# the GENERAL RADIO Experimenter

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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

# A NEW UNIT OSCILLATOR—50 to 250 Mc (TYPE 1215-A)

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● **GENERAL RADIO** Unit Oscillators,[1] particularly those covering the v-h-f and u-h-f ranges, have found a wide acceptance in the electronics industry as power sources for use in measurements and testing. These compact, low-priced units cover wide frequency ranges with single-dial control, furnish adequate power for measurement purposes, and are equipped with coaxial fittings at the output terminals to facilitate connection to coaxial equipment.

[1]Eduard Karplus, "V-H-F and U-H-F Unit Oscillators," *General Radio Experimenter*, Vol. XXIV, No. 12, page 7, May, 1950.

Figure 1. View of the Type 1215-A Unit Oscillator.


File Courtesy of GRWiki.org

Two models have hitherto been available, the TYPE 1209-A, which has a frequency range of 250 to 920 megacycles, thus including all u-h-f television channels, and the TYPE 1208-A, 65 to 500 megacycles. A new model, TYPE 1215-A, which will be available for sale next month, covers a frequency range of 50 to 250 megacycles. Both the TYPE 1209-A and the TYPE 1215-A Unit Oscillators use butterfly[2]-type tuning units that are, essentially, the same as those used in the oscillator sections of the TYPE 1021-AU and 1021-AV Standard-Signal Generators.[3] Their frequency stability and their precision of setting are very good. Hence they can be used with confidence for applications that involve heterodyning the operating frequency to produce low-frequency beats.

The TYPE 1208-A Unit Oscillator has the important advantage of a considerably wider frequency range, which is obtained at some sacrifice of stability and ease of setting. The tuned circuit in this unit is a sliding contact type, which is inherently less stable than the butterfly. There has, therefore, been a definite need for a more stable unit oscillator in the v-h-f range.

Like other General Radio Unit Oscillators, the TYPE 1215-A operates from the TYPE 1203-A Unit Power Supply,[4] connection being made through a multipoint connector. The oscillator tube is a 12AT7-type twin-triode miniature, operating in a push-pull circuit. The oscillator unit with its cast aluminum support is mounted on an L-shaped bracket which serves as panel and base. A cylindrical shield is clamped over the oscillator to keep leakage to a minimum. As in the TYPE 1209-A, the output coupling system is a short length of 50-ohm coaxial line with a coupling coil at one end and a TYPE 874 Coaxial Connector at the other end. The assembly is mounted on the cylindrical shield, and the output level is set by rotating or retracting the output assembly. A large wing nut permits clamping the output coupling assembly firmly in any selected position.

Modulation terminals are provided in the cathode circuit for amplitude modulating the new oscillator over the

2Eduard Karplus, "The Butterfly Circuit," *General Radio Experimenter*, Vol. XIX, No. 5, October, 1944.

3Eduard Karplus and E. E. Gross, "A Standard-Signal Generator for Frequencies between 50 and 920 Mc," *General Radio Experimenter*, Vol. XXIV, No. 10, March, 1950.

4"New Unit Instruments—Power Supplies—Modulator," *General Radio Experimenter*, Vol. XXVI, No. 2, July, 1951.

Figure 2. Interior view of the Type 1215-A Unit Oscillator with shield cover removed.

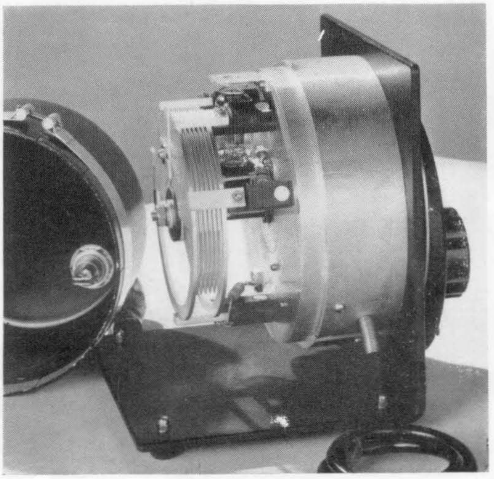
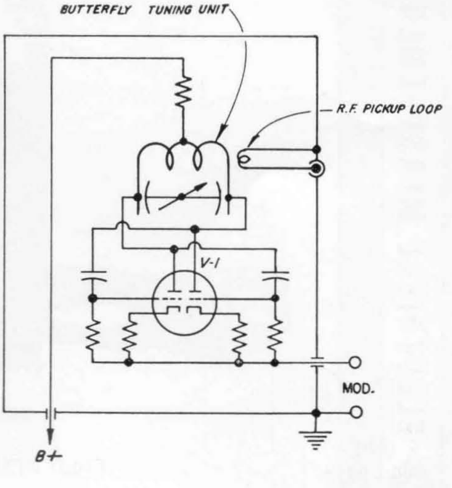


Figure 3. Elementary schematic circuit diagram of the oscillator.




File Courtesy of GRWiki.org

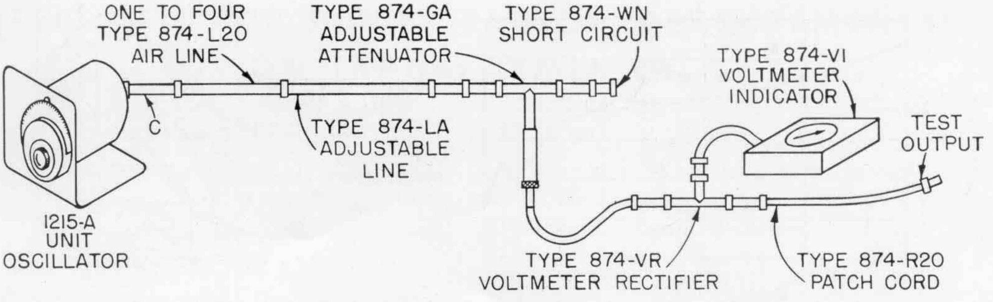



**Figure 4. The Unit Oscillator can be assembled with simple auxiliary equipment to form a test-signal generator.**

audio frequency range. The TYPE 1214-A Unit Oscillator[4] (400 and 1000 cycles) is well suited for use as the modulating oscillator and provides about 25 per cent amplitude modulation. If amplitude modulation with no significant incidental f-m is desired, the output can be modulated with the TYPE 1023-A Modulator[5] (up to 220 Mc) or with the TYPE 1000-P6 Crystal Modulator.[6]

## USES

The usefulness of General Radio u-h-f and v-h-f unit oscillators is greatly enhanced by the availability of coaxial accessories, by means of which the oscillators can be conveniently adapted for specific purposes. Important among these are the TYPE 1000-P6 Crystal Diode Modulator[6] and the TYPE 874-MR Mixer Rectifier.[7] The crystal modulator permits the output to be picture modulated, thus converting the oscillator to a test-signal generator for television frequencies. With the mixer rectifier, the unit oscillator is used as the local oscillator of a heterodyne converter system with a communications receiver as the i-f detector. This system is a universal null detector for high frequencies. It has the further advantage that much less shielding is required than is necessary when the detector and the generator operate at the same frequency.

The output connector is a General Radio TYPE 874 Coaxial Connector which allows connection to be made directly to the various coaxial elements of the TYPE 874 series, as well as the TYPE 874-LB Slotted Line and the TYPE 1602-A U-H-F Admittance Meter. Connection to other coaxial types can be made through TYPE 874-P[8] Adaptors, which are available for both plug and jack types of N, BNC, C, and U-H-F connectors.

— A. G. BOUSQUET

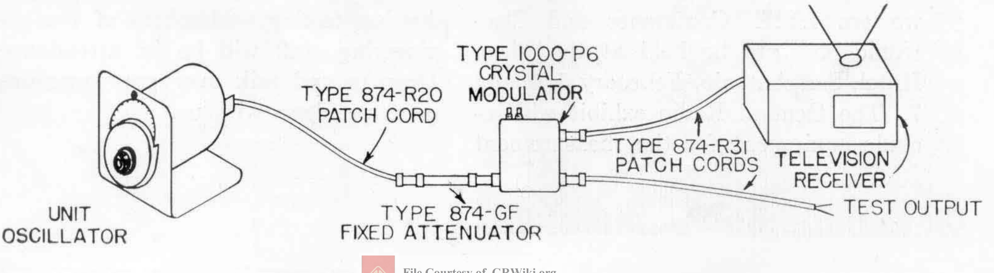
[5] D. B. Sinclair, "A Versatile Amplitude Modulator for V-H-F Standard Signal Generators," *General Radio Experimenter*, Vol. XXIV, No. 6, November, 1949.

[6] W. F. Byers, "An Amplitude Modulator for Video Frequencies," *General Radio Experimenter*, Vol. XXIV, No. 10, March, 1950.

[7] W. R. Thurston, "Simple, Complete Coaxial Measuring Equipment for the U-H-F Range," *General Radio Experimenter*, Vol. XXIV, No. 8, January, 1950.

[8] R. A. Soderman, "New Coaxial Accessories," *General Radio Experimenter*, Vol. XXVII, No. 5, October, 1952.

**Figure 5. The Crystal Diode Modulator permits the oscillator to be modulated at video frequencies for testing television receivers.**

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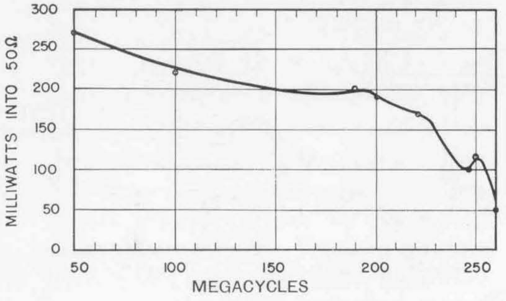



Figure 6. Typical curves of output vs. frequency for the Type 1215-A Unit Oscillator.

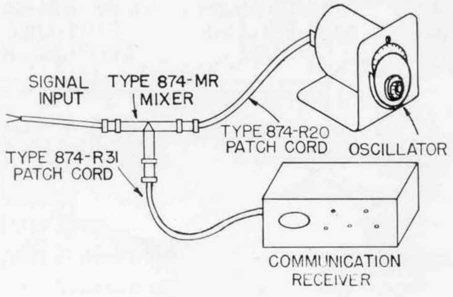



Figure 7. The Unit Oscillator and Mixer Rectifier used as a frequency converter.

## SPECIFICATIONS

**Frequency Range:** 50-250 Mc.

**Tuned Circuit:** A semi-butterfly with no sliding contacts.

**Frequency Control:** A 6-inch dial with direct frequency calibration over 140 degrees. Slow motion drive, 4:1 ratio.

**Frequency Calibration Accuracy:** 1 per cent at no load.

**Warm-up Frequency Drift:** 0.4 per cent.

**Output System:** Short coaxial line with a coupling loop at one end and a Type 874 Coaxial Connector on the other end. Maximum power can be delivered to load impedances normally encountered in coaxial systems.

**Output Power:** At least 80 milliwatts into a 50-ohm load.

**Power Supply Requirements:** 370 volts d-c at 25 ma and 6.3 volts a-c or d-c at 0.3 ampere. The Type 1203-A Unit Power Supply is recommended.

**Modulation:** Direct amplitude modulation over the audio-frequency range can be obtained with an external audio oscillator. The impedance at the modulation terminals is about 15,000 ohms. A convenient audio source is the Type 1214-A Unit Oscillator which will deliver about 55 volts at 400 or 1000 cycles and will yield about 25 per cent modulation. The Type 1000-P6 Crystal Diode Modulator can be used for modulation at video frequencies essentially free of fm. Type 1023-A Amplitude Modulator can be used (up to 220 Mc) to obtain accurately calibrated amplitude modulation with no incidental fm.

**Tube:** Type 12AT7 miniature twin-triode which is supplied with the instrument.

**Mounting:** The oscillator is mounted in an aluminum casting and is shielded with a spun-aluminum cover. The assembly is mounted on an L-shaped panel and chassis.

**Accessories Supplied:** Type 874-R20 Patch Cord, Type 874-C Cable Connector, Type 874-P Panel Connector, and Type CDMS-466-4 Multipoint Connector.

**Accessories Available:** Type 1000-P6 Modulator, Type 1023-A Modulator, Type 1203-A Power Supply, Type 1204-B Power Supply, Type 1214-A Oscillator, and the Type 874 Coaxial Elements such as adaptors, attenuators, voltmeters, mixer, etc.

**Dimensions:** 7 x 8 x 9½ inches, over-all.

**Net Weight:** 7½ pounds.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **1215-A** | **Unit Oscillator, *50 to 250 Mc** | ADOPT | **$190.00** |
| **1203-A** | **Unit Power Supply** | ALIVE | **47.50** |

*U. S. Patents Nos. 2,367,681; 2,548,457; 2,125,816.

## SOUTHWESTERN I.R.E. CONFERENCE

General Radio products will be exhibited in Booths 6 and 7 at the Southwestern I.R.E. Conference and Electronic Show to be held at the Plaza Hotel, San Antonio, February 5, 6, and 7. The General Radio exhibit will include equipment for the measurement of sound and noise, u-h-f impedance measuring devices, and bridges for production testing. Members of our engineering staff will be in attendance. Drop in and talk over your measurement problems with us.

File Courtesy of GRWiki.org

# TEST CELL FOR POWER FACTOR MEASUREMENTS ON TRANSFORMER OIL

An improved test cell for the power-factor testing of insulating oil used in transformers is described in a recent article in *Electric Light and Power*.[1] The conventional test cell gave results that were often erratic and too low for accurate reading when the water content in the oil was small.

To improve the accuracy of the measurements, the oil samples were passed through filter paper, and the filter paper was then tested between flat-plate electrodes. The consistent results obtained led to the design and construction of the test cell shown in Figure 1. A disk of filter paper, previously heated to eliminate moisture, is clamped between metal electrodes, which are perforated to allow the oil to pass through. The dissipation factor is measured on a General Radio Type 740-BG Capacitance Test Bridge.[2] An initial reading without oil is taken as a check on the dryness of the paper.

A sample of the oil to be tested is then poured in the upper container. The moisture is held by the filter paper, while the oil passes through, and the power factor rises in proportion to the moisture content of the oil, as shown in Figure 2.

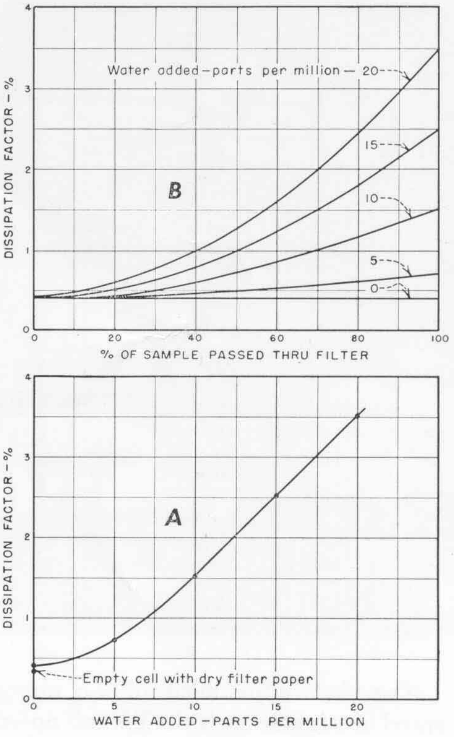



Figure 2.

