak voltmeter, calibrated to read rms values of a sine wave or 0.707 of the peak value of a complex wave. On distorted waveforms the percentage deviation of the reading from the rms value may be as large as the percentage of harmonics present. On the lowest range the instrument approaches rms operation.

Frequency Characteristics: Low-frequency roll-off is <3% at 20 Hz. On 1500-V range, internal voltage divider adds <2% additional error up to 500 kHz.

Probe resonant frequency is above 3000 MHz. Above several hundred megahertz, probe should be used in a 50-Ω coaxial system with the 1806-P1 Tee Connector.

OHMMETER

Range: 0.2 Ω to 1000 MΩ in four ranges with center scale values of 10 Ω, 1 kΩ, 100 kΩ, and 10 MΩ.

Test Voltage: The dc test voltage is positive and never exceeds 1.5 V. The max current (which is delivered to a short circuit on the lowest resistance range) is approx 43 mA. The max available power from the ohmmeter circuit is 16 mW.

Accuracy: ±5% of indicated value from 1 to 10 on scale, approaching ±10% of indicated value at 100 on scale.

GENERAL

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 20 W approx. The case is grounded by the third wire in the power cord. The voltmeter circuit can be disconnected from the case and operated as much as 300 V dc off ground. The low input terminal remains by-passed to the case.

Probe Storage: A socket and reel store both probe and cable.

Accessories Supplied: Spare fuses, an assortment of probe tips.

Mounting: Flip-Tilt Case.

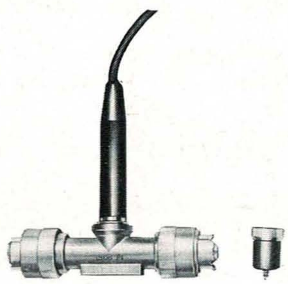
Dimensions (width x height x depth): 7½ x 8½ x 11½ in. (190 x 220 x 295 mm).

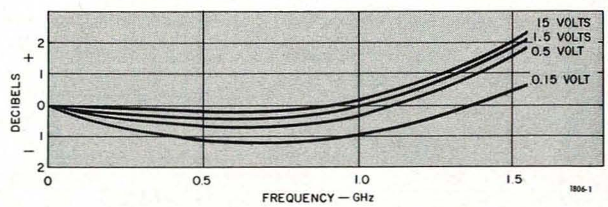
Weight: Net, 10 lb (4.6 kg); shipping, 13 lb (6 kg).

Catalog Number	Description	Price in USA
1806-9701	**1806-A Electronic Voltmeter**	**$595.00**

Type 1806-P1

TEE CONNECTOR





Typical high-frequency response characteristics of the probe and tee connector operating in a 50-ohm system.

The Tee Connector screws onto the probe in place of the regular probe tip, permitting voltage measurements to 1500 MHz across a 50-ohm coaxial line with minimum reflections.

specifications — with 1806-P1

AC Voltage: 150 V, max.

Frequency Characteristic: Low-frequency roll-off of the voltmeter and tee connector combination is <3% at 1 kHz. At high frequencies, the response is a function of voltage level because of transit-time effects, as shown in accompanying plot. Total error is <±3 dB below 1500 MHz.

VSWR: The VSWR of the tee connector and probe is <1.10 below 1 GHz.

Connectors: GR874 locking connectors. Adaptors to other coaxial connectors are available.

Dimensions (1806-P1): 4 x 1 x 1⅛ in. (102 x 25 x 28 mm).

Net Weight: 3½ oz (100 g).

Catalog Number	Description	Price in USA
1806-9601	**1806-P1 Tee Connector**	**$40.00**

Type 1806-P2

10:1 RANGE MULTIPLIER

Range multiplier installed on probe.

The Range Multiplier is a 10:1 capacitive voltage divider that screws onto the probe in place of the regular probe tip. It permits use of the probe (desirable above 150 kHz) for voltages from 150 to 1500 volts.

specifications — with 1806-P2

Multiplication Ratio: 10:1 ±5%. Adjustment is provided for matching 1806-P2 to voltmeter to within ±2%.

Frequency Characteristic: Low-frequency roll-off of voltmeter and multiplier combined is <3% at 10 kHz. At higher frequencies multiplier does not affect the over-all voltmeter response.

Input Impedance: Equivalent input resistance of probe-multiplier combination is approx 100 times that of probe alone. Equivalent parallel capacitance is approx 2 pF.

Dimensions (1806-P2): ⅝ in. dia. x 1¼ in. (16 x 32 mm).

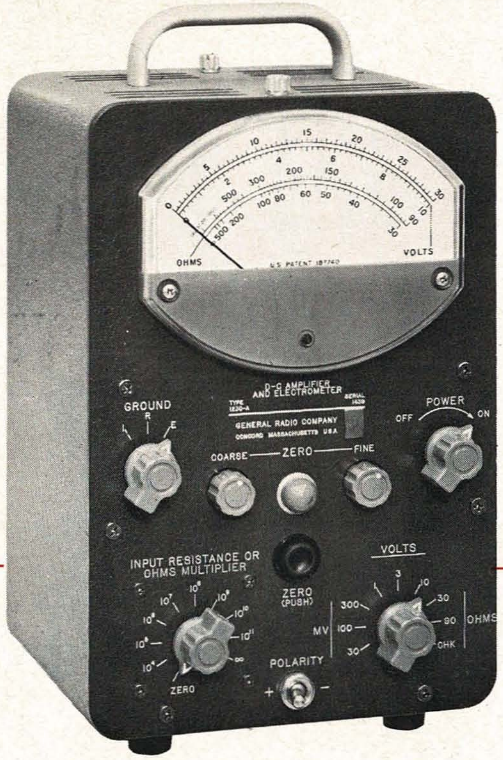
Net Weight: ½ oz (15 g).

Catalog Number	Description	Price in USA
1806-9602	**1806-P2 10:1 Range Multiplier**	**$30.00**

File Courtesy of GRWiki.org

ELECTROMETER AND DC AMPLIFIER

Type 1230-A



- high sensitivity:
  current: to 3×10^{-13} A
  resistance: to 5×10^{14} ohms
- input impedance 10^{14} ohms
- guarded measuring terminals
- recorder output

The Electrometer and DC Amplifier has a wide variety of applications in physics, chemistry, engineering, and industry. Typical uses include the measurement of

Currents: Ionization currents, photo currents, grid currents in electron tubes, leakage currents in semiconductors and insulators, and time-current curves of capacitors during charge and discharge.

Voltages: Piezoelectric potentials, bioelectric potentials, contact potentials, electrostatic-field potentials, and pH indications.

Resistances: Back resistance of silicon-junction diodes, insulation resistance of electrical equipment, and voltage coefficient of resistance.

— Write for **GR Reprint E-101** for more details.

specifications

RANGES OF MEASUREMENT

Voltage: ±30, 100, and 300 mV, ±1, 3, and 10 V, dc, full scale.

Current: ±1 mA (10^{-3} A) dc, full scale, to ±300 fA (3×10^{-13} A) full scale. (Measured in terms of voltage.)

Resistance: Direct reading from 300 kΩ to 10 TΩ (10^{13} Ω) full scale (5×10^{14} Ω at smallest meter division). There are 16 ranges, two per decade. Voltage across the unknown resistance is 9.1 V.

Extension of Range: With batteries, or other suitable external supply, the resistance range can be extended, the voltage across the unknown can be increased, and the voltage coefficient of resistors can be measured.

With a 300-V battery, the highest resistance range is 10^{15} Ω full scale (6×10^{16} Ω at the smallest meter division). The full battery voltage appears across the unknown resistance. The maximum permissible voltage is 600 V if the external supply is grounded; somewhat greater if ungrounded.

ACCURACY

Voltage: ±2% of full scale on the five highest ranges, ±4% of full scale on the 30-mV range.

Current: ±3% of full scale from 10^{-3} to 10^{-9} A, ±10% of full scale from 3×10^{-10} to 3×10^{-13} A.

Resistance: ±3% from 3×10^{5} to 10^{10} Ω at full scale (low-resistance end), ±8% from 3×10^{10} to 10^{13} Ω.

Resistance Standards: 10^4, 10^5, 10^6, 10^7, 10^8, 10^9, 10^{10}, and 10^{11} Ω. The switch also includes zero and infinity positions. The 10^4- and 10^5-Ω resistors are wire wound and are accurate to ±0.25%. The 10^6-, 10^7-, and 10^8-Ω resistors are of deposited-carbon construction and are accurate to ±1%. The 10^9-, 10^{10}-, and 10^{11}-Ω resistors are carbon, have been treated to prevent adverse humidity effects, and are accurate to ±5%. A switch position permits quick checking of the higher-resistance standards in terms of the wire-wound units.

INPUT

Resistance: The input resistance is determined by the setting of the resistance standards switch. In the infinity position, it is approximately 10^{14} Ω.

Capacitance: Less than 35 pF.

Terminals: The input is connected through a GR874 coaxial terminal assembly at the rear of the instrument. In addition, there are three low terminals to provide versatility in guard and ground connections, as required, for example, in three-terminal network measurements. These are low-thermal-emf binding posts.

Switch: A panel switch permits disconnection of the unknown without transient electrical disturbances in either the unknown or the measuring circuit.

Insulation: Entirely Teflon or silicone-treated glass.

OUTPUT

Indication: Voltage, current, and resistance are indicated on a panel meter.

Recorder: Terminals are available for connecting a 5-mA or 1-mA recorder.

AMPLIFIER CHARACTERISTICS

Max Transconductance: 167 m℧ (for 30-mV input, the output current is 5 mA).

Output Load: Max allowable recorder resistance is 1500 Ω.

Drift: Less than 2 mV per hour after one-hour warmup.

FREQUENCY CHARACTERISTICS

With a 1500-Ω load at the output terminals, the frequency characteristic is flat within 5% from zero to 10, 30, 100, 300, 1000, and 3000 Hz at the 30-, 100-, 300-mV, 1-, 3-, and 10-V ranges, respectively.

GENERAL

Humidity, Line-Voltage Effects: Negligible.

Accessories Supplied: One adaptor to GR874 connector, one panel-adaptor assembly, one 274-SB Plug, power cord, and spare fuses.

Accessories Available: 1521-B Graphic Level Recorder.

Power Required: 105 to 125, 195 to 235, or 210 to 250 V, 50 to 60 Hz, approx 45 W. Instruments will operate satisfactorily up to 400 Hz.

Mounting: Lab-Bench Cabinet.

Dimensions (width x height x depth): 7⅝ x 13¼ x 9 in. (195 x 340 x 230 mm).

Weight: Net, 15¼ lb (7 kg); shipping, 24 lb (11 kg).

Catalog Number	Description	Price in USA
1230-9701	**1230-A Electrometer and DC Amplifier**	**$595.00**

PATENT NOTICE. See Note 15.

Megohm Bridges page 108 ff

File Courtesy of GRWiki.org

OUTPUT POWER METER

Type 1840-A

- 20 Hz to 20 kHz
- 0.1 mW to 20 W
- 0.6-Ω to 32-kΩ input impedance
- true rms reading

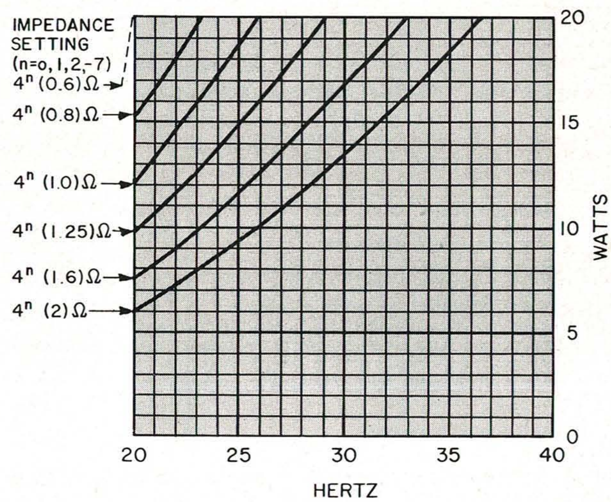
The 1840-A measures audio-frequency power into any desired load. Its important uses include the measurement of:

- Power output of oscillators, amplifiers, preamplifiers, transformers, transducers, and low-frequency lines.
- Output impedance, by adjustment of the load to yield maximum power indication.
- Frequency-response characteristics of amplifiers, transformers, and other audio-frequency devices.

This instrument is basically a multi-tapped audio-frequency transformer with a fixed secondary load. Its two front-panel switches connect eight identical primary windings and six secondary taps in various combinations to provide a total of 48 different primary impedances.

The maximum power rating can be extended for any given impedance with the use of a simple T-network attenuator, design data for which are supplied with the instrument.

— See **GR Experimenter** for January-February 1962.



Derating vs impedance setting and frequency.

specifications

RANGES

Power: 0.1 mW to 20 W, 40 Hz to 20 kHz. Below 40 Hz, max rating is reduced by up to 50% (at 25 Hz), depending on impedance selected. See curve. Auxiliary dB scale reads from −15 to +43 dB re 1 mW.

Impedance: 0.6 Ω to 32 kΩ in two ranges; yielding 48 individual impedances spaced approximately $\sqrt[3]{2}$ apart.

ACCURACY

Power: At 1 kHz, ±0.3 dB;
50 Hz to 6 kHz, ±0.5 dB;
30 Hz to 10 kHz, ±1 dB;
at 20 Hz, −1.5 dB max, −1 dB avg;
at 20 kHz, −5 dB max, ±1.5 dB avg.

Impedance: At 1 kHz, ±6% max, −0.5% avg;
70 Hz to 2.5 kHz, ±7% above 10 kΩ;
70 Hz to 5 kHz, ±7% below 10 kΩ;
at 20 Hz, −15% max, −8% avg;
at 20 kHz, ±50% max, ±12% avg.

Waveform Error: Meter will indicate true rms with as much as 20% second and third harmonics present in the input signal.

GENERAL

Mounting: Convertible-Bench Cabinet. Adaptors for rack mounting available.

Dimensions (width x height x depth): 12 x 4 x 8 in. (305 x 105 x 205 mm). Rack-adaptor panel height, 3½ in.

Weight: Net, 10¾ lb (4.9 kg); shipping, 17 lb (8 kg).

Catalog Number	Description	Price in USA
1840-9701	**1840-A Output Power Meter**	**$325.00**
0480-9622	**480-P212 Relay-Rack Adaptor Set**	**6.00**

File Courtesy of GRWiki.org

STROBOSCOPES

THE ELECTRONIC STROBOSCOPE

The electronic stroboscope is a bright light source with an oscillator and triggering circuits that flash the light at accurately known rates. The flashing light of the stroboscope, when used to illuminate a cyclically moving object, can produce the optical illusion of stopping or slowing down the motion.

"STOPPED" AND SLOW MOTION

Motion is "stopped" when the flashing rate of the stroboscope and the cyclic rate of the object being observed are the same; from this principle stems the stroboscope's well known value as a tachometer. Motion is "slowed" when the flashing rate is offset slightly from the cyclic rate of the object. The apparent slow motion, moreover, is an exact replica of the actual high-speed motion, and the stroboscope is thus an important tool in motion and fluid-flow analysis. A complete discussion of the power of stroboscopy in motion analysis and illustrated examples of the uses for stroboscopes are available from GR in the **Handbook of Stroboscopy,** $1.00.

HIGH-SPEED PHOTOGRAPHY

The short flash of a stroboscope offers the photographer a means of reducing exposure time to about a millionth of a second, and so the stroboscope has become standard equipment in the field of ultra-high-speed photography. This subject, of increasing interest to scientists and engineers as well as to photographers, is covered fully in the **Handbook of High-Speed Photography,** $1.00.

STROBOSCOPE APPLICATIONS

The applications for the stroboscope are beyond enumeration. Wherever motion is too fast for the human eye, there is a place for a stroboscope. Here are just a few of the ways in which stroboscopes are paying for themselves many times over:

Stroboscopes are widely used by educators to demonstrate certain laws of physics, such as the relation between frequency and wavelength, the finite velocity of light, the effects of combining colors, the properties of standing waves, the laws of gravity, the principle of strobscopy itself, etc.

Stroboscopes are used to calibrate mechanical tachometers.

Stroboscopes are used in the development of loudspeakers and of other audio devices.

Stroboscopes are used to check registration on fast-moving printing presses.

Stroboscopes are used to measure the amount of slip between two shafts, between motor and belt, etc.

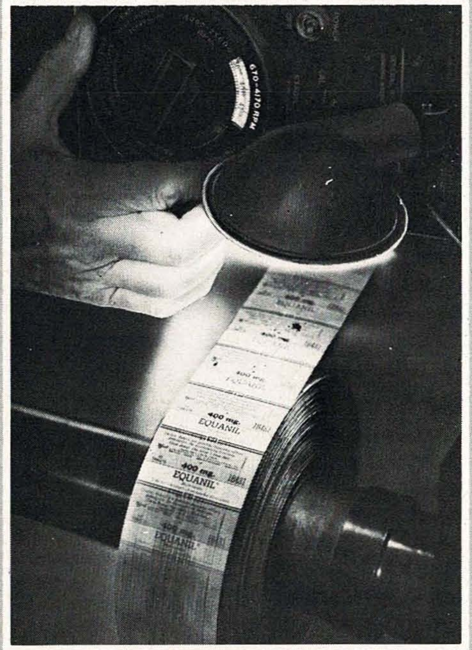
Stroboscopes are used throughout the textile industry to help design, monitor, and trouble-shoot looms, knitting machines, spinning frames, etc.

A stroboscope, combined with simple accessories, can be used to measure torque, belt tension, and horsepower.

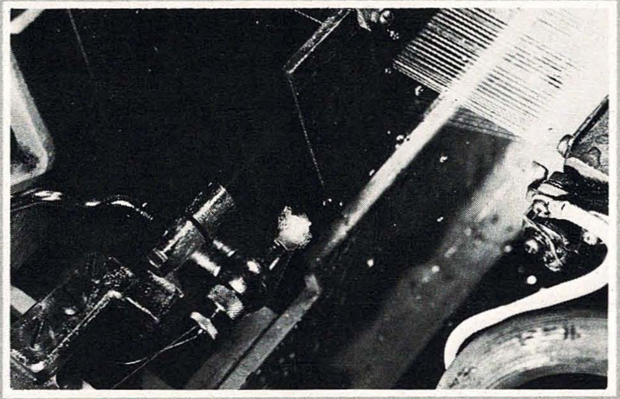
Stroboscopes are used to study the effects of cavitation on turbine blades and on other hydraulic equipment.

THE STROBOSCOPE AT WORK . . .

. . . . IN THE ENVIRONMENTAL TEST LAB



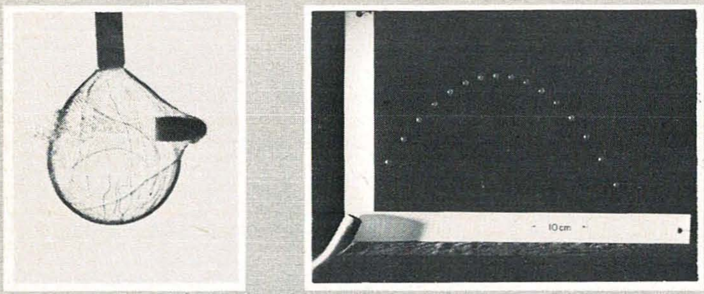
. . . . AT THE PRINTING PRESS



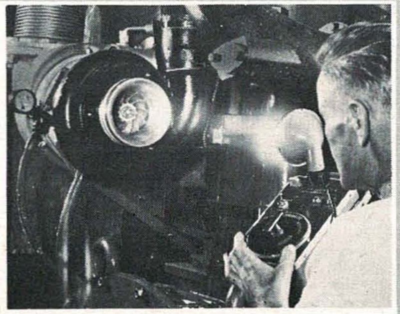
. . . . IN THE TEXTILE PLANT

File Courtesy of GRWiki.org

STROBOSCOPES (cont'd)

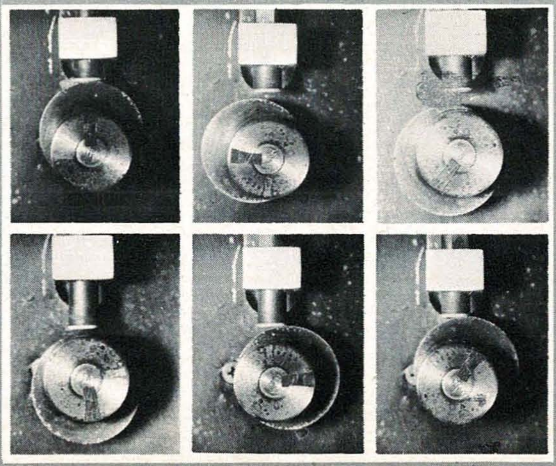


. . . . IN THE PHOTO STUDIO AND CLASSROOM



. . . . IN THE AIR-MOVING INDUSTRY

. . . . IN THE MEDICAL RESEARCH LAB



. . . . IN MACHINE DESIGN

Stroboscopes are used in high-speed motion-picture, as well as still, photography.

Stroboscopes are used in the design, production-line checkout, and servicing of electric motors, appliances, and virtually all kinds of production, handling, and packaging machinery.

Stroboscopes are used to help design and to trouble-shoot data-processing equipment, such as sorters, punches, etc.

A stroboscope is a versatile instrument, made even more versatile by the ingenious user. Few industries can afford to be without it.

Further information about the wide range of uses for stroboscopy is presented in **Strobotactics,** a new GR quarterly publication. Subscription is free on request.

THE GENERAL RADIO LINE OF STROBOSCOPES

General Radio's stroboscopic instruments are the result of over 30 years of continuous development engineering in this area. A major step forward in this program was the development, a few years ago, of the Type 1531 Strobotac® electronic stroboscope, which is much faster, much brighter, and yet smaller than earlier models. Thousands of these instruments are now in use in schoolrooms, research laboratories, printing plants, textile mills, chemical plants, and in virtually every type of manufacturing activity. The Type 1531-AB is an outstanding stroboscope at a low price.

For the most demanding applications, General Radio offers the Type 1538-A Strobotac® electronic stroboscope. With a flashing-rate range of up to 150,000 flashes per minute, the Type 1538-A will easily keep pace with the fastest machines known. With battery or ac-line operation, the new stroboscope goes wherever the action is. And with an accessory plug-in storage capacitor, this stroboscope can produce single, short flashes of light at an intensity of 44 million beam candelas (at a distance of one meter). Any one of these features — speed, battery operation, intensity — alone would make the new Strobotac noteworthy. Together they put it in a class by itself.

Another new member of our line of stroboscopes is the Type 1539-A Stroboslave, a stroboscopic light source that requires external control of its flashing rate. The Stroboslave, whose light output is the same as that of the Type 1531-AB Strobotac stroboscope, was designed specifically for the many applications where motion study or photography, rather than speed measurement, is required. Because of its compact size, it can easily be built into machines and systems requiring continuous stroboscopic light.

STROBOSCOPE ACCESSORIES

The usefulness of a stroboscope can be multiplied many fold by a small additional investment in accessories. The photoelectric pickoffs, for example, can synchronize the stroboscope flash with almost any kind of motion, without physical connection to the object being observed. The 1537-A pickoff will directly trigger the 1538-A Strobotac and the 1539-A Stroboslave. The 1536-A pickoff with the 1531-P2 Flash Delay further extends the usefulness of any stroboscope by permitting observation of aperiodic repetitive motion at any point in its cycle. An inexpensive set of nylon disks (Type 1531-P3 Surface-Speed Wheel) converts linear speed (as, for instance, of belts, rollers, etc) into rpm for tachometric measurement with the stroboscope.

File Courtesy of GRWiki.org

STROBOTAC®
ELECTRONIC STROBOSCOPE

Type 1531-AB

- "stops" rapid motion visually
- 1% accurate speed measurements to 250,000 rpm
- intense light source for high-speed photography
- simple to use — easy to handle

The Strobotac® electronic stroboscope is a small portable flashing-light source used to measure the speed of fast-moving devices or to produce the optical effect of stopping or slowing down high-speed motion for observation. A few of this instrument's many uses are:

- Observation and speed measurement of gears, cams, linkages, shuttles, spindles, motor rotors, and any other elements having repetitive motion.
- Observation of vibrating members, fuel-nozzle spray patterns, and vibrations of components under test in wind tunnels.
- High-speed photography of repetitive or non-repetitive motion.

The flashing-rate range of 110 to 25,000 flashes per minute is divided into three direct-reading ranges; to avoid reading errors, only the particular range in use is illuminated. The flash lamp can be triggered externally to "stop" motion for photography. The combination of the 1531-P2 Flash Delay and the 1536-A Photoelectric Pickoff can be used as an external triggering source, which also provides an adjustable delay of the stroboscope flash with respect to the triggering pulse from the photoelectric pickoff.

A built-in calibration system uses the power-line frequency for quick, easy check and readjustment of the flashing-rate calibration.

The strobotron flash lamp and reflector assembly pivots in a plane perpendicular to the panel and swivels 360 degrees on its own axis. The case is equipped with a ¼ x 20 socket for mounting the instrument on a tripod.

This instrument is listed as approved by CSA Testing Laboratories.

specifications

Flashing-Rate Range: 110 to 25,000 flashes per minute in three direct-reading ranges: 110 to 690, 670 to 4170, and 4000 to 25,000. Speeds up to 250,000 rpm can be measured.

Accuracy: ±1% of dial reading after calibration on middle range.

Calibration: Two panel adjustments permit calibration against power-line frequency.

Flash Duration: Approx 0.8, 1.2, and 3 μs for high-, medium-, and low-speed ranges, respectively, measured at ⅓ peak intensity.

Peak Light Intensity: Typical on high-, medium-, and low-speed ranges, respectively, 0.6, 3.5, and 11 million beam candelas (6×10^5, 3.5×10^6, and 11×10^6 lux at 1 meter distance at the center of the beam); for single flash, 18 million beam candelas (18×10^6 lux at 1 meter distance at the center of the beam). Photographic guide number is 30 for ASA 400 film speed and high-intensity flash.

Reflector Beam Angle: 10° at half-intensity points.

Output Trigger: 500- to 1000-V negative pulse available at panel jack.

External Triggering: The flash can be triggered by the opening of a mechanical contactor or by a 6-V pk-pk signal (2-V rms sine-wave signal down to 5 Hz).

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 35 W.

Accessories Supplied: Adjustable neck strap, plug to fit input and output jacks, spare fuses.

Accessories Available: 1531-P2 Flash Delay and 1536-A Photoelectric Pickoff, 1539-A Stroboslave with 1531-P4 Trigger Cable.

Mounting: Flip-Tilt Case.

Dimensions (width x height x depth): 10⅝ x 6⅝ x 6⅛ in. (270 x 170 x 160 mm).

Weight: Net, 7¼ lb (3.3 kg); shipping, 9 lb (4.1 kg).

Catalog Number	Description	Price in USA
1531-9430	**1531-AB Strobotac® electronic stroboscope**	**$310.00**
1538-9601	**1538-P1 Strobotron Replacement Flash Lamp**	**15.00**

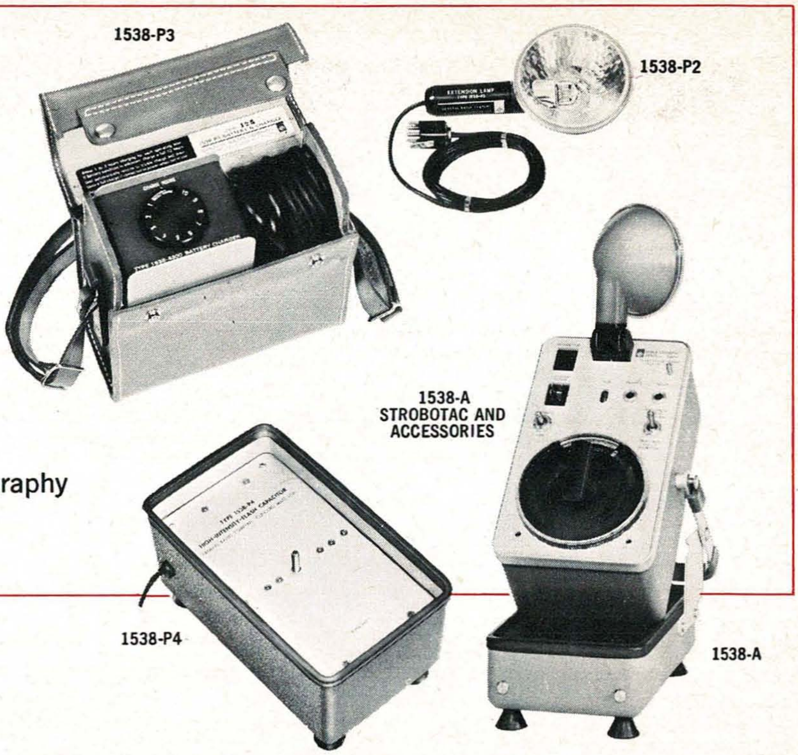
PATENT NOTICE. See Notes 6 and 22.