According to the author, absorption of moisture by the filter paper simulates the actual conditions in a transformer, in which water carried by the oil is absorbed by the organic insulating materials on the winding. The filter paper soaks up water to about the same extent as the transformer insulation.

[1] E. C. Schurch, "Improved Test Cell Stabilizes Oil Measurements," *Electric Light and Power*, July, 1952.

[2] This bridge has been discontinued, but the current Type 1611-A Capacitance Test Bridge can be used equally well.

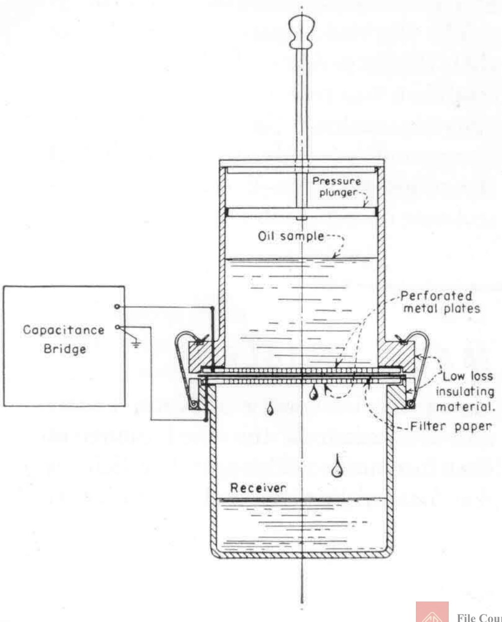
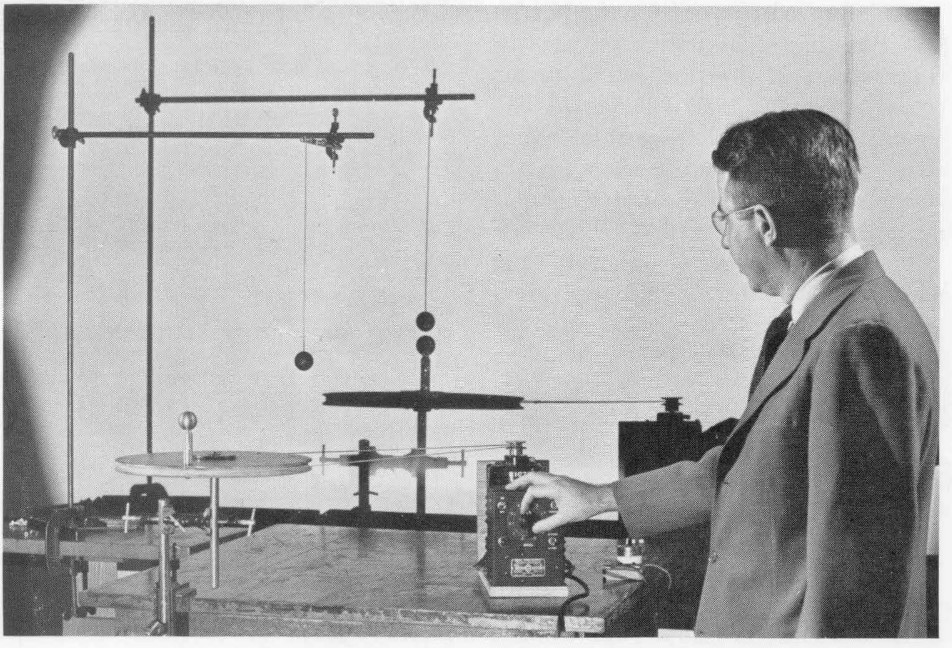



Figure 1.

File Courtesy of GRWiki.org

# VARIAC® SPEED CONTROL HELPS TO DEMONSTRATE SIMPLE HARMONIC MOTION



The close adjustment of d-c motor speed obtainable with the Variac® Speed Control is well illustrated by a demonstration used by the Physics Department of Cornell University. A horizontal turntable is rotated just below an oscillating pendulum, and, when the turntable speed is properly adjusted, the shadow of a ball mounted on the periphery of the turntable will track closely with the shadow of the pendulum. This demonstration aptly illustrates the equivalence of simple harmonic motion and the projection of uniform circular motion, a concept on which mathematical analysis of periodic mechanical motion and a-c electrical operation is based.

The Physics Department informs us that this experiment had been unsuccessful in the past because of the difficulty in making the turntable speed correspond precisely to the period of the pendulum. The Variac Speed Control now does the job perfectly.

# AIR CURRENTS MADE VISIBLE

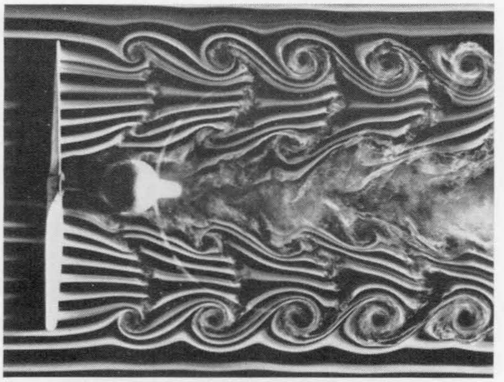
This interesting Strobolume photograph comes to us through the courtesy of Prof. F. N. M. Brown, Head of the Department of Aeronautical Engineering at the University of Notre Dame, and was taken in the wind tunnel at that institution. The propeller (left) is one foot in diameter and is turning at

File Courtesy of GRWiki.org

4080 rpm. The air speed is about 45 feet per second, design advance for the model propeller.

The smoke that makes the air currents visible is produced by burning wheat straw under a slight pressure, but with insufficient oxygen. Tars are removed from the smoke by condensation in a bank of water-cooled pipes and by filtering.

The General Radio TYPE 1532-B Strobolume is the light source used for photography. The duration of the light flash from this instrument is about two one-hundred-thousandths of a second. Conventional camera equipment was used, with a lens opening of f6.3. The film was Eastman Type B. To produce extreme contrast, the film is overdeveloped in D-11, developing time being fifteen minutes instead of the usual five.



Smoke techniques in this wind tunnel have been used for the study of many phases of fundamental aerodynamics, results of which were reported by Professor Brown in a paper presented at the Second Midwestern Conference on Fluid Dynamics.

## NEW BRANCH PLANT

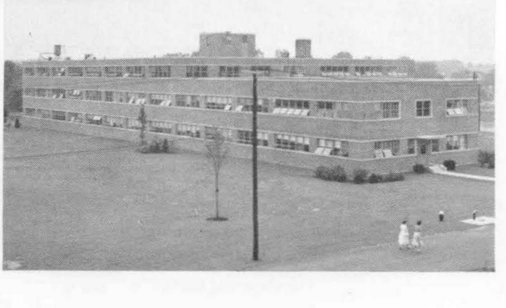
*(concluded)*

In our last issue we noted the opening of our new manufacturing branch in West Concord, Massachusetts, which first went into operation in April, 1952.

Production has been steadily increasing, and now the plant is in virtually full operation.

It is by no means a simple operation to increase the production of precision equipment. It is necessarily a careful process if the quality and accuracy of the finished products are to be maintained. Operations of the new plant are now, however, going smoothly, and the beneficial effect of this added capacity is already attested by the fact that many popular items, including Variacs, Strobotacs, and impedance bridges, are available either from stock or with no more than thirty days' delay in delivery.

Our main offices and about two-thirds of our manufacturing operations are still at the Cambridge plant where all communications to the Company should be addressed.



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# MISCELLANY

**RECENT VISITORS** from overseas to the General Radio plant and laboratories include Mr. Michael Nomikos, Director of Communications, Civil Aviation Department, Greek Air Ministry, Athens; Mr. André Danzin, Director General of Societé Le Condensation Ceramique, Paris; and Mr. Paul Fabricant of Radiophon, Paris, exclusive representatives for General Radio products in France and the French Colonies.

**CREDITS**—The Type 1482 Standard Inductors described in the November *Experimenter* were originally developed by Robert F. Field. Manufacturing techniques and mechanical design were handled by H. S. Wilkins. After Mr. Field's retirement in December, 1950, the project was completed by H. W. Lamson.

Like the Type 1652-A Resistance Limit Bridge described in the January, 1952, *Experimenter*, the Type 1604-A Comparison Bridge described last month is the outgrowth of a survey of General Radio's own production-test requirements. Prototype versions have been in use in our own laboratories and shops for several years.

Several engineers contributed to the development of this instrument. The early development was done by A. M. Eames under the direction of D. B. Sinclair. Several features of mechanical design were contributed by H. C. Littlejohn, while the author of the foregoing article completed the over-all development.

## INSTRUCTION MANUAL FOR THE ADMITTANCE METER

A complete instruction manual for the Type 1602-A U-H-F Admittance Meter is now available. Copies have been sent to all who returned the cards that were enclosed with admittance meters already shipped. If you are using the admittance meter and have not yet received a copy of the instruction book, please request it on your company letterhead.

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

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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

# TYPE 1212-A UNIT NULL DETECTOR

*Also*

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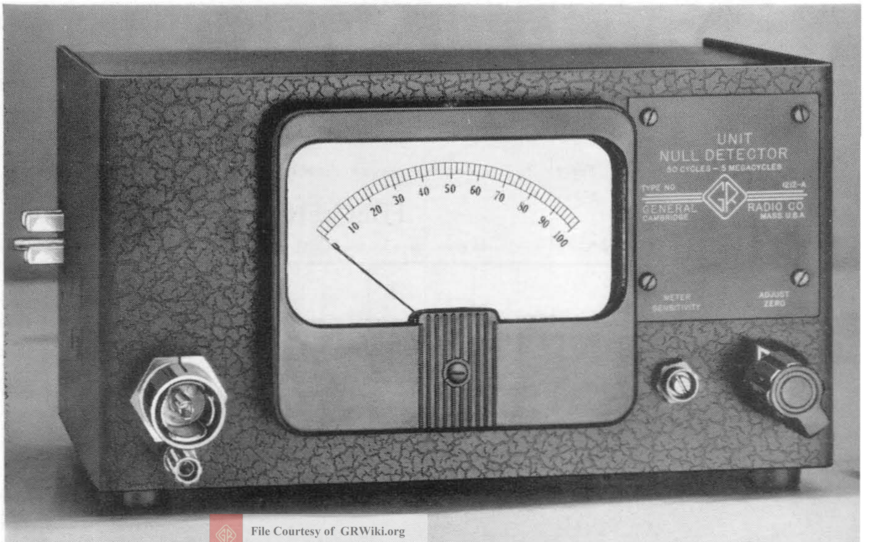
**THE ADDITION** of the Type 1212-A Unit Null Detector to the unit instruments already announced[1] marks another step towards the completion of a comprehensive set of building-block instruments.

In recognition of the increasing complexity of measuring equipment, the unit instruments have been designed, individually, to perform fundamental tasks simply and well. Taken in combination, they have also been planned to work cooperatively in systems of greater complexity. Sound electrical circuitry, combined with mechanical design that incorporates only the essential features, makes these instruments the equal in quality of any made by General Radio. They are small in size, light

[1]See references at end of article.

Figure 1. Panel view of the Unit Null Detector. The plug at the left connects to the Type 1203-A or Type 1204-B Unit Power Supply. At the option of the user, the power supply may be plugged in for easy assembly and disassembly or permanently bolted to the instrument to form a complete rigid assembly.

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in weight, and basically "miniaturized," since the two standard cabinets have been found, in general, to be about as small, for the heat developed within them, as good engineering practice will allow.

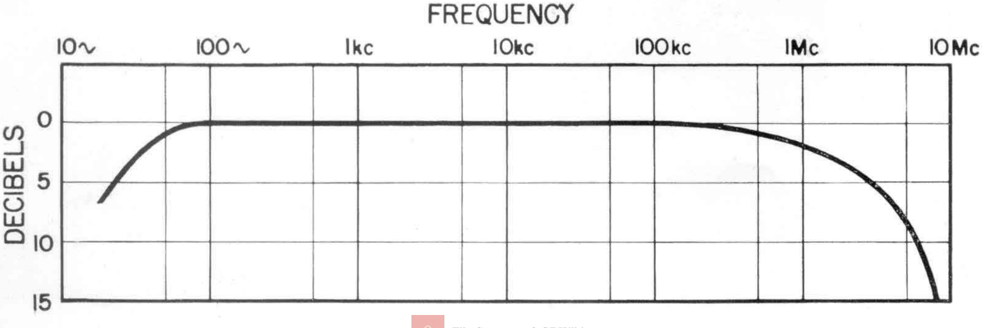
In the unit instruments the user therefore receives, at modest cost, laboratory quality for accuracy, dependability, and sturdiness; miniaturized packaging for maximum convenience and minimum use of bench space; straightforward, simple design for easy utility; and versatility that permits wide application in either simple or complex measuring systems.

The Type 1212-A Unit Null Detector, intended primarily as a balance indicator for a-c bridges, is useful generally as a sensitive, wide-frequency-range voltage indicator. Its frequency characteristic is flat within about 1 db from 50 c to 500 kc, and it is satisfactory as an indicator at frequencies between about 20 c and 5 Mc. Its over-all gain is about 70 db, and it provides a deflection of one per cent of full scale for an input signal of less than 40 $\mu$v. An approximately logarithmic relationship between input voltage and meter reading is displayed on an arbitrary 0-100 scale, and the combination of high sensitivity at low input levels with a full-scale deflection of about 100 volts yields an on-scale range of approximately 120 db. Typical frequency-response and voltage-response curves are shown in Figures 2 and 3.

For a bridge detector, there are two important advantages of an instrument having these characteristics. The wide frequency range makes possible its use not only with such audio-frequency bridges as the Type 716-C Capacitance Bridge, Type 667-A Inductance Bridge, and Type 561-D Vacuum-Tube Bridge but also with the medium-frequency Type 916-AL Radio-Frequency Bridge and, for the lower part of their frequency ranges, with the Type 916-A Radio-Frequency Bridge and the Type 821-A Twin-T Impedance-Measuring Circuit. The quasi-logarithmic input-output relationship prevents overload caused by large unbalances from masking the approach to balance, and increases the sensitivity automatically as the balance is approached, with consequent maximum precision at the time it is wanted.

These advantages are offset, to some extent, by the noise level resulting from the wide frequency range, which limits the maximum sensitivity that can be usefully supplied, but this limited sensitivity in turn can be offset by an increase in generator voltage to maintain adequate over-all system sensitivity. In fact, it is desirable to obtain the necessary over-all sensitivity by increasing the generator voltage to as high a level as the measuring equipment or the device to be measured will allow, so that any extraneous voltages entering the measuring system will cause minimum disturbance, and the sensitivity of the

Figure 2. Frequency response characteristic of the Unit Null Detector.