File Courtesy of GRWiki.org

STROBOTAC®
electronic stroboscope

Type 1538-A

- flashing rates up to 150,000 per minute
- speed measurements to 1 million rpm
- battery or power-line operation
- remote flash lamp on extension cable
- extra-high-intensity single flash for photography



1538-A STROBOTAC AND ACCESSORIES

The 1538-A Strobotac is able to satisfy a broader range of applications than the 1531-A. In addition to its higher maximum flashing rate, it has several accessories available for extending its performance and convenience. It can be operated from a power line, or, if there is no power outlet nearby, from the rechargeable battery pack. The accessory extension lamp is useful in illuminating hard-to-reach areas.

This stroboscope is ideally suited for photographic applications requiring a high light intensity. With the 1538-P4 High-Intensity-Flash Capacitor, it produces 8-microsecond flashes of 44 million beam candelas at one-meter distance. This results in a guide number of about 250 when a film rated at ASA 3000 is used.

The 1538-A circuits are all transistorized. This not only makes possible battery operation but also ensures greater stability of the flashing rate.

The flash can be triggered externally by a simple contact closure across the input terminals, by a positive pulse, or by a sine wave. With a photoelectric pickoff, the flash can be triggered by pulses that are synchronized with a mechanical motion. The 1537-A Photoelectric Pickoff connects directly to the 1538-A and contains a light-activated switch but no light source. The 1536-A pickoff contains a photocell and light source, for which power is supplied by the 1531-P2 Flash Delay. With this combination, an adjustable delay is introduced between the time a selected point on a moving object passes the pickoff and the time at which the Strobotac flashes. Three-way synchronization of the camera shutter, the mechanical motion, and the Strobotac flash is a very useful feature of this combination. Both the Strobotac and the 1538-P4 High-Intensity-Flash Capacitor are equipped with sockets for attaching the two together and for tripod mounting.

— See **GR Experimenter** for April 1966.

specifications

Flashing-Rate Range: 110 to 150,000 flashes per minute in four direct-reading ranges: 110 to 690, 670 to 4170, 4000 to 25,000, and 24,000 to 150,000 rpm. Speeds to 1 million rpm can be measured.

Accuracy: ±1% on all ranges after calibration on 670- to 4170-rpm range against 50- or 60-Hz line frequency.

Flash Duration: Approx 0.5, 0.8, 1.2, and 3 μs for high-to-low speed ranges, respectively, measured at ⅓ peak intensity; 8 μs for single flashes with 1538-P4 High-Intensity-Flash Capacitor.

Peak Light Intensity: Typically 0.16, 1, 5, and 15 million beam candelas (0.16, 1, 5, and 15×10^6 lux measured at 1 meter distance at the beam center) for high-to-low speed ranges, respectively; 44 million beam candelas at 1 meter for single flash, with 1538-P4 High-Intensity-Flash Capacitor.

Reflector Beam Angle: 10° at half-intensity points.

Output Trigger: Greater than 6-V positive pulse behind 400 Ω.

External Triggering: Either a switch closure across the input jack terminals, a 1-V (peak) positive pulse, or a 0.35-V (rms) sine wave down to 100 Hz increasing to 3.5 V (rms) at 5 Hz.

Power Required: 100 to 125 or 195 to 250 V, 50 to 400 Hz, 15 W (max) or 20 to 30 V dc, 12 W (max).

Accessories Supplied: Adjustable neck strap, phone plug for input and output jacks, spare fuse, power cord.

Accessories Available: 1538-P2 Extension Lamp, 1538-P4 High-Intensity-Flash Capacitor (1538-P2 and -P4 cannot be used simultaneously), 1538-P3 Battery and Charger, 1531-P2 Flash Delay, 1536-A Photoelectric Pickoff (use with flash delay), 1537-A Photoelectric Pickoff, and 1539-A Stroboslave.

Mounting: Flip-Tilt Case.

Dimensions (width x height x depth): 10⅝ x 6⅝ x 6⅛ in. (270 x 170 x 160 mm).

Weight: Net, 7¼ lb (3.3 kg); shipping, 10 lb (4.6 kg).

Catalog Number	Description	Price in USA
1538-9701	**1538-A Strobotac® electronic stroboscope**	**$465.00**
1538-9601	**1538-P1 Replacement Strobotron flash lamp**	**15.00**
1538-9602	**1538-P2 Extension Lamp**	**55.00**
1538-9603	**1538-P3 Battery and Charger**	**260.00**
1538-9604	**1538-P4 High-Intensity-Flash Capacitor**	**80.00**
1560-2101	**1560-P76 Patch Cord,** connects output of 1538 to input of another 1538 or 1531 Strobotac, a 1539 Stroboslave, or a 1531-P2 Flash Delay.	**3.00**

PATENT NOTICE. See Notes 6, 22, 30.

File Courtesy of GRWiki.org

STROBOSLAVE

Type 1539-A

- low cost, compact
- removable lamp on 5-foot cable
- high light output — same as Type 1531
- choice of trigger sources

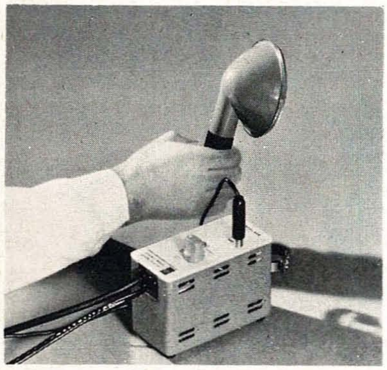
Tripod socket is provided on Stroboslave case.

The Stroboslave is a stroboscopic light source that satisfies the basic requirements for motion studies and high-speed photography. It is suitable for all stroboscope applications except speed measurement. More than one Stroboslave can be used where there is a need for multiple light sources. When the reflector is removed from the end of the extension cord, the strobotron lamp assembly can be inserted through a hole as small as one inch, making it possible to observe objects in otherwise inaccessible areas.

The Stroboslave has no internal oscillator for setting the flashing rate. It will operate directly from a switch closure, a 1537-A Photoelectric Pickoff, or a 1531-P2 Flash Delay with a 1536-A Photoelectric Pickoff. A stroboslave with the latter two accessories is available as the 1539-Z Motion-Analysis and Photography Set for high-speed photography with conventional cameras and for visual analysis where speed need not be measured. In addition, the Stroboslave will operate from the output of the 1538-A Strobotac® electronic stroboscope directly, from the output of a 1531 Strobotac through a 1531-P4 Trigger Cable, or from any source of a positive electrical pulse of at least 2 volts peak.

The Stroboslave produces the same light output as the 1531 Strobotac and operates over the same three basic ranges from 0 to 25,000 flashes per minute. The strobotron lamp and reflector are connected to the unit by a five-foot flexible cable so that the light can be positioned close to the subject to be observed.

— See **GR Experimenter** for April 1966.



Lamp, at end of five-foot cable, can be held in hand as shown here or attached to case as shown above.

specifications

Flashing-Rate Ranges: 0 to 700, 0 to 4200, 0 to 25,000 flashes per min on high-, medium-, and low-intensity ranges, respectively.

Flash Duration: Approx 0.8, 1.2, and 3 μs, measured at ⅓ peak intensity, for the low-, medium-, and high-intensity ranges, respectively.

Peak Light Intensity: Typically 0.6, 3.5, and 11 million beam candelas (0.6, 3.5 and 11×10^6 lux measured at 1-m distance at the beam center), for low-, medium-, and high-intensity ranges, respectively. For single flash, 18 million beam candelas at 1 meter. Photographic guide number is 30 for high-intensity range and ASA 400 film speed.

Reflector Beam Angle: 10° at half-intensity points.

External Triggering: Either a switch closure across the input jack terminals or a 2-V (peak) positive pulse.

Power Required: 100 to 125 or 195 to 250 V, 50 to 400 Hz, 16 W (max) at 115 V.

Accessories Supplied: Phone plug for input, mounting bracket.

Accessories Available: 1531-P2 Flash Delay with a 1536-A Photoelectric Pickoff (available with a 1539-A as the 1539-Z Motion-Analysis and Photography Set), 1537-A Photoelectric Pickoff.

Mounting: Metal case with detachable lamp housing.

Dimensions (width x height x depth): 2½ x 8⅜ x 4⅛ in. (64 x 215 x 105 mm).

Weight: Net, 2¾ lb (1.3 kg); shipping, 8 lb (3.7 kg).

Catalog Number	Description	Price in USA
1539-9701	**1539-A Stroboslave**	**$195.00**
1531-9604	**1531-P4 Trigger Cable (for use with 1531 Strobotac)**	**17.50**
	1539-Z Motion-Analysis and Photography Set	
1539-9900	for 115-V operation	**470.00**
1539-9901	for 230-V operation	**on request**

PATENT NOTICE. See Note 6.

File Courtesy of GRWiki.org

FLASH DELAY

Type 1531-P2

- synchronize GR stroboscopes for
  high-speed photography with most cameras
  controlled visual inspection
- stop motion at any point in cycle

Strobotac shown with Flash Delay and Photoelectric Pickoff.

The 1531-P2 permits GR stroboscopes to be synchronized with moving objects and provides control of the flash occurrence relative to the position of the object by introducing a variable time delay between the position-sensing transducer (photocell) and the stroboscope. This permits all phases of the motion to be studied. For photography, the camera shutter, the motion of the subject, and the strobe flash can all be synchronized.

With the pickoff, one can view and photograph moving objects having variable or unsteady speeds.

The flash delay is a valuable accessory to the 1531 Strobotac® electronic stroboscope as it amplifies and conditions the triggering pulse for reliable operation from external triggers. It will also drive the 1538-A Strobotac and the 1539-A Stroboslave.

— See **GR Experimenter** for August 1963.

specifications

Time-Delay Range: Approx 100 μs to 0.8 s in three ranges.

Output Pulse: Better than 13 V available for triggering the 1531-A and 1538-A Strobotac electronic stroboscopes and the 1539-A Stroboslave.

Sensitivity: As little as 0.3-V input will produce sufficient output to trigger the stroboscope.

Inputs: Phone jacks for triggering; jack for camera synchronization.

Accessories Supplied: Trigger cable with pushbutton, phone-plug adaptor, carrying case, and spare fuses.

Accessories Available: 1536-A Photoelectric Pickoff.

Power Required: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 5 W with 1536-A connected.

Mounting: Aluminum case with bracket, which clips directly onto the Strobotac electronic stroboscope.

Dimensions (width x height x depth): 5⅛ x 3⅛ x 3¾ in. (135 x 80 x 96 mm).

Weight: Net, 2 lb (1 kg); shipping, 5 lb (2.3 kg).

Catalog Number	Description	Price in USA
1531-9602	**1531-P2 Flash Delay**	**$195.00**

MOTION-ANALYSIS AND PHOTOGRAPHY SET

Type 1539-Z

new

The 1539-Z is an assembly of three strobe instruments into an economical stroboscope for high-speed photography and for motion-analysis applications where speed need not be measured. It is excellent for use where a stroboscope is to be permanently mounted on machinery for frequent inspections while the machine is operating.

VISUAL MOTION ANALYSIS

Having no internal oscillator, the 1539-Z depends on its photoelectric pickoff for synchronization to the motion under observation. The 1531-P2 Flash Delay, also included, permits the operator to set the time of occurrence of the flash to coincide with the desired point in the machine's operating cycle. The 1539 Stroboslave, operating from the delay triggering, provides the intense, microsecond-long light flashes.

HIGH-SPEED PHOTOGRAPHY

For high-speed photography, the 1539-Z can also be triggered from the photoelectric pickoff or other synchonizing sensor: magnetic, acoustic, etc. The flash delay can be set to expose the photograph at precisely the desired moment with a single flash or repetitive flashes.

A most useful 92-page publication, The Handbook of High-Speed Photography, is available from General Radio on request, $1.00.

specifications

1539-Z Comprises: 1539-A Stroboslave, 1531-P2 Flash Delay, and 1536-A Photoelectric Pickoff. See full descriptions elsewhere in this section.

Weight (combined): Net, 6 lb (2.7 kg); shipping, 17 lb (7.8 kg).

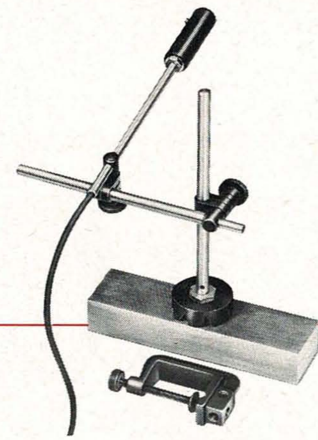
Catalog Number	Description	Price in USA
	1539-Z Motion Analysis and Photography Set	
1539-9900	115-V Model	**$470.00**
1539-9901	230-V Model	**on request**

File Courtesy of GRWiki.org

PHOTOELECTRIC PICKOFFS

Type 1536-A
Type 1537-A

- optical triggering of GR stroboscopes
- small, maneuverable, sturdy mounting
- triggering rate up to 150,000 rpm



These photoelectric pickoffs produce an output whenever the photosensitive element senses a change in light such as would be produced by a piece of reflective tape on a moving object. If the resulting pulse is used to trigger a stroboscope, the flashes will occur in synchronism with the motion and permit the object to be viewed or photographed as though stationary.

The 1536-A pickoff with the 1531-P2 Flash Delay should be selected for use with the 1531 Strobotac® electronic stroboscope and for applications requiring control of the time of occurrence of the flash relative to the position of the moving object. The 1536 contains, in addition to its photocell and lens, a light source that requires power. The 1531-P2 contains the power supply for the 1536-A, amplifies and shapes the output for positive operation of the stroboscopes, and permits a time delay to be introduced between pickoff and stroboscope.

The 1537-A pickoff will directly trigger the 1538-A Strobotac (though not the 1531) and the 1539-A Stroboslave without the use of an additional instrument, but, lacking a built-in lamp, it must be triggered from a strong external light source.

— See **GR Experimenter** for April 1966.

specifications

1536-A

Operating Rate: Approx 2500 pulses/s as limited by the 200-μs time constant of the photocell and cable combination.

Power Required: 20 to 28 V dc, 40 mA. Power is supplied by the 1531-P2 Flash Delay.

1537-A

Operating Rate: Greater than 2500 pulses/s.

Power Required: 3 to 25 V dc; 0 to 100 μA depending on operating rate. Power is supplied by instrument with which it is used.

GENERAL

Accessories Supplied: 10-ft roll of ⅜-in. black tape; 10-ft roll of ⅜-in. silver tape; carrying case.

Mounting: C-clamp (capacity 1⁵⁄₁₆-in.; flat or round) or 1½-in. magnet, both supplied.

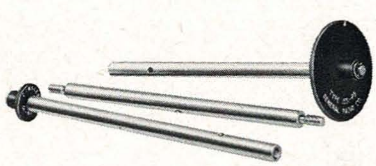
Dimensions: Pickoff head, ¹¹⁄₁₆-in. dia, 2 in. long. Linkage consists of two ⁵⁄₁₆-in. diameter stainless-steel rods, 6 and 6¼ in. long, and adjustable connecting clamp. Cable is 8 ft long, terminated in phone plug.

Weight: Net, 1¼ lb (0.6 kg); shipping, 4 lb (1.9 kg).

Catalog Number	Description	Price in USA
1536-9701	**1536-A Photoelectric Pickoff**	**$80.00**
1537-9701	**1537-A Photoelectric Pickoff**	**65.00**

SURFACE-SPEED WHEEL

Type 1531-P3



The 1531-P3 is used with the 1531-A and 1538-A Strobotac® electronic stroboscopes to make accurate measurements of the linear surface speed of belts, pulleys, wheels, drums, rollers, etc.

Two black nylon wheels of different diameters are mounted on the ends of a sectioned steel rod. The selected wheel is held against the moving object and observed with the stroboscope to determine directly the surface speed.

— See **GR Experimenter** for August 1963.

specifications

Speed Range: 10 to 2500 ft/min with small wheel and 50 to 12,500 ft/min with large wheel.

Dimensions: Wheels are 0.764 and 1.910 in. dia, respectively. Three-section shaft totals 20 in. in length.

Weight: Net, 8 oz (0.3 kg); shipping, 2 lb (1 kg).

Catalog Number	Description	Price in USA
1531-9603	**1531-P3 Surface-Speed Wheel**	**$25.00**

File Courtesy of GRWiki.org

VARIAC® AUTOMATIC VOLTAGE REGULATORS

General Radio Variac® automatic voltage regulators have many advantages for both laboratory and industrial use in any application where controlled line voltage is needed.

Variac regulators

Regulate to 0.25% or better.

Are not load sensitive; they work equally well on all loads from open circuit to maximum rating for continuous service.

Have up to 10 times rating for transients.

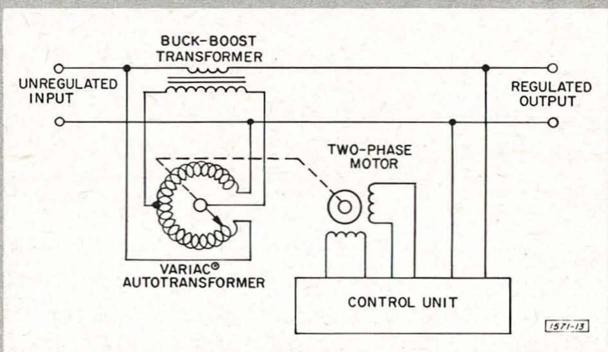
Introduce no distortion.

Have no power-factor restrictions.

Have high response speed — comparable with magnetic types.

Use all-solid-state control circuits.

Are available in many models, differing in power rating, correction range, voltage, frequency, and packaging.



Elementary schematic diagram of General Radio's voltage regulators. The 1591 uses no step-down transformer.

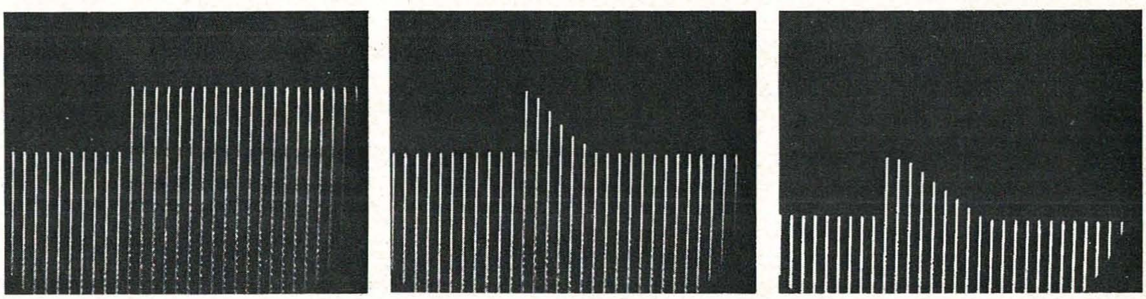
PRINCIPLE OF OPERATION

The regulator comprises a motor-driven Variac® adjustable autotransformer, an auxiliary step-down transformer in the larger models, that multiplies the power rating of the autotransformer, and a solid-state control unit, which automatically positions the autotransformer to hold the output voltage constant.

The regulator's output voltage is compared to a reference voltage; the resultant error signal controls a servo motor, providing a true proportional-control system, rather than an on-off circuit. The accompanying oscillograms illustrate a typical response to a 2% step change in line voltage. The traces are greatly expanded and show only the ac voltage peaks.

The use of a true proportional-control system provides not only fast correction but also smooth control of voltage, completely free of the voltage jumps introduced by an on-off control system. The absence of relays provides long trouble-free life, and tolerance of 1000% transient overloads is made possible by the Duratrak® commutator surface of the Variac autotransformer.

Five models are available: Type 1591, an economical, high-performance 1-kVA unit for portable or rack-mount use; Type 1571, a militarized version; Types 1581 and 1582, which differ primarily in power ratings; and Type 1583, for three-phase applications. In the many variations listed for the above models, power ratings, closeness of regulation, correction range, and speed of response are interdependent. For complete detailed listings, see following pages.



Oscillograms of line-voltage peaks show response speed of Variac® automatic voltage regulators: left, 2% step change in line voltage; center and right, resulting output transients for 1581 and 1582 Regulators, respectively.

File Courtesy of GRWiki.org

- 1-kVA basic capacity
- low cost, small size
- ±0.2% accuracy
- true rms detection, no distortion

VARIAC® AUTOMATIC VOLTAGE REGULATOR

Type 1591

new

Electromechanical voltage regulators have always offered large power capacity with little bulk and cost. These advantages are now available in a 1-kVA regulator, thanks to a new, simple control circuit. Still, as with the larger GR regulators, there is no distortion added to the input waveform so average- and peak-voltage values are also quite constant. Regulation accuracy is independent of line frequency, load variations, and power factor.

Output voltage is controlled by a servo-driven Variac® adjustable autotransformer so the regulator has the same ability to handle 1000% transient overloads as the Variac. The 1591 is mechanically rugged, having proven itself in severe vibration and shock tests. Its typical temperature coefficient of 75 ppm/°C is so small as to be negligible under normal operating conditions.

— See **GR Experimenter** for October 1967.

specifications

	115-V Models	230-V Models
Output kVA	1.0	0.8
Output Current	8.7 A	3.4 A
Input-Voltage Range	100 to 130 V	200 to 260 V
Output-Voltage Range (adjustable)	105 to 125 V	210 to 250 V
Max Correction	±15 V	±30 V
Frequency	57 to 63 Hz	48 to 63 Hz

Correction Time (cycles): 6 c + 1.5 c/V for 115-V models, 6 c + 0.7 c/V for 230-V models.

Output-Voltage Accuracy: ±0.2% for any combination of line voltage or frequency, load, or power factor.

Power Factor: 0 to 1, leading or lagging.

Response: Rms.

Distortion: None added.

Power Dissipation (approx): No load, 40 W; full load, 95 W.

ENVIRONMENT

Ambient Temperature (operating): −20 to +52°C, rack model; −20 to +40°C, portable model.

Vibration: Rack model, 30 mils pk-pk at 10 to 50 Hz, three planes, 15 min each plane.

Shock (rack model, operating and nonoperating): AF bench-drop test; 30 g for 11 ms.

GENERAL

Accessories Supplied: Spare fuses.

Dimensions (width x height x depth): Portable, 12¾ x 9½ x 5⅜ in. (325 x 245 x 140 mm); rack, 19 x 5¼ x 6⅜ in. (485 x 135 x 165 mm).

Net Weight: Portable, 17 lb (8 kg); rack, 22 lb (10 kg).

Shipping Weight: Portable, 25 lb (11.5 kg); rack, 31 lb (14.5 kg).

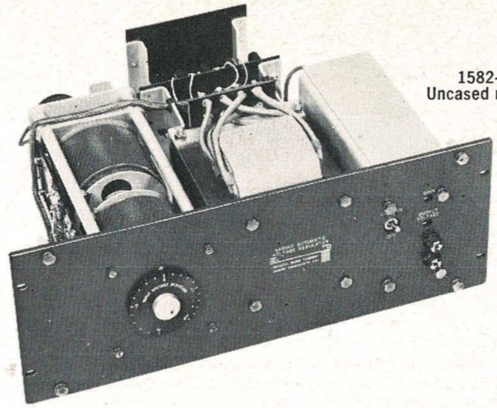
Catalog Number	Description	Price in USA, Quantity 1-9	10-19	20-49	50-99	100 & over
	Variac® Automatic Voltage Regulator					
1591-9700	**1591-A,** 115 V, Portable Model	**$295**	**$283**	**$279**	**$274**	**$271**
1591-9701	**1591-AH,** 230 V, Portable Model	**320**	**307**	**303**	**298**	**295**
1591-9712	**1591-AR,** 115 V, Rack Model	**325**	**312**	**308**	**303**	**300**
1591-9713	**1591-AHR,** 230 V, Rack Model	**350**	**335**	**331**	**326**	**323**

File Courtesy of GRWiki.org

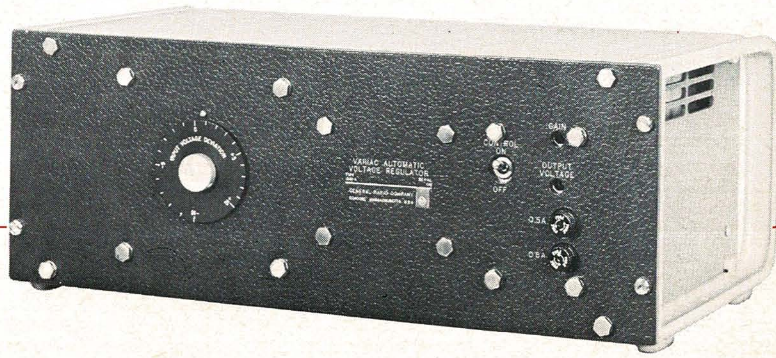
VARIAC® AUTOMATIC VOLTAGE REGULATORS

Types 1581-A and 1582-A

- fast response, high accuracy
- distortionless regulation
- large power-handling capacity
- output voltage independent of load
- no power-factor restriction
- tolerates 1000% transient overloads



1582-A
Uncased model



1581-A, bench model

The 1581-A and 1582-A all-solid-state regulators automatically compensate for ac line-voltage fluctuations to provide a reliable constant-voltage source over a specified correction range. These units combine high accuracy with large capacity for both laboratory use and industrial installations. They are especially useful in maintaining stable operating conditions for computers, measurement systems, transmitter supplies, and critical industrial processes.

Power output of the standard models ranges from 2 to 20 kVA, depending upon the model selected. Several models are available in each of the 115-, 230-, and 460-volt classifications and in four different styles: bench, rack, wall, or without case.

Any of the 60-Hz models can be connected for 50-to 60-Hz operation by a connection change on the Variac autotransformer. This will affect the correction ranges, as indicated on the chart.

THREE-PHASE LINES

Standard single-phase regulators, as listed, can be used to regulate three-phase lines. Three such regulators can be connected in a wye or closed-delta configuration or two in an open delta, sensing line-to-neutral or line-to-line voltages. The individual regulators should be selected based on the voltage magnitude to be sensed and the individual line currents to be carried.

PRINCIPLE OF OPERATION

The regulator comprises a motor-driven Variac® adjustable autotransformer, an auxiliary step-down transformer, which multiplies the power rating of the autotransformer, and a solid-state control unit, which automatically positions the autotransformer to hold the rms output voltage constant.

The use of a true proportional control system provides both fast correction and smooth control.

— See **GR Experimenter** for January 1966.

specifications

Frequency: 60-Hz models operate from 57 to 63 Hz but can be modified by a connection change to operate from 48 to 63 Hz (50 to 60, nominal); 400-Hz models operate from 350 to 450 Hz.

Response: Rms. **Distortion:** None added.

Power Dissipation (approx): Type 1581-A — no load, 35 W; full load, 115 W. Type 1582-A — no load, 45 W; full load, 120 W.

Ambient Temperature: Operating, −20° to +52°C; in storage, −54° to 85°C.