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Type 1212-A Unit Null Detector under these conditions will normally yield precision of balance for all General Radio bridges well within the bridge accuracy ratings. However, when extreme precision is desired, for instance in determining very small differences in capacitance or dissipation factor with the Type 716-C Capacitance Bridge, the use of head telephones will provide approximately 20 db more sensitivity than the meter. Terminals for head telephones are provided at the rear of the instrument.

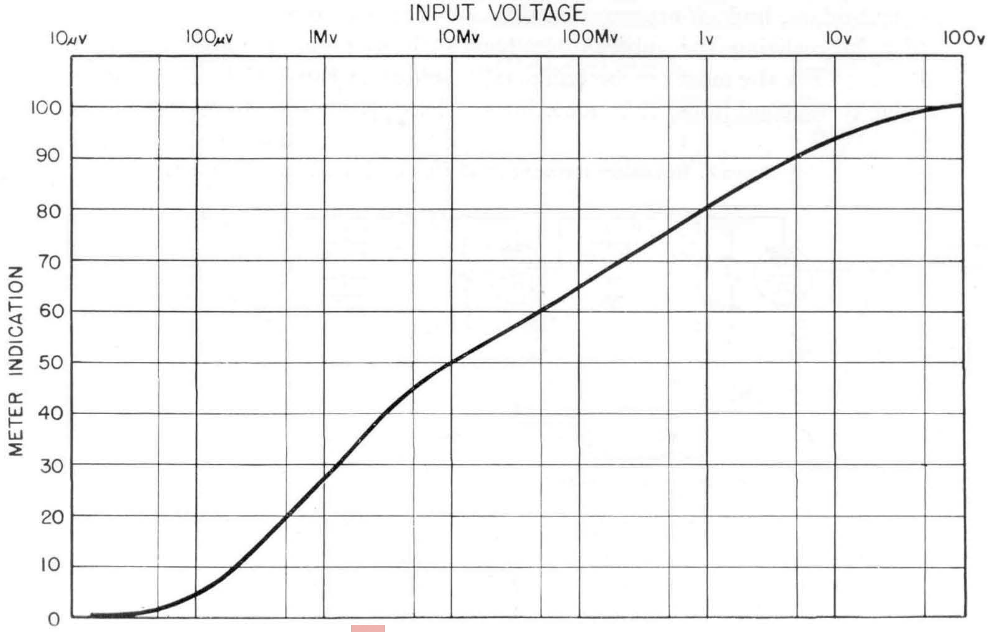
Even when satisfactorily high levels of input voltage are used, however, extraneous signals and noise can be bothersome with a detector of 40 $\mu$v sensitivity and 5 Mc band width, and it is often desirable to use a filter tuned to the generator frequency to obtain maximum precision. Two filters, described in accompanying articles, are available as accessories to remedy commonly encountered difficulties.

The first of these, the Type 1212-P1 High-Pass Filter, is a simple R-C filter designed to reduce the gain of the Type 1212-A Unit Null Detector by about 50 db at 60 cycles. With this filter, measurements can be made at any frequency above about 10 kc without difficulties arising from pickup of power-line frequencies, even in relatively open measuring assemblies. A plot of attenuation as a function of frequency for this filter is shown in the article describing it.

The second of these, the Type 1951-A Filter, is intended to provide, at the common 400-cycle and 1000-cycle audio test frequencies, rejection both of extraneous pickup and of harmonics present in the generator voltage or developed in non-linear elements in the bridge itself. Taken in combination, the Type 1214-A Unit Oscillator, which provides substantial power output at 400 cycles and 1000 cycles, the Type 1951-A Filter, and the Type 1212-A Unit Null Detector form an excellent generator-detector system for all General Radio audio-frequency bridges.

An interesting application of this sort, in illustration, is found with the Type 667-A Inductance Bridge. The relatively

Figure 3. Voltage response curve for the Unit Null Detector.

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low impedance of this bridge often requires particularly high sensitivity in the detector to assure adequate precision of balance. The Type 1951-A Filter, which is provided with a "tap-down" arrangement to match different impedances, actually provides voltage gains of the order of 20 to 30 db from resonant rise at these low impedance levels. Even in this exacting use the combination of the Type 1951-A Filter and the Type 1212-A Unit Null Detector therefore makes a detector of entirely satisfactory sensitivity.

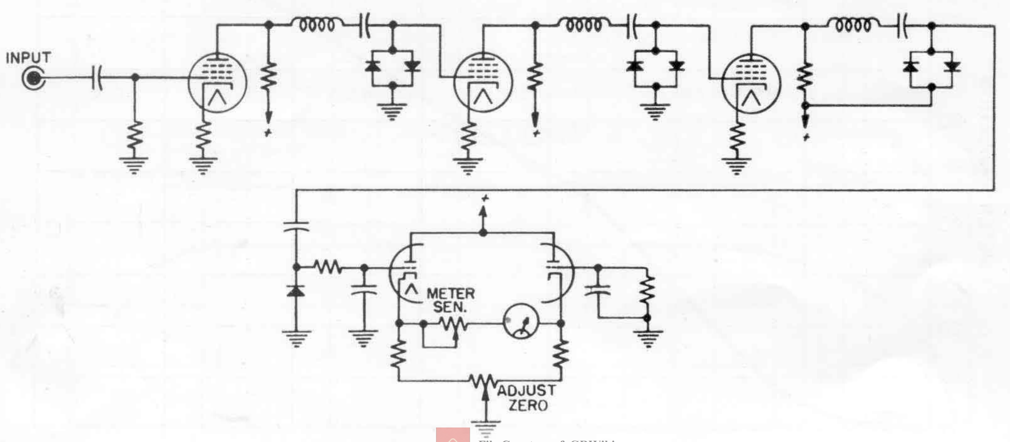
Another special application occurs when the combination of the Type 1214-A, Type 1951-A, and Type 1212-A is used with the Type 561-D Vacuum-Tube Bridge. Two problems arise with this system. The first comes about because the generator voltage is limited to a level that will not cause shift in measured tube coefficients caused by too large excursions over the non-linear tube characteristic curves, with consequent limitation of over-all sensitivity. The second comes about from noise generated by the tube being measured. The net effect is a signal-to-noise ratio considerably larger than that encountered with other bridges, and an exaggerated difficulty in realizing the inherent bridge accuracy. For the most precise balances, under these conditions, it is sometimes desirable to use head telephones so that the extra discrimination of the ear in separating signal from noise can be used to supplement the electrical filtering.

The Type 1212-A Unit Null Detector is provided with a meter to make possible bridge balancing over a frequency range far in excess of that to which the ear will respond. For most tube measurements, the meter is entirely satisfactory but, for unusually noisy tubes, it may be desirable to accept the inconvenience of head telephones to obtain extra discrimination, which is useful not only in rejecting noise but in identifying sources of pick-up and distortion.

For frequencies above the audio range, the Type 1212-A Unit Null Detector is useful for most laboratory applications either with no filter or with the Type 1212-P1 High-Pass Filter when hum pickup is bothersome. For field application, however, particularly when physically large devices are to be measured, tuned-circuit filters are frequently desirable. Simple home-made filters of the type shown in Figure 5 can be easily constructed to fit the particular requirements of the problem at hand.

For the most exacting applications, such as antenna measurements in the broadcast band, high-grade communication-type radio receivers are recom-

Figure 4. Elementary schematic circuit diagram of the Unit Null Detector.

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mended to supply the desired selectivity and sensitivity. For less difficult measurement problems, however, the small size and easily read meter of the TYPE 1212-A Unit Null Detector make it a preferable detector.

Figure 4 is an elementary schematic of the TYPE 1212-A. The instrument is seen to be a relatively conventional three-stage broad-band amplifier using series-peaking compensation. The unconventional feature is the use of germanium-diode clippers to obtain the quasi-logarithmic input-output relationship. This method of shaping is important to the proper operation of the instrument since it eliminates the long time-constant that would be necessary to secure proper automatic-volume-control action at low audio frequencies and insures a speed of

[1]Edward Karplus, "V-H-F and U-H-F Unit Oscillators," *General Radio Experimenter*, XXIV, 12, May, 1950.
"New Unit Instruments—Power Supplies—Modulator," *General Radio Experimenter*, XXVI, 2, July, 1951.
Robert B. Richmond, "The Unit Crystal Oscillator," *General Radio Experimenter*, XXVI, 9, February, 1952.
A. G. Bousquet, "A New Unit Oscillator—50 to 250 Mc," *General Radio Experimenter*, XXVII, 8, January, 1953.

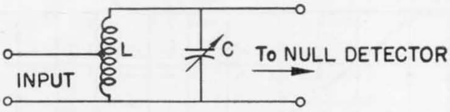


Figure 5. Simple tuned-circuit filter.

response that is limited only by the ballistics of the meter used.[2] These ballistics are so chosen that the instrument is critically damped to make bridge balancing easy and rapid. The balanced meter circuit, combined with regulation of the tube voltages, maintains good stability of meter deflection as the line voltage is varied, and inherent noise in the amplifier is just enough to cause a small meter deflection which can be corrected by the ADJUST ZERO adjustment on the panel. A METER SENSITIVITY control on the panel can be used to set the full-scale meter reading for the voltage range to be displayed.

— ROBERT B. RICHMOND

[2]It should be noted that the clipping destroys the waveshape of the output signal except at very low input levels. Head telephones should, therefore, be used to study distortion or pick-up only near bridge balance.

## SPECIFICATIONS

**Sensitivity:** Less than 40 microvolts input at 1 kc is required to deflect one per cent of full scale on the meter.

**Voltage Response:** See Figure 3.

**Frequency Response:** See Figure 2.

**Tubes:** The instrument requires three Type 6AK5, one Type 12AX7, and one Type OA2 Tubes which are shipped installed.

**Accessories Available:** TYPES 1212-P1 and 1951-A Filters. TYPE 1203-A Unit Power Supply.

**Dimensions:** (Width) 9½ x (height) 5⅜ x (depth) 6 inches, over-all.

**Net Weight:** 5½ pounds.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **1212-A** | **Unit Null Detector*** | ALACK | **$160.00** |
| **1203-A** | **Unit Power Supply** | ALIVE | **47.50** |

*U. S. Patents Nos. 2,125,816 and 2,548,457.

# TYPE 1212-P1 HIGH-PASS FILTER

The TYPE 1212-P1 10-kc High-Pass Filter is designed primarily for use with the TYPE 1212-A Unit Null Detector to attenuate low-frequency noise and hum. It is a shielded R-C type filter and provides about 50 db attenuation at 60 cycles when used in conjunction with the TYPE 1212-A and fed from a low-impedance source.

It can be used equally well with other equipment, provided the load impedance is of the order of one megohm or higher.

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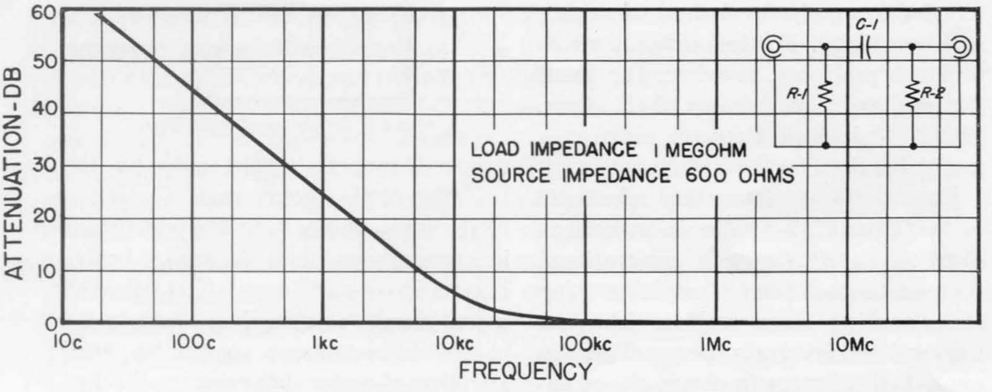


Figure 1. Attenuation characteristics of the Type 1212-P1 High-Pass Filter. The circuit diagram is shown at the upper right.

At lower load impedances or at source impedances of several thousand ohms, the attenuation characteristic will be modified, but useful rejection of low-frequency noise and hum will be found in most cases.

The attenuation characteristic plotted in Figure 1 was measured with a load impedance of one megohm and a source impedance of 600 ohms. The circuit diagram is shown in the inset.

The filter is housed in a Type 874-X Insertion Unit Case, equipped with Type 874 Coaxial Connectors at each end. The filter is symmetrical and either end may be used as input or output.

## SPECIFICATIONS

**Attenuation Characteristic:** See curve (Figure 1).
**Nominal Load Impedance:** 1 megohm.
**Input Voltage Limit:** 150 volts maximum.
**Terminals:** Type 874 Connector at each end.
**Dimensions:** 7/8 inch diameter by 4 3/8 inches long.
**Net Weight:** 3 ounces.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **1212-P1** | **High-Pass Filter** | UNCLE | **$12.00** |

U. S. Patents Nos. 2,125,816 and 2,548,457.

# TYPE 1951-A FILTER

The Type 1951-A Filter is a parallel-resonant *L-C* circuit which is tuned to 400 or 1000 cycles per second ±2 per cent. It is designed to operate at the input to high-gain amplifiers such as the General Radio Type 1212-A or

Figure 1. Panel view of the Type 1951-A Filter.

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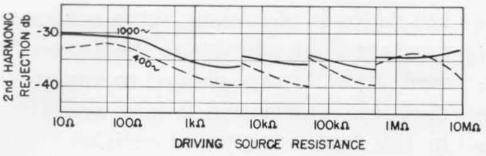
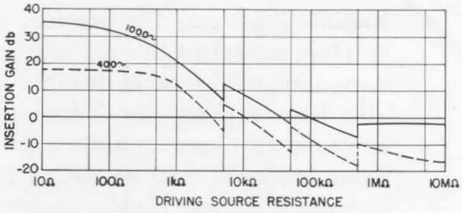



Figure 2. Second harmonic rejection (above) and insertion gain (right) of the Type 1951-A Filter.




Type 1231-B. In this position, large amplitude spurious signals such as 60-cycle pickup are attenuated before they have an opportunity to overload the amplifier. This feature is particularly useful when measuring direct capacitance by the 3-terminal method or when using other methods in which portions of the circuit under test are floating above ground and subject to pickup of external voltages. A capacitive divider on the input side allows the filter to be operated at close to optimum conditions regardless of the impedance it sees at its input.

The insertion gain or loss, working into a one megohm load, and the second harmonic rejection are shown in the curves, Figure 2.

The inductor of the Type 1951-A Filter is wound on a molybdenum-permalloy dust-core toroid and enclosed in a permalloy shield. All circuit elements are shielded against electrostatic pickup. These precautions are taken so that the filter may be used at the very low voltage levels encountered at the input to high-gain amplifiers such as the General Radio Type 1212-A or Type 1231-B. Any pickup that remains can usually be eliminated by properly positioning and orienting the filter.