Mechanical Data:

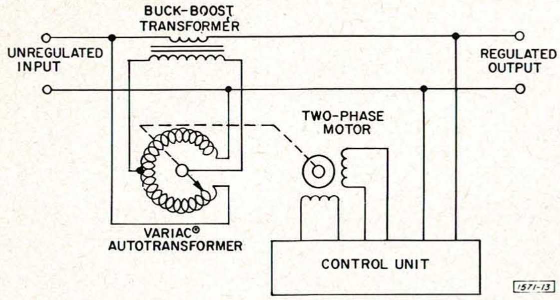
TYPE 1581

	Width		Height		Depth		Net Wt		Ship Wt	
	in.	mm	in.	mm	in.	mm	lb	kg	lb	kg
Without case	19	485	7	180	10½	270	41½	19	92	42
Bench	19	485	7⅜	190	12	305	51	23.5	100	46
Rack	19	485	7	180	11¾	300	51	23.5	100	46
Wall	19½	495	8⅛	210	11¼	290	54	24.5	104	48

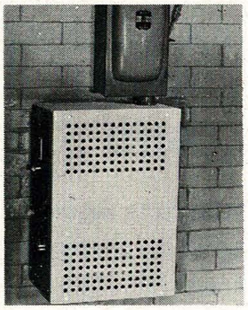
TYPE 1582

	Width		Height		Depth		Net Wt		Ship Wt	
	in.	mm	in.	mm	in.	mm	lb	kg	lb	kg
Without case	19	485	7	180	14¼	365	61	28	110	50
Bench	19	485	7⅜	190	16	410	71	33	121	55
Rack	19	485	7	180	15¾	400	71	33	121	55
Wall	19½	495	8⅛	210	16	410	77	35	126	58

File Courtesy of GRWiki.org



Elementary schematic diagram of General Radio's voltage regulators, Types 1581, 1582, 1583 and 1571.



View of wall-mounted regulator. This model is used to regulate line voltages in the General Radio development and testing laboratories.

Output Voltage	Correction Range* %	Output Current (A)	KVA	Correction Time in cycles (c) **	Accuracy (% of output V)	Mounting or Style	60 Hz Type Number	60 Hz Catalog Number	60 Hz Price in USA	400 Hz Type Number	400 Hz Catalog Number	400 Hz Price in USA
115 V Adjustable ±10%	90 to 110	50	5.8	2.5 c + 1.5 c/V	0.25	No cabinet	1581-AL	1581-9831	$530.00	1581-ALJ	1581-9551	$565.00
						Bench	1581-ALM	1581-9964	565.00	1581-ALMJ	1581-9552	600.00
						Rack	1581-ALR	1581-9974	565.00	1581-ALRJ	1581-9554	600.00
						Wall	1581-ALW	1581-9980	555.00	1581-ALWJ	1581-9555	590.00
		85	9.8	2.5 c + 3.0 c/V	0.25	No cabinet	1582-AL	1582-9831	600.00	1582-ALJ	1582-9551	635.00
						Bench	1582-ALM	1582-9964	635.00	1582-ALMJ	1582-9552	670.00
						Rack	1582-ALR	1582-9974	635.00	1582-ALRJ	1582-9554	670.00
						Wall	1582-ALW	1582-9980	625.00	1582-ALWJ	1582-9555	660.00
	82 to 124	25	2.9	2.5 c + 0.7 c/V	0.5	No cabinet	1581-AL2	1581-9898	530.00	1581-AL2J	1581-9556	565.00
						Bench	1581-ALM2	1581-9901	565.00	1581-ALM2J	1581-9557	600.00
						Rack	1581-ALR2	1581-9923	565.00	1581-ALR2J	1581-9558	600.00
						Wall	1581-ALW2	1581-9924	555.00	1581-ALW2J	1581-9559	590.00
		42.5	4.9	2.5 c + 1.5 c/V	0.5	No cabinet	1582-AL2	1582-9898	600.00	1582-AL2J	1582-9556	635.00
						Bench	1582-ALM2	1582-9901	635.00	1582-ALM2J	1582-9557	670.00
						Rack	1582-ALR2	1582-9923	635.00	1582-ALR2J	1582-9558	670.00
						Wall	1582-ALW2	1582-9924	625.00	1582-ALW2J	1582-9559	660.00
230 V Adjustable ±10%	95 to 105	40	9.2	2.5 c + 1.5 c/V	0.25	No cabinet	1581-AH5	1581-9516	530.00	1581 AH5J	1581-9530	565.00
						Bench	1581-AHM5	1581-9517	565.00	1581-AHM5J	1581-9531	600.00
						Rack	1581-AHR5	1581-9518	565.00	1581-AHR5J	1581-9532	600.00
						Wall	1581-AHW5	1581-9521	555.00	1581-AHW5J	1581-9533	590.00
		85	19.7	2.5 c + 3.0 c/V	0.25	No cabinet	1582-AH5	1582-9516	600.00	1582-AH5J	1582-9530	635.00
						Bench	1582-AHM5	1582-9517	635.00	1582-AHM5J	1582-9531	670.00
						Rack	1582-AHR5	1582-9518	635.00	1582-AHR5J	1582-9532	670.00
						Wall	1582-AHW5	1582-9521	625.00	1582-AHW5J	1582-9533	660.00
	90 to 110	20	4.6	2.5 c + 0.7 c/V	0.25	No cabinet	1581-AH	1581-9817	530.00	1581-AHJ	1581-9522	565.00
						Bench	1581-AHM	1581-9951	565.00	1581-AHMJ	1581-9523	600.00
						Rack	1581-AHR	1581-9961	565.00	1581-AHRJ	1581-9524	600.00
						Wall	1581-AHW	1581-9971	555.00	1581-AHWJ	1581-9525	590.00
		42.5	9.8	2.5 c + 1.5 c/V	0.25	No cabinet	1582-AH	1582-9817	600.00	1582-AHJ	1582-9522	635.00
						Bench	1582-AHM	1582-9951	635.00	1582-AHMJ	1582-9523	670.00
						Rack	1582-AHR	1582-9961	635.00	1582-AHRJ	1582-9524	670.00
						Wall	1582-AHW	1582-9971	625.00	1582-AHWJ	1582-9525	660.00
	82 to 124	10	2.3	2.5 c + 0.4 c/V	0.5	No cabinet	1581-AH2	1581-9770	530.00	1581-AH2J	1581-9526	565.00
						Bench	1581-AHM2	1581-9771	565.00	1581-AHM2J	1581-9527	600.00
						Rack	1581-AHR2	1581-9772	565.00	1581-AHR2J	1581-9528	600.00
						Wall	1581-AHW2	1581-9773	555.00	1581-AHW2J	1581-9529	590.00
		21.3	4.9	2.5 c + 0.7 c/V	0.5	No cabinet	1582-AH2	1582-9770	600.00	1582-AH2J	1582-9526	635.00
						Bench	1582-AHM2	1582-9771	635.00	1582-AHM2J	1582-9527	670.00
						Rack	1582-AHR2	1582-9772	635.00	1582-AHR2J	1582-9528	670.00
						Wall	1582-AHW2	1582-9773	625.00	1582-AHW2J	1582-9529	660.00
460 V Adjustable ±10%	95 to 105	34	15.6	2.5 c + 1.5 c/V	0.25	No cabinet	1582-AK5	1582-9535	600.00	1582-AK5J	1582-9546	635.00
						Bench	1582-AKM5	1582-9536	635.00	1582-AKM5J	1582-9547	670.00
						Rack	1582-AKR5	1582-9537	635.00	1582-AKR5J	1582-9548	670.00
						Wall	1582-AKW5	1582-9538	625.00	1582-AKW5J	1582-9549	660.00
	90 to 110	17	7.8	2.5 c + 0.7 c/V	0.25	No cabinet	1582-AK	1582-9819	600.00	1582-AKJ	1582-9541	635.00
						Bench	1582-AKM	1582-9534	635.00	1582-AKMJ	1582-9542	670.00
						Rack	1582-AKR	1582-9426	635.00	1582-AKRJ	1582-9544	670.00
						Wall	1582-AKW	1582-9821	625.00	1582-AKWJ	1582-9545	660.00
	82 to 124	8.5	3.9	2.5 c + 0.4 c/V	0.5	No cabinet	1582-AK2	1582-9391	600.00	1582-AK2J	1582-9395	635.00
						Bench	1582-AKM2	1582-9392	635.00	1582-AKM2J	1582-9396	670.00
						Rack	1582-AKR2	1582-9393	635.00	1582-AKR2J	1582-9397	670.00
						Wall	1582-AKW2	1582-9394	625.00	1582-AKW2J	1582-9398	660.00

*Range is given as % of output voltage and for 57- to 63-hertz operation. For 48- to 63-hertz operation, corresponding correction ranges are 95 to 105%, 91 to 109%, and 84 to 119%.

**Time given in cycles of line frequency for 50- or 60-Hz. Correction rate of 400-Hz models is approx same, so cycles given in table must be multiplied by 7.

File Courtesy of GRWiki.org

VARIAC® AUTOMATIC VOLTAGE REGULATOR

Type 1583

- 3-phase voltage regulation
- fast, accurate, distortionless
- large power-handling capacity
- no power-factor limitation
- tolerates 1000% transient overloads

new

Like the GR 1581 and 1582 single-phase regulators, the 1583 employs the servo-driven buck/boost principle, extending its economy, reliability, and high performance to the control of three-phase power without significant increase in size or cost.

The 1583 offers wide selection of voltage (and frequency), power-handling capacity, and physical mounting. Other combinations are available on special order.

The two, ganged, servo-operated Variac® autotransformers apply opposing or aiding voltages to two series-regulating step-down transformers that are connected in an open delta. Because of this configuration, the 1583 is rated in terms of line-to-line voltages and line current. Care should be taken not to confuse this with the more common use of line-to-neutral or phase voltages in rating wye-connected loads and regulators.

— See **GR Experimenter** for October 1967.

specifications

Frequency: 60-Hz models operate from 57 to 63 Hz, and can be modified by a connection change for 48 to 63 Hz; 400-Hz models operate from 350 to 450 Hz.

Power Dissipation: No load, 45 W; full load. 120 W.

No-Load Power: 45 W.

Ambient Temperature: Operating, −20°C to +52°C; storage, −54°C to +85°C.

Dimensions (width x height x depth):
Uncased, 19 x 7 x 14¾ in. (485 x 180 x 375 mm);
Bench, 19 x 7⅜ x 16 in. (485 x 190 x 410 mm);
Rack, 19 x 7 x 15 in. (485 x 180 x 385 mm);
Wall, 19½ x 8⅛ x 16 in. (495 x 210 x 410 mm).

Weight:
Uncased, Net, 54 lb (24.5 kg); shipping, 104 lb (47.5 kg);
Bench, Net, 64 lb (29 kg); shipping, 114 lb (52 kg);
Rack, Net, 64 lb (29 kg); shipping, 114 lb (52 kg);
Wall, Net, 70 lb (32 kg); shipping, 120 lb (54.5 kg).

Output Voltage (line-to-line)	Correction Range * (%)	Line Current (A)	Load kVA	Correction Time in cycles (c)	Accuracy (% of output V)	Mounting or Style	Type Number	Catalog Number	Price in USA
230-volt (line-to-line), 60-Hz models									
230 V Adjustable ±10%	95 to 105	34.0	13.7	2.5 c + 3.0 c/V	0.25	Uncased	**1583-H5**	1583-9516	**$620.00**
						Bench	**1583-HM5**	1583-9517	**655.00**
						Rack	**1583-HR5**	1583-9518	**655.00**
						Wall	**1583-HW5**	1583-9521	**645.00**
	90 to 110	17.0	6.8	2.5 c + 1.5 c/V	0.25	Uncased	**1583-H**	1583-9817	**620.00**
						Bench	**1583-HM**	1583-9951	**655.00**
						Rack	**1583-HR**	1583-9961	**655.00**
						Wall	**1583-HW**	1583-9971	**645.00**
	82 to 124	8.5	3.4	2.5 c + 0.7 c/V	0.5	Uncased	**1583-H2**	1583-9770	**620.00**
						Bench	**1583-HM2**	1583-9771	**655.00**
						Rack	**1583-HR2**	1583-9772	**655.00**
						Wall	**1583-HW2**	1583-9773	**645.00**
115-volt (line-to-line), 400-Hz models									
115 V Adjustable ±10%	90 to 110	42.5	8.5	18 c + 20 c/V	0.25	Uncased	**1583-LJ**	1583-9551	**655.00**
						Bench	**1583-LMJ**	1583-9552	**690.00**
						Rack	**1583-LRJ**	1583-9554	**690.00**
						Wall	**1583-LWJ**	1583-9555	**680.00**
	82 to 124	21.2	4.2	18 c + 10 c/V	0.5	Uncased	**1583-L2J**	1583-9556	**655.00**
						Bench	**1583-LM2J**	1583-9557	**690.00**
						Rack	**1583-LR2J**	1583-9558	**690.00**
						Wall	**1583-LW2J**	1583-9559	**680.00**

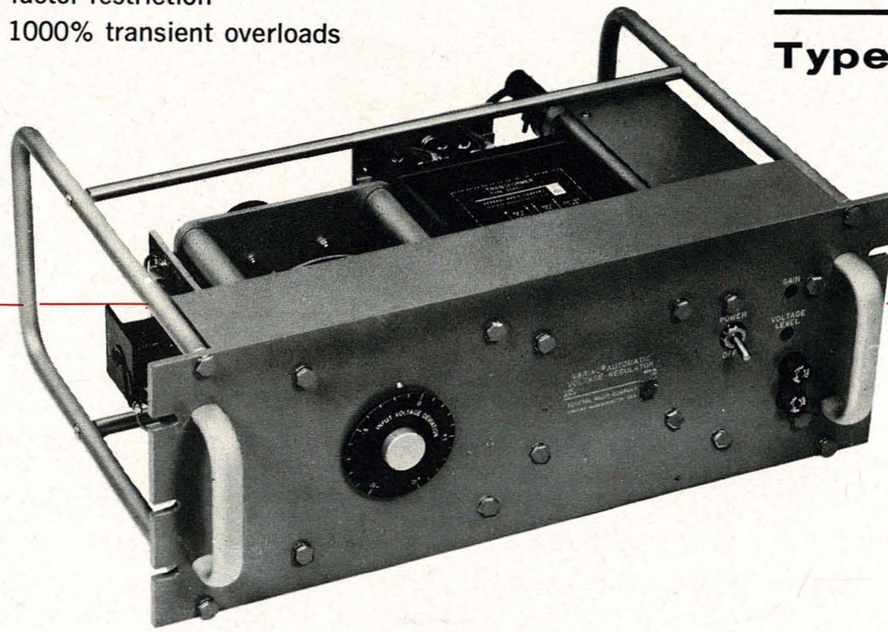
* Ranges listed are for 57- to 63-Hz operation; for 48- to 63-Hz operation, corresponding correction ranges are 95 to 105%, 91 to 109%, and 84 to 119%.

File Courtesy of GRWiki.org

VARIAC® AUTOMATIC VOLTAGE REGULATOR

Type 1571-A

- militarized
- fast response, high accuracy
- distortionless regulation
- large power-handling capacity
- output voltage independent of load
- no power-factor restriction
- tolerates 1000% transient overloads



The 1571-A is a militarized version of the 1581-A described on the preceding pages. It is designed to meet the appropriate sections of military specifications MIL-E-4158B and MIL-E-16400C. These models are particularly useful where mechanical shock or vibration is encountered. Models are available for use on both 115- and 230-volt ac lines, 400 Hz or 60 Hz (50 to 60 Hz by a change in connection on the autotransformer), and with various output currents and correction ranges. All units are designed for relay-rack mounting.

— See **GR Experimenter** for January 1966.

specifications

Output Voltage: Adjustable over a range of ±10% from a base value of 115 V (for 1571-AL) or 230 V (for 1571-AH), set by a front-panel screwdriver adjustment.

Frequency: 60-Hz models operate from 57 to 63 Hz but can be modified by connection change to operate from 48 to 63 Hz; 400-Hz models operate from 350 to 450 Hz.

Response: Rms.

Distortion: None added.

Power Dissipation (approx): No load, 35 W; full load, 115 W.

Ambient Temperature: Operating, −29° to +52°C; in storage, −54° to 85°C.

Dimensions (width x height x depth): 19 x 7 x 12 in. (485 x 180 x 305 mm).

Weight: Net, 52½ lb (24.5 kg); shipping, 103 lb (47 kg).

Output Voltage	Correction Range* %	Output Current (A)	KVA	Correction Time in cycles (c) **	Accuracy (% of output V)	Mounting	60 Hz Type Number	60 Hz Catalog Number	60 Hz Price in USA	400 Hz Type Number	400 Hz Catalog Number	400 Hz Price in USA
115 V Adjustable ±10%	90 to 110	50	5.8	2.5 c + 1.5 c/V	0.25	Rack	**1571-AL**	1571-9831	**$700.00**	**1571-ALJ**	1571-9551	**$735.00**
	82 to 124	25	2.9	2.5 c + 0.7 c/V	0.5	Rack	**1571-AL2**	1571-9898	**700.00**	**1571-AL2J**	1571-9556	**735.00**
230 V Adjustable ±10%	95 to 105	40	9.2	2.5 c + 1.5 c/V	0.25	Rack	**1571-AH5**	1571-9516	**700.00**	**1571-AH5J**	1571-9530	**735.00**
	90 to 110	20	4.6	2.5 c + 0.7 c/V	0.25	Rack	**1571-AH**	1571-9817	**700.00**	**1571-AHJ**	1571-9522	**735.00**
	82 to 124	10	2.3	2.5 c + 0.4 c/V	0.5	Rack	**1571-AH2**	1571-9770	**700.00**	**1571-AH2J**	1571-9526	**735.00**

*Range is given as % of output voltage and for 57- to 63-Hz operation. For 48- to 63-Hz operation, corresponding correction ranges are 95 to 105%, 91 to 109%, and 84 to 119%.

**Time given in cycles of line frequency for 50- or 60-Hz. Correction rate of 400-Hz models is approx same, so cycles given in table must be multiplied by 7.

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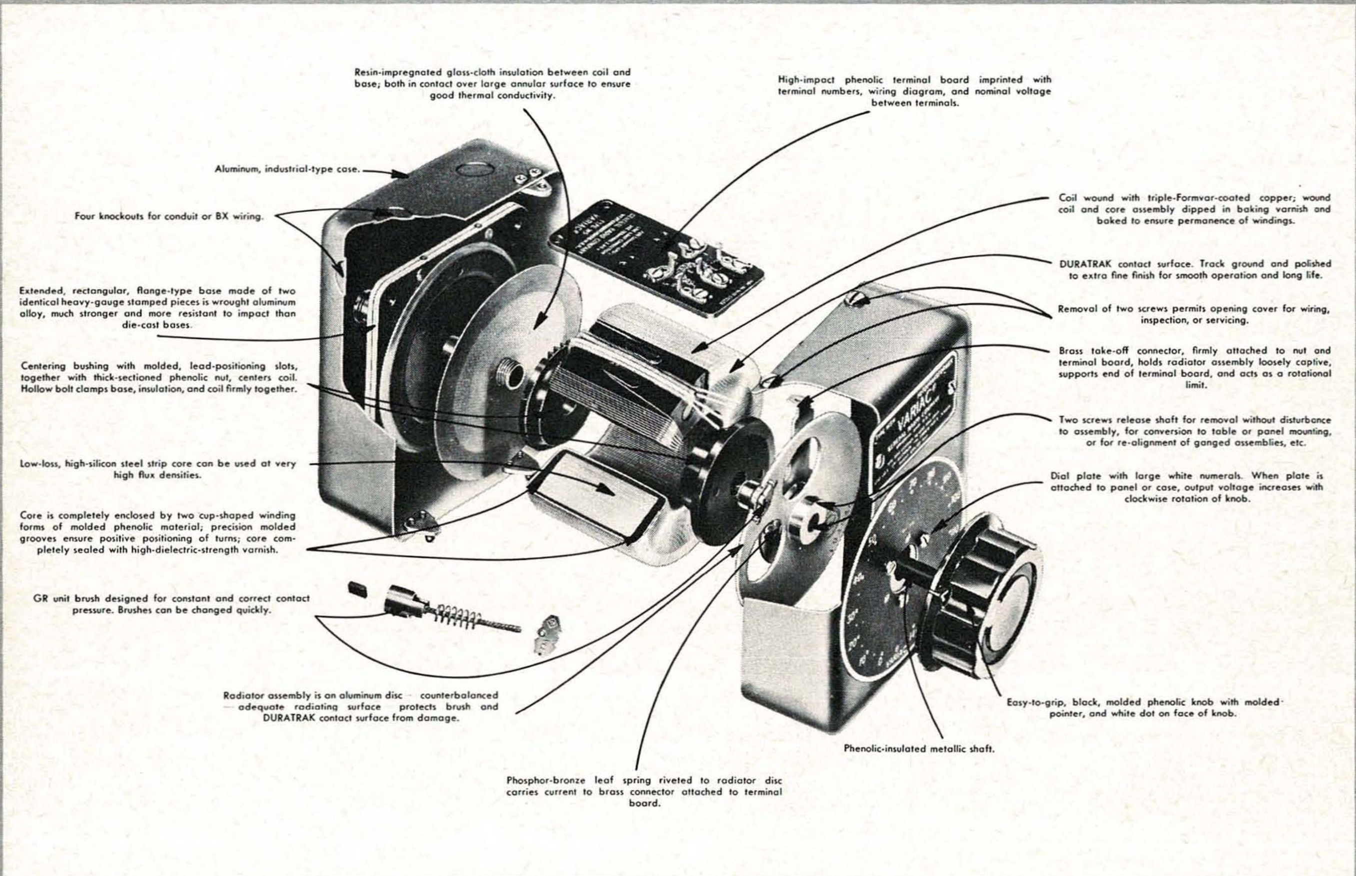
VARIAC®

ADJUSTABLE AUTOTRANSFORMERS



Since General Radio introduced the first adjustable autotransformer 35 years ago and branded it "Variac,"* over a million of these units have seen service in virtually every industry. They control ac voltage and thus in turn anything powered by ac voltage. Light, heat, motor speed — all are controlled smoothly, dependably, by VARIAC® autotransformers.

The autotransformer has important advantages over other methods of voltage control: It does not waste power by dissipating heat; it can withstand as high as 1000 percent short-term overload; and it does not affect waveform or power factor. To these basic advantages the VARIAC adds the value of 35 years of continuous refinement by General Radio and 35 years of proved performance in industry.

Wherever ac voltage is to be adjusted, there is a use for the VARIAC autotransformer. Some typical applications are:

- Lighting control in theaters, auditoriums, photographic studios, and darkrooms.
- Control of electric heaters and ovens in laboratory, pilot plant, and production line.
- Motor-speed control.
- Control of ac voltage in test and development work.
- Overvoltage and undervoltage tests.
- Meter calibration by voltage control.

The VARIAC autotransformer consists of a single layer winding on a toroidal silicon-steel core. As the control

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knob is rotated, a graphitic brush traverses the winding, tapping a portion of the total voltage across the winding. The brush is in continuous contact with the winding, and the voltage between turns is always less than 1 volt, even in the largest model; in the smallest model it is only about 0.3 volt. The brush always spans more than one turn, and the change in voltage as the brush moves is practically continuous. The brush is so designed that excessive heating cannot occur in the turns that it spans.

Duratrak®† All VARIAC autotransformers feature the DURATRAK contact surface, a uniform silver-alloy coating to prevent injurious high-temperature oxidation and resultant brush-track deterioration. The track shows no significant wear after 1,000,000 cycles of brush operation from zero to maximum and return. Because of DURATRAK contact surface, the life of a VARIAC autotransformer is essentially the same as that of a fixed-ratio power transformer.

FEATURES:

- **Regulation:** Output voltage is substantially independent of load.
- **Smooth Control:** Can be set very closely to any voltage in its range. Output voltage is continuously adjustable from zero to maximum.
- **Efficiency:** Low losses under all load conditions.
- **Long Life:** Life is essentially the same as that of a fixed-ratio transformer.
- **Linear Output Voltage:** Output voltage varies linearly with dial rotation.
- **Overvoltage:** Maximum output voltage is greater than input voltage.
- **Low Maintenance:** Occasional cleaning of contact surface ensures long, trouble-free operation.

* "Variac" is the registered trade name of the General Radio brand of adjustable autotransformers and associated control equipment in which these adjustable autotransformers are used.
† "Duratrak" is the registered trade name for the contact surface applied to the brush tracks of Variac autotransformers.

general specifications and terminology

Frequency: W series, 50 to 60 Hz; M series, 350 to 1200 Hz, except as otherwise noted. Most W models can also be operated at rated current and voltage at line frequencies of 50 to 400 Hz. Models designed for 240-volt, 50- to 60-Hz service can be used on a 25-Hz supply at full current rating and one-half their voltage and kVA ratings.

Protective Devices: MT and MT3 types have built-in circuit breakers with manual resets. Types W5L, W20H, W30, W30H, W50, and W50H have built-in fuse-type protectors. However, these should not be considered a substitute for normal fusing practices.

Overload Ratings: Rated currents can be safely exceeded with short-term overloads (see curves). The shaded area shows the limits for models with built-in fuse-type protective devices.

Temperature Effects: Ratings are based on a temperature rise of not more than 50°C above ambient temperature. For operation in ambient temperatures above 50°C, see derating chart.

Dials: Dial plates are reversible: 0 to 120 volts on one side, 0 to 140 volts on the other. Dials on H models are marked 0 to 240 and 0 to 280. Dials for ganged assemblies are marked 0 to 10. All models have 320-degree rotation and include knob and dial unless otherwise specified.

Terminals: The following types have combination soldering and screw-type terminals: W2, W5, W5L, W8, W8L, W10, W10H, W30H, and W50H. The W30 and W50 models use clamp-type terminals to accommodate the larger conductors required. MT types have NEMA-standard three-wire connectors.

Overvoltage Connection is that connection which gives an output voltage range of zero to 117 percent of input voltage.

Line-Voltage Connection is that connection which gives an output voltage range of zero to input (line) voltage.

Rated Current is the current that can be drawn at any output voltage.

Maximum Current is the current that can be drawn at maximum output voltage when the line-voltage connection is used.

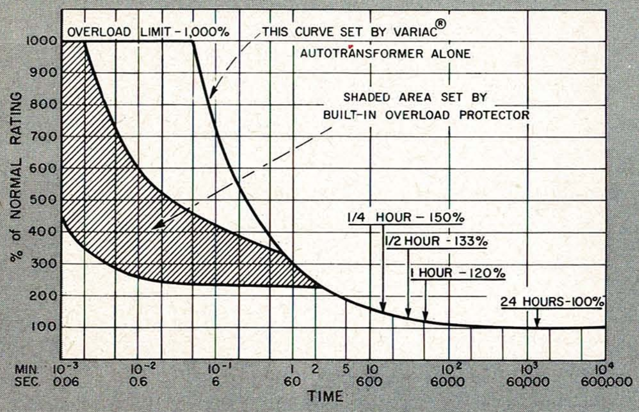
Output Voltage Range is the range of voltage available at the output terminals when the stated input voltage is applied to the input terminals.

KVA Load Rating is the maximum current multiplied by the nominal input line voltage. At any lower voltage setting, a Variac autotransformer can handle a constant-impedance load that draws a current no greater than maximum current with rated input voltage.

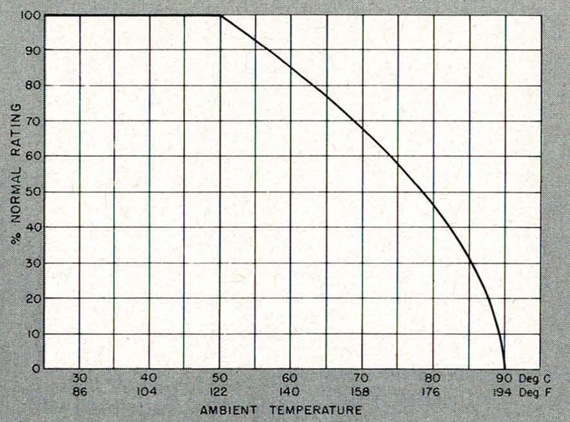
No-Load Loss is the power consumed at rated line voltage and frequency, with the load disconnected. This loss will not exceed the stated value.