If a shielded input is desired, the Type 274-MB and Type 274-ND Double Plugs may be used. The output cord may be terminated in the Type 874-Q6 Adaptor for Type 874 Connectors, the Type 274-MB or Type 274-ND for ¾ inch spaced binding posts, or left unterminated for telephone tip leads.

## SPECIFICATIONS

**Frequency:** 400 cycles and 1000 cycles.

**Maximum Allowable R-M-S Input Voltage:**

| *Input Impedance Range* | *1000~* | *400~* |
|---|---|---|
| 0 — 5KΩ | 10 v | 4 v |
| 5KΩ — 50KΩ | 40 v | 16 v |
| 50KΩ — 500KΩ | 145 v | 58 v |
| 500KΩ — — | 200 v | 165 v |

**Insertion Loss:** See Figure 2.

**Second Harmonic Rejection:** See Figure 2.

**Accessories Supplied:** One Type 274-MB Double Plug, one Type 274-ND Shielded Plug, and one Type 874-Q6 Adaptor*.

**Dimensions:** 3⅛ x 3¼ x 4⅜ inches, over-all.

**Net Weight:** 1¾ pounds.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **1951-A** | **Filter** | FIBRE | **$65.00** |

*U. S. Patents Nos. 2,125,816 and 2,548,457.

# THE MEASUREMENT OF CABLE CHARACTERISTICS

Coaxial cables play an important role in today's electronic world. They are vital elements in television circuits, radar, blind landing devices, and practically every other electronic device employing high frequencies. The electrical characteristics of the cables used in these applications must meet very rigid

File Courtesy of GRWiki.org

specifications[1] and the problem of accurately measuring the characteristics is important to the cable designer to enable him to check his designs, to the cable manufacturer to inspect the cable being produced, and to the cable user to make it possible for him to determine accurately the properties of the cables with which he is working.

There has for some time been an evident need for published information on the methods of making these measurements and the selection of the necessary equipment. We are pleased to announce that this information is now available, in the form of a paper entitled "The Measurement of Cable Characteristics," by William R. Thurston of the General Radio engineering staff.

This paper will be of interest to all manufacturers and users of coaxial, dual coaxial, and shielded twin-conductor cables. A copy will be sent free on request.

[1]Joint Army-Navy Specifications, JAN-C-17A, dated July 25, 1946, "Cables, Coaxial and Twin-Conductor, for Radio Frequency."

## "UNIVERSAL" COAXIAL ADAPTORS

Since the introduction of the new General Radio 874-Q Coaxial Adaptors,[1] it has been called to our attention that these adaptors provide the basis for a truly universal adaptor system for UG-type coaxial connectors. Interconnection between any pair of connector systems is possible with only a limited number of adaptor units.

For example, to connect a TYPE-N Jack to a TYPE-C Plug, two adaptors are needed, the TYPE 874-QNP and the TYPE 874-QCJ. These are plugged into the respective TYPE-N and TYPE-C terminals and the TYPE 874 fittings are then plugged together.

The advantages of TYPE 874-Q Adaptors for this purpose are twofold. First, only a limited number of adaptors is needed to make any desired connection between the different UG types and, second, the joint thus formed has a very low standing-wave ratio, owing to the excellent electrical characteristics of the adaptors.

[1]"New Coaxial Accessories," *General Radio Experimenter*, XXVII, 5, October, 1952, pp. 1-4.

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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

# TRANSISTOR MEASUREMENTS WITH THE VACUUM-TUBE BRIDGE

*Also* IN THIS ISSUE

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● **WHILE FOR MANY YEARS** the Type 561-D Vacuum-Tube Bridge has been used mainly for measuring vacuum-tube coefficients, it has also proved useful for determining the characteristics of more complex circuit arrangements under different load conditions.[1] The advent of the transistor emphasizes the versatility of this bridge. Low-frequency coefficients are as easily determined for transistors as for vacuum tubes.[2] The bridge indicates the input and output resistance of transistors, their forward and reverse transfer conductance, and their voltage-amplification factors. The current-amplification factor is the product of two of the coefficients indicated by the bridge.

When vacuum-tube coefficients are being measured, the plate resistance, forward transconductance, and forward voltage amplification are the only coefficients of interest, because the input (grid) resistance is essentially infinite at the measuring frequency (1000 cycles); the reverse transconductance and reverse amplification are negligible. The forward and reverse parameters of the transistor are much more interdependent. The input resistance can be quite low, and its value is definitely a function of the load at the output terminals. Gain in both directions is also important. Indeed, under carefully chosen operating conditions,

[1]Edward H. Green, "A Precise Laboratory Exercise Using a Vacuum-Tube Bridge," *American Journal of Physics*, Vol. 16, No. 3, pp. 151–155, March, 1948.

[2]L. J. Giacoletto, "Transistor Characteristics at Low and Medium Frequencies," *Tele-Tech*, March, 1933.

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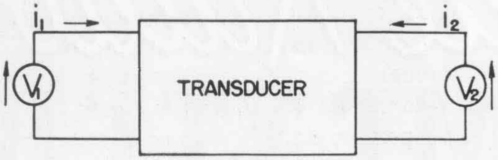



Figure 1. Functional diagram of a four-terminal transducer.

equal power gains in the two directions are feasible,[3] though admittedly this is not the usual circuit application. However, to obtain sufficient design information even for normal applications, both the forward and the reverse coefficients of the transistor are needed.

In spite of the tremendous range in parameters found for the various types of transistors, the Type 561-D Bridge is entirely adequate. It will measure resistance (input or output) from 10 ohms to 100 Megohms; the transconductance range is from 0.001 to 100,000 micromhos; the voltage amplification range is from 0.0001 to 10,000.

The transistor, the vacuum tube, the amplifier (single- or multi-stage), the attenuator can each be represented as a four-terminal transducer (Figure 1). When known voltages are applied to the terminals and the resultant currents are noted, two equations are sufficient to define the characteristics of the transducer. The impedance or admittance parameters that interrelate the voltages and currents are useful for intercomparing transducers and for devising circuits to use them.

[3]R. M. Ryder and R. J. Keicher, "Some Circuit Aspects of the Transistor," *B.S.T.J.*, Vol. XXVIII, pp. 367–401, July, 1949.

In standardizing methods for testing tubes,[4] the Institute of Radio Engineers adopted the nodal form of equations and expressed the parameters as admittances. At the low frequency (1000 cycles) used for the Type 561-D Bridge, the conductance component is of primary interest. The equations are, then,

$$i_1 = g_{11}v_1 + g_{12}v_2$$
$$i_2 = g_{22}v_2 + g_{21}v_1$$

$g_{11}$ and $g_{21}$ are the input conductance and the forward transconductance obtained with the output terminals shorted. $g_{22}$ and $g_{12}$ are the output conductance and the reverse transfer (feedback) conductance obtained with the input terminals shorted.

When these parameters are measured on the Type 561-D Bridge, the reciprocals of the input and output conductances are obtained ($r_p$ on the bridge). The bridge is not limited to resistance (or conductance) measurements of networks with short-circuit terminations, however. It is immaterial to the bridge what the termination is.

The forward and reverse transconductances ($g_m$ on the bridge) and the voltage-amplification factors for both directions ($\mu$) are indicated directly at bridge balance.

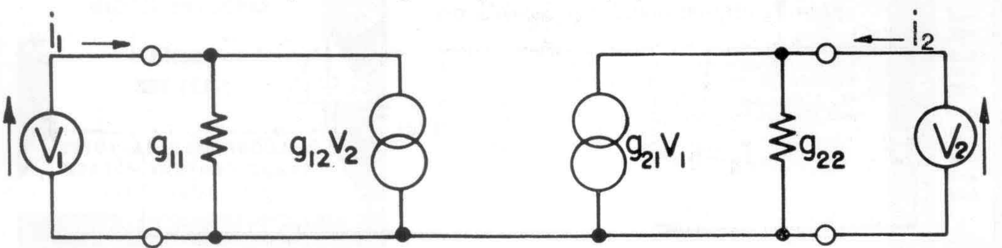
The various amplification factors can be derived from the conductance values as follows:

Forward current-amplification factor,

$$\alpha_{21} = -\frac{g_{21}}{g_{11}}$$

[4]"Standards on Electron Tubes: Methods of Testing," *Proceedings of the I.R.E.*, Vol. 38, Nos. 8 and 9, August and September, 1950.

Figure 2. Two-generator, nodal-derived, equivalent network.

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Reverse current-amplification factor,

$$\alpha_{12} = -\frac{g_{12}}{g_{22}}$$

Forward voltage-amplification factor,

$$\mu_{21} = -\frac{g_{21}}{g_{22}}$$

Reverse voltage-amplification factor,

$$\mu_{12} = -\frac{g_{12}}{g_{11}}$$

Forward power-amplification factor,

$$\phi_{21} = \frac{(g_{21})^2}{4\, g_{11} g_{22}}$$

Reverse power-amplification factor,

$$\phi_{12} = \frac{(g_{12})^2}{4\, g_{11} g_{12}}$$

The current-amplification factor is a significant coefficient of the transistor, just as the voltage-amplification factor is important in the vacuum tube. The current-amplification factor of a junction-type transistor, common-base connected, is usually very nearly unity. For a point-contact-type transistor, it is sometimes between two and three.

The vacuum tube can be operated with grounded cathode, grounded grid, or grounded plate (cathode-follower). Similarly, the transistor can be connected with grounded emitter, grounded base, or grounded collector. The Type 561-D Bridge can be used to measure the transistor coefficients for any of these circuit connections. If the coefficients have been determined for any one circuit arrangement, the coefficients for the other circuit arrangements can be computed from simple transformation equations.[5]

When a picture of the equivalent circuit of a transducer is attempted, the nodal equations lead to a two-generator network as shown in Figure 2.

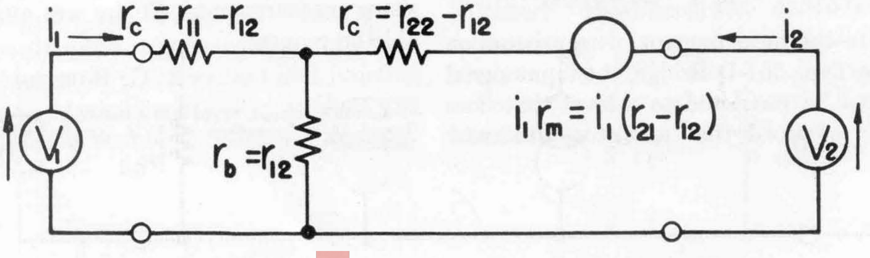
The parameters of the nodal equations can be transformed very simply[5] to new parameters that are depicted by a one-generator $\pi$-network.

In the measurement of vacuum-tube coefficients with the Type 561-D Bridge, the third significant figure can usually be determined unless the tube under measurement is very noisy. Transistors have acquired the reputation of being noisier than tubes, though noise measurements on some newer designs indicate definite improvements. However, many junction-type transistors have noise figures of about 20-25 db and the figure for point-contact-type transistors is around 40-50 db. It is gratifying, therefore, to find that even point-contact-type transistors are readily measured on the Type 561-D Bridge and yield results that are entirely satisfactory for design-information purposes.

While the junction transistor is very stable, the point-contact type, because of inherent positive feedback, can be unstable. Stable operation is obtained either by confining operation to known stable circuit conditions or by introducing some positive external resistance in series with one of the electrodes to counteract the effects of the internal negative resistance. Manufacturers usually advise 500 to 1000 ohms.

[5]See the recent issue of the Operating Instructions for the Type 561-D Vacuum-Tube Bridge.

Figure 3. One-generator, loop-derived, equivalent network.

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This external resistor is a factor which led to the early adoption of measurement methods that stressed constant current at the transducer terminals rather than constant voltage. The voltage-current equations are then of the loop (mesh) variety; parameter measurements are under open-circuit-termination conditions, the parameters are expressed as impedances (or resistances at low frequencies), and the equivalent one-generator circuit is a T-network as in Figure 3.

The measurement of these parameters becomes difficult because the equations assume open-circuit-termination conditions. This can be accomplished, however, by the use of parallel-feed choke coils that are of sufficiently high impedance at 1000 cycles or by feeding through the plate circuit of a pentode which has a very high plate resistance. The supply voltage must, of course, be relatively high.

Fortunately, the junction-type transistor will very likely be the preferred type for use in oscillators and amplifiers. Since it is, in many respects, analogous to the vacuum tube, it can be expected that the equivalent network adopted by the IRE Standards for the vacuum tube will also be found most useful for transistor applications. In any event, it is a simple matter to translate from one form of equivalent circuit to the other:

| *Nodal* | *Loop* |
|---|---|
| $g_{11}=r_{22}\div\Delta r$ | $r_{11}=g_{22}\div\Delta g$ |
| $g_{12}=-r_{12}\div\Delta r$ | $r_{12}=-g_{12}\div\Delta g$ |
| $g_{21}=-r_{21}\div\Delta r$ | $r_{21}=-g_{21}\div\Delta g$ |
| $g_{22}=r_{11}\div\Delta r$ | $r_{22}=g_{11}\div\Delta g$ |
| $\Delta r=r_{11}r_{22}-r_{21}r_{12}$ | $\Delta g=g_{11}g_{22}-g_{21}g_{12}$ |

In the measurement of transistors on the Type 561-D Bridge, the input signal must be restricted to a level that does not overload the transistor; otherwise the indicated value of coefficient will be in error. This is also true in vacuum-tube measurements. The obvious way to determine the safe level is to apply increments of voltage and note the level at which the measured coefficient no longer remains constant. This method, though correct, can be tedious and time-consuming. A quicker method is to obtain an approximate balance and to advance the voltage level to a point where distortion just becomes noticeable (in the detector headphones). This has been found to be a safe operating level.

Incidentally, when noisy transistors are being measured, the high sensitivity of the ear to the signal in the presence of noise yields surprisingly satisfactory results. The use of filters is less trying on the operator but does not greatly improve the balance condition. The new Type 1212-A Unit Null Detector[6], when used with phones, provides an excellent detection system since the clipping inherent in the logarithmic response reduces the noise but does not affect the low level signal at balance.

A recommended signal source is the General Radio Company Type 1214-A Unit Oscillator. Since the d-c voltages required for measuring the transistor are low and current drain is small, the use of batteries as power supplies is feasible. Sockets for the transistors can easily be mounted on the universal adapter plate furnished with the bridge.

The operating instructions for the Type 561-D Vacuum-Tube Bridge have been expanded considerably to include much information pertinent to transistor measurements. Copies are available on request.

— A. G. Bousquet

[6]Robert B. Richmond, "Type 1212-A Unit Null Detector," *General Radio Experimenter*, XXVII, No. 9, February, 1953.

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## MODERNIZATION OF VACUUM-TUBE BRIDGES

In the course of the last few years, several changes have been made in the Type 561-D Vacuum-Tube Bridge in order to meet the test requirements of the latest types of vacuum tubes. Our Service Department is equipped to make these changes in existing older-type bridges or to supply kits and directions to the user who wishes to do the work in his own shop. Write to the Service Department for further information.