Driving Torque is the torque required to turn the shaft.

For a complete description of principles, circuits, and uses, refer to **The Handbook of Voltage Control,** available free on request from General Radio Company.



Short-time overload limits. For high initial surge current (as with motors, incandescent lamps, etc.) and other short-time overloads, the rated current may be exceeded as shown, when line-voltage connection is used.



For ambient temperatures above 50°C, ratings should be decreased according to this curve.

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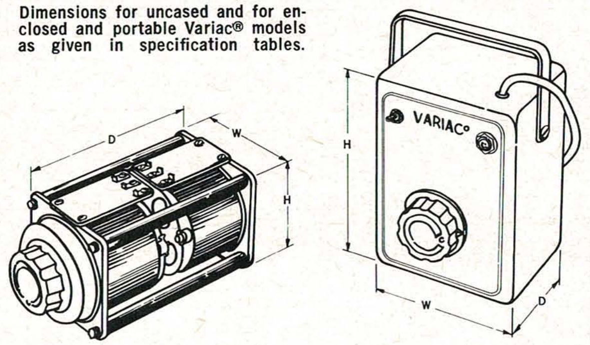
Dimensions for uncased and for enclosed and portable Variac® models as given in specification tables.



General Radio Variac® adjustable autotransformers are available in virtually unlimited variety to answer the electrical and mechanical needs of almost any application with combinations of line voltage and frequency, output current or power, 1- or 3-phase, method of mounting, metering, and manual or motor drive. The many models for choosing are grouped on the following pages as follows:

Once the correct page has been determined from the above considerations, the specific model can be selected from the table on the basis of current or power output required, enclosure, and physical size.

HIGH-FREQUENCY MODELS — 350 to 1200 Hz

The M-series Variac® autotransformers are mechanically similar to the 60-Hz model, but are smaller and lighter, and manufactured to conform to military specifications for shock, vibration, salt-spray, tropicalization, and wide-temperature-range lubrication. The regulation obtained from the M-series models is considerably better at 400 Hz than that of 60-Hz models operated at 400 Hz. The smallest, 2-ampere model, M2, has 400 turns giving adequate resolution for many computing and controlling applications. Nonstandard versions available on special order.

PORTABLE AND METERED MODELS

A wide selection of single-phase units is offered as fully-enclosed portable models with carrying handle, attached power cord and output receptacle, switch, and, in some models, meters for convenient monitoring of output volts, amperes, or watts. These handy, compact units have many uses in the laboratory and on the test bench, among them over- and undervoltage tests, and trouble shooting. The meters have expanded scales for easy reading and are accurate to ±3% of full scale, except for 5% ammeters in the W20-size models.

MOTOR-DRIVEN MODELS

For remote-adjustment applications, all W- and M-series Variac® autotransformers can be supplied with motor drives. The motor-driven assemblies include a totally enclosed, two-phase, gear-reduction motor of the servo type, limit switches, a phase-shift capacitor, and a Variac autotransformer equipped with ball bearings.

Limit switches are included on all models and are adjusted to limit the traverse to approximately 320°.

The W-series, motor-driven models are available as either open or totally enclosed assemblies; the M-series models are available in open mounting only. Non-standard, motor-driven models are available on special order.

MOTOR SPECIFICATIONS

Supply: 120 V, 60 Hz.
Impedance: 2500 Ω.
Inductive Resistance: 2200 Ω.
Ac Resistance: 1300 Ω.
(Impedance, inductive resistance and ac resistance: for each winding, at 60 Hz.)
Dc Resistance: 575 Ω.
Traverse: 320°.
Traverse Times Available: 2, 4, 8, 16, 32, 64, and 128 seconds at 60 Hz. For 50-Hz supply, multiply time by 6/5.

W50-P1 PARALLELLING CHOKE new

Many of the Variac® autotransformers listed on the following pages are indicated to require one or more Type W50-P1 Choke. This unit is used when two or more autotransformer outputs are to be connected in parallel; it prevents the flow of potentially damaging currents from one unit to the other. Instructions for proper interconnecting are included with each unit.

Catalog Number	Description	Price in USA
3150-5016	**W50-P1 Choke**	**$16.00**

REPLACEMENT BRUSHES

Occasionally, as a result of accident or excessive wear or current, it may be necessary to replace the autotransformer's carbon brush or brushes. They may be ordered from the table below.

Catalog Number	Description	Price in USA
3200-5901	**VB-1 Brush,** for M2, W2, W5H	**$1.00**
3200-5900	**VB-2 Brush,** for M5, W5, W5L	**1.00**
3200-5923	**VB-3 Brush,** for W8, W8L	**1.00**
3200-5910	**VBT-10 Brush,** for M10, W10	**1.75**
3200-5911	**VBT-11 Brush,** for W10H	**1.75**
3200-5908	**VBT-8 Brush Set,** for M20, W20	**3.00**
3200-5912	**VBT-12 Brush Set,** for W20H	**3.25**
3200-5913	**VBT-13 Brush Set,** for W30	**4.75**
3200-5914	**VBT-14 Brush Set,** for W30H	**4.75**
3200-5906	**VBT-6 Brush Set,** for W50	**8.50**
3200-5907	**VBT-7 Brush Set,** for W50H	**8.50**

BALL BEARINGS

W-series and M-series models can be supplied with ball bearings, which provide more precise alignment with slightly lower and more nearly constant torque.

When ordering Variac® autotransformers equipped with ball bearings, add the suffix "BB" to the type number, and add the price shown in the tables.

Ball bearings are standard equipment on motor-driven units and on 4- and 6-gang, W30 and W50 models, and are included in the price.

SPECIAL VARIAC® AUTOTRANSFORMERS

Special models can be supplied to meet specific requirements, such as additional winding taps, fungicide treatment, special shaft lengths, or with voltage outputs or ranges differing from those of standard models. They can also be supplied on special order less knob, dial, etc., at lower net prices and with slightly extended delivery time.

The General Radio Company welcomes inquiries on special models, and is glad to furnish them when the quantities involved are sufficient to make production economically practicable.

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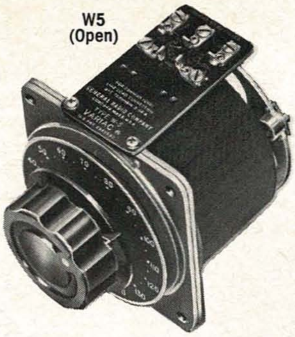
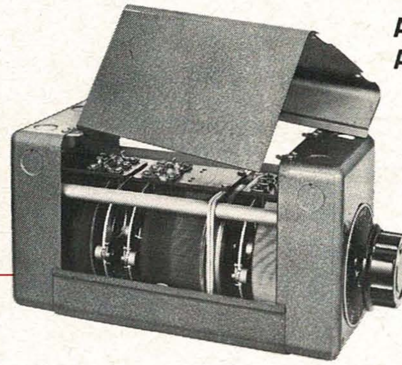
VARIAC®

ADJUSTABLE AUTOTRANSFORMERS

W5M (Enclosed)



W5 (Open)



W5LG3M (3-Gang)

Single-phase, 120-volt input, 50-60 Hz

Output: Rated Current Amperes	Output: Max Current Amperes	Output: Output Voltage	Type	Description: Mounting	Description: Notes	W50-PI Chokes Req'd	Catalog Number	Price in USA	Add for Ball Bearings	Net Weight lb	Approx Shipping Wt lb	Dimensions (inches) W	Dimensions (inches) H	Dimensions (inches) D
2.0	2.6	0-140	**W2M**	Encl			3010-5111	**$ 21.50**	**$ 8.00**	4	9	4 1/8	5 9/16	4 3/8†
2.4	3.1	0-140	**W2**	Open			3010-5110	**15.00**	**8.00**	3	4	3 1/4	3 11/16	3 15/16†
5.0	6.5	0-140	**W5M**	Encl			3030-5111	**26.00**	**8.00**	7	13	4 7/8	6 9/16	4 3/8*†
6.0	7.8	0-140	**W5**	Open			3030-5110	**18.00**	**8.00**	6	8	4 1/2	4 15/16	3 15/16*†
7.1	9.2	0-120	**W5LM**	Encl	60 Hz only		3050-5111	**26.00**	**8.00**	7	13	4 7/8	6 9/16	4 3/8
8.5	11.0	0-120	**W5L**	Open	60 Hz only		3050-5110	**18.00**	**8.00**	7	8	4 1/2	4 15/16	4 11/16*
8.5	11.0	0-140	**W8**	Open			3038-5110	**21.00**	**8.00**	8	9	4 1/2	4 15/16	4 7/16
10.0	13.0	0-120	**W8L**	Open	60 Hz only		3058-5110	**21.00**	**8.00**	8	12	4 1/2	4 15/16	4 7/16
10.0	13.0	0-140	**W10**	Open			3060-5110	**33.00**	**9.00**	12	13	5 3/4	6 5/16	3 15/16*†
10.0	13.0	0-140	**W10M**	Encl			3060-5111	**46.00**	**9.00**	15	17	6 3/4	9 1/2	5 1/4*†
14.2	18.4	0-120	**W5LG2M**	Encl	60 Hz only	1	3050-5121	**54.00**	**13.00**	15	23	5 1/8	6 3/4	8 1/8
17.0	22.0	0-120	**W5LG2**	Open	60 Hz only	2	3050-5120	**42.00**	**13.00**	14	16	4 1/2	4 15/16	8
17.0	22.0	0-140	**W8G2**	Open		1	3038-5120	**48.00**	**13.00**	16	19	4 1/2	4 15/16	9 5/16
20.0	26.0	0-140	**W20**	Open			3090-5110	**50.00**	**9.00**	21	24	7 1/2	8 1/16	4 5/8*†
20.0	26.0	0-140	**W20M**	Encl			3090-5111	**65.00**	**9.00**	24	29	8 5/8	11 15/16	5 3/8†
20.0	26.0	0-120	**W8LG2**	Open	60 Hz only	1	3058-5120	**48.00**	**13.00**	17	19	4 1/2	4 15/16	9 5/16
21.3	27.6	0-120	**W5LG3M**	Encl	60 Hz only	3	3050-5131	**74.00**	**15.00**	22	32	5 1/8	6 3/4	12 1/4
25.5	33.0	0-120	**W5LG3**	Open	60 Hz only	3	3050-5130	**61.00**	**15.00**	20	22	4 1/2	4 15/16	12 1/8
25.5	33.0	0-140	**W8G3**	Open		3	3038-5130	**70.00**	**15.00**	25	27	4 1/2	4 15/16	13 15/16
28.0	32.0	0-140	**W30M**	Encl			3120-5111	**103.00**	**12.00**	37	47	11	14 3/4	5 3/4
30.0	36.0	0-140	**W30**	Open			3120-5110	**85.00**	**12.00**	30	38	10	11 13/16	4 1/8
30.0	39.0	0-120	**W8LG3**	Open	60 Hz only	3	3058-5130	**70.00**	**15.00**	25	27	4 1/2	4 15/16	13 15/16
40.0	52.0	0-140	**W20G2M**	Encl		1	3090-5121	**134.00**	**15.00**	48	56	9	12 1/16	9 3/8
40.0	52.0	0-140	**W20G2**	Open		1	3090-5120	**110.00**	**15.00**	43	48	7 1/2	8 1/16	9 3/16
40.0	45.0	0-140	**W50M**	Encl			3150-5111	**152.00**	**12.00**	57	74	13 7/16	16 7/8	7 1/4*†
50.0	50.0	0-140	**W50**	Open			3150-5110	**127.00**	**12.00**	50	57	12 1/2	13 3/4	6 1/4*†
56.0	64.0	0-140	**W30G2M**	Encl		1	3120-5121	**218.00**	**18.00**	67	90	11 3/8	14 15/16	10 1/16
60.0	72.0	0-140	**W30G2**	Open		1	3120-5120	**188.00**	**18.00**	61	80	10	11 13/16	9 7/8
60.0	78.0	0-140	**W20G3M**	Encl		3	3090-5131	**188.00**	**18.00**	71	82	9	12 1/16	13 15/16
60.0	78.0	0-140	**W20G3**	Open		3	3090-5130	**162.00**	**18.00**	65	71	7 1/2	8 1/16	13 3/4
80.0	90.0	0-140	**W50G2M**	Encl		1	3150-5121	**312.00**	**18.00**	123	160	13 13/16	17 1/16	14 11/16
84.0	96.0	0-140	**W30G3M**	Encl		3	3120-5131	**311.00**	**22.00**	99	125	11 3/8	14 15/16	14 11/16
90.0	108.0	0-140	**W30G3**	Open		3	3120-5130	**276.00**	**22.00**	93	113	12 1/2	13 3/4	20 7/8
100.0	100.0	0-140	**W50G2**	Open		1	3150-5120	**272.00**	**18.00**	112	147	12 1/2	13 3/4	14 1/2
120.0	135.0	0-140	**W50G3M**	Encl		3	3150-5131	**448.00**	**22.00**	179	221	13 13/16	17 1/16	21 1/16
150.0	150.0	0-140	**W50G3**	Open		3	3150-5130	**403.00**	**22.00**	163	206	12 1/2	13 3/4	20 7/8
160.0	180.0	0-140	**W50G4BBM**	Encl		4	3150-5241	**612.00**	—	240	313	13 13/16	17 1/16	27 7/16
200.0	200.0	0-140	**W50G4BB**	Open		4	3150-5240	**564.00**	—	215	288	12 1/2	13 3/4	27 1/4
240.0	270.0	0-140	**W50G6BBM**	Encl		6	3150-5261	**899.00**	—	355	430	13 13/16	17 1/16	40 3/16
300.0	300.0	0-140	**W50G6BB**	Open		6	3150-5260	**845.00**	—	325	400	12 1/2	13 3/4	40

* Listed under Re-examination Service of the Underwriters' Laboratory.

† Approved by the Canadian Standards Association.

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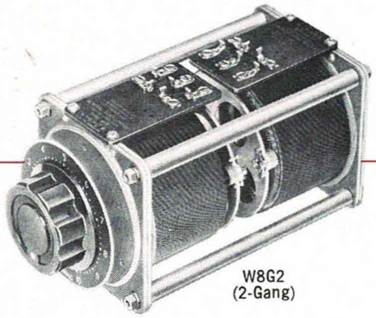
Variac® autotransformers

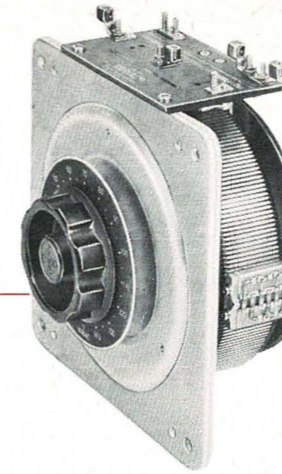
VARIAC®

ADJUSTABLE AUTOTRANSFORMERS



W8G2
(2-Gang)

W20M
(Enclosed)



W50
(Open)

Single-phase, 240-volt input, 50-60 Hz

Output: Rated Current Amperes	Output: Max Current Amperes	Output: Output Voltage	Type	Description: Mounting	Description: Connection	Description: W50-PI Chokes Req'd	Catalog Number	Price in USA	Add for Ball Bearings	Net Weight lb	Approx Shipping Wt lb	Dimensions (inches): W	Dimensions (inches): H	Dimensions (inches): D
2.0	2.6	0-280	**W5H**	Open			3040-5110	**$ 21.50**	**$ 8.00**	6	8	4 1/2	4 15/16	3 15/16†
2.0	2.6	0-280	**W5HM**	Encl			3040-5111	**29.50**	**8.00**	7	13	4 7/8	6 9/16	4 3/8†
2.4	3.1	0-280	**W2G2**	Open	Series		3010-5120	**36.00**	**13.00**	7	9	3 1/4	3 11/16	7 15/16
4.0	5.2	0-280	**W10H**	Open			3070-5110	**35.00**	**9.00**	11	12	5 3/4	6 5/16	4 11/16†
4.0	5.2	0-280	**W10HM**	Encl			3070-5111	**48.00**	**9.00**	14	17	6 3/4	9 1/2	5 1/4†
5.0	6.5	0-280	**W5G2M**	Encl	Series		3030-5121	**54.00**	**13.00**	15	23	5 1/8	6 3/4	8 1/8
6.0	7.8	0-280	**W5G2**	Open	Series		3030-5120	**42.00**	**13.00**	14	15	4 1/2	4 15/16	8
8.0	10.4	0-280	**W20H**	Open			3100-5110	**52.00**	**9.00**	20	23	7 1/2	8 1/16	4 5/8*†
8.0	10.4	0-280	**W20HM**	Encl			3100-5111	**67.00**	**9.00**	23	28	8 5/8	11 15/16	5 3/8*†
8.5	11.0	0-280	**W8G2**	Open	Series		3038-5120	**48.00**	**13.00**	16	19	4 1/2	4 15/16	9 5/16
10.0	13.0	0-240	**W8LG2**	Open	Series 60 Hz only		3058-5120	**48.00**	**13.00**	17	19	4 1/2	4 15/16	9 5/16
10.0	13.0	0-280	**W10G2**	Open	Series		3060-5120	**73.00**	**15.00**	25	27	5 3/4	6 5/16	9 5/16
10.0	13.0	0-280	**W10G2M**	Encl	Series		3060-5121	**93.00**	**15.00**	29	34	7 1/8	9 11/16	9 1/2
12.0	15.6	0-280	**W30H**	Open			3130-5110	**85.00**	**12.00**	29	36	10	11 13/16	4 1/8
12.0	15.6	0-280	**W30HM**	Encl			3130-5111	**103.00**	**12.00**	36	45	11	14 3/4	5 3/4
16.0	20.8	0-280	**W20HG2**	Open	Parallel	1	3100-5120	**114.00**	**15.00**	41	46	7 1/2	8 1/16	9 3/16
16.0	20.8	0-280	**W20HG2M**	Encl	Parallel	1	3100-5121	**138.00**	**15.00**	45	54	9	12 1/16	9 3/8
20.0	26.0	0-280	**W20G2**	Open	Series		3090-5120	**110.00**	**15.00**	43	48	7 1/2	8 1/16	9 3/16
20.0	26.0	0-280	**W20G2M**	Encl	Series		3090-5121	**134.00**	**15.00**	48	56	9	12 1/16	9 3/8
20.0	31.0	0-280	**W50HM**	Encl			3160-5111	**152.00**	**12.00**	60	76	13 7/16	16 7/8	7 1/4*†
24.0	31.2	0-280	**W30HG2**	Open	Parallel	1	3130-5120	**188.00**	**18.00**	59	76	10	11 13/16	9 7/8
24.0	31.2	0-280	**W30HG2M**	Encl	Parallel	1	3130-5121	**218.00**	**18.00**	64	87	11 3/8	14 15/16	10 1/16
25.0	32.5	0-280	**W50H**	Open			3160-5110	**127.00**	**12.00**	53	60	12 1/2	13 3/4	6 1/4*†
28.0	32.0	0-280	**W30G2M**	Encl	Series		3120-5121	**218.00**	**18.00**	67	90	11 3/8	14 15/16	10 1/16
30.0	36.0	0-280	**W30G2**	Open	Series		3120-5120	**188.00**	**18.00**	61	80	10	11 13/16	9 7/8
36.0	46.8	0-280	**W30HG3**	Open	Parallel	3	3130-5130	**276.00**	**22.00**	90	107	12 1/2	13 3/4	20 7/8
36.0	46.8	0-280	**W30HG3M**	Encl	Parallel	3	3130-5131	**311.00**	**22.00**	97	120	11 3/8	14 15/16	14 11/16
40.0	62.0	0-280	**W50HG2M**	Encl	Parallel	1	3160-5121	**312.00**	**18.00**	126	165	13 13/16	17 1/16	14 11/16
50.0	65.0	0-280	**W50HG2**	Open	Parallel	1	3160-5120	**272.00**	**18.00**	116	153	12 1/2	13 3/4	14 1/2
60.0	93.0	0-280	**W50HG3M**	Encl	Parallel	3	3160-5131	**448.00**	**22.00**	183	230	13 13/16	17 1/16	21 1/16
75.0	97.5	0-280	**W50HG3**	Open	Parallel	3	3160-5130	**403.00**	**22.00**	167	214	12 1/2	13 3/4	20 7/8
80.0	124.0	0-280	**W50HG4BBM**	Encl	Parallel	4	3160-5241	**612.00**	—	255	328	13 13/16	17 1/16	27 7/16
100.0	130.0	0-280	**W50HG4BB**	Open	Parallel	4	3160-5240	**564.00**	—	230	300	12 1/2	13 3/4	27 1/4
120.0	186.0	0-280	**W50HG6BBM**	Encl	Parallel	6	3160-5261	**899.00**	—	385	458	13 13/16	17 1/16	40 3/16
150.0	195.0	0-280	**W50HG6BB**	Open	Parallel	6	3160-5260	**845.00**	—	355	428	12 1/2	13 3/4	40

* Listed under Re-examination Service of Underwriters' Laboratory.

† Approved by Canadian Standards Association.

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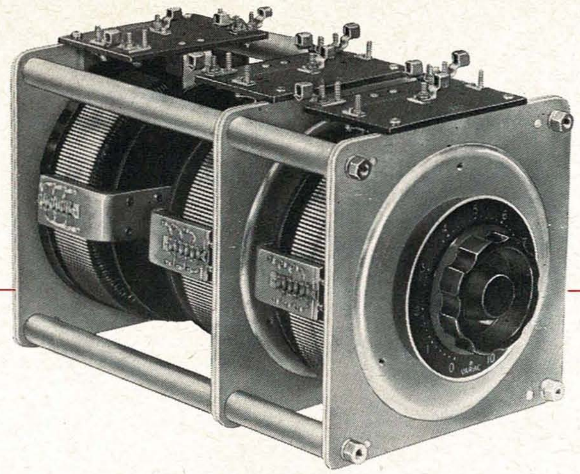

W50G3

Three-phase, 208-volt input, 60-Hz only

Output: Rated Current Amperes	Output: Max Current Amperes	Output: Output Voltage	Description: Type	Description: Mounting	Description: Connection	Description: W50-PI Chokes Req'd	Catalog Number	Price in USA	Add for Ball Bearings	Net Weight lb	Approx Shipping Wt lb	Dimensions (inches): W	Dimensions (inches): H	Dimensions (inches): D
7.1	9.2	0-208	**W5LG3M**	Encl	Wye		3050-5131	**$ 74.00**	**$ 15.00**	22	32	5 1/8	6 3/4	12 1/4
8.5	11.0	0-208	**W5LG3**	Open	Wye		3050-5130	**61.00**	**15.00**	20	23	4 1/2	4 15/16	12 1/8
10.0	13.0	0-208	**W8LG3**	Open	Wye		3058-5130	**70.00**	**15.00**	25	27	4 1/2	4 15/16	13 5/16

Three-phase, 208/240-volt input, 50-60 Hz

Except for open-delta connection, overvoltage not recommended. For 208-volt input, overvoltage may be used.

Rated Current Amperes	Max Current Amperes	Output Voltage	Type	Mounting	Connection	W50-PI Chokes Req'd	Catalog Number	Price in USA	Add for Ball Bearings	Net Weight lb	Approx Shipping Wt lb	W	H	D
2.0	2.6	0-280	**W5HG2**	Open	Open Delta		3040-5120	**$ 49.00**	**$ 13.00**	13	15	4 1/2	4 15/16	8
2.0	2.6	0-280	**W5HG2M**	Encl	Open Delta		3040-5121	**61.00**	**13.00**	15	23	5 1/8	6 3/4	8 1/8
2.0	2.6	0-240	**W2G3M**	Encl	Wye		3010-5131	**63.00**	**15.00**	12	21	4 3/8	5 3/4	12 1/8
2.4	3.1	0-240	**W2G3**	Open	Wye		3010-5130	**52.00**	**15.00**	11	13	3 1/4	3 11/16	12
4.0	5.2	0-280	**W10HG2**	Open	Open Delta		3070-5120	**77.00**	**15.00**	24	27	5 3/4	6 5/16	9 5/16
4.0	5.2	0-280	**W10HG2M**	Encl	Open Delta		3070-5121	**97.00**	**15.00**	29	33	7 1/8	9 11/16	9 1/2
5.0	6.5	0-240	**W5G3M**	Encl	Wye		3030-5131	**74.00**	**15.00**	22	32	5 1/8	6 3/4	12 1/4
6.0	7.8	0-240	**W5G3**	Open	Wye		3030-5130	**61.00**	**15.00**	20	22	4 1/2	4 15/16	12 1/8
8.0	10.4	0-280	**W20HG2**	Open	Open Delta		3100-5120	**114.00**	**15.00**	41	46	7 1/2	8 1/16	9 3/16
8.0	10.4	0-280	**W20HG2M**	Encl	Open Delta		3100-5121	**138.00**	**15.00**	45	54	9	12 1/16	9 3/8
8.5	11.0	0-240	**W8G3**	Open	Wye		3038-5130	**70.00**	**15.00**	25	27	4 1/2	4 15/16	13 15/16
10.0	13.0	0-240	**W10G3**	Open	Wye		3060-5130	**108.00**	**18.00**	37	40	5 3/4	6 5/16	14
10.0	13.0	0-240	**W10G3M**	Encl	Wye		3060-5131	**129.00**	**18.00**	43	47	7 1/8	9 11/16	14 3/16
12.0	15.6	0-280	**W30HG2**	Open	Open Delta		3130-5120	**188.00**	**18.00**	59	76	10	11 13/16	9 7/8
12.0	15.6	0-280	**W30HG2M**	Encl	Open Delta		3130-5121	**218.00**	**18.00**	64	87	11 3/8	14 15/16	10 1/16
20.0	26.0	0-240	**W20G3**	Open	Wye		3090-5130	**162.00**	**18.00**	65	71	7 1/2	8 1/16	13 3/4
20.0	26.0	0-240	**W20G3M**	Encl	Wye		3090-5131	**188.00**	**18.00**	71	82	9	12 1/16	13 15/16
20.0	31.0	0-280	**W50HG2M**	Encl	Open Delta		3160-5121	**312.00**	**18.00**	126	165	13 13/16	17 1/16	14 11/16
25.0	32.5	0-280	**W50HG2**	Open	Open Delta		3160-5120	**272.00**	**18.00**	116	153	12 1/2	13 3/4	14 1/2
28.0	32.0	0-240	**W30G3M**	Encl	Wye		3120-5131	**311.00**	**22.00**	99	125	11 3/8	14 15/16	14 11/16
30.0	36.0	0-240	**W30G3**	Open	Wye		3120-5130	**276.00**	**22.00**	93	113	12 1/2	13 3/4	20 7/8
40.0	45.0	0-240	**W50G3M**	Encl	Wye		3150-5131	**448.00**	**22.00**	179	221	13 13/16	17 1/16	21 1/16
50.0	50.0	0-240	**W50G3**	Open	Wye		3150-5130	**403.00**	**22.00**	163	206	12 1/2	13 3/4	20 7/8
40.0	62.0	0-280	**W50HG4BBM**	Encl	Open Delta	2	3160-5241	**612.00**	—	255	328	13 13/16	17 1/16	27 7/16
50.0	65.0	0-280	**W50HG4BB**	Open	Open Delta	2	3160-5240	**564.00**	—	230	300	12 1/2	13 3/4	27 1/4
80.0	90.0	0-240	**W50G6BBM**	Encl	Wye	3	3150-5261	**899.00**	—	355	430	13 13/16	17 1/16	40 3/16
100.0	100.0	0-240	**W50G6BB**	Open	Wye	3	3150-5260	**845.00**	—	325	400	12 1/2	13 3/4	40

Three-phase, 480-volt input, 50-60 Hz

(Overvoltage connection not recommended)

Rated Current Amperes	Max Current Amperes	Output Voltage	Type	Mounting	Connection	W50-PI Chokes Req'd	Catalog Number	Price in USA	Add for Ball Bearings	Net Weight lb	Approx Shipping Wt lb	W	H	D
2.0	2.6	0-480	**W5HG3**	Open	Wye		3040-5130	**$ 71.50**	**$ 15.00**	20	22	4 1/2	4 15/16	12 1/8
2.0	2.6	0-480	**W5HG3M**	Encl	Wye		3040-5131	**84.50**	**15.00**	22	31	5 1/8	6 3/4	12 1/4
4.0	5.2	0-480	**W10HG3**	Open	Wye		3070-5130	**114.00**	**18.00**	36	39	5 3/4	6 5/16	14
4.0	5.2	0-480	**W10HG3M**	Encl	Wye		3070-5131	**135.00**	**18.00**	42	46	7 1/8	9 11/16	14 3/16
8.0	10.4	0-480	**W20HG3**	Open	Wye		3100-5130	**168.00**	**18.00**	61	68	7 1/2	8 1/16	13 3/4
8.0	10.4	0-480	**W20HG3M**	Encl	Wye		3100-5131	**194.00**	**18.00**	67	79	9	12 1/16	13 15/16
12.0	15.6	0-480	**W30HG3**	Open	Wye		3130-5130	**276.00**	**22.00**	90	107	12 1/2	13 3/4	20 7/8
12.0	15.6	0-480	**W30HG3M**	Encl	Wye		3130-5131	**311.00**	**22.00**	97	120	11 3/8	14 15/16	14 11/16
20.0	31.0	0-480	**W50HG3M**	Encl	Wye		3160-5131	**448.00**	**22.00**	183	230	13 13/16	17 1/16	21 1/16
25.0	32.5	0-480	**W50HG3**	Open	Wye		3160-5130	**403.00**	**22.00**	167	214	12 1/2	13 3/4	20 7/8
40.0	62.0	0-480	**W50HG6BBM**	Encl	Wye	3	3160-5261	**899.00**	—	385	458	13 13/16	17 1/16	40 3/16
50.0	65.0	0-480	**W50HG6BB**	Open	Wye	3	3160-5260	**845.00**	—	355	428	12 1/2	13 3/4	40

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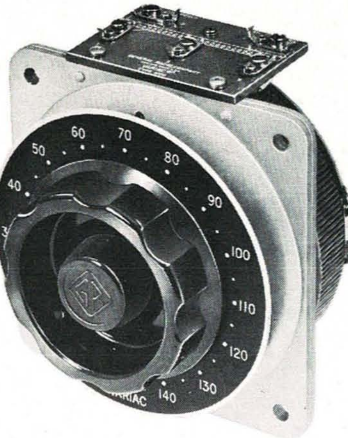


M20

W5MT3A

W10MT3

M-Series for 350- to 1200-Hz Service

Output: Rated Current Amperes	Output: Max Current Amperes	Output: Output Voltage	Description: Type	Description: Mounting	Description: Connection	Catalog Number	Price in USA	Add for Ball Bearings	Net Weight lb	Approx Shipping Wt lb	Dimensions (inches) W	H	D
Single-Phase, 120-volt, 400-Hz													
2.4	3.1	0-140	**M2**	Open		3410-5110	**$ 15.50**	**$ 8.00**	2	3	3 1/4	3 11/16	2 11/16†
6.0	7.8	0-140	**M5**	Open		3430-5110	**18.50**	**8.00**	3	4	4 1/2	4 15/16	2 11/16†
10.0	13.0	0-140	**M10**	Open		3460-5110	**35.00**	**9.00**	6	8	5 3/4	6 5/16	3 7/16†
20.0	26.0	0-140	**M20**	Open		3490-5110	**54.00**	**9.00**	13	15	7 1/2	8 1/16	3 5/8†
Three-phase, 120-volt, 400-Hz													
1.39	1.8	0-140	**M2G2**	Open	Open Delta	3410-5120	**$ 38.00**	**$ 13.00**	4	5	3 1/4	3 11/16	5 7/16
3.47	4.5	0-140	**M5G2**	Open	Open Delta	3430-5120	**44.00**	**13.00**	7	8	4 1/2	4 15/16	5 1/2
5.77	7.5	0-140	**M10G2**	Open	Open Delta	3460-5120	**78.00**	**15.00**	12	16	5 3/4	6 5/16	6 13/16
11.6	15.0	0-140	**M20G2**	Open	Open Delta	3490-5120	**116.00**	**15.00**	26	30	7	8 1/16	7 3/16
Three-phase, 120/208/240-volt, 400-Hz													
2.4	3.1	0-Line	**M2G3**	Open	Wye	3410-5130	**$ 54.50**	**$ 15.00**	5	7	3 1/2	3 11/16	8 1/4
6.0	7.8	0-Line	**M5G3**	Open	Wye	3430-5130	**63.50**	**15.00**	10	12	4 1/2	4 15/16	8 3/8
10.0	13.0	0-Line	**M10G3**	Open	Wye	3460-5130	**115.00**	**18.00**	19	23	5 3/4	6 15/16	10 1/4
20.0	26.0	0-Line	**M20G3**	Open	Wye	3490-5130	**172.00**	**18.00**	38	43	7 1/2	8 1/16	10 3/4

17% overvoltage connection is permitted on 120/208, three-phase lines.

Portable and Metered/Portable

Rated Current Amperes	Max Current Amperes	Output Voltage	Type	Meter Ranges (full scale): Amperes	Watts	Volts	2- or 3-wire cord and receptacle	Catalog Number	Price in USA	Add for Ball Bearings	Net Weight lb	Approx Shipping Wt lb	W	H	D
Single-phase, 120-volt input, 50-60 Hz															
5.0	—	0-140	**W5MT**	—	—	—	2	3030-5118	**$ 31.50**	—	8	15	4 7/8	6 9/16	4 3/8*†
5.0	—	0-140	**W5MT3**	—	—	—	3	3030-5119	**33.00**	—	8	15	4 7/8	6 9/16	4 3/8*†
5.0	—	0-140	**W5MT3VM**	—	—	150	3	3030-5015	**60.00**	—	8	19	4 7/8	6 9/16	4 3/8
5.0	—	0-140	**W5MT3A**	1/5	—	150	3	3030-5012	**95.00**	—	11	19	6 3/4	9 1/2	5 1/4
5.0	—	0-140	**W5MT3W**	—	150/750	150	3	3030-5013	**125.00**	—	12	19	6 3/4	9 1/2	5 1/4
5.0	—	0-140	**W5MT3AW**	1/5	150/750	150	3	3030-5014	**160.00**	—	12	21	11 15/16	8 5/8	5 3/8
7.1	—	0-120	**W5LMT3**[1]	—	—	—	3	3050-5119	**33.00**	—	8	18	4 7/8	6 9/16	4 3/8
10.0	—	0-140	**W10MT**	—	—	—	2	3060-5118	**56.00**	—	16	24	6 3/4	9 1/2	5 1/4†
10.0	—	0-140	**W10MT3**	—	—	—	3	3060-5119	**57.50**	—	16	24	6 3/4	9 1/2	5 1/4†
10.0	—	0-140	**W10MT3A**	2/10	—	150	3	3060-5012	**115.00**	—	18	30	8 5/8	11 15/16	5 3/8
10.0	—	0-140	**W10MT3W**	—	300/1500	150	3	3060-5013	**150.00**	—	18	30	8 5/8	11 15/16	5 3/8
18.0	—	0-140	**W20MT3A**	20	—	150	3	3090-5012	**145.00**	—	27	34	8 5/8	11 15/16	5 3/8
20.0	—	0-140	**W20MT3**	—	—	—	3	3090-5119	**98.00**	—	20	23	8 5/8	11 15/16	5 3/8†
Single-phase, 240-volt input, 50-60 Hz															
2.0	—	0-280	**W5HMT**	—	—	—	2	3040-5118	**$ 35.00**	—	8	15	4 7/8	6 9/16	4 3/8†
4.0	—	0-280	**W10HMT**	—	—	—	2	3070-5118	**58.00**	—	15	24	6 3/4	9 1/2	5 1/4
4.0	—	0-280	**W10HMT3**	—	—	—	3	3070-5119	**60.00**	—	15	24	6 3/4	9 1/2	5 1/4
8.0	—	0-280	**W20HMT3**	—	—	—	3	3100-5119	**100.00**	—	27	35	8 5/8	11 15/16	5 3/8†
8.0	—	0-280	**W20HMT3A**	10	—	300	3	3100-5012	**145.00**	—	25	31	8 5/8	11 15/16	5 3/8

[1] 60 Hz only

Types MT and MT3 have overvoltage connections and corresponding dial scales, but can be supplied on special order with line-voltage connections and dial scales.

* Listed under Re-examination Service of Underwriters' Laboratory.

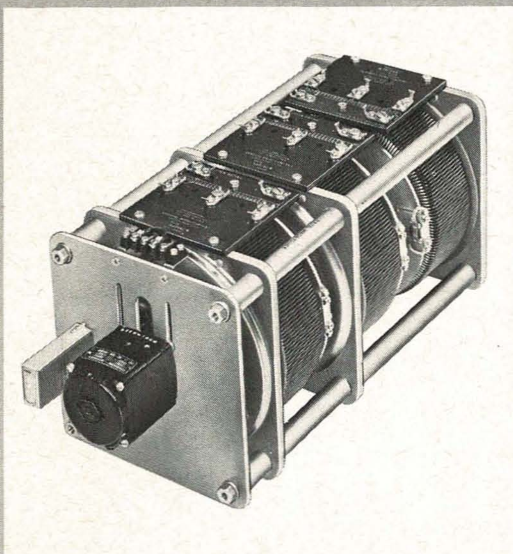
† Approved by Canadian Standards Association.

File Courtesy of GRWiki.org

VARIAC®
ADJUSTABLE AUTOTRANSFORMERS

PRICE LIST FOR MOTOR-DRIVEN VARIAC® AUTOTRANSFORMERS[1]

Ball bearings included in price



[1] Prices in table are for quantities of 5 or more. Add $12.00 prorated setup charge to quantities of 1-4.

All motor traverse times shown are for 60-Hz operation. With 50-Hz operation, times will be increased approx 20%.

All inquiries for drives not shown in table should be referred to Sales Department.

SYMBOLS FOR MOTOR-DRIVEN ATTACHMENTS

Motor Drive Only	D
Capacitor	C
Limit Switches	K
Case	M

EXAMPLE:

W5HG3D8CKM

W5H, three-gang, motor drive, 8-second sweep, capacitor, limit switches, and case. Price: $168.50 plus $12.00 Set-up charge plus $18.00 for case. Total $198.50

Dimensions: Width and height are same as for component Variac. Depth is approx 6 inches greater than that of equivalent manually operated model.

Traverse times are nominal for 60-Hz supply. Actual speeds may vary ±15% from these values. Specify speed on order (e.g. D4, D32, etc). so = Available on special order.

Ball bearings included in price shown

Seconds for 320° Traverse	2	4	8	16	32	64	128	Add for enclosure
M2	$105.50	105.50	105.50	105.50	105.50	105.50	...	...
M2G2	133.00	133.00	133.00	133.00	133.00	133.00	...	...
M2G3	...	151.50	151.50	151.50	151.50	151.50	...	...
M5	108.50	108.50	108.50	108.50	108.50	108.50	...	...
M5G2	139.00	139.00	139.00	139.00	139.00	139.00	...	...
M5G3	...	160.50	160.50	160.50	160.50	160.50	...	...
M10	149.00	149.00	149.00	149.00	149.00	149.00	149.00	...
M10G2	so	198.00	198.00	198.00	198.00	198.00	198.00	...
M10G3	so	so	238.00	238.00	238.00	238.00	238.00	...
M20	...	173.00	173.00	173.00	173.00	173.00	173.00	...
M20G2	so	so	241.00	241.00	241.00	241.00	241.00	...
M20G3	so	so	300.00	300.00	300.00	300.00	300.00	...
W2	105.00	105.00	105.00	105.00	105.00	105.00	...	$12.00
W2G2	131.00	131.00	131.00	131.00	131.00	131.00	...	13.00
W2G3	...	149.00	149.00	149.00	149.00	149.00	...	14.00
W5	108.00	108.00	108.00	108.00	108.00	108.00	...	16.00
W5G2	137.00	137.00	137.00	137.00	137.00	137.00	...	17.00
W5G3	...	158.00	158.00	158.00	158.00	158.00	...	18.00
W5H	111.50	111.50	111.50	111.50	111.50	111.50	...	16.00
W5HG2	144.00	144.00	144.00	144.00	144.00	144.00	...	17.00
W5HG3	...	168.50	168.50	168.50	168.50	168.50	...	18.00
W5L	108.00	108.00	108.00	108.00	108.00	108.00	...	16.00
W5LG2	137.00	137.00	137.00	137.00	137.00	137.00	...	17.00
W5LG3	...	158.00	158.00	158.00	158.00	158.00	...	18.00
W8	111.00	111.00	111.00	111.00	111.00	111.00	...	...
W8G2	143.00	143.00	143.00	143.00	143.00	143.00	...	...
W8G3	...	167.00	167.00	167.00	167.00	167.00	...	...
W8L	111.00	111.00	111.00	111.00	111.00	111.00	...	...
W8LG2	143.00	143.00	143.00	143.00	143.00	143.00	...	...
W8LG3	...	167.00	167.00	167.00	167.00	167.00	...	...
W10	139.00	139.00	139.00	139.00	139.00	139.00	139.00	32.00
W10G2	so	185.00	185.00	185.00	185.00	185.00	185.00	33.00
W10G3	so	so	223.00	223.00	223.00	223.00	223.00	34.00
W10H	141.00	141.00	141.00	141.00	141.00	141.00	141.00	32.00
W10HG2	so	189.00	189.00	189.00	189.00	189.00	189.00	33.00
W10HG3	so	so	229.00	229.00	229.00	229.00	229.00	34.00
W20	so	161.00	161.00	161.00	161.00	161.00	161.00	35.00
W20G2	so	so	227.00	227.00	227.00	227.00	227.00	37.00
W20G3	so	so	282.00	282.00	282.00	282.00	282.00	39.00
W20H	so	163.00	163.00	163.00	163.00	163.00	163.00	35.00
W20HG2	so	so	231.00	231.00	231.00	231.00	231.00	37.00
W20HG3	so	so	288.00	288.00	288.00	288.00	288.00	39.00
W30	so	218.00	218.00	218.00	218.00	218.00	218.00	49.00
W30G2	...	so	so	319.00	319.00	319.00	319.00	54.00
W30G3	...	...	so	so	407.50	407.50	407.50	59.00
W30G4	...	...	so	so	496.00	496.00	496.00	62.00
W30G6	...	...	so	so	693.00	693.00	693.00	68.00
W30H	so	218.00	218.00	218.00	218.00	218.00	218.00	49.00
W30HG2	...	so	so	319.00	319.00	319.00	319.00	54.00
W30HG3	...	...	so	so	407.50	407.50	407.50	59.00
W30HG4	...	...	so	so	496.00	496.00	496.00	62.00
W30HG6	...	...	so	so	693.00	693.00	693.00	68.00
W50	...	so	so	264.00	264.00	264.00	264.00	55.00
W50G2	...	...	so	so	400.00	400.00	400.00	60.00
W50G3	...	...	so	so	535.00	535.00	535.00	65.00
W50G4	...	...	so	so	so	so	674.00	68.00
W50G6	...	...	so	so	so	so	955.00	74.00
W50H	...	so	so	264.00	264.00	264.00	264.00	55.00
W50HG2	...	...	so	so	400.00	400.00	400.00	60.00
W50HG3	...	...	so	so	535.00	535.00	535.00	65.00
W50HG4	...	...	so	so	so	so	674.00	68.00
W50HG6	...	...	so	so	so	so	955.00	74.00

Not available with these models (M2 through M20G3)

Not available with these models (W8 through W8LG3)

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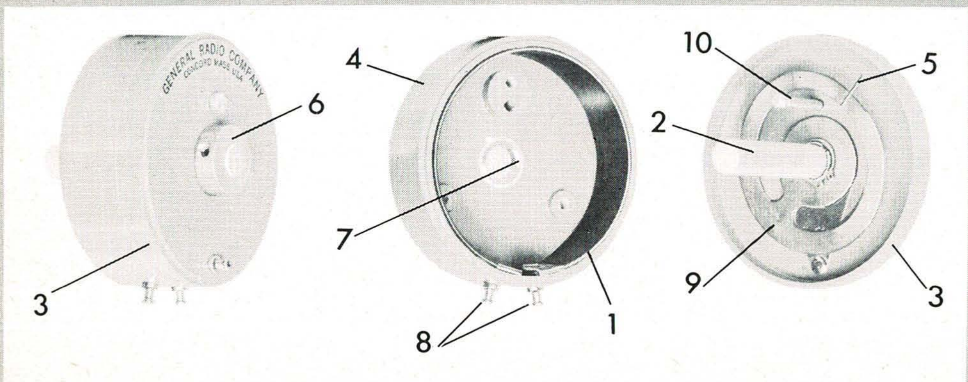
parts and accessories

POTENTIOMETERS

970-Series

These potentiometers are moderately priced controls with high-quality performance. They can be used at dc, throughout the audio- and ultrasonic-frequency ranges, and, in many applications, at low radio frequencies.



HIGH LEAKAGE RESISTANCE
LOW CAPACITANCE TO GROUND

2 Glass-reinforced-polyester shaft
3 New diallyl-phthalate dust-proof cover
4 New diallyl-phthalate body

HIGH RESOLUTION

5 Small-diameter brush of precious-metal alloy

LOW NOISE

1 Firm clean track
5 Precious-metal contact
9 Uniform contact pressure

SIMPLE MECHANICAL ADJUSTMENT
EXCELLENT MECHANICAL STABILITY
EXCELLENT REPEATABILITY

6 Projecting hub permits adjustment of shaft with respect to contact brush while case is closed. Hub rotates in a recessed brass insert molded into cover to form a metal-to-metal bearing close to plane of brush.

7 A second bearing is provided by a nylon-graphite insert to guide shaft into base.

EXCELLENT LINEARITY
LOW TEMPERATURE COEFFICIENT
LOW INDUCTANCE

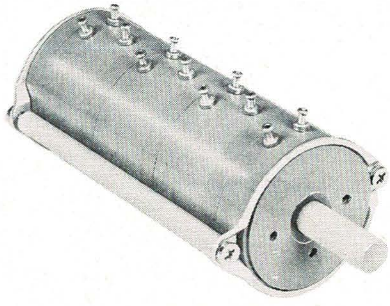
1 Uniformly wound, low-temperature coefficient resistance element on a thin, phenolic-laminate mandrel firmly cemented into body molding.

HIGH RELIABILITY

8 Turret terminals are both riveted to end of clamps and soldered to ends of winding and to silver-plated, spring-bronze contact take-off in cover so that none of the fixed internal connections depends on pressure alone.

9 Brush arm and spring are combined into a single stamping of spring-temper phosphor-bronze.

10 Screw that holds cover to base passes through a horseshoe-shaped slot in brush arm to serve as a rotational stop that exerts no force on brush.



GANGING

When ganged, the 970-Series Potentiometers retain their low-capacitance characteristics. Units are designed to be nested with molded spacing rings, stacked on a long shaft, and held together with thin metal clamping rings and tie rods. This assembly allows units to be set in any desired phase relationship.

Type	Effective Electrical Rotation	Total Mechanical Rotation	Standard Resistance Tolerance	Average Torque oz/in.	Independent Linearity %	Power Rating at 0°C ambient temp*	
						Mounted on Alum Panel	Suspended in Air
971	315° ± 5°	330° ± 5°	±5%	1¾	±2	5.6	3.5
972	315° ± 5°	330° ± 5°	±5%	1¾	±2	7.8	5.8
973	320° ± 5°	330° ± 5°	±5%	2½	±1	8.4	5.9
974	320° ± 5°	330° ± 5°	±5%	2½	±1	12.0	9.4
975	320° ± 2°	330° ± 5°	±2%	4	±0.5	13.4	10.7
976	320° ± 2°	330° ± 5°	±2%	4	±0.5	19.0	16.8

* Power rating in watts decreases linearly with rising ambient temperature to zero at 100°C.

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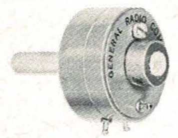
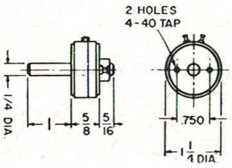
970-SERIES POTENTIOMETERS

(All dimensions in inches)

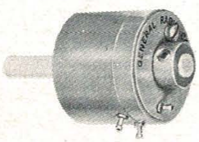
971

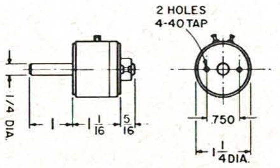




Wt: Approx ½ oz

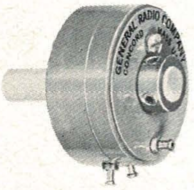
972

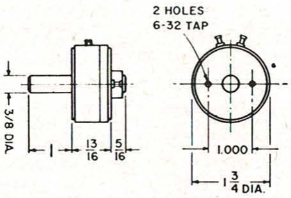




Wt: Approx ¾ oz

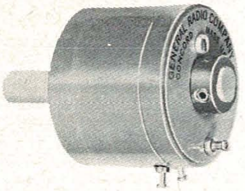
973

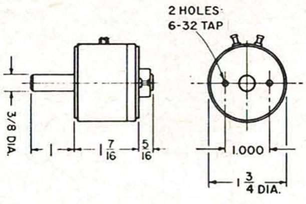




Wt: Approx 1 oz

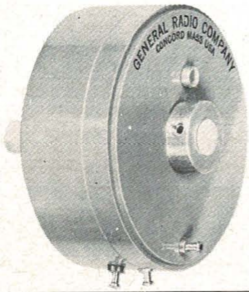
974

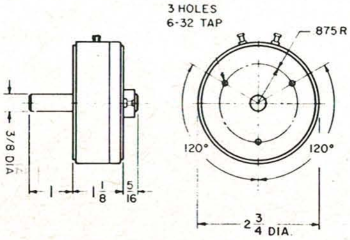




Wt: Approx 1¾ oz

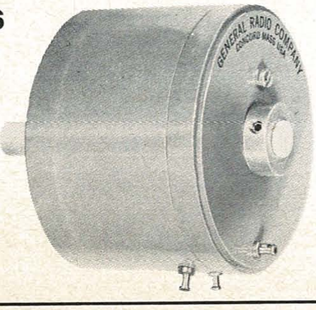
975

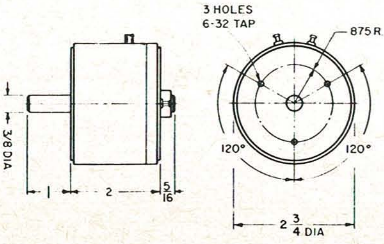




Wt: Approx 3 oz

976





Wt: Approx 4 oz

Type	Nominal Resistance Ohms	Temperature Coefficient of Resistance %	Resolution %	Catalog Number	Price in USA
971-B	2	±0.07	<1	0971-9702	$8.00
971-C	5	±0.07	<1	0971-9703	8.00
971-D	10	±0.002	<1	0971-9704	8.00
971-E	20	±0.002	<1	0971-9705	8.00
971-F	50	±0.002	<0.5	0971-9706	8.00
971-G	100	±0.002	<0.5	0971-9707	8.00
971-H	200	±0.002	<0.5	0971-9708	8.00
971-J	500	±0.002	<0.5	0971-9710	8.00
971-K	1000	±0.002	<0.5	0971-9711	8.00
971-L	2000	±0.002	<0.5	0971-9712	8.00
971-M	5000	±0.002	<0.2	0971-9713	8.25
971-N	10,000	±0.002	<0.2	0971-9714	8.25
971-P	20,000	±0.002	<0.2	0971-9716	8.50
972-F	50	±0.002	<1	0972-9706	8.00
972-G	100	±0.002	<0.5	0972-9707	8.00
972-H	200	±0.002	<0.5	0972-9708	8.00
972-J	500	±0.002	<0.5	0972-9710	8.00
972-K	1000	±0.002	<0.5	0972-9711	8.00
972-L	2000	±0.002	<0.5	0972-9712	8.00
972-M	5000	±0.002	<0.5	0972-9713	8.00
972-N	10,000	±0.002	<0.2	0972-9714	8.00
972-P	20,000	±0.002	<0.2	0972-9716	8.75
972-Q	50,000	±0.002	<0.2	0972-9717	8.75
973-C	5	±0.07	<0.5	0973-9703	8.75
973-D	10	±0.07	<0.5	0973-9704	8.75
973-E	20	±0.002	<0.5	0973-9705	8.75
973-F	50	±0.002	<0.5	0973-9706	8.75
973-G	100	±0.002	<0.5	0973-9707	8.75
973-H	200	±0.002	<0.5	0973-9708	8.75
973-J	500	±0.002	<0.2	0973-9710	8.75
973-K	1000	±0.002	<0.2	0973-9711	8.75
973-L	2000	±0.002	<0.2	0973-9712	8.75
973-M	5000	±0.002	<0.2	0973-9713	8.75
973-N	10,000	±0.002	<0.1	0973-9714	8.75
973-P	20,000	±0.002	<0.1	0973-9716	9.25
973-Q	50,000	±0.002	<0.1	0973-9717	9.25
974-D	10	±0.07	<0.5	0974-9704	9.25
974-E	20	±0.07	<0.5	0974-9705	9.25
974-F	50	±0.002	<0.5	0974-9706	9.25
974-G	100	±0.002	<0.5	0974-9707	9.25
974-H	200	±0.002	<0.5	0974-9708	9.25
974-J	500	±0.002	<0.5	0974-9710	9.25
974-K	1000	±0.002	<0.2	0974-9711	9.25
974-L	2000	±0.002	<0.2	0974-9712	9.25
974-M	5000	±0.002	<0.2	0974-9713	9.25
974-N	10,000	±0.002	<0.2	0974-9714	9.25
974-P	20,000	±0.002	<0.1	0974-9716	9.75
974-Q	50,000	±0.002	<0.1	0974-9717	9.75
974-R	100,000	±0.002	<0.1	0974-9718	11.25
975-J	500	±0.002	<0.2	0975-9710	10.00
975-K	1000	±0.002	<0.2	0975-9711	10.00
975-L	2000	±0.002	<0.2	0975-9712	10.00
975-M	5000	±0.002	<0.2	0975-9713	10.00
975-N	10,000	±0.002	<0.1	0975-9714	10.00
975-P	20,000	±0.002	<0.1	0975-9716	10.00
975-Q	50,000	±0.002	<0.05	0975-9717	11.75
975-R	100,000	±0.002	<0.05	0975-9718	11.75
976-K	1000	±0.002	<0.2	0976-9711	11.25
976-L	2000	±0.002	<0.2	0976-9712	11.25
976-M	5000	±0.002	<0.2	0976-9713	11.25
976-N	10,000	±0.002	<0.2	0976-9714	12.00
976-P	20,000	±0.002	<0.1	0976-9716	12.00
976-Q	50,000	±0.002	<0.1	0976-9717	13.00
976-R	100,000	±0.002	<0.05	0976-9718	14.25
976-T	200,000	±0.002	<0.05	0976-9720	15.25

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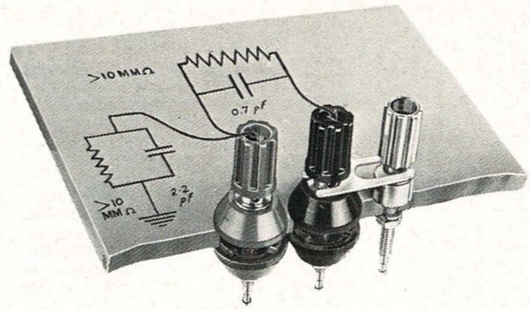
parts

BINDING POSTS

Type 938



- wide selection
  - gold-plated copper for low thermal emf or nickel-plated brass for economy
  - five colors in metal and plastic
- excellent electrical characteristics

The excellent electrical properties and ingenious mechanical design of the GR 938 Binding Posts provide all the properties needed for modern electronic instruments. Two styles are available: nickel-plated brass for economy, and gold-plated copper for high conductivity and low thermal emf with connection to copper wires. Both styles are available with either metal or insulated tops designed for easy hand-tightening, or 3/8-in., 12-point wrenches can be used for more permanent connections. The polycarbonate insulation has high insulation resistance and low dissipation factor and is available in red, black, and gray for color coding.