## 1953 RADIO ENGINEERING SHOW

General Radio will be in the same location as in previous years in the Radio Engineering Show at Grand Central Palace, March 23–26.

The GR Display will include a demonstration of the remarkable overload characteristics of the Variac® autotransformer, resulting from General Radio's new Duratrak process for stabilizing the brush track. Also on display will be the new Type V-2 Variac® autotransformer, a new 2-ampere model.

The Type 1602-A Admittance Meter will be set up for operation at ultra-high frequencies, with all necessary accessories for impedance measurements on receiver input circuits, components, lines, antennas, etc. If you are working with u-h-f TV receiving or transmitting circuits, be sure to see it and operate it. No other impedance-measuring device combines the accuracy and convenience of the admittance meter.

Unit Instruments, an impressive line of high quality, low-priced items for the laboratory, will be displayed. These building-block instruments now number some ten different models with several more soon to be announced.

Transistors — the Type 561-D Vacuum-Tube Bridge will be set up to measure the characteristics of transistors, both point-contact and junction types. Measurements of impedance and gain of a complete transistor amplifier will also be demonstrated. An experimental transistor oscillator will be set up for operation with General Radio Decade Capacitors and Inductors as the frequency-determining elements.

Type 874 Coaxial Elements, including many types of adaptors, will be displayed. Be sure to see the new adaptors to the u-h-f and v-h-f coaxial lines used on TV transmitters. The low VSWR of these adaptors is typical of GR Coaxial Elements, designed for accurate measurements over wide ranges of frequency.

Limit bridges for production testing — the Type 1652-A Resistance-Limit Bridge for d-c resistor measurements and the Type 1604-A Comparison Bridge for audio frequency measurements on capacitors, inductors, and resistors are convenient, rapid, test instruments for production line or laboratory that will speed up the selection of close-tolerance components for electronic circuits.

GR's famous TV Monitor, for checking the frequency of both transmitters and the modulation percentage of the aural transmitter, will also be on display. This monitor, for both v-h-f and u-h-f stations, has had a wide acceptance of transmitter manufacturers and station engineers. This accurate, dependable monitor is used by some 95% of all TV stations now on the air.

See these outstanding General Radio instruments at Booths 1-121 and 1-122.

File Courtesy of GRWiki.org

# PORTABLE TEST AUTOTRANSFORMERS


A source of manually controlled variable low voltage is required for many tests and maintenance activities associated with the operation of a power system. Over the past several years the Tennessee Valley Authority has purchased a number of continuously variable autotransformers to meet such needs in its power organization. Most of them have been in the 2.4-kva class although some smaller ones are used on light test work.

The General Radio Type V-20HM Variac is one type of variable autotransformer that has been made into a convenient, portable, general test instrument, as shown in the attached photograph by the Authority's development laboratory. Input and output connections are brought out to terminal posts to provide adequate facilities for connections. A voltage selector switch is installed to reduce the chances of incorrect connections in a test setup. Input and output connectors are also made to a Jones plug, which allows rapid, complete connections of the Variac into a standard relay test setup by merely plugging in a multiconductor test cable. Full fuse protection is provided, using slow-blow fuses in both input leads and in the brush lead. The slow-blow-type fuse takes care of the surge current when power is turned on, yet protects the Variac from overloads. A special magazine-type spare fuse holder keeps proper size replacement fuses at the test engineer's finger tips. The whole instrument is protected from mechanical damage by a metal enclosure, which also provides suitable mounting for a convenient carrying strap.

It has been found that fusing these devices has reduced burn-outs to practically zero whereas, previous to the time fuses were installed, burn-outs occurred rather regularly mainly because of improper connections into test circuits.

A single fuse is installed in the brush lead of the Type V-5 Variac without external visual evidence of such addition to the Variac. For example, in the V-5HM Variac, the fuse holder is strapped to the central post of the base plate with the end of the holder accessible for replacing the fuse from the bottom of the Variac.

Probably one of the most important, and certainly the most frequent, uses to which this device is put is in the testing and adjusting of the many protective relays found on a power system. In many of these testing operations, the autotransformer supplies power directly to the relay up to its rated current-carrying capacity. When heavier currents are needed, the autotransformer is used to control a loading transformer, which may furnish current of 100

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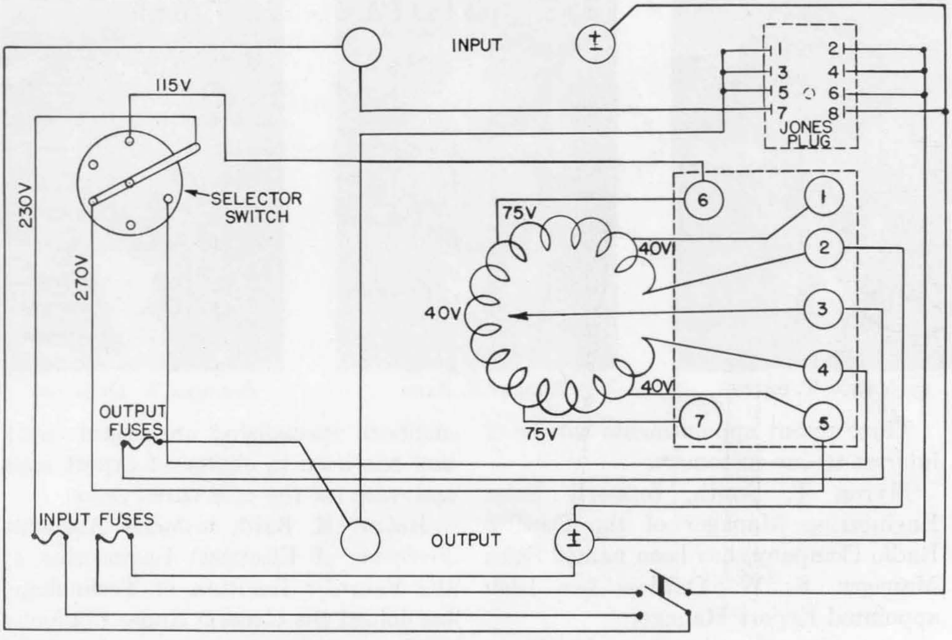



amperes or more to the relay under test.

In addition to the many general and usual uses to which these devices are put by the Authority are occasional out-of-ordinary uses such as its use with a special 4-prong test prod and milliammeter as a bar-to-bar tester in motor work. For a controllable source of 100 amperes at low voltage and minimum weight and space for use in a micro-ohmmeter, a few turns of heavy conductor to serve as a secondary winding are added around an adjustable auto-transformer's core over a non-used portion of the regular winding.

— R. F. Bennington

Mr. Bennington is Supervisor of Laboratories Section, Electrical Laboratory and Test Branch, Tennessee Valley Authority, Chattanooga, Tennessee. The publication of this material with the approval of the Tennessee Valley Authority does not constitute an endorsement of the General Radio Company's product by the Authority.

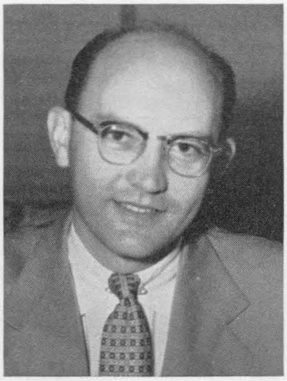
# MISCELLANY

**RECENT VISITORS** to the General Radio Plant and Laboratories — Dr. Ing. Agostino Belotti of Ing. S. Belotti and Co. of Milan, our exclusive representative for Italy; Eric Monsted, Test Engineer, E.M.A.I.L., Sydney, Australia; Dr. Itaro Umeda and Mr. Katso Hogino of Oki Electric Engineering Co., Tokyo, Japan.

**PAPERS** — "Testing and Adjusting Speaker Installation with the Sound-Survey Meter," by William R. Thurston, at the Audio Fair, New York, 1952; "Steady-State Measurement — A Survey of Basic Methods," by William R. Thurston, at the Study Group on measurement techniques, New York Section, A.I.E.E., February 3, 1953; "Measurement and Its Place in Engineering," by William M. Ihde, at a meeting of the Student IRE Section, Valparaiso Technical Institute, December 11, 1952.

File Courtesy of GRWiki.org

Myron T. Smith



Robert E. Bard

Stephen W. DeBlois

Three recent appointments will be of interest to our customers.

Myron T. Smith, formerly Sales Engineering Manager of the General Radio Company, has been named Sales Manager. S. W. DeBlois has been appointed Export Manager.

After his graduation from M.I.T. in 1931, Mr. Smith came with the General Radio Company as a development engineer. He served in this capacity until he was appointed manager of the New York district office. He subsequently managed the Los Angeles and Chicago districts, becoming Sales Engineering Manager in 1944.

Mr. DeBlois was graduated from Cornell University in 1936, and was later associated with Armco International. He served in the Signal Corps, U. S. Army, in the Mediterranean Theater during the war and was discharged a captain in 1945. He came to General Radio in 1946 as a sales engineer specializing in export work and has been in charge of export sales activities for the past three years.

Robert E. Bard, formerly Associate Professor of Electrical Engineering at the Fournier Institute of Technology, has joined the General Radio Company staff as Sales Engineer. Mr. Bard received his B.S. degree in Electrical Engineering from the Illinois Institute of Technology in 1942, after which he taught electrical engineering at that institution. He was associated with C. G. Conn, Ltd., as Engineer in the Research Department, leaving to enter the U. S. Navy, where he taught a course in Radar Fundamentals. From 1945 to 1948, he was employed by the American Phenolic Corporation as Senior Engineer in the Development and Research Divisions, and from 1948 to 1952 he has been on the faculty of the Fournier Institute of Technology.

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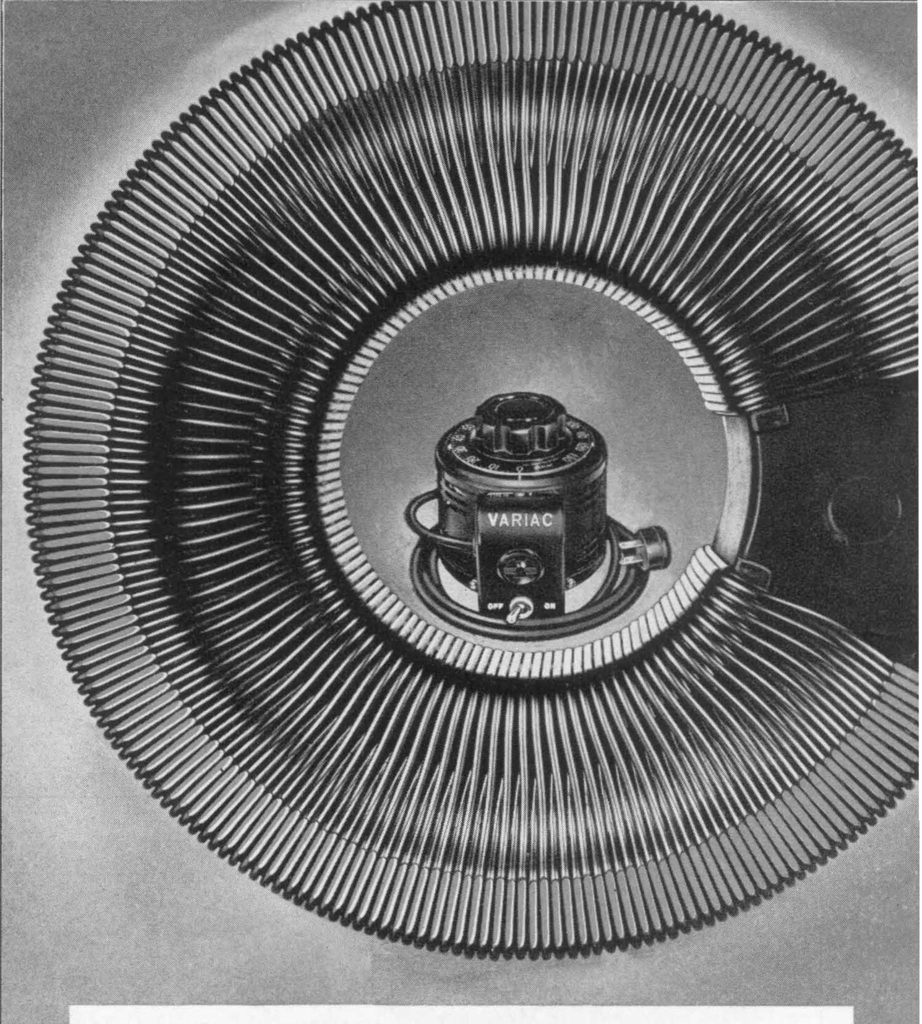
ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS




*Duratrak*, the new General Radio brush-track surface for VARIAC® autotransformers, is the most important advance since the original development of the variable autotransformer by General Radio twenty years ago. Today's VARIAC® autotransformer truly sets a new standard of reliability for the industry.

File Courtesy of GRWiki.org

# A NEW STANDARD OF RELIABILITY IN VARIABLE AUTOTRANSFORMERS VARIAC® WITH DURATRAK

The Variac® continuously adjustable autotransformer was first introduced by General Radio in 1933. It found ready and rapid acceptance as a laboratory instrument for the control of alternating voltages. For a given rating, it was more efficient, less cumbersome, cooler, and had better regulation than resistive controls previously employed for such service.

These same features proved to be equally attractive in the industrial field, and the Variac rapidly moved out of the laboratory and into the industrial plant. This trend was accelerated by the rapid expansion of the electronic and electrical control industries during and after World War II. Off came the "lab" coat and on went the overalls.

This new usage was vastly different from the original laboratory service. Variacs were expected to operate twenty-four hours a day, month after month— in some cases, year in and year out — often at some particular fixed setting. Ratings were pushed to the limit (and often beyond) in ambient temperatures and contaminating atmospheres that could not be tolerated in a laboratory but that are industrial commonplaces. As a result, Variacs were subjected to service conditions far more severe than those for which they were originally designed. The relatively few service failures under these conditions have been a continuing tribute to their inherently conservative design, and the prompt adjustment of these few failures by our Service Department has meant a minimum of inconvenience to our customers.

Service experience over the years has shown that perhaps 99% of the failures that do occur in continuously adjustable autotransformers are caused by overheating at the brush or, more specifically, at the winding underneath the brush, resulting in a cumulative deterioration of the brush track. This field experience checks well with what would be expected from the known design limitations of such devices.

This problem has now been solved as the result of an intensive development program started several years ago. General Radio's new *Duratrak* process makes the Variac as durable as a fixed-ratio transformer.