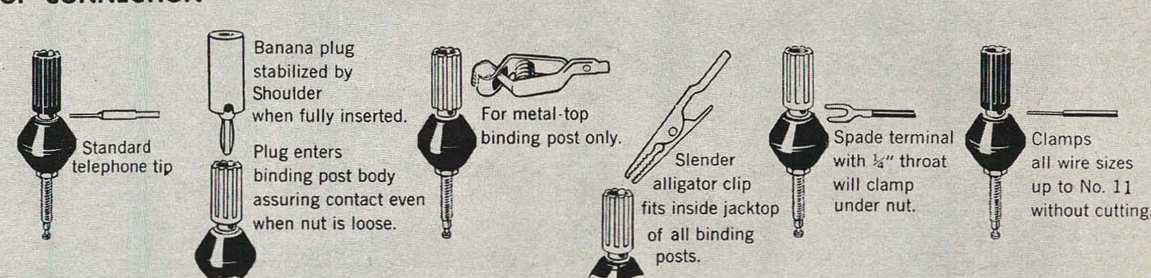
These binding posts can be mounted on metal or insulating panels of a thickness from zero to 5/16 in. A recent design improvement, reducing the diameter of the panel insulators slightly, now provides 1/16-in. clearance between insulators when the binding posts are mounted on standard 3/4-in. centers. Mechanical details and methods of connection are shown below.

The binding post has the same height above panel as the nonlocking GR874 coaxial connector, whose center contact will take a Type 274 Plug, so that a grounded binding post can be mounted adjacent to the coaxial connector to fit a Type 274-MB Double Plug.

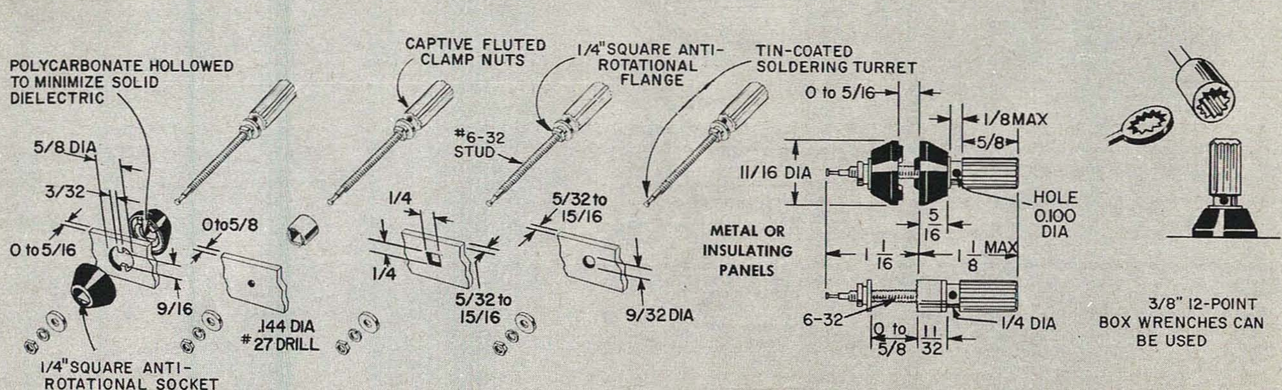
specifications

Rating: 30 A peak, 4 kV peak.
Breakdown: 10 kV peak.
Dissipation Factor: <0.0005 at 1 kHz.

METHODS OF CONNECTION



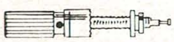
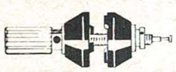
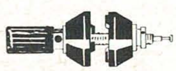
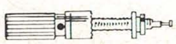
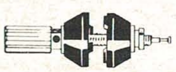
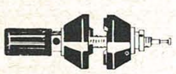
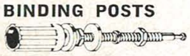
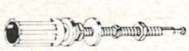
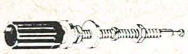
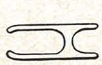
MECHANICAL DETAILS



Locking keys in 5/8-inch mounting holes can be omitted if only moderate resistance to rotation is needed.

File Courtesy of GRWiki.org

BINDING POSTS

TYPE 938 BINDING POSTS	Type	□ brass, nickel plated ■ copper, gold plated	Net Weight for 10		Catalog Number	Unit Price* in USA in Lots of			
			oz	g		10† to 99	100 to 999	1000 to 1999	2000 up
ASSEMBLIES 	938-P	**Metal Top/Spacers,** brass. Assembly of 938-A, 938-F	5	145	0938-9726	0.52	0.38	0.36	0.34
	938-W	**Metal Top/Black Insulators,** brass. Assembly of 938-A, 938-BB	5	145	0938-9743	0.60	0.41	0.38	0.35
	938-R	**Metal Top/Red Insulators,** brass. Assembly of 938-A, 938-BR	5	145	0938-9728	0.60	0.41	0.38	0.35
	938-S	**Metal Top/Gray Insulators,** brass. Assembly of 938-A, 938-BG	5	145	0938-9738	0.60	0.41	0.38	0.35
	938-WB	**Black Top/Black Insulators,** brass. Assembly of 938-C, 938-BB	4	115	0938-9872	0.75	0.52	0.49	0.45
	938-WR	**Red Top/Red Insulators,** brass. Assembly of 938-D, 938-BR	4	115	0938-9882	0.75	0.52	0.49	0.45
	938-WG	**Gray Top/Gray Insulators,** brass. Assembly of 938-B, 938-BG	4	115	0938-9892	0.75	0.52	0.49	0.45
	938-GM	**Metal Top/Spacers,** copper. Assembly of 938-G, 938-FG	6½	183	0938-9834	1.10	0.98	0.92	0.92
	938-GB	**Metal Top/Black Insulators,** copper. Assembly of 938-G, 938-BB	6½	183	0938-9842	1.10	0.92	0.86	0.86
	938-GR	**Metal Top/Red Insulators,** copper. Assembly of 938-G, 938-BR	6½	183	0938-9845	1.10	0.92	0.86	0.86
	938-GG	**Metal Top/Gray Insulators,** copper. Assembly of 938-G, 938-BG	6½	183	0938-9848	1.10	0.92	0.86	0.86
	938-HB	**Black Top/Black Insulators,** copper. Assembly of 938-H, 938-BB	5	145	0938-9852	1.00	0.83	0.78	0.78
	938-KR	**Red Top/Red Insulators,** copper. Assembly of 938-K, 938-BR	5	145	0938-9855	1.00	0.83	0.78	0.78
	938-EG	**Gray Top/Gray Insulators,** copper. Assembly of 938-E, 938-BG	5	145	0938-9858	1.00	0.83	0.78	0.78
BINDING POSTS 	938-A	**Metal-Top Binding Post,** brass	4	115	0938-9731	0.40	0.29	0.27	0.25
	938-C	**Black-Top Binding Post,** brass	3	85	0938-9733	0.55	0.40	0.38	0.35
	938-D	**Red-Top Binding Post,** brass	3	85	0938-9734	0.55	0.40	0.38	0.35
	938-B	**Gray-Top Binding Post,** brass	3	85	0938-9735	0.55	0.40	0.38	0.35
	938-G	**Metal-Top Binding Post,** copper	5½	158	0938-9707	0.90	0.80	0.75	0.75
	938-H	**Black-Top Binding Post,** copper	4	115	0938-9708	0.80	0.71	0.67	0.67
	938-K	**Red-Top Binding Post,** copper	4	115	0938-9711	0.80	0.71	0.67	0.67
	938-E	**Gray-Top Binding Post,** copper	4	115	0938-9709	0.80	0.71	0.67	0.67
INSULATORS 	938-BB	**Black Insulators,** pair	1	30	0938-9818	0.20	0.12	0.11	0.10
	938-BR	**Red Insulators,** pair	1	30	0938-9822	0.20	0.12	0.11	0.10
	938-BG	**Gray Insulators,** pair	1	30	0938-9813	0.20	0.12	0.11	0.10
	938-YB	**Double Insulators.** Interlocking bosses permit mounting on very thin panels	2	60	0938-9873	0.30	0.18	0.16	0.15
ACCESSORIES 	938-F	**Spacer,** nickel-plated brass. Square anti-rotational socket and anti-rotational teeth	1	30	0938-9706	0.12	0.09	0.09	0.09
	938-FG	**Spacer,** gold-plated brass. Square anti-rotational socket and anti-rotational teeth	1	30	0938-9830	0.20	0.18	0.17	0.17
	938-L	**Shorting Link,** nickel-plated brass. For two binding posts mounted on ¾-in. centers	1	30	0938-9712	0.10	0.09	0.09	0.09
	938-LG	**Shorting Link,** gold-plated brass. For two binding posts mounted on ¾-in. centers	1	30	0938-9503	0.25	0.22	0.20	0.20

* Net prices. No further discounts. † Minimum quantity sold.

Prices for binding-post assemblies are for shipment unassembled. When assembly and/or individual packaging before shipment is required, add 10¢ per binding post for assembly, 8¢ for packaging.

File Courtesy of GRWiki.org

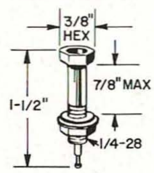
JACKS AND PLUGS

Dimensions in Inches

Unit Price† in USA in Lots of

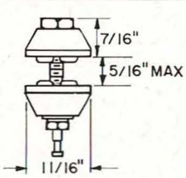
JACKS

The Type 938 Jacks also fit Type 274 Plugs. The Type 938-J Jack has a longer shank than the Type 274 Jack. The Type 938-X Jack Assembly consists of the Type 938-J Jack and Type 938-B Insulators.



938-J JACK. Fits Type 274 Plugs, has long unthreaded shank that makes it suitable for mounting in Types 938-BB, 938-BR, and 938-BG Insulators or Type 938-F Spacers. Net Weight for 10: 3 oz (85 g).

Catalog Number	10 to 99	100 to 999	1000 to 1999	2000 up
0938-9710	0.34	0.30	0.27	0.25

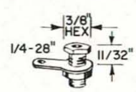


938-XB JACK ASSEMBLY, black. Net Weight for 10: 4 oz (115 g).

938-XR JACK ASSEMBLY, red.

938-XG JACK ASSEMBLY, gray.

Catalog Number	10 to 99	100 to 999	1000 to 1999	2000 up
0938-9877 (938-XB)	0.41	0.36	0.32	0.30
0938-9878 (938-XR)	0.41	0.36	0.32	0.30
0938-9879 (938-XG)	0.41	0.36	0.32	0.30

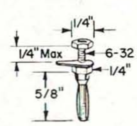


274-J JACK. Rated at 15 A, nickel-plated brass, fits Type 274 Plugs. Net Weight for 20: 3 oz (85 g).

Catalog Number	10 to 99	100 to 999	1000 to 1999	2000 up
0274-9710	—	0.09	0.08	0.07

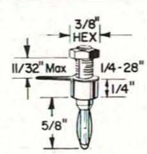
PLUGS

Type 274 Jacks and Plugs are rated at 15 amperes. Plugs have nickel-plated brass studs and beryllium copper springs. Jacks are nickel-plated brass. These plugs and jacks are designed for positive and reliable contact, typically 1 milliohm. The plug seats firmly in the jack so that the plug springs are not depended upon for mechanical stability.



274-P PLUG. Rated at 15 A, nickel-plated brass stud and beryllium copper springs, fits Type 274 and Type 938 Jacks. Net Weight for 20: 2 oz (60 g).

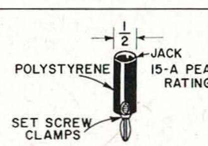
Catalog Number	10 to 99	100 to 999	1000 to 1999	2000 up
0274-9716	—	0.14	0.13	0.12



274-U PLUG. Rated at 15 A, nickel-plated brass stud and beryllium copper springs, fits Type 274 and Type 938 Jacks. Net Weight for 10: 3 oz (85 g).

Catalog Number	10 to 99	100 to 999	1000 to 1999	2000 up
0274-9721	0.30	0.26	0.23	0.22

The Type 274-DB Insulated Single Plug is a styrene-insulated plug with a jack top. A set-screw clamp is provided on the plug end.

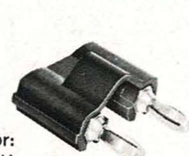


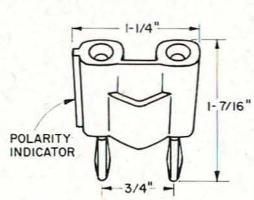
274-DB1 INSULATED SINGLE PLUG, black. Net Weight for 5: 2 oz (60 g).

274-DB2 INSULATED SINGLE PLUG, red.

Catalog Number	10 to 99	100 to 999	1000 to 1999	2000 up
0274-9454 (274-DB1)	0.50	0.44	0.39	0.39
0274-9455 (274-DB2)	0.50	0.44	0.39	0.39

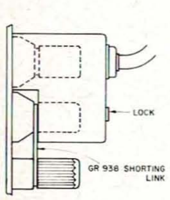
Rating:
15 A, peak;
4 kV, peak.
Breakdown:
10 kV, peak.
Dissipation Factor:
<0.0005 at 1 kHz.



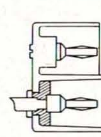


274-MB INSULATED DOUBLE PLUG. Molded styrene double-plug assembly, which fits Type 938 Binding Posts or Type 274 Jacks on standard ¾-inch spacing. Jack top permits stacking for multiple connections. A formed side strap provides strain relief for attached cables up to 0.2-inch diameter. The plug is completely insulated; for safety, all metal parts are effectively enclosed.

Catalog Number	10 to 99	100 to 999	1000 to 1999	2000 up
0274-9875	0.63	0.56	0.49	0.49



Rating:
15 A, peak;
1.2 kV, peak.
Breakdown:
3.4 kV, peak.
Dissipation Factor:
<0.0005 at 1 kHz.



274-NK SHIELDED DOUBLE PLUG. Double plug in an aluminum case for completely shielded connections to 938 Binding Posts. Accepts cables with 0.2-inch OD. Stepped case permits a 938-L(G) Shorting Link to be used between low-terminal binding post and a ground binding post without interfering with proper shielding. High terminal of double plug remains fully shielded. The 274-NK can be locked to binding posts; turning a screw expands one pin inside body of the binding post. This plug terminates the Type 274-NL, 776-A, and 874-R34 Patch Cords. Net Weight each: 3 oz (90 g).

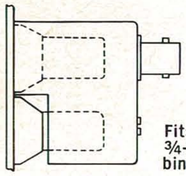
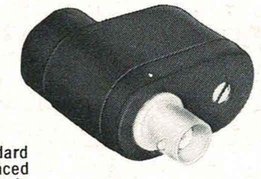
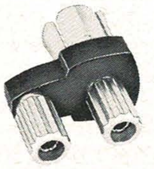
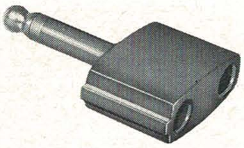
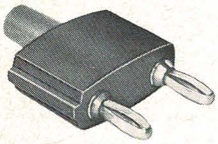
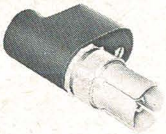
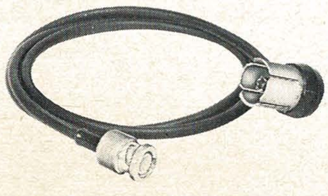
Catalog Number	10 to 99	100 to 999	1000 to 1999	2000 up
0274-9877				$1.60 each

† Net prices. No further quantity discounts.

File Courtesy of GRWiki.org

ADAPTORS AND CORDS

new

	Type		Description	Length in.	Length mm	Net Weight oz	Net Weight g	Catalog Number	Price in USA
ADAPTORS  Fits standard ¾-in.-spaced binding posts 	274-QBJ	Adaptor	Shielded banana plugs in the Type 274-QBJ Adaptor provide connection from standard ¾-inch-spaced binding posts to a type BNC Plug. The adaptor will lock onto the binding posts providing semipermanent adaptation to BNC.	—	—	3	90	0274-9884	$2.75
 Fits Type 274 Double-Plug Patch Cords	874-Q2	Adaptor	This adaptor provides connection from GR874 coaxial connectors to binding posts.	—	—	2	60	0874-9870	4.50
	777-Q1	Adaptor	The 777-Q1 contains a phone plug and two jacks with ¾-inch spacing to accept double or individual GR 274 plugs.	—	—	1	30	0777-9701	1.50
	777-Q2	Adaptor	The 777-Q2 combines, in a molded assembly, a phone jack and two GR 274 plugs with ¾-inch spacing. It thus adapts a phone plug to GR 938 Binding Posts.	—	—	1	30	0777-9702	2.25
	777-Q3	Adaptor	This adaptor provides fully shielded connection from GR874 coaxial connectors to Type 938 Binding Posts with ¾-inch spacing. Constructed like a GR 274-NK, the adaptor shares many of its features; it can be locked to binding posts by a turn of a screw for semipermanent conversion to GR874.	—	—	2	60	0777-9703	6.00
ADAPTOR CABLES 	776-A	Patch Cord	This 3-ft shielded cable will connect between a BNC jack, often found on instrument panels, and binding posts ¾-inch spaced. The cable is fitted with a BNC plug (male) and a GR 274-NK Shielded Double Plug.	36	920	3	90	0776-9701	5.00
	776-B	Patch Cord	The 776-B consists of a 3-ft shielded cable fitted with a BNC plug (male) and a GR874 coaxial connector. It is convenient for interconnecting instruments with differing connectors, i.e. GR874 and a BNC jack. A right-angle cable access to the GR874 conserves space.	36	920	3	90	0776-9702	6.50

File Courtesy of GRWiki.org

cords

CORDS

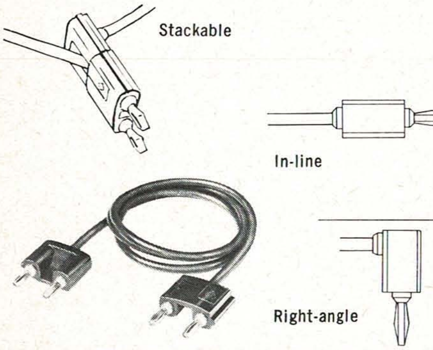
PATCH CORDS

new

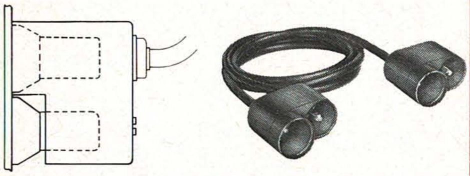
Type		Length in.	Length mm	Net Weight oz	Net Weight g	Catalog Number	Price in USA
	This 3-ft shielded cable has a BNC plug (male) on each end for interconnecting devices fitted with panel-mounted BNC jacks.						
776-C	**Patch Cord**	36	920	2	60	0776-9703	$5.00

new

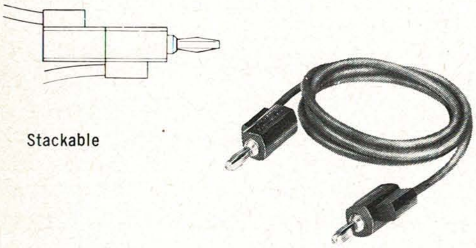
Type		Length in.	Length mm	Net Weight oz	Net Weight g	Catalog Number	Price in USA
	The 776-D Patch Cord is a shielded cable with GR874 connectors at each end. For convenience around instrument front-panel controls and space-saving rear-panel connections, the cable enters the molded GR874 connector body from the side. Not intended for high-frequency use where VSWR is a consideration.						
776-D	**Patch Cord**	36	920	2	60	0776-9704	8.00



Type		Length in.	Length mm	Net Weight oz	Net Weight g	Catalog Number	Price in USA
	The connector bodies are encapsulated first in polystyrene for its electrical properties and then in cellulose-acetate butyrate for its high-impact properties. The configuration of the connectors is such that any double plug can be connected to any other — whether in-line or right-angle.						
274-NQ	**Double-Plug Patch Cord,** in-line cord	36	920	3	85	0274-9860	3.75
274-NQM	**Double-Plug Patch Cord,** in-line cord	24	610	2	60	0274-9896	3.75
274-NQS	**Double-Plug Patch Cord,** in-line cord	12	305	1½	45	0274-9861	3.75
274-NP	**Double-Plug Patch Cord,** right-angle cord	36	920	3	85	0274-9880	3.75
274-NPM	**Double-Plug Patch Cord,** right-angle cord	24	610	2	60	0274-9892	3.75
274-NPS	**Double-Plug Patch Cord,** right-angle cord	12	305	1½	45	0274-9852	3.75

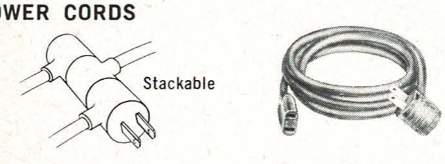


Type		Length in.	Length mm	Net Weight oz	Net Weight g	Catalog Number	Price in USA
	The Type 274-NK Shielded Double Plugs used on these cords are made of aluminum and provide strain relief for the cable.						
274-NL	**Shielded Double-Plug Patch Cord**	36	920	6	170	0274-9883	5.00
274-NLM	**Shielded Double-Plug Patch Cord**	24	610	5	145	0274-9882	5.00
274-NLS	**Shielded Double-Plug Patch Cord**	12	305	4	115	0274-9862	5.00



Type		Length in.	Length mm	Net Weight oz	Net Weight g	Catalog Number	Price in USA
	The connector bodies are encapsulated first in polystyrene for its electrical properties and then in cellulose-acetate butyrate for its high-impact properties. They include a jack for stacking, and the plugs seat firmly in jacks so that plug springs are not depended on for mechanical stability. Contact resistance is in the order of one milliohm.						
274-LLB	**Single-Plug Patch Cord,** black	36	920	1½	45	0274-9468	1.50
274-LLR	**Single-Plug Patch Cord,** red	36	920	1½	45	0274-9492	1.50
274-LMB	**Single-Plug Patch Cord,** black	18	460	1	30	0274-9847	1.50
274-LMR	**Single-Plug Patch Cord,** red	18	460	1	30	0274-9848	1.50
274-LSB	**Single-Plug Patch Cord,** black	9	230	1	30	0274-9849	1.50
274-LSR	**Single-Plug Patch Cord,** red	9	230	1	30	0274-9850	1.50

POWER CORDS



Type		Length in.	Length mm	Net Weight oz	Net Weight g	Catalog Number	Price in USA
	Made of plastic-covered number 18 conductor. Plug and connector bodies are molded integrally with the cord, and the hammerhead design permits stacking. Type SVT cord rated by Underwriters Laboratories at 7 amperes and 300 volts, rms. Female connector fits either 2-wire or 3-wire plug.						
CAP-35	**2-Wire Power Cord**	7 feet	2.14 meters	7	200	4200-9635	1.75

Type		Length in.	Length mm	Net Weight oz	Net Weight g	Catalog Number	Price in USA
	Made of plastic-covered number 18 conductor. Plug and connector bodies are molded integrally with the cord, and the hammerhead design permits stacking. Type SVT cord rated at 7 amperes and 230 volts. The connectors, designed for 125-volt operation, conform to the American Standard for Grounding Type Attachment Plug Caps and Receptacles, ASA C73.11-1963.						
CAP-22	**3-Wire Power Cord**	7 feet	2.14 meters	9	255	4200-9622	2.50

File Courtesy of GRWiki.org

RACK ADAPTORS AND SETS

Listed below are the instrument-panel extensions and hardware, supplied in complete sets, for converting bench-model instruments for mounting in standard 19-inch relay racks. In many cases, these instruments are offered in a choice of rack or bench mounting and should be ordered initially according to mounting requirements, as complete cabinets and hardware are included. When retrofitting is necessary the adaptors below should be ordered.

Instruments missing from this list may require more extensive changes than can be done by simple kits or may be unavailable for rack mounting other than by special order. In these cases, a General Radio district office or representative should be consulted.

Instrument	Height (in.)	Catalog Number		Price in USA
		Charcoal	White	
1142-A	5¼	0480-9632	0480-9832	$ 6.50
1210 + 1201 or 1203	7	0480-9986	—	12.00
1211-C	7	0480-9648	0480-9848	10.00
1211-C + 1267 or 1269	7	0481-9642	0481-9842	20.00
1211-C + 1263 or 1264	7	0481-9646	0481-9846	21.00
1212-A + 1201 or 1203	7	0480-9986	—	12.00
1215-C	7	same as 1211		
1217-C + 1201 or 1203	7	0480-9986	—	12.00
1218-B	7	0481-9642	0481-9842	20.00
1218-B + 1267 or 1269	7	0481-9646	0481-9846	21.00
1218-B + 1263 or 1264	14	0482-9642	0482-9842	24.00
1232-A	5¼	0480-9638	0480-9838	7.00
1232-A + 1311	5¼	0480-9636	0480-9836	6.00
1232-A + 1232-P1 + 1311	5¼	0480-9337	0480-9837	6.00
1240-A	5¼	0480-9636	0480-9836	6.00
1240-AP	5¼	0480-9337	0480-9837	6.00
1241-9701, 1241-9703	7	0480-9660	0480-9670	7.00
1241-9705	14	0480-9661 and 0480-9648	0480-9671 and 0480-9848	8.00 10.00
1236	7	0480-9648	0480-9848	10.00
1236 with oscillator	7	see 1241's		
1263	7	0480-9648	0480-9848	10.00
1264	7	0480-9648	0480-9848	10.00
1309-A	5¼	0480-9638	0480-9838	7.00
1310-A	5¼	0480-9638	0480-9838	7.00
1311	5¼	0480-9638	0480-9838	7.00
1311 + 1232-A	5¼	0480-9636	0480-9836	6.00
1311 + 1232-A + 1232-P1	5¼	0480-9337	0480-9837	6.00
1361-A	7	same as 1211-C		
1362	7	same as 1211-C		
1363	7	same as 1211-C		
1381	3½	—	0480-9722	23.00
1382	3½	—	0480-9722	23.00
1390-B	7	0480-9642	0480-9842	7.00
1396-A	5¼	0480-9638	—	7.00
1396-B	5¼	—	0480-9723	22.00
1397-A	5¼	0480-9634	0480-9834	6.00
1398-A	5¼	0480-9632	0480-9832	6.50
1398-A + 1398-P1	5¼	0480-9337	0480-9837	6.00
1433 4-dial	3½	—	0480-2080	8.00
5-dial	3½	—	0480-2060	8.00
6-dial	3½	—	0480-2020	8.00
7-dial	5¼	—	0480-2091	8.00
1491-A, -B, -C	8¾	—	0480-9715	25.00
-D, -F, -G	8¾	—	0480-9705	20.00
1455 4-dial	3½	0480-2070	0480-2060	8.00
5-dial	3½	0480-2010	0480-2020	8.00
1840-A	3½	0480-9622	0480-9822	6.00

File Courtesy of GRWiki.org

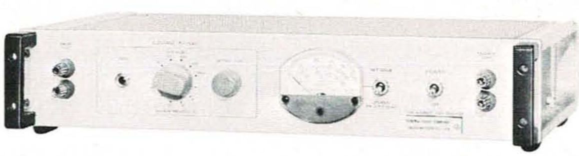
CABINETS AND MOUNTING

General Radio instrument cabinets are rugged, attractive, and versatile. Heavy-gauge aluminum and tough finishes combine to keep GR instruments operating and looking like new through many years of hard service.

We use four basic cabinet types: (1) rack and bench cabinets, with standard 19-inch rack-width panels and optional bench or rack-mounts, (2) Flip-Tilt cases, for portable instruments, (3) convertible-bench cabinets, for smaller laboratory instruments, and (4) lab-bench cabinets, for laboratory standards, decade boxes, and similar instruments.