## DESIGN CONSIDERATIONS

A Variac autotransformer is similar to a conventional autotransformer or two-winding power transformer in many respects. It is also similar to a motor in having a carbon brush, and a moving element and commutator. It differs from a motor, however, in two fundamental respects: (1) The brush is often left in a fixed position drawing full current for long periods of time, and (2) Variac brushes operate at current densi-

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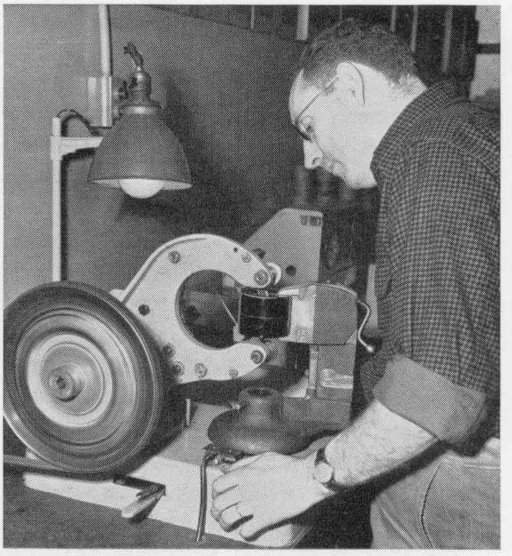
ties many times those encountered in motor practice due to the dimensional limitations of a commutator formed from the winding itself, the segments of which are spanned by the brush. The heating that occurs at the brush-to-commutator interface is thus localized, whereas in a motor the heat is distributed uniformly about the periphery of the commutator.

This localized heating at the contact is inherent in the device. In fact, control of this heating was the key to making the Variac a practical commercial device. In continuously adjustable autotransformers, the brush makes contact with two or more adjacent turns. There is therefore a circulating current flowing through the brush, in addition to the load current. The problem is to minimize the net power loss by balancing power loss in the short-circuited turn against the power loss due to load current drawn out through the brush.[1] Analysis has shown that the proper design calls for a brush contact drop such that the power dissipated is equal approximately to the full load current multiplied by the volts per turn of the winding.

The actual temperature rise that results from the power dissipation can be reduced by proper radiator design but, because of the relatively low thermal conductivity of carbon materials, only a portion of the generated heat can flow into the radiator and the balance must flow into the copper winding.

## Cumulative Deterioration

With proper design of brush and radiator structure, the temperature rise can be held to a reasonable value. Under severe load conditions, however, the exposed copper to which contact is made tends to oxidize if the brush is left at a fixed setting for a long period of time. The oxides of copper have relatively high resistance, and this causes a cumulative heating effect under conditions of fixed load. It is obvious that a potentially destructive cycle exists in this situation. Under certain adverse conditions (high ambient, high load, fixed brush setting, continuous operation, infrequent maintenance), a destructive cycle can be initiated which will ultimately lead to failure.



Variacs are precision wound on toroidal winders of our own design and manufacture.

## The Remedy, Duratrak — an Improved Commutator Surface

Intensive study of this problem led to the realization that the solution lay in developing a commutator surface whose contact resistance or voltage drop would remain relatively constant in the face of long-time exposures to elevated temperatures. A silver coating is, within the limits of our present knowledge, completely stable, and a method has now been developed of applying it to the brush track. In the course of the experi-

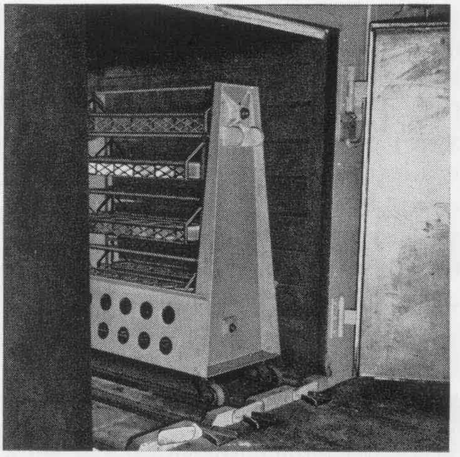
[1] Karplus and Tuttle, U. S. Patent No. 2,009,013.

File Courtesy of GRWiki.org

mental work, it was determined that a large number of alloys and noble metals met the requirement of stable contact resistance. It should be noted that the use of silver and precious metal alloy materials in general for electrical contact processes is as old as the electrical art itself. It is important to note, however, that in the usual application these materials are used for an entirely different reason. The usual objective is to obtain a low contact resistance, but in the Variac low resistance is of no help at all — the required resistance is prescribed by minimum loss considerations and must be high enough to limit circulating currents to safe values. A non-deteriorating surface is used to insure that the initial value of voltage drop is maintained even if, under heavy load, the brush is allowed to remain at a fixed setting.

## FIELD TESTS

For three years Variacs with the treated track surface have been under extensive and tortuous tests in General Radio laboratories. While controlled laboratory tests are important, every



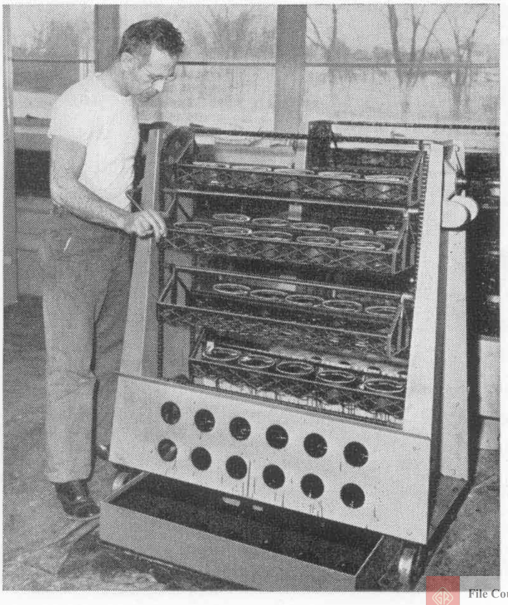
Rack, with load of Variacs, then goes into an oven to bake the thermosetting varnish.

engineer concerned with industrial devices knows that field tests under a wide variety of conditions are even more important. Accordingly, these new Variacs have been extensively field tested in increasing numbers as our confidence in performance and method of manufacture has grown. Field tests have been conducted under conditions of unusually severe service where old-style Variacs had required an exorbitant amount of maintenance or had actually failed.

In contrast, not a single field failure has been reported to date with the several thousand Duratrak units in service.

### Lighting Control

One of the earliest uses of these new Variacs was in the new liners *S. S. Constitution* and *S. S. Independence*. Variacs are used to provide complete and flexible control of the lighting in salons and dining rooms of these luxurious ships. It is obvious that the nature of the service places a high premium on reliability. To



After winding, Variac coils are dipped in baking varnish in specially designed racks.

File Courtesy of GRWiki.org

achieve the necessary reliability is particularly difficult because of the conditions of installation and use. High ambient temperature, salt air, enclosed mounting, and a minimum of maintenance combined with fixed settings and the high inrush currents of incandescent lamp loads conspired to make this service about as severe as anything that one would expect to encounter. Yet the installations are functioning satisfactorily after two years.

## Laboratory Tests

Under laboratory test, the performance of the treated Variacs has been quite spectacular, and any user of adjustable autotransformers will recognize from the description of these tests the tremendous improvement that has been realized. He may also recognize that one of the tests was inadvertent.

In one instance a Type V-20 Variac, conventionally rated at 20 amperes, was subjected to a load current at mid-point setting of 30 amperes for a period of approximately one month. There was no visible damage to the Variac winding and, to make a more severe test, the unit was enclosed in a thoroughly insulated cubicle to simulate conditions of unusually poor ventilation or heat transfer. After several days at 30 amperes, the current was raised to 45 amperes and held there for a period of four days. The ambient temperature within the box under these conditions was about 55°C., and the temperature rise in the winding of the Variac estimated at the order of 175°C. Clearly, this temperature is well beyond the safe limits for Class A insulation, but the important point is that *no damage occurred to the brush track*. As a final test, *a current of 100 amperes* was drawn for a few minutes at a low voltage setting. The brush heating from this current was sufficient to cause the carbon to become *incandescent*. Failure of the Variac still did not occur, although, of course, the organic (Class A) insulation was very badly charred by the high temperatures developed. With this extreme test, a slight discoloration and damage of the brush track occurred, but not sufficient to have any serious effect on the performance of the unit.

Another startling comparison between the new Variacs and a conventional unit was obtained in the process of operating a new unit and an untreated unit on a "pump-back" test. In this connection, the circuit current is limited only by internal impedance of the two units, and the voltage difference between the two brushes must be kept small. In one instance the brush of one unit was rotated far enough to develop practically full line voltage in the low impedance circuit. The resulting circulating current burned out the untreated unit almost instantaneously. The treated unit was substantially undamaged.

**The *Duratrak* process, which follows baking, coats the brush track with the silver surface shown on these partially assembled units.**

File Courtesy of GRWiki.org

Testing, which is continuous, has indicated to date a mechanical life of *many millions of brush traverses under severe overload without detectable deterioration.* Surge and inrush currents at least twice as great as before can be safely handled. While deliberate overload for extended periods gradually affects insulation condition (as with any transformer), there is no accelerated deterioration of the brush track, as invariably occurs with an unstabilized, copper brush track.

Prior to shipment, all Variacs must pass a series of rigid electrical tests to assure conformance to specifications.

With this new development, the limitation of the brush and track has essentially been removed from the adjustable transformer, and the rating and use of such a device are therefore limited solely by the same considerations that control the use of any fixed ratio transformer, namely the temperature rating of the electrical insulation used therein.

Ratings, which are conservatively based on accepted (NEMA, AIEE) standards of temperature rise, remain unchanged. We leave for time and even more extended field experience the determination of practical overload or short-term, high-temperature ratings.

We sincerely believe that this new development is the most significant advance in the adjustable autotransformer art since the conception of the Variac itself some twenty years ago. General Radio is proud to offer these new units, which are already establishing new high standards of reliability and durability.

—Gilbert Smiley
Ivan G. Easton

The authors wish to extend their thanks and credit to the members of the General Radio Company staff, without whose cooperation this development could not have been brought to fruition. Particular credit is due to:

Mr. Harold S. Wilkins for patient, step-by-step testing of materials and methods in the development of production techniques.

Mr. Harold M. Wilson for the design of materials handling equipment to put the process on an economic basis.

Mr. Charles A. Tashjian for his cooperation and supervision in adapting the pilot-plant techniques to full-scale manufacture.

# EXPANDED REPAIR SERVICES

Since the opening of our new branch plant in West Concord, Massachusetts, in April, 1952, a considerable number of our instruments are being manufactured and repaired there. Because of this, it is important that our customers write to the Service Department, 275 Massachusetts Avenue, Cambridge 39, Massachusetts, giving the type and serial number of their instrument, before returning it for reconditioning, recalibration, or for any other reason. A return material tag will then be mailed with shipping instructions for the return of the equipment to either our repair facilities in Cambridge or our West Concord

File Courtesy of GRWiki.org

plant, depending upon the type of instrument involved. If this procedure is followed, the time consumed in handling can be held to a minimum.

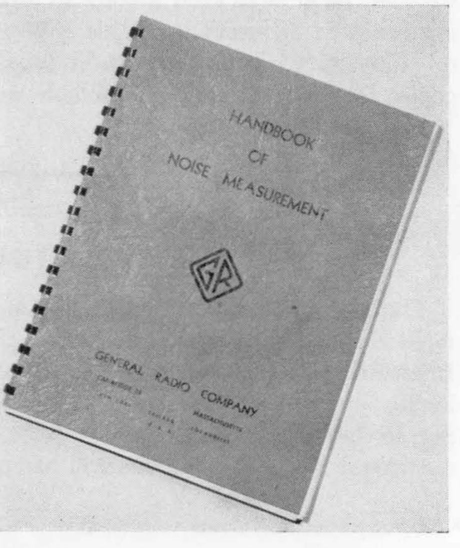
Customers in Canada should write to Bayly Engineering Limited, 5 First Street, Ajax, Ontario, or phone WAverly 6866 through the Toronto exchange. This firm is our authorized repair service and is equipped to give prompt and competent attention to all General Radio instruments.

West Coast users of General Radio instruments can have their equipment repaired and recalibrated in California by writing to the Western Instrument Company, 826 North Victory Boulevard, Burbank, California, or phoning ROckwell 9-3013. This firm is also an authorized repair service for General Radio products.

Each of these companies has a well-equipped shop and laboratory, and can give prompt and satisfactory repair service on all General Radio instruments. The repairs and calibrations are made to the same specifications and standards as are used at our own repair facilities.

## HANDBOOK OF NOISE MEASUREMENT

A new publication, the "Handbook of Noise Measurement," is now available, replacing the old "Noise Primer." This new book, consisting of over 100 pages, covers thoroughly the measurement of noise and other airborne sounds, including definitions, standards, measuring equipment, measurement procedures, and interpretation of results. The authors, Dr. A. P. G. Peterson of the General Radio Engineering Staff and Dr. Leo L. Beranek of M.I.T., are well known in the field of acoustic measurement, and their treatment of the subject of noise measurement is based on many years' experience.




Copies of this handbook are available from the General Radio Company at a price of $1.00 each postpaid.

## RECENT VISITORS TO GENERAL RADIO

Mr. Erland Cossel, Instructor, Department of Theoretical Electrical Engineering, University of Stockholm, Sweden; Dr. Ing. Agostino Belotti, of Ing. S. Belotti and Co., of Milan, our exclusive representatives for Italy; Mr. Harald Molinari, Engineer, Seyffer and Co., Zurich, our exclusive representatives for Switzerland; Dr. Toyohiko Okabe, of Tokyo Shibarua Electric Co., Ltd., Tokyo, Japan; and Dr. Shigeru Nakajima, Japan Radio Co., Tokyo.

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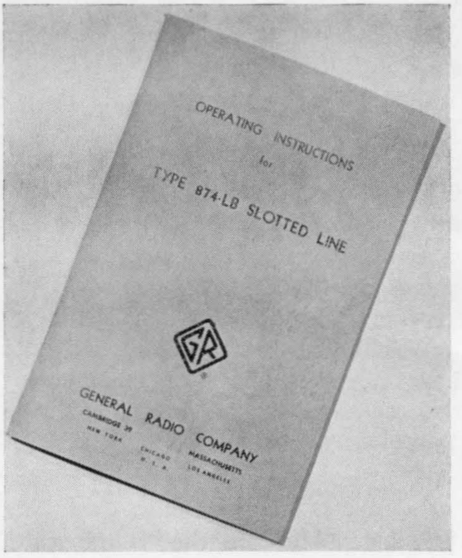
# NEW INSTRUCTION MANUAL FOR SLOTTED LINE




Users of the TYPE 874-LB Slotted Line will be glad to learn that the complete instruction book for that instrument is now available. Copies have been sent to all who returned the cards that were enclosed with slotted lines already shipped. If you are using the General Radio Slotted Line and have not yet received a copy of the instruction book, please request it on your company letterhead.

This book is a more comprehensive operating manual on slotted-line measurements than any other that we have seen. It should be very useful for classroom and laboratory instruction, and we shall be glad to send a copy to any teacher who requests it on his college or university letterhead. Additional copies for student use are available at a nominal price to cover the cost of printing.

# RESEARCH EQUIPMENT EXHIBIT

The Third Annual Research Equipment Exhibit, sponsored by the National Institute of Health, will be held April 27-30, 1953, at the Clinical Center Building, Bethesda, Maryland.

General Radio instruments will be on display at Booth 56, and General Radio sales engineers will be on hand to discuss your measurement problems and to answer your questions. A cordial invitation to visit this display is extended to all our readers in the Washington area.

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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

# A NEW 2-AMPERE VARIAC®

## TWICE THE POWER FOR THE SAME PRICE

*Also* IN THIS ISSUE

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● **A NEW VARIAC,** the TYPE V-2, is the latest addition to the General Radio line of adjustable autotransformers. Designed to supplant the older TYPE 200-B, with which it is generally interchangeable, TYPE V-2 offers *twice the power rating for the same price*. In addition, TYPE V-2 incorporates such desirable features of V-line Variacs as the GR unit brush and Duratrak, the stable brush track that resists deterioration from use and abuse.

Like the TYPE 200-B, the new TYPE V-2 is intended primarily for panel mounting, and so is supplied with a reversible dial-plate (0-115 volts; 0-135 volts) and pointer knob for panel installation. Although the depth behind panel is slightly greater, mounting bolts and bolt locations for TYPE V-2 are the same as for TYPE 200-B, as is the radial clearance required back of panel. This latter was accomplished by operating the brush on the face of the winding, instead of on the periphery, and by optimum use of copper and modern core material.

Unlike TYPE 200-B, TYPE V-2 has a metal base for improved cooling and strength and a terminal board on which the circuit is clearly indicated. This unit can be operated at both 50 and 60 cycles for either line or overvoltage connections.

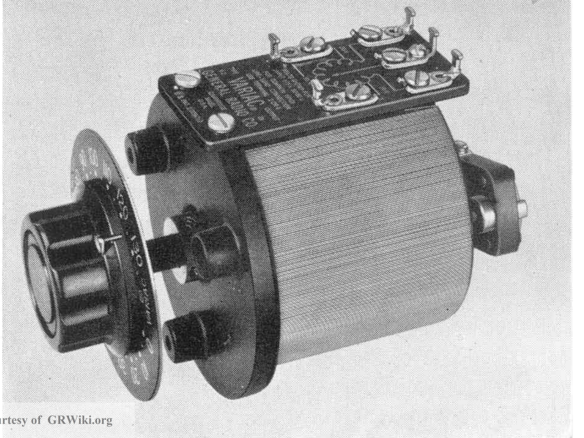


Figure 1. Designed for panel mounting, the new Type V-2 Variac Autotransformer gives more watts per dollar than its predecessor.

File Courtesy of GRWiki.org

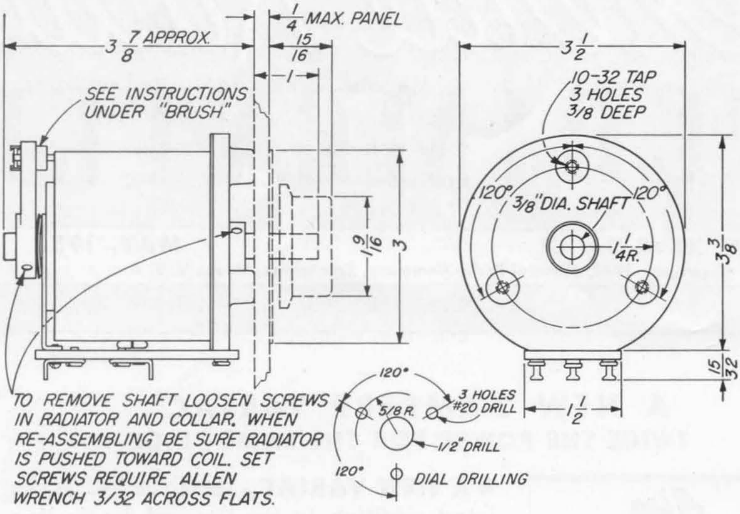



Figure 2. Dimensions of the Type V-2 Variac. Mounting dimensions and radial clearance are the same as for the older Type 200-B. Depth behind panel is slightly greater.

The Type V-2 assembly is a strong, simplified design that will withstand shock and vibration tests such as those under MIL-T-945-A. With its rating of 0.345 KVA and its many desirable features, Type V-2 Variac offers excellent value for your autotransformer dollar.

— Gilbert Smiley

## SPECIFICATIONS

**Input Voltage:** 115 volts.
**Load Rating:** 0.345 kva.
**Line Frequency:** 50 to 60 cycles.
**Output Voltage:** Overvoltage connection, 0 to 135 volts; line-voltage connection, 0 to 115 volts.
**Rated Current:** 2 amperes.
**Maximum Current:** Overvoltage connection, 2 amperes; line-voltage connection, 3 amperes.
**No-Load Loss at 60 Cycles:** 3.5 watts.
**Driving Torque:** 15 to 30 inch-ounces.
**Dimensions:** See Figure 2.
**Net Weight:** 3½ pounds.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **V-2** | **2-Ampere Variac®** | BEADY | **$12.50** |

# TYPE 1551-P1 CONDENSER MICROPHONE SYSTEM

## TINY MICROPHONE EXTENDS USEFUL FREQUENCY RANGE OF TYPE 1551-A SOUND-LEVEL METER TO 15 KILOCYCLES

During the development of the Type 1551-A Sound-Level Meter,[1] much thought was given to the choice of microphone. Because of its low cost, high sensitivity, and good frequency response, the Rochelle-salt crystal microphone was chosen as standard equipment. It was recognized, however, that no one microphone would satisfy all the demands that would be made on a sound-level meter and that special purpose or accessory microphones would be needed. A dynamic microphone has already been made available[2] for those applications

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

[2]E. E. Gross, Jr., "A Dynamic Microphone for the Sound-Level Meter," *General Radio Experimenter*, Vol. XXV, No. 11, April, 1951.

File Courtesy of GRWiki.org

requiring a long cable between microphone and sound-level meter. There are also many measurements where a wide frequency range is essential. For example, when response measurements are to be made over the full range of high-fidelity loud-speaker systems, the measurement microphone must be usable from 20 to about 15,000 cycles per second, which is well beyond the requirements of the standard[3] on sound-level meters. Similarly, when noise measurements are made on jet engines, air blasts, knitting and weaving rooms in textile mills, or when they are made to evaluate deafness risk[4] or to aid in solving an annoyance problem, good high frequency response is essential.

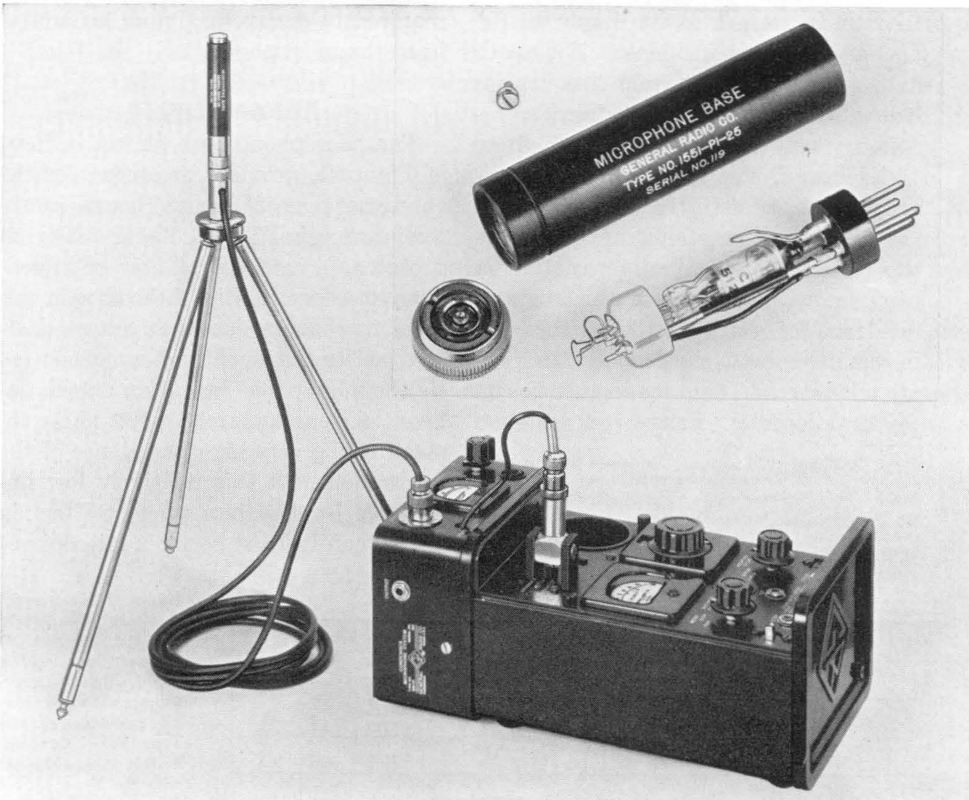
[3]ASA, American Standard for Sound-Level Meters for Measurement of Noise and Other Sounds, Z-24.3, 1944.

[4]Gordon D. Hoople, "Unsolved Problems Relating to Hearing Loss in Industry," *Journal of the Acoustical Society of America*, Vol. 24, No. 6, pp. 765-766, November, 1952.

The new TYPE 1551-P1 Condenser Microphone System was developed to satisfy this need for making sound measurements over wide frequency ranges. It takes advantage of the wide frequency range of the amplifier in the TYPE 1551-A Sound-Level Meter, and the combination has a good frequency response characteristic from 20 to 15,000 cycles per second.

This new accessory is a portable, battery-operated unit just as the sound-level meter is, so that the complete measuring equipment is readily portable. The basic elements are the condenser microphone, a preamplifier, an extension cable, and a battery unit. As shown in Figure 1, the condenser microphone

**Figure 1. View of the Type 1551-A Condenser Microphone System attached to the Type 1551-A Sound-Level Meter. Inset shows microphone, microphone base, and preamplifier.**




File Courtesy of GRWiki.org

mounts on a small cylindrical base which houses a sub-miniature tube preamplifier. The microphone base plugs into one end of a 10-foot extension cable which has a tripod fitting. The other end of the cable plugs into a compact, battery-operated power supply, which is readily fastened to the end of the sound-level meter cabinet. Connection is made to the sound-level meter input or microphone socket by a short flexible cable on the power supply.

## MICROPHONE CHARACTERISTICS

The Altec Type 21-C Condenser Microphone used with this system is well suited to making acoustic measurements over wide frequency ranges. It is similar to the earlier Type 21-B Microphone[5, 6], but modifications in the cap have extended the high-frequency response. The typical response curves in Figure 2 show that the response of the microphone to sounds normal to its diaphram (0° or perpendicular incidence) is smooth and essentially flat from frequencies below 20 cycles to 8 kilocycles. The response then remains within ±3 db to 14 kilocycles. The small size of this microphone is a distinct advantage from the measurement standpoint since, as the curves show, it limits variation in response with changes in the angle of incidence of sound striking the diaphragm. Figure 2 shows that this variation is less than 6 db for frequencies up to 10 kilocycles. Larger microphones commonly used in sound measurements are much poorer in this respect. For example, the difference between grazing (90°) and perpendicular (0°) incidence response for the standard crystal microphone or the dynamic microphone (Type 759-P25)[2] is 6 db at approximately 4,000 cycles. By making such comparisons, it can be seen that this new microphone shows a substantial improvement in response over the microphone furnished with the sound-level meter or the Type 759-P25 Dynamic Microphone. The sensitivity of the microphone is approximately –48 db (re 1 volt per μbar) which is 10 db greater than the crystal microphone normally used with the sound-level meter. The output impedance is approximately 6 μμf. At low frequencies this is an extremely high source impedance (over 1,000 megohms at 20 cycles), so an amplifier with high input impedance is required to derive maximum usefulness from the microphone.

[5]J. K. Hilliard, "Miniature Condenser Microphone," *J. of the Soc. of Motion Picture and Television Engineers*, Vol. 54, pp. 303-314, March, 1950.

[6]R. J. Carrington, "Miniature Capacitor Microphone-Omnidirectional at All Frequencies," *Electrical Manufacturing*, Vol. 48, No. 4, pp. 128-133, October, 1950.

## PREAMPLIFIER

The microphone base, shown in inset of Figure 1, provides mounting for the condenser microphone and houses a subminiature tube (Type CK-512-AX) connected as a cathode follower or impedance transformer. Use of the tube in this fashion produces an output voltage nearly equal to the signal voltage generated by the microphone but at an impedance level of approximately 6,000 ohms instead of the very high impedance of the microphone. At this relatively low impedance level, cables up to 25 feet in length can be used between microphone

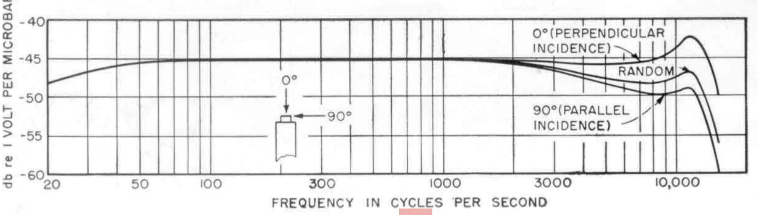



Figure 2. Frequency-response characteristics for different directions of incident sound. These characteristics show the overall response of the Type 1551-P1 Condenser Microphone System with the Type 1551-A Sound-Level Meter.

File Courtesy of GRWiki.org

Figure 4. The consenser microphone system is furnished in a compact leather carrying case of top-grain cowhide.

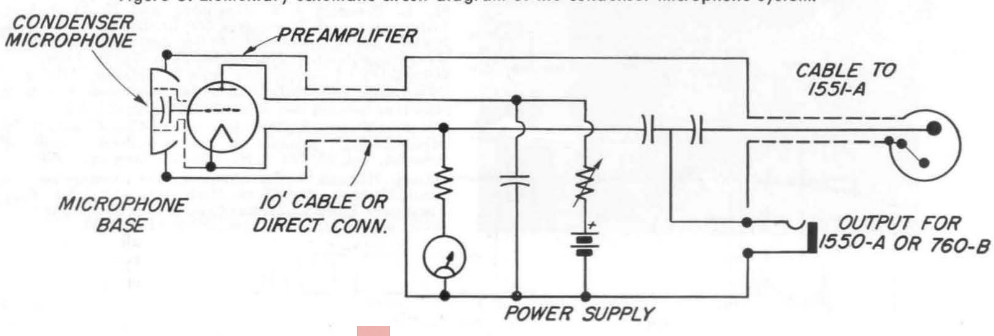
base and sound-level meter without cable correction. Figure 3 is an elementary schematic diagram of the system. As is indicated, no external grid-leak is used to determine the bias for the preamplifier. The insulating material supporting the back plate structure of the microphone is a glass-bonded mica with a leakage resistance of more than $10^7$ megohms and is specially treated to remove and seal out moisture. So long as the leakage resistance is maintained at this high value, the grid bias is established by the voltage gradient within the electron cloud surrounding the cathode. Under these conditions it has been found that the bias is stable and the noise level over the 20-kilocycle band at the output of the preamplifier is approximately 20 $\mu$volts or low enough so that sound levels of 40 db (re 0.0002 $\mu$bar) can be measured with the system. The output of a 50-db microphone is 20 $\mu$volts for a sound-pressure level of 30 db (re 0.0002 $\mu$bar).