PEDESTAL CABINET

RACKABLE CABINET



RACK-BENCH CABINET
For bench use, the rack-bench cabinet is equipped with aluminum end frames.

RACK-BENCH INSTRUMENTS

General Radio instruments with 19-inch-wide front panels are supplied in a choice of mounting for either relay-rack installation or for use on a bench where portability counts. All cabinets, whether for rack or bench use, are effective shields preventing mutual interference with other nearby instruments.

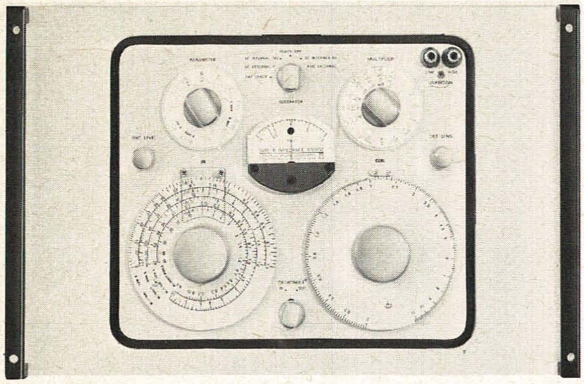
Newer instrument models are mounted in either a "pedestal" cabinet for bench use or a "rackable" cabinet, each specifically designed for its particular function. The pedestal cabinet raises instrument slightly on a recessed pedestal that not only provides a handhold for lifting, but, in smaller instruments, is the base for a tilting mechanism and inside, provides storage space for instruction manuals and small accessories. For convenient carrying, larger instruments and assemblies in the pedestal cabinet have hinged heavy-duty handles recessed into the sides near the top of the cabinet. Slides in both pedestal and rackable cabinets permit easy removal for servicing. The rackable cabinet has all the provisions for mounting the instrument in a standard 19-inch relay rack with universal mounting-hole spacing per EIA Standard RS-310 and includes rear-support brackets as well.

Many instruments with 19-inch panels are supplied in the easily converted rack-bench cabinet. For rack mounting, the addition of side-support hardware allows the in-

Locked closed, with accessories and instruction manual inside, the instrument is well protected against damage by the Flip-Tilt case.

Flip-Tilt case in one of its many operating positions. Rubber gasket provides friction to allow almost any tilt angle.

File Courtesy of GRWiki.org



Another of the many faces of the versatile Flip-Tilt, which here has traded cover and handle for a rack adaptor panel.

strument cabinet to be mounted in a rack and act as a drawer slide. The same cabinet becomes the bench version by the substitution of end frames for the side supports. These end frames act as carrying handles and feet, and permit several similarly equipped instruments to be stacked and bolted together without additional hardware.

FLIP-TILT CASES

General Radio's exclusive Flip-Tilt case includes three main parts: the instrument cabinet, a captive cover, and a carrying-handle and lever assembly. When the instrument is closed for storage or transit, the cover is locked in place over the front panel by means of slide-buttons and latches on the carrying handle. To open the cabinet, the user slides the buttons out of the latches and pushes down on the carrying handle. The lever action of the handle raises the cabinet from the cover. The cabinet is then easily flipped into position for operation. The operating position may be fully open and locked squarely in the cover or tilted at almost any angle. A rubber seal around the edge of the cover provides friction to hold the cabinet in the tilted position. When the instrument is closed, the same gasket provides a tight seal for the enclosure. Accessories and instruction manual are conveniently stored in the Flip-Tilt cover.

Certain Flip-Tilt instruments are also available in standard relay-rack cabinets; most other Flip-Tilt instruments are available adapted for rack mounting. In such adaptations, the Flip-Tilt case (minus cover and handle) is neatly and securely mounted in a relay-rack adaptor panel.

CONVERTIBLE-BENCH CABINETS

Small and medium-sized instruments commonly used on the bench are housed in GR's unique convertible-bench cabinet, designed primarily for the bench but offering quick relay-rack adaptability.

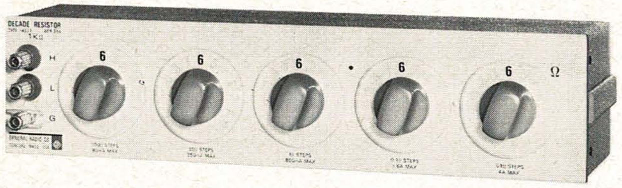
The convertible-bench cabinet is made of sturdy aluminum finished in GR medium gray wrinkle. The dust cover can be readily removed.

Instruments with panel meters can be tilted to the most convenient angle.

Conversion for relay-rack mounting is easy: matching panel extensions are simply attached by means of screws to the instrument and to the relay rack.

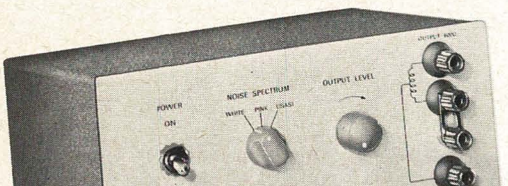
LAB-BENCH CABINETS

Lab-bench cabinets are simple enclosures used primarily for laboratory standards and decade boxes. Two U-shaped pieces of ⅛-inch extruded aluminum are strip-locked together to form the sides, and an aluminum bottom plate and $\frac{3}{16}$-inch aluminum panel complete the enclosure. The result is a cabinet well shielded, structurally solid, and efficiently manufactured.



LAB-BENCH CABINET

Two aluminum extrusions are strip-locked together to form the sides, heavy aluminum panel and bottom plate are added, and this precision capacitor is given the excellent shielding and trim appearance of the lab-bench cabinet.



Convertible-bench instruments with meters tilt on extendible bail for easy viewing of front panel. Panel extensions are used for rack mount.

OTHER CABINETS

While most General Radio instruments are housed in the five cabinets described above, several other types of mounting are used to serve the special demands of various instruments. These range from the pocket-sized cases used for certain portable sound-measuring instruments to the specialized structures of a slotted line or an admittance meter.

Accessory mounting hardware, such as end frames, relay-rack supports, and relay-rack adaptor panels, may be ordered separately by those customers wishing to convert from one type of mounting to another. Many of these accessories are listed along with the related instruments. Further information on such hardware, dimensions, etc., is available on request.

File Courtesy of GRWiki.org

ABBREVIATIONS, SYMBOLS AND PREFIXES

In this catalog, as in other General Radio publications, our use of symbols, prefixes, and abbreviations follows the recommendations of the International Electrotechnical Commission, the American Standards Association, the Institute of Electrical and Electronics Engineers, and other scientific and engineering organizations. Where there is not agreement among these groups, we generally choose the usage favored by the majority.

ABBREVIATIONS AND SYMBOLS

A	ampere
ac	alternating current
aF	attofarad
afc	automatic frequency control
a-m	amplitude modulation
ASTM	American Society for Testing Materials
avc	automatic volume control
avg	average
B	susceptance
BCD	binary-coded decimal
C	capacitance
C	Celsius (Centigrade)
CIF	cost, insurance, freight
cm	centimeter
COD	cash on delivery
cw	continuous wave
D	dissipation factor
dB	decibel
dBm	decibel referred to one milliwatt
dc	direct current
dia	diameter
DTL	diode-transistor logic
E	voltage
EIA	Electronics Industries Association
emf	electromotive force
F	farad, Fahrenheit
f	frequency
fm	frequency modulation
FOB	free on board
G	conductance
g	gram, gravitational constant
GHz	gigahertz
g_m	transconductance
H	henry
h	hour
hf	high frequency
h_f	forward current-transfer ratio
h_i	short-circuit input impedance
h_o	open-circuit output admittance
h_r	reverse voltage-transfer ratio
Hz	hertz (cycle per second)
I	current
ID	inside diameter
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
i-f	intermediate frequency
in.	inch
ISO	International Standards Organization
j	$\sqrt{-1}$
kHz	kilohertz
kV	kilovolt
kVA	kilovoltampere
kW	kilowatt
kΩ	kilohm
L	inductance
lb	pound
LC	inductance-capacitance
log	logarithm
m	meter
mA	milliampere
max	maximum
mbar	millibar
MHz	megahertz
mH	millihenry
mil	0.001 inch
min	minimum, minute
mm	millimeter
mV	millivolt
mW	milliwatt
m℧	millimho
mΩ	milliohm
MΩ	megohm
N	newton
ns	nanosecond
n℧	nanomho
oz	ounce
p	page, parallel (as L_p)
PF	power factor
pF	picofarad
ppm	parts per million
pps	pulses per second
pk-pk	peak-to-peak
PRF	pulse repetition frequency
Q	quality factor (storage factor
R	resistance
®	registered trademark
rad	radian
RC	resistance-capacitance
re	referred to
rf	radio frequency
RH	relative humidity
rms	root-mean-square
rpm	revolutions per minute
s	second, series (as L_s)
shf	super high frequency
sq	square
sync	synchronous, synchronizing
T	period
t	time
uhf	ultra high frequency
USASI	United States of America Standards Institute
v	velocity
V	volt
VA	volt ampere
vhf	very high frequency
vlf	very low frequency
W	watt
wt	weight
X	reactance
Y	admittance
Z	impedance
α	short-circuit forward current-transfer ratio (common base)
β	short-circuit forward-current-transfer ratio (common emitter)
Γ	reflection coefficient
Δ	increment
δ	loss angle
θ	phase angle
λ	wavelength
μA	microampere
μbar	microbar
μF	microfarad
μH	microhenry
μs	microsecond
μV	microvolt
Ω	ohm
℧	mho
ω	angular velocity ($2\pi f$)

PREFIXES

Orders of magnitude from 10^{-18} to 10^{12} are designated by the following prefixes:

Order	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

File Courtesy of GRWiki.org

DECIBEL CONVERSION TABLES

In communications systems the ratio between any two amounts of electric or acoustic power is usually expressed in units on a logarithmic scale. The decibel (1/10th of the bel) on the briggsian or base-10 scale and the neper on the napierian or base-e scale are in almost universal use for this purpose.

Since voltage and current are related to power by impedance, both the decibel and the neper can be used to express voltage and current ratios, if care is taken to account for the impedances associated with them. In a similar manner the corresponding acoustical quantities can be compared.

From Table I and Table II on the following pages conversions can be made in either direction between the number of decibels and the corresponding power, voltage, and current ratios. Both tables can also be used for nepers by application of a conversion factor.

Decibel — The number of decibels N_{dB} corresponding to the ratio between two amounts of power P_1 and P_2 is

$$N_{dB} = 10 \log_{10} \frac{P_1}{P_2}$$

When two voltages E_1 and E_2 or two currents I_1 and I_2 operate in identical impedances,

$$N_{dB} = 20 \log_{10} \frac{E_1}{E_2} \quad \text{and} \quad N_{dB} = 20 \log_{10} \frac{I_1}{I_2}.$$

If E_1 and E_2 and I_1 and I_2 operate in unequal impedances,

$$N_{dB} = 20 \log_{10} \frac{E_1}{E_2} + 10 \log_{10} \frac{Z_2}{Z_1} + 10 \log_{10} \frac{k_1}{k_2}$$

and $$N_{dB} = 20 \log_{10} \frac{I_1}{I_2} + 10 \log_{10} \frac{Z_1}{Z_2} + 10 \log_{10} \frac{k_1}{k_2},$$

where Z_1 and Z_2 are the absolute magnitudes of the corresponding impedances and k_1 and k_2 are the values of power factor for the impedances. E_1, E_2, I_1, and I_2 are also the absolute magnitudes of the corresponding quantities. Note that Table I and Table II can be used to evaluate the impedance and power factor terms, since both are similar to the expression for power ratio.

Neper — The number of nepers N_{nep} corresponding to a power ratio $\frac{P_1}{P_2}$ is

$$N_{nep} = \frac{1}{2} \log_e \frac{P_1}{P_2}.$$

For voltage ratios $\frac{E_1}{E_2}$ or current ratios $\frac{I_1}{I_2}$ working in identical impedances,

$$N_{nep} = \log_e \frac{E_1}{E_2} \quad \text{and} \quad N_{nep} = \log_e \frac{I_1}{I_2}.$$

Relations Between Decibels and Nepers

Multiply decibels by 0.1151 to find nepers
multiply nepers by 8.686 to find decibels

TO FIND VALUES OUTSIDE THE RANGE OF CONVERSION TABLES

Table I: Decibels to Voltage and Power Ratios

Number of decibels positive (+): Subtract +20 decibels successively from the given number of decibels until the remainder falls within range of Table I. To find the voltage ratio, multiply the corresponding value from the right-hand voltage-ratio column by 10 for each time you subtracted 20 dB. To find the power ratio, multiply the corresponding value from the right-hand power-ratio column by 100 for each time you subtracted 20 dB.

Example — Given: 49.2 dB
49.2 dB − 20 dB − 20 dB = 9.2 dB

Voltage ratio: 9.2 dB ⟶ 2.884
2.884 × 10 × 10 = 288.4

Power ratio: 9.2 dB ⟶ 8.318
8.318 × 100 × 100 = 83180

Number of decibels negative (−): Add +20 decibels successively to the given number of decibels until the sum falls within the range of Table I. For the voltage ratio, divide the value from the left-hand voltage-ratio column by 10 for each time you added 20 dB. For the power ratio, divide the value from the left-hand power-ratio column by 100 for each time you added 20 dB.

Example — Given: −49.2 dB
+49.2 dB + 20 dB + 20 dB = −9.2 dB

Voltage ratio: −9.2 dB ⟶ 0.3467
0.3467 × 1/10 × 1/10 = 0.003467

Power ratio: −9.2 dB ⟶ 0.1202
0.1202 × 1/100 × 1/100 = 0.00001202

Table II: Voltage Ratios to Decibels

For ratios smaller than those in table — Multiply the given ratio by 10 successively until the product can be found in the table. From the number of decibels thus found, subtract +20 decibels for each time you multiplied by 10.

Example — Given: Voltage ratio = 0.0131
0.0131 × 10 × 10 = 1.31

From Table II, 1.31 ⟶ 2.345 dB
2.345 dB − 20 dB − 20 dB = −37.655 dB

For ratios greater than those in table — Divide the given ratio by 10 successively until the remainder can be found in the table. To the number of decibels thus found, add +20 dB for each time you divided by 10.

Example — Given: Voltage ratio = 712
712 × 1/10 × 1/10 = 7.12

From Table II, 7.12 ⟶ 17.050 dB
17.050 dB + 20 dB + 20 dB = 57.050 dB

File Courtesy of GRWiki.org

TABLE I

GIVEN: Decibels — **TO FIND: Power and {Voltage / Current} Ratios**

TO ACCOUNT FOR THE SIGN OF THE DECIBEL

For positive (+) values of the decibel — Both voltage and power ratios are greater than unity. Use the two right-hand columns.

For negative (−) values of the decibel — Both voltage and power ratios are less than unity. Use the two left-hand columns.

Example — *Given:* ±9.1 dB; *Find:*

	Power Ratio	*Voltage Ratio*
+9.1 dB	8.128	2.851
−9.1 dB	0.1230	0.3508

Voltage Ratio (−dB)	*Power Ratio* (−dB)	*dB*	*Voltage Ratio* (+dB)	*Power Ratio* (+dB)
1.0000	**1.0000**	**0**	**1.000**	**1.000**
.9886	.9772	.1	1.012	1.023
.9772	.9550	.2	1.023	1.047
.9661	.9333	.3	1.035	1.072
.9550	.9120	.4	1.047	1.096
.9441	.8913	.5	1.059	1.122
.9333	.8710	.6	1.072	1.148
.9226	.8511	.7	1.084	1.175
.9120	.8318	.8	1.096	1.202
.9016	.8128	.9	1.109	1.230
.8913	**.7943**	**1.0**	**1.122**	**1.259**
.8810	.7762	1.1	1.135	1.288
.8710	.7586	1.2	1.148	1.318
.8610	.7413	1.3	1.161	1.349
.8511	.7244	1.4	1.175	1.380
.8414	.7079	1.5	1.189	1.413
.8318	.6918	1.6	1.202	1.445
.8222	.6761	1.7	1.216	1.479
.8128	.6607	1.8	1.230	1.514
.8035	.6457	1.9	1.245	1.549
.7943	**.6310**	**2.0**	**1.259**	**1.585**
.7852	.6166	2.1	1.274	1.622
.7762	.6026	2.2	1.288	1.660
.7674	.5888	2.3	1.303	1.698
.7586	.5754	2.4	1.318	1.738
.7499	.5623	2.5	1.334	1.778
.7413	.5495	2.6	1.349	1.820
.7328	.5370	2.7	1.365	1.862
.7244	.5248	2.8	1.380	1.905
.7161	.5129	2.9	1.396	1.950
.7079	**.5012**	**3.0**	**1.413**	**1.995**
.6998	.4898	3.1	1.429	2.042
.6918	.4786	3.2	1.445	2.089
.6839	.4677	3.3	1.462	2.138
.6761	.4571	3.4	1.479	2.188
.6683	.4467	3.5	1.496	2.239
.6607	.4365	3.6	1.514	2.291
.6531	.4266	3.7	1.531	2.344
.6457	.4169	3.8	1.549	2.399
.6383	.4074	3.9	1.567	2.455
.6310	**.3981**	**4.0**	**1.585**	**2.512**
.6237	.3890	4.1	1.603	2.570
.6166	.3802	4.2	1.622	2.630
.6095	.3715	4.3	1.641	2.692
.6026	.3631	4.4	1.660	2.754
.5957	.3548	4.5	1.679	2.818
.5888	.3467	4.6	1.698	2.884
.5821	.3388	4.7	1.718	2.951
.5754	.3311	4.8	1.738	3.020
.5689	.3236	4.9	1.758	3.090

Voltage Ratio (−dB)	*Power Ratio* (−dB)	*dB*	*Voltage Ratio* (+dB)	*Power Ratio* (+dB)
.5623	**3162**	**5.0**	**1.778**	**3.162**
.5559	.3090	5.1	1.799	3.236
.5495	.3020	5.2	1.820	3.311
.5433	.2951	5.3	1.841	3.388
.5370	.2884	5.4	1.862	3.467
.5309	.2818	5.5	1.884	3.548
.5248	.2754	5.6	1.905	3.631
.5188	.2692	5.7	1.928	3.715
.5129	.2630	5.8	1.950	3.802
.5070	.2570	5.9	1.972	3.890
.5012	**.2512**	**6.0**	**1.995**	**3.981**
.4955	.2455	6.1	2.018	4.074
.4898	.2399	6.2	2.042	4.169
.4842	.2344	6.3	2.065	4.266
.4786	.2291	6.4	2.089	4.365
.4732	.2239	6.5	2.113	4.467
.4677	.2188	6.6	2.138	4.571
.4624	.2138	6.7	2.163	4.677
.4571	.2089	6.8	2.188	4.786
.4519	.2042	6.9	2.213	4.898
.4467	**.1995**	**7.0**	**2.239**	**5.012**
.4416	.1950	7.1	2.265	5.129
.4365	.1905	7.2	2.291	5.248
.4315	.1862	7.3	2.317	5.370
.4266	.1820	7.4	2.344	5.495
.4217	.1778	7.5	2.371	5.623
.4169	.1738	7.6	2.399	5.754
.4121	.1698	7.7	2.427	5.888
.4074	.1660	7.8	2.455	6.026
.4027	.1622	7.9	2.483	6.166
.3981	**.1585**	**8.0**	**2.512**	**6.310**
.3936	.1549	8.1	2.541	6.457
.3890	.1514	8.2	2.570	6.607
.3846	.1479	8.3	2.600	6.761
.3802	.1445	8.4	2.630	6.918
.3758	.1413	8.5	2.661	7.079
.3715	.1380	8.6	2.692	7.244
.3673	.1349	8.7	2.723	7.413
.3631	.1318	8.8	2.754	7.586
.3589	.1288	8.9	2.786	7.762
.3548	**.1259**	**9.0**	**2.818**	**7.943**
.3508	.1230	9.1	2.851	8.128
.3467	.1202	9.2	2.884	8.318
.3428	.1175	9.3	2.917	8.511
.3388	.1148	9.4	2.951	8.710
.3350	.1122	9.5	2.985	8.913
.3311	.1096	9.6	3.020	9.120
.3273	.1072	9.7	3.055	9.333
.3236	.1047	9.8	3.090	9.550
.3199	.1023	9.9	3.126	9.772

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TABLE I (continued)

Voltage Ratio ← dB	Power Ratio ← dB	dB	Voltage Ratio dB →	Power Ratio dB →
.3162	**.1000**	**10.0**	**3.162**	**10.000**
.3126	.09772	10.1	3.199	10.23
.3090	.09550	10.2	3.236	10.47
.3055	.09333	10.3	3.273	10.72
.3020	.09120	10.4	3.311	10.96
.2985	.08913	10.5	3.350	11.22
.2951	.08710	10.6	3.388	11.48
.2917	.08511	10.7	3.428	11.75
.2884	.08318	10.8	3.467	12.02
.2851	.08128	10.9	3.508	12.30
.2818	**.07943**	**11.0**	**3.548**	**12.59**
.2786	.07762	11.1	3.589	12.88
.2754	.07586	11.2	3.631	13.18
.2723	.07413	11.3	3.673	13.49
.2692	.07244	11.4	3.715	13.80
.2661	.07079	11.5	3.758	14.13
.2630	.06918	11.6	3.802	14.45
.2600	.06761	11.7	3.846	14.79
.2570	.06607	11.8	3.890	15.14
.2541	.06457	11.9	3.936	15.49
2512	**.06310**	**12.0**	**3.981**	**15.85**
.2483	.06166	12.1	4.027	16.22
.2455	.06026	12.2	4.074	16.60
.2427	.05888	12.3	4.121	16.98
.2399	.05754	12.4	4.169	17.38
.2371	.05623	12.5	4.217	17.78
.2344	.05495	12.6	4.266	18.20
.2317	.05370	12.7	4.315	18.62
.2291	.05248	12.8	4.365	19.05
.2265	.05129	12.9	4.416	19.50
.2239	**.05012**	**13.0**	**4.467**	**19.95**
.2213	.04898	13.1	4.519	20.42
.2188	.04786	13.2	4.571	20.89
.2163	.04677	13.3	4.624	21.38
.2138	.04571	13.4	4.677	21.88
.2113	.04467	13.5	4.732	22.39
.2089	.04365	13.6	4.786	22.91
.2065	.04266	13.7	4.842	23.44
.2042	.04169	13.8	4.898	23.99
.2018	.04074	13.9	4.955	24.55
.1995	**.03981**	**14.0**	**5.012**	**25.12**
.1972	.03890	14.1	5.070	25.70
.1950	.03802	14.2	5.129	26.30
.1928	.03715	14.3	5.188	26.92
.1905	.03631	14.4	5.248	27.54
.1884	.03548	14.5	5.309	28.18
.1862	.03467	14.6	5.370	28.84
.1841	.03388	14.7	5.433	29.51
.1820	.03311	14.8	5.495	30.20
.1799	.03236	14.9	5.559	30.90
.1778	**.03162**	**15.0**	**5.623**	**31.62**
.1758	.03090	15.1	5.689	32.36
.1738	.03020	15.2	5.754	33.11
.1718	.02951	15.3	5.821	33.88
.1698	.02884	15.4	5.888	34.67
.1679	.02818	15.5	5.957	35.48
.1660	.02754	15.6	6.026	36.31
.1641	.02692	15.7	6.095	37.15
.1622	.02630	15.8	6.166	38.02
.1603	.02570	15.9	6.237	38.90

Voltage Ratio ← dB	Power Ratio ← dB	dB	Voltage Ratio dB →	Power Ratio dB →
.1585	**.02512**	**16.0**	**6.310**	**39.81**
.1567	.02455	16.1	6.383	40.74
.1549	.02399	16.2	6.457	41.69
.1531	.02344	16.3	6.531	42.66
.1514	.02291	16.4	6.607	43.65
.1496	.02239	16.5	6.683	44.67
.1479	.02188	16.6	6.761	45.71
.1462	.02138	16.7	6.839	46.77
.1445	.02089	16.8	6.918	47.86
.1429	.02042	16.9	6.998	48.98
.1413	**.01995**	**17.0**	**7.079**	**50.12**
.1396	.01950	17.1	7.161	51.29
.1380	.01905	17.2	7.244	52.48
.1365	.01862	17.3	7.328	53.70
.1349	.01820	17.4	7.413	54.95
.1334	.01778	17.5	7.499	56.23
.1318	.01738	17.6	7.586	57.54
.1303	.01698	17.7	7.674	58.88
.1288	.01660	17.8	7.762	60.26
.1274	.01622	17.9	7.852	61.66
.1259	**.01585**	**18.0**	**7.943**	**63.10**
.1245	.01549	18.1	8.035	64.57
.1230	.01514	18.2	8.128	66.07
.1216	.01479	18.3	8.222	67.61
.1202	.01445	18.4	8.318	69.18
.1189	.01413	18.5	8.414	70.79
.1175	.01380	18.6	8.511	72.44
.1161	.01349	18.7	8.610	74.13
.1148	.01318	18.8	8.710	75.86
.1135	.01288	18.9	8.811	77.62
.1122	**.01259**	**19.0**	**8.913**	**79.43**
.1109	.01230	19.1	9.016	81.28
.1096	.01202	19.2	9.120	83.18
.1084	.01175	19.3	9.226	85.11
.1072	.01148	19.4	9.333	87.10
.1059	.01122	19.5	9.441	89.13
.1047	.01096	19.6	9.550	91.20
.1035	.01072	19.7	9.661	93.33
.1023	.01047	19.8	9.772	95.50
.1012	.01023	19.9	9.886	97.72
.1000	**.01000**	**20.0**	**10.000**	**100.00**

Voltage Ratio ← dB	Power Ratio ← dB	dB	Voltage Ratio dB →	Power Ratio dB →
3.162×10^{-1}	**10^{-1}**	**10**	**3.162**	**10**
10^{-1}	10^{-2}	20	10	10^{2}
3.162×10^{-2}	10^{-3}	30	3.162×10	10^{3}
10^{-2}	10^{-4}	40	10^{2}	10^{4}
3.162×10^{-3}	10^{-5}	50	3.162×10^{2}	10^{5}
10^{-3}	10^{-6}	60	10^{3}	10^{6}
3.162×10^{-4}	10^{-7}	70	3.162×10^{3}	10^{7}
10^{-4}	10^{-8}	80	10^{4}	10^{8}
3.162×10^{-5}	10^{-9}	90	3.162×10^{4}	10^{9}
10^{-5}	**10^{-10}**	**100**	**10^{5}**	**10^{10}**

To find decibel values outside the range of this table, see page 273.

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TABLE II

GIVEN: {Voltage / Current} Ratio **TO FIND: Decibels**

POWER RATIOS

To find the number of decibels corresponding to a given power ratio — Assume the given power ratio to be a voltage ratio and find the corresponding number of decibels from the table. The desired result is exactly one-half of the number of decibels thus found.

Example— *Given:* a power ratio of 3.41.

Find: 3.41 in the table:

3.41 → 10.655 dB (voltage)
10.655 dB × ½ = 5.328 dB (power)

Voltage Ratio	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
1.0	**.000**	**.086**	**.172**	**.257**	**.341**	**.424**	**.506**	**.588**	**.668**	**.749**
1.1	.828	.906	.984	1.062	1.138	1.214	1.289	1.364	1.438	1.511
1.2	1.584	1.656	1.727	1.798	1.868	1.938	2.007	2.076	2.144	2.212
1.3	2.279	2.345	2.411	2.477	2.542	2.607	2.671	2.734	2.798	2.860
1.4	2.923	2.984	3.046	3.107	3.167	3.227	3.287	3.346	3.405	3.464
1.5	3.522	3.580	3.637	3.694	3.750	3.807	3.862	3.918	3.973	4.028
1.6	4.082	4.137	4.190	4.244	4.297	4.350	4.402	4.454	4.506	4.558
1.7	4.609	4.660	4.711	4.761	4.811	4.861	4.910	4.959	5.008	5.057
1.8	5.105	5.154	5.201	5.249	5.296	5.343	5.390	5.437	5.483	5.529
1.9	5.575	5.621	5.666	5.711	5.756	5.801	5.845	5.889	5.933	5.977
2.0	**6.021**	**6.064**	**6.107**	**6.150**	**6.193**	**6.235**	**6.277**	**6.319**	**6.361**	**6.403**
2.1	6.444	6.486	6.527	6.568	6.608	6.649	6.689	6.729	6.769	6.809
2.2	6.848	6.888	6.927	6.966	7.008	7.044	7.082	7.121	7.159	7.197
2.3	7.235	7.272	7.310	7.347	7.384	7.421	7.458	7.495	7.532	7.568
2.4	7.604	7.640	7.676	7.712	7.748	7.783	7.819	7.854	7.889	7.924
2.5	7.959	7.993	8.028	8.062	8.097	8.131	8.165	8.199	8.232	8.266
2.6	8.299	8.333	8.366	8.399	8.432	8.465	8.498	8.530	8.563	8.595
2.7	8.627	8.659	8.691	8.723	8.755	8.787	8.818	8.850	8.881	8.912
2.8	8.943	8.974	9.005	9.036	9.066	9.097	9.127	9.158	9.188	9.218
2.9	9.248	9.278	9.308	9.337	9.367	9.396	9.426	9.455	9.484	9.513
3.0	**9.542**	**9.571**	**9.600**	**9.629**	**9.657**	**9.686**	**9.714**	**9.743**	**9.771**	**9.799**
3.1	9.827	9.855	9.883	9.911	9.939	9.966	9.994	10.021	10.049	10.076
3.2	10.103	10.130	10.157	10.184	10.211	10.238	10.264	10.291	10.317	10.344
3.3	10.370	10.397	10.423	10.449	10.475	10.501	10.527	10.553	10.578	10.604
3.4	10.630	10.655	10.681	10.706	10.731	10.756	10.782	10.807	10.832	10.857
3.5	10.881	10.906	10.931	10.955	10.980	11.005	11.029	11.053	11.078	11.102
3.6	11.126	11.150	11.174	11.198	11.222	11.246	11.270	11.293	11.317	11.341
3.7	11.364	11.387	11.411	11.434	11.457	11.481	11.504	11.527	11.550	11.573
3.8	11.596	11.618	11.641	11.664	11.687	11.709	11.732	11.754	11.777	11.799
3.9	11.821	11.844	11.866	11.888	11.910	11.932	11.954	11.976	11.998	12.019
4.0	**12.041**	**12.063**	**12.085**	**12.106**	**12.128**	**12.149**	**12.171**	**12.192**	**12.213**	**12.234**
4.1	12.256	12.277	12.298	12.319	12.340	12.361	12.382	12.403	12.424	12.444
4.2	12.465	12.486	12.506	12.527	12.547	12.568	12.588	12.609	12.629	12.649
4.3	12.669	12.690	12.710	12.730	12.750	12.770	12.790	12.810	12.829	12.849
4.4	12.869	12.889	12.908	12.928	12.948	12.967	12.987	13.006	13.026	13.045
4.5	13.064	13.084	13.103	13.122	13.141	13.160	13.179	13.198	13.217	13.236
4.6	13.255	13.274	13.293	13.312	13.330	13.349	13.368	13.386	13.405	13.423
4.7	13.442	13.460	13.479	13.497	13.516	13.534	13.552	13.570	13.589	13.607
4.8	13.625	13.643	13.661	13.679	13.697	13.715	13.733	13.751	13.768	13.786
4.9	13.804	13.822	13.839	13.857	13.875	13.892	13.910	13.927	13.945	13.962
5.0	**13.979**	**13.997**	**14.014**	**14.031**	**14.049**	**14.066**	**14.083**	**14.100**	**14.117**	**14.134**
5.1	14.151	14.168	14.185	14.202	14.219	14.236	14.253	14.270	14.287	14.303
5.2	14.320	14.337	14.353	14.370	14.387	14.403	14.420	14.436	14.453	14.469
5.3	14.486	14.502	14.518	14.535	14.551	14.567	14.583	14.599	14.616	14.632
5.4	14.648	14.664	14.680	14.696	14.712	14.728	14.744	14.760	14.776	14.791
5.5	14.807	14.823	14.839	14.855	14.870	14.886	14.902	14.917	14.933	14.948
5.6	14.964	14.979	14.995	15.010	15.026	15.041	15.056	15.072	15.087	15.102
5.7	15.117	15.133	15.148	15.163	15.178	15.193	15.208	15.224	15.239	15.254
5.8	15.269	15.284	15.298	15.313	15.328	15.343	15.358	15.373	15.388	15.402
5.9	15.417	15.432	15.446	15.461	15.476	15.490	15.505	15.519	15.534	15.549

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TABLE II (continued)

Voltage Ratio	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
6.0	**15.563**	**15.577**	**15.592**	**15.606**	**15.621**	**15.635**	**15.649**	**15.664**	**15.678**	**15.692**
6.1	15.707	15.721	15.735	15.749	15.763	15.778	15.792	15.806	15.820	15.834
6.2	15.848	15.862	15.876	15.890	15.904	15.918	15.931	15.945	15.959	15.973
6.3	15.987	16.001	16.014	16.028	16.042	16.055	16.069	16.083	16.096	16.110
6.4	16.124	16.137	16.151	16.164	16.178	16.191	16.205	16.218	16.232	16.245
6.5	16.258	16.272	16.285	16.298	16.312	16.325	16.338	16.351	16.365	16.378
6.6	16.391	16.404	16.417	16.430	16.443	16.456	16.469	16.483	16.496	16.509
6.7	16.521	16.534	16.547	16.560	16.573	16.586	16.599	16.612	16.625	16.637
6.8	16.650	16.663	16.676	16.688	16.701	16.714	16.726	16.739	16.752	16.764
6.9	16.777	16.790	16.802	16.815	16.827	16.840	16.852	16.865	16.877	16.890
7.0	**16.902**	**16.914**	**16.927**	**16.939**	**16.951**	**16.964**	**16.976**	**16.988**	**17.001**	**17.013**
7.1	17.025	17.037	17.050	17.062	17.074	17.086	17.098	17.110	17.122	17.135
7.2	17.147	17.159	17.171	17.183	17.195	17.207	17.219	17.231	17.243	17.255
7.3	17.266	17.278	17.290	17.302	17.314	17.326	17.338	17.349	17.361	17.373
7.4	17.385	17.396	17.408	17.420	17.431	17.443	17.455	17.466	17.478	17.490
7.5	17.501	17.513	17.524	17.536	17.547	17.559	17.570	17.582	17.593	17.605
7.6	17.616	17.628	17.639	17.650	17.662	17.673	17.685	17.696	17.707	17.719
7.7	17.730	17.741	17.752	17.764	17.775	17.786	17.797	17.808	17.820	17.831
7.8	17.842	17.853	17.864	17.875	17.886	17.897	17.908	17.919	17.931	17.942
7.9	17.953	17.964	17.975	17.985	17.996	18.007	18.018	18.029	18.040	18.051
8.0	**18.062**	**18.073**	**18.083**	**18.094**	**18.105**	**18.116**	**18.127**	**18.137**	**18.148**	**18.159**
8.1	18.170	18.180	18.191	18.202	18.212	18.223	18.234	18.244	18.255	18.266
8.2	18.276	18.287	18.297	18.308	18.319	18.329	18.340	18.350	18.361	18.371
8.3	18.382	18.392	18.402	18.413	18.423	18.434	18.444	18.455	18.465	18.475
8.4	18.486	18.496	18.506	18.517	18.527	18.537	18.547	18.558	18.568	18.578
8.5	18.588	18.599	18.609	18.619	18.629	18.639	18.649	18.660	18.670	18.680
8.6	18.690	18.700	18.710	18.720	18.730	18.740	18.750	18.760	18.770	18.780
8.7	18.790	18.800	18.810	18.820	18.830	18.840	18.850	18.860	18.870	18.880
8.8	18.890	18.900	18.909	18.919	18.929	18.939	18.949	18.958	18.968	18.978
8.9	18.988	18.998	19.007	19.017	19.027	19.036	19.046	19.056	19.066	19.075
9.0	**19.085**	**19.094**	**19.104**	**19.114**	**19.123**	**19.133**	**19.143**	**19.152**	**19.162**	**19.171**
9.1	19.181	19.190	19.200	19.209	19.219	19.228	19.238	19.247	19.257	19.226
9.2	19.276	19.285	19.295	19.304	19.313	19.323	19.332	19.342	19.351	19.360
9.3	19.370	19.379	19.388	19.398	19.407	19.416	19.426	19.435	19.444	19.453
9.4	19.463	19.472	19.481	19.490	19.499	19.509	19.518	19.527	19.536	19.545
9.5	19.554	19.564	19.573	19.582	19.591	19.600	19.609	19.618	19.627	19.636
9.6	19.645	19.654	19.664	19.673	19.682	19.691	19.700	19.709	19.718	19.726
9.7	19.735	19.744	19.753	19.762	19.771	19.780	19.789	19.798	19.807	19.816
9.8	19.825	19.833	19.842	19.851	19.860	19.869	19.878	19.886	19.895	19.904
9.9	19.913	19.921	19.930	19.939	19.948	19.956	19.965	19.974	19.983	19.991

Voltage Ratio	0	1	2	3	4	5	6	7	8	9
10	**20.000**	**20.828**	**21.584**	**22.279**	**22.923**	**23.522**	**24.082**	**24.609**	**25.105**	**25.575**
20	26.021	26.444	26.848	27.235	27.604	27.959	28.299	28.627	28.943	29.248
30	29.542	29.827	30.103	30.370	30.630	30.881	31.126	31.364	31.596	31.821
40	32.041	32.256	32.465	32.669	32.869	33.064	33.255	33.442	33.625	33.804
50	33.979	34.151	34.320	34.486	34.648	34.807	34.964	35.117	35.269	35.417
60	35.563	35.707	35.848	35.987	36.124	36.258	36.391	36.521	36.650	36.777
70	36.902	37.025	37.147	37.266	37.385	37.501	37.616	37.730	37.842	37.953
80	38.062	38.170	38.276	38.382	38.486	38.588	38.690	38.790	38.890	38.988
90	39.085	39.181	39.276	39.370	39.463	39.554	39.645	39.735	39.825	39.913
100	**40.000**	—	—	—	—	—	—	—	—	—

To find decibel values outside the range of this table, see page 273.

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REACTANCE CHART

Always use corresponding scales

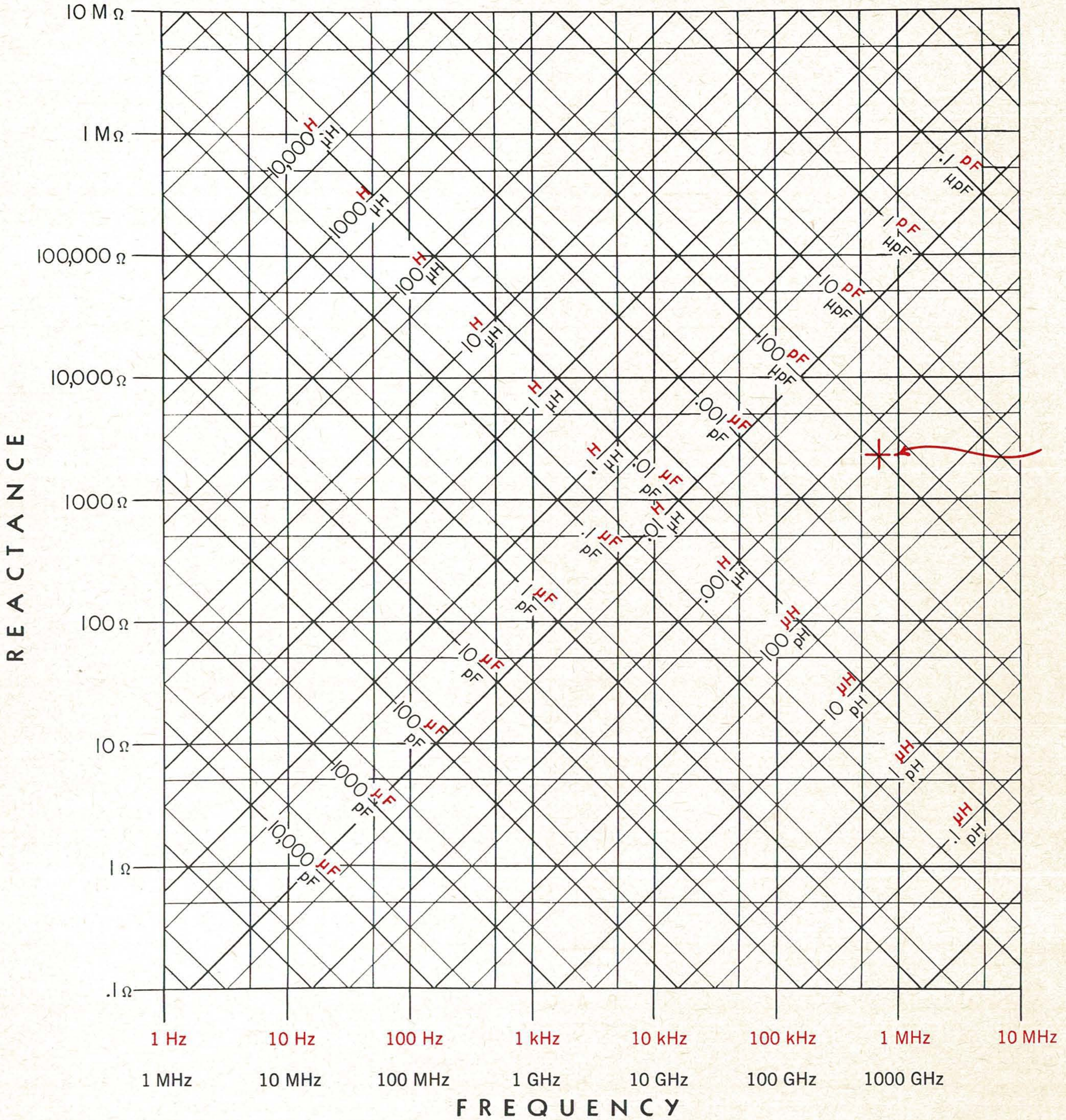

FIGURE 1

Figure 1 is the complete chart, used for rough calculations. Figure 2, which is a single decade of Figure 1 enlarged approximately 7 times, is used where two or three significant figures are to be determined.

TO FIND REACTANCE

Enter the charts vertically from the bottom (frequency) and along the lines slanting upward to the left (capacitance) or to the right (inductance). Corresponding scales (red or black) must be used throughout. Project horizontally to the left from the intersection and read reactance.

TO FIND RESONANT FREQUENCY

Enter the slanting lines for the given inductance and capacitance. Project downward and read resonant frequency from the bottom scale. **Corresponding scales (red or black) must be used throughout.**

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REACTANCE CHART

Always obtain approximate value from Figure 1 before using Figure 2

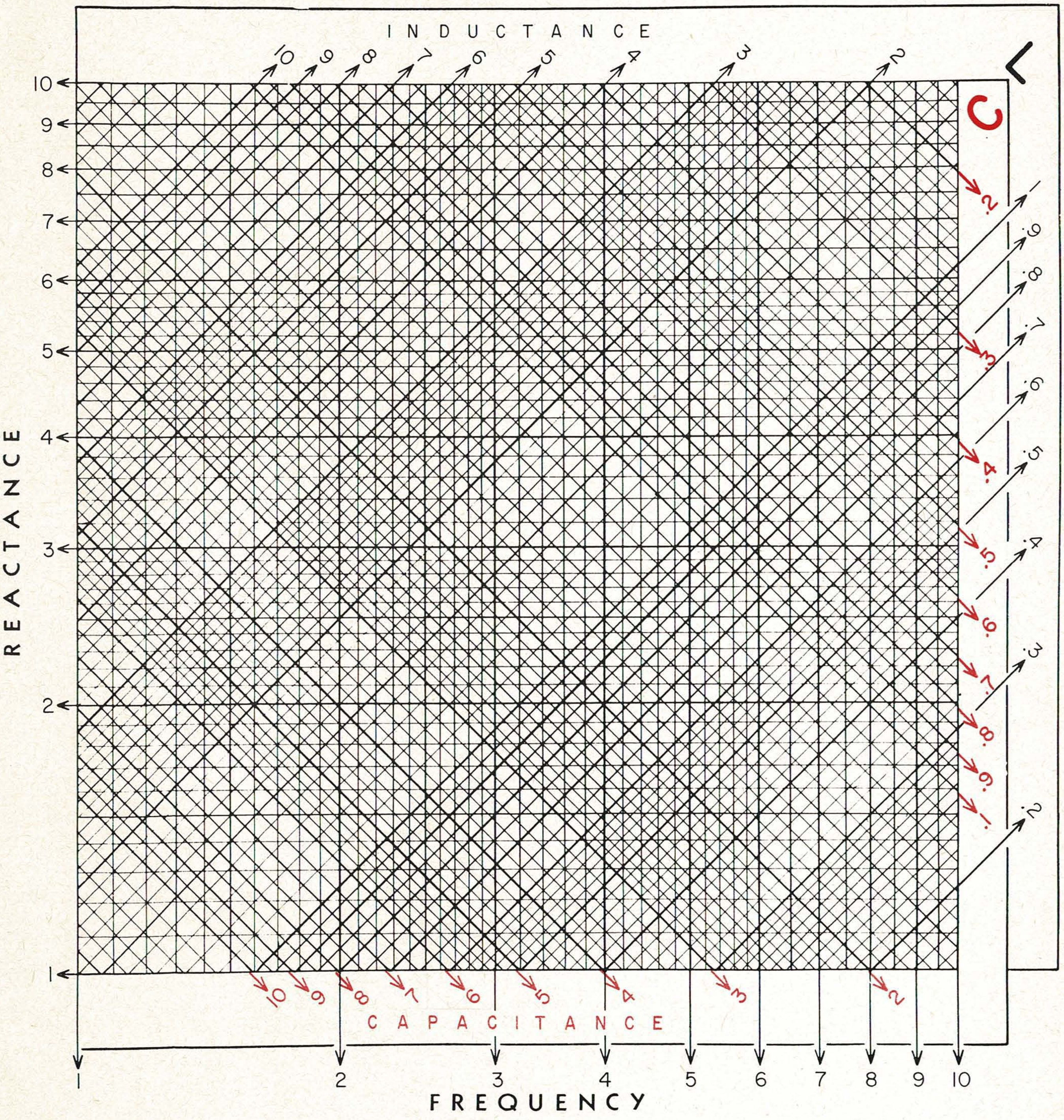

FIGURE 2

Example: The point indicated in Figure 1 corresponds to a frequency of about 700 kHz and an inductance of 500 μH, or a capacitance of 100 pF, giving in either case a reactance of about 2000 ohms. The resonant frequency of a circuit containing these values of inductance and capacitance is, of course, 700 kHz, approximately.

USE OF FIGURE 2

Figure 2 gives additional precision but does not place the decimal point, which must be located from a preliminary entry on Figure 1. Since the chart necessarily requires two logarithmic decades for inductance and capacitance for every single decade of frequency and reactance, unless the correct decade for L and C is chosen, the calculated values of reactance and frequency will be in error by a factor of 3.16. In Figure 2, the capacitance scale is red; inductance scale is black.

Example: (Continued) The reactance corresponding to 500 μH or 100 pF is 2230 ohms at 712 kHz, their resonant frequency.

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Index By Subject and Title

(cont'd)

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Index By Subject and Title

(cont'd)

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Federal Stock Numbers for GR Instruments

GR Type No.	Fed. Stock No.
M2	5950-519-7789
M2G2	5950-557-6989
M2G3	5950-557-6988
M5	5950-504-9090
M5G3	5950-521-8076
M5G3BB	6120-023-3819
M10	6120-812-7681
M10BB	5950-906-3350
M10G2	5950-755-9349
M10G3	5950-504-9047
M20G3	6120-725-4226
W2	5950-606-8682
W2M	5950-683-3641
W2G2	5950-082-8153
W2G3	6120-837-7133
W5	5950-754-5940
W5M	5950-504-9454
W5MT	5950-688-5722
W5MT3	5950-617-9242
W5MT3W	4931-777-1385
W5G2	6120-884-1441
W5G3	6120-681-6930
W5G3M	6120-879-3698
W5H	5950-809-5379
W5HM	5950-835-4462
W5HMT	5950-681-7431
W5L	6120-845-1176
W5LG3	5820-756-5566
W10	5950-699-5022
W10M	6120-816-1517
W10MT	6120-772-7917
W10MT3	5950-682-2557
W10MT3A	6120-054-7794
W10G3	6120-805-0745
W10H	6120-660-9211
W10HM	6120-828-1490
W10HMT	5950-686-2153
W10HMT3	6625-073-2226
W20	6120-800-2482
W20M	6120-834-2923
W20MT3	6120-833-0904
W20G3	6120-669-8565
W20BB	6120-987-5874
W20BBM	5950-927-7805
W20G2BBM	5950-927-7803
W20G3BB	5950-068-5180
W20H	6120-710-5747
W20HM	5950-877-7923
W20HMT3A	5950-926-0742
W30	5905-078-1445
W50	6120-681-6862
W50M	6120-769-1140
W50BBM	6120-894-1826
W50HG2BBM	6120-927-7826
VB1	5977-520-6209
VB2	5977-505-7048
VBT-4	5977-542-7940
VBT-5	5977-533-8036
VBT-6	5977-775-6799
VBT-8	5977-727-9061
VBT-10	5977-948-3303
VBT-11	5977-033-8550
VBT-12	5977-877-6844
107-J	6625-669-0342
107-K	6625-669-0343
107-L	6625-310-8813
107-M	6625-448-0307
107-N	6625-989-5438
510-AA	6625-690-5156
510-A	6625-553-8082
510-B	6625-311-6104
510-C	6625-993-1190
510-D	6625-864-6074
510-E	6625-709-0308
510-F	6625-709-0310
510-G	6625-708-7235
546-C	6625-474-5292
631-P1	5960-193-5124
716-C	6625-649-2961
874-A3	6145-020-8773
874-C8A	5935-916-0791
874-C58A	5935-981-7264
874-CL58A	5935-914-8878
874-D20L	5985-912-1544
874-D50L	6625-623-0067
874-EL	5935-627-0622

GR Type No.	Fed. Stock No.
874-EL-L	5935-933-8153
874-F1000L	5915-937-5404
874-F2000L	5915-907-8721
874-F4000L	5915-907-8722
874-GAL	5950-921-6008
874-G3	5985-525-3010
874-G6	5905-812-9250
874-G10	5905-755-2378
874-G10L	5985-087-4715
874-G20	6625-739-1200
874-K	6625-887-7753
874-L10	6625-713-2108
874-L20	6625-713-2109
874-L30	6625-715-5578
874-LAL	5985-911-0540
874-LR	6625-059-7768
874-LTL	5975-999-7278
874-MR	6625-624-7149
874-PBA	5935-840-7284
874-PB8A	5935-965-6178
874-PFL	5935-925-6261
874-Q2	5935-782-6929
874-QBJL	5935-961-5498
874-QBJA	5985-671-8325
874-QBPA	5935-984-5563
874-QCJA	5985-707-2830
874-QCP	5935-706-2827
874-QHPA	5935-921-8789
874-QLJA	5935-053-0040
874-QLTJ	5935-983-9825
874-QLTP	5935-983-9824
874-QMDP	5935-887-6008
874-QNJL	5935-905-5335
874-QNJA	5935-087-5374
874-QNP	5935-919-5915
874-QTNJ	5935-758-9529
874-QUJ	5935-502-8354
874-QUP	5935-666-4873
874-R20A	6625-789-4723
874-R22LA	5995-933-6852
874-R33	6625-793-1351
874-R34	6625-729-4629
874-T	5935-864-9958
874-UBL	6625-713-2110
874-VI	6625-864-1551
874-VQ	6625-793-1352
874-VR	5985-778-2146
874-WN3	6625-706-2829
874-WO	5985-888-4296
874-WO3	5985-707-2831
874-W50B	5985-992-2109
874-X	5935-669-5817
900-BT	5935-000-0202
900-QNJ	5935-838-2722
900-QNP	5935-838-2723
916-AL	6625-649-3054
940-E	6625-842-4869
940-F	6625-842-4871
940-G	6625-842-4868
940-H	6625-842-4872
1001-A	6625-866-0168
1115-B (-9802)	6625-538-9694
1115-B (-9812)	6625-994-1734
1142-A	6625-099-4059
1201-C	6625-902-9745
1203-B	6130-777-6438
1208-C	6625-935-1343
1209-C	6625-226-5581
1209-CL	6625-929-4278
1210-C	4920-925-7490
1212-A	6625-472-9585
1215-C	6625-965-8235
1216-A	6625-783-9002
1217-C	6625-903-5469
1218-B	6625-920-1006
1230-A	6625-975-4005
1232-A	6625-873-6684
1262-B	4931-891-3070
1263-C	5995-686-4684
1304-BR	6625-585-9736
1311-A	4931-916-8255
1330-A	6625-553-0969
1390-B	6625-799-8999
1403-A	6625-730-8565
1403-D	6625-804-7402
1403-G	6625-804-7401

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1403-K	6625-804-9059
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1404-A	4931-916-5948
1409-F	6625-629-1983
1409-G	6625-804-9058
1409-K	6625-585-4052
1409-L	6625-585-4053
1409-M	6625-583-0038
1409-R	6625-557-0876
1409-T	6625-585-4051
1409-U	6625-585-4050
1409-X	6625-653-1565
1409-Y	6625-629-1980
1419-A	6625-953-7537
1419-K	6625-585-1670
1419-M	6625-220-9441
1422-CB	6625-891-5939
1422-CD	6625-779-3602
1422-D	6625-987-9060
1422-ME	6625-060-1818
1423-A	6625-775-1753
1424-A	6625-731-7404
1432-J	6625-585-3150
1432-K	6625-669-4037
1432-L	6625-975-1359
1432-M	6625-553-7652
1432-N	6625-649-0034
1432-P	6625-649-2782
1432-Q	6625-585-3151
1432-T	6625-893-2212
1432-U	6625-892-4783
1432-X	6625-947-7534
1432-Y	6625-038-2372
1434-G	6625-067-9025
1450-TA	6625-201-8779
1450-TB	6625-612-1837
1454-A	6625-602-2087
1454-AH	6625-989-6596
1482-B	6625-583-0040
1482-C	6625-804-4125
1482-D	6625-806-8627
1482-E	6625-567-2700
1482-F	6625-580-1501
1482-G	6625-580-1502
1482-H	6625-583-0041
1482-J	6625-993-9456
1482-K	6625-556-8585
1482-L	6625-556-8584
1482-M	6625-804-4129
1482-N	6625-804-4130
1482-P	6625-583-0044
1482-Q	6625-993-9458
1482-R	6625-993-9459
1482-T	6625-583-0043
1490-D	6625-808-9523
1521-P1	5905-448-5331
1521-P2	5905-448-5335
1521-P3	5905-448-5334
1521-P4	5905-448-5712
1521-9349	6685-870-7015
1521-9463	6625-862-0632
1531-AB	6680-799-7616
1531-P1	5960-844-5968
1551-C	6625-969-4136
1553-A	6625-977-5779
1556-B	6625-994-9424
1560-P21B	6625-086-9982
1564-A	6625-883-8858
1565-A	6625-912-6149
1571-AL	6110-891-6131
1602-B	6625-511-0512
1603-A	6625-976-7969
1605-AHM	6625-993-5608
1606-A	6625-513-3888
1608-AM	6625-902-8687
1632-A	6625-476-0593
1632-AR	6625-777-4118
1633-A	6625-470-0593
1644-A	6625-867-6628
1650-A	6625-444-6084
1652-A	6625-331-0611
1652-AR	6625-802-5040
1750-A	6625-087-0632
1806-A	6625-832-8956
1840-A	6625-707-3407
1862-C	6625-880-9446

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