## POWER SUPPLY

The battery-operated power supply furnishes the filament and plate supply for the CK-512-AX tube in the preamplifier and the 200 volts necessary to polarize the condenser microphone. Polarization is achieved by raising the cathode 200 volts above ground. The 200 volts is accurately determined by using a precision cathode resistor and measuring the cathode current with the panel meter. The normal grid bias is approximately –1 volt, so that when the cathode voltage is 200 volts the polarizing voltage is actually 199 volts. If for any reason the grid bias increases beyond approximately –12 volts, the voltage drop across the preamplifier tube exceeds 100 volts and, since the B battery is 300 volts, it becomes impossible to set the cathode voltage to 200 volts. Thus a warning is given if the polarizing voltage is in error by 6 per cent or more.

The power supply is contained in a simply formed aluminum case finished with black lacquer. As indicated in Figure 1, it can be fastened to the end frame of the sound-level meter. In addition to the short flexible cable on the power supply, which connects the output of the system to the input of the sound-level meter, there is an OUTPUT jack to

Figure 3. Elementary schematic circuit diagram of the condenser microphone system.

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facilitate connection of the microphone system to the input of other instruments such as analyzers or recorders.

## CALIBRATION

The frequency response of the microphone is checked in our testing laboratory, and the 400-cycle level of the system is supplied. In addition, a calibration adaptor is included which permits measurement of the 400-cycle level at any time by using the TYPE 1552-A Sound-Level Calibrator.[7]

## APPLICATIONS

The TYPE 1551-P1 Condenser Microphone System offers in a small, battery-operated, and convenient package a wide-range pickup for the sound-level meter that will prove useful in many sound measurements. It extends the useful range of the sound-level meter from an upper limit of 8 or 9 kilocycles to 15 kilocycles. Not only is its high-frequency operation superior to previous microphones that we have offered, but its low-frequency response remains constant to 20 cycles. It should prove useful in the fields of industrial noise measurements, checks on high-fidelity sound systems, measurements of jet-engine noises, or noise and sound measurements of any type where low-, medium-, or high-frequency components are of special interest. Owing to the small size of the microphone and microphone base, the response is relatively independent of sound incidence when the microphone is mounted on a tripod and separated from the sound-level meter. The mechanical impedance of the microphone diaphragm is high enough for measurements of sound pressures in cavities, making the microphone useful for measuring earphone characteristics in earphone-coupling cavities and for measurement of acoustic impedance. The small dimensions and cylindrical shape of the microphone and base make the unit easily adaptable for use as a probe microphone for the study of noise levels in ventilating ducts.[8, 9]

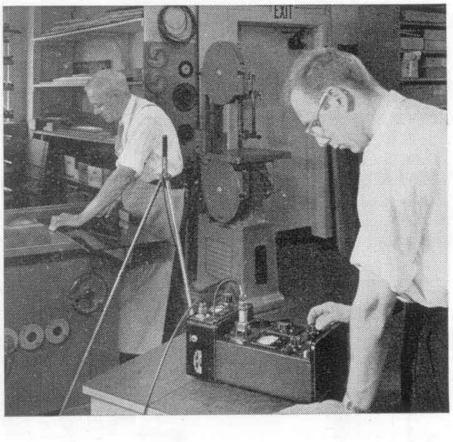
Probe tubes[10] can be used with the microphone for exploring sound fields in small cavities where even this small microphone offers an obstruction.

A probe tube can also be used where the temperature of the sound field to be explored is extremely high and it is desirable to maintain some distance between the microphone and the probe point in the field.[11]

Because of its uniform response, this pickup system should prove especially useful in all measurements where accurate analysis of all components pres-

[7]E. E. Gross, Jr., "An Acoustic Calibrator for the Sound-Level Meter," *General Radio Experimenter*, Vol. XXIV, No. 7, December, 1949.

Figure 5. High-frequency sound, produced by a power saw, is measured with the sound-level meter and condenser microphone system.




[8]L. L. Beranek, J. L. Reynolds, and K. E. Wilson, "Apparatus and Procedures for Predicting Ventilating System Noise," *Journal of the Acoustical Society of America*, Vol. 25, No. 2, pp. 313-321, March, 1953.

[9]Clifford E. Piestrup and John E. Wesler, "Noise of Ventilating Fans," *Journal of the Acoustical Society of America*, Vol. 25, No. 2, pp. 322-326, March, 1953.

[10]Robert W. Benson, "Calibration and Use of Probe-Tube Microphones," *Journal of the Acoustical Society of America*, Vol. 25, No. 1, pp. 128-134, January, 1953.

[11]J. K. Hilliard, "Microphone for the Measurement of Sound-Pressure Levels of High Intensity over Wide Frequency Range," *Transactions of the IRE Professional Group on Audio*, PGA-7, pp. 38-45, May, 1952.

File Courtesy of GRWiki.org

ent in the noise is desired. The microphone is very rugged and durable and will withstand very high sound-pressure levels without damage. The upper limit of measurement before its output becomes noticeably distorted is 140 db. When higher sound-pressure levels are to be measured, other versions of this microphone,[12] the Altec Types 21BR-180 and 21BR-200, can replace the Type 21-C on the microphone base for measurements up to 180 db. For example, the 21BR-180 can be used for sound levels from about 60 db to 160 db.

To make the use of the condenser microphone system as convenient as possible, a leather carrying case, illustrated in Figure 4, is supplied as a part of the system. Compartments are provided for each unit for handy storage and transportation of the system. With a case such as this, the problem of keeping all necessary components together and easily available, whether in the laboratory or on field trips, is neatly solved.

— E. E. Gross, Jr.

[12] J. K. Hilliard, "Applications of High-Intensity Microphones," presented at IRE National Convention, Session 38, March 26, 1953, New York City, N. Y.

## SPECIFICATIONS

**Frequency Response:** Useful range of the Type 1551-A Sound-Level Meter with Type 1551-P1 Condenser Microphone System is 20 cycles to 15 kilocycles. Typical frequency response curves are shown in Figure 2.

**Sensitivity:** Open circuit output of typical microphone and preamplifier is 48 db below one volt per microbar. This sensitivity is about 10 db greater than the crystal microphone supplied with the sound-level meter. When the levels of the sound components exceed 60 db (re 0.0002 $\mu$bar), the Condenser Microphone System can be connected directly to the Type 760-B Sound Analyzer or the Type 1550-A Octave-Band Noise Analyzer.

**Calibration:** The output level of the microphone system is measured at several frequencies against a standard microphone that is calibrated periodically by the National Bureau of Standards. The measured level at 400 cycles is supplied. A Calibration Adaptor is provided for use with the Type 1552-A Sound-Level Calibrator.

**Maximum Safe Sound-Pressure Level:** At levels above 140 db the output of the microphone becomes non-linear. For levels up to 180 db the Altec Type 21-BR-200 can be used in place of the Altec Type 21-C. (The Type 21-BR-200 is not furnished as part of the Type 1551-P1.)

**Cable Correction:** No correction is necessary for the 10-foot cable supplied.

**Internal Noise Level:** Under normal conditions the noise level of the Type 1551-P1 Condenser Microphone System is low enough to permit satisfactory measurements of sound-pressure levels as low as 40 db (re 0.0002 $\mu$bar).

**Output Terminals:** A short flexible output cable on the power unit plugs into the microphone socket of the Type 1551-A Sound-Level Meter in place of the standard crystal microphone. In addition, a jack located on the side of the power supply provides a direct connection to the Type 760-B Sound Analyzer or the Type 1550-A Octave-Band Noise Analyzer.

**Batteries:** One 1½-volt size-D flashlight cell (Eveready 950 or equivalent) and one 300-volt B battery (Eveready 493 or Burgess V-200) are supplied.

**Tubes:** One Raytheon Type CK-512-AX is supplied in the Type 1551-P1-25 Microphone Base.

**Mounting:** Microphone on microphone base plugs into one end of 10-foot cable, which has fitting to mount on the tripod. Other end of 10-foot cable connects to power supply unit, which fastens to the end frame of the Sound-Level Meter.

**Dimensions:** Microphone — (diameter) ⅝ x (length) 2 1/64 inches; Microphone Base — (diameter) ¾ x (length) 3 inches; Power Supply — (height) 7 x (length) 3¼ x (width) 7½ inches.

Leather carrying case with compartment for microphone and microphone base, power supply, 10-foot cable, and calibration adaptor has overall outside dimensions of approximately (height) 7 x (length) 5½ x (width) 8½ inches.

**Net Weight:** Altec 21-C Microphone, less than ½ oz.

Microphone and Base, 1.2 oz.

Power Supply, 3 lbs. 11 oz.

Complete System in Carrying Case, 7 lbs. 6 oz.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **1551-P1** | **Condenser Microphone System** | NONAL | **$225.00** |

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## VISITORS FROM OVERSEAS

The recent annual convention of the Institute of Radio Engineers afforded a welcome opportunity to greet many of our friends from overseas. Among those visiting our plant after the convention were:

Mr. Marius Berlin, of Radiophon, Paris, exclusive distributors for General Radio products in France and the French colonies; Mr. John C. Lagercrantz, of Stockholm, exclusive distributor for Sweden; and Mr. Harnam V. Montwane, of Eastern Electric and Engineering Co., Bombay, exclusive distributors for India.

We were also privileged to have as guests at our booth in the Radio Engineering Show, and later at our factory, a group of nine overseas business men from Latin America and European countries, who are now on a five-weeks' tour of electronic plants in the United States. This group, all engaged in selling electronic equipment of U. S. manufacturers in their respective countries, are representatives of Ad. Auriema, Inc., New York export agents for U. S. firms. The accompanying photograph shows the group in the General Radio booth at the Radio Engineering Show.


(*Left to right*) Mr. Mario R. Aguilar, Mexico City; Mr. John Dorman, Ad. Auriema, Inc.; Mr. Richard Bohn, Ad. Auriema, Inc.; Mr. Edmund C. Paca, Ad. Auriema, Inc.; Mr. Nathan Blomhof, Brussels, Belgium; Mr. Guillermo Lucas Royo, Havana, Cuba; Mr. Joseph Sedacca, Ad. Auriema, Inc.; Mr. Angel Mokuvos, Montevideo, Uruguay; Mr. Barnett Phillips, Ad. Auriema, Inc.; Mr. Leopoldo Brandt, Buenos Aires, Argentina; Mr. Andres Lara Saenz, Madrid, Spain; Mr. Anthony Forani, Brussels, Belgium; Mr. Ad. Auriema, President, Ad. Auriema, Inc.; Mr. R. C. Auriema, Ad. Auriema, Inc.; Mr. J. Augusto Gerlinger, Sao Paulo, Brazil; Mr. Richard Minnich, Ad. Auriema, Inc., and Mr. S. W. DeBlois, Export Manager, General Radio Company.

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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS®

# APPROXIMATE FREQUENCY ANALYSIS FROM WEIGHTING-NETWORK DATA IN ACOUSTIC NOISE MEASUREMENTS

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A Clip-Type Lock for Coaxial Connectors ............... 7

● **IN THE EVALUATION** of the character of a noise, there is no adequate substitute for a frequency analysis by either a continuous-spectrum analyzer or an octave-band analyzer, whether the purpose of the measurement be to determine the characteristics of a noise source or to estimate the effects of a noisy environment. In some noise surveys, however, which are commonly made with a single instrument, such as the Type 1555-A Sound-Survey Meter, it is often helpful to be able to estimate the spectral distribution of the noise.

The following article by Mr. Jerome R. Cox, Jr., of the Loss Prevention Department, Liberty Mutual Insurance Company, outlines a method of making this estimate.

—*Editor*

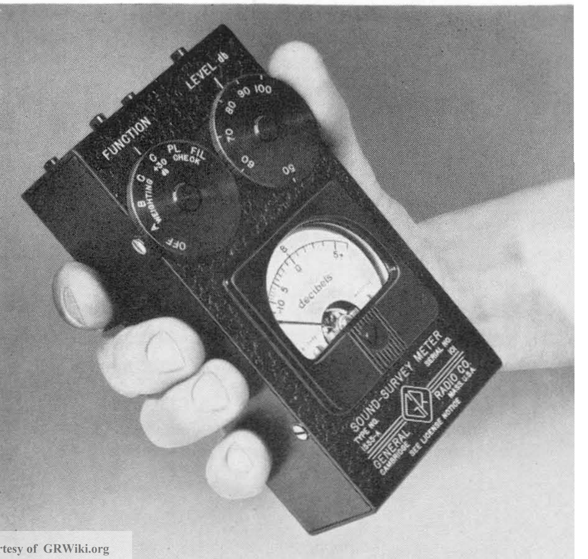



Figure 1. View of the Type 1555-A Sound-Survey Meter. When noise measurements are made with this instrument, the approximate frequency analysis is particularly useful.

File Courtesy of GRWiki.org

The standard sound-level meter[1] has three weighting networks, which have the frequency characteristics shown in Figure 2. One of these is usually selected for a given measurement according to the observed level, so that only one reading is taken. Actually, of course, since these weighting networks differ in frequency response, one can expect to learn more about the noise by taking three readings than by taking only one. Consequently, many engineers regularly use all three weighting networks whenever they measure a noise.

On the basis of the relative readings obtained by using the three weighting networks, some estimate of the distribution of noise energy as a function of frequency is often made. This estimate is usually colored by the experience and intuition of the engineer, particularly when he is guided by a subjective estimate of the sound.

It is possible, however, to set up a systematic procedure to estimate the approximate frequency distribution. As an initial attempt in this direction, the set of charts shown in Figure 3 has been prepared. Obviously, this method of determining the spectrum of a noise is not an accurate one; the weighting networks are not designed to perform the function of frequency analysis, and the tolerances on the response of these networks are comparatively large.

[1]ASA Z24.3–1944, Sound-Level Meters, American Standards Association.

## Division into Three Bands

Since there will be three readings for each noise, it has been assumed that approximate levels in three bands could be obtained. A study of the network characteristics led to a division of the spectrum as follows: A low-frequency band from 20 to 150 c; a middle frequency band from 150 to 600 c; and a high-frequency band from 600 to 8,000 c. For comparison, the eight bands of the octave-band analyzer are 20 to 75 c, 75 to 150 c, 150 to 300 c, 300 to 600 c, 600 to 1200 c, 1200 to 2400 c, 2400 to 4800 c, and 4800 to 10,000 c.

The band from 600 to 8,000 c seems unusually wide, but it is easy to see that this width is dictated by the network characteristics. Figure 2 shows that the response of the three networks is essentially the same above 600 c. Thus a noise that has no components below 600 c would give nearly the same readings on a sound-level meter for all three weighting networks, and one could not tell directly from the three level read-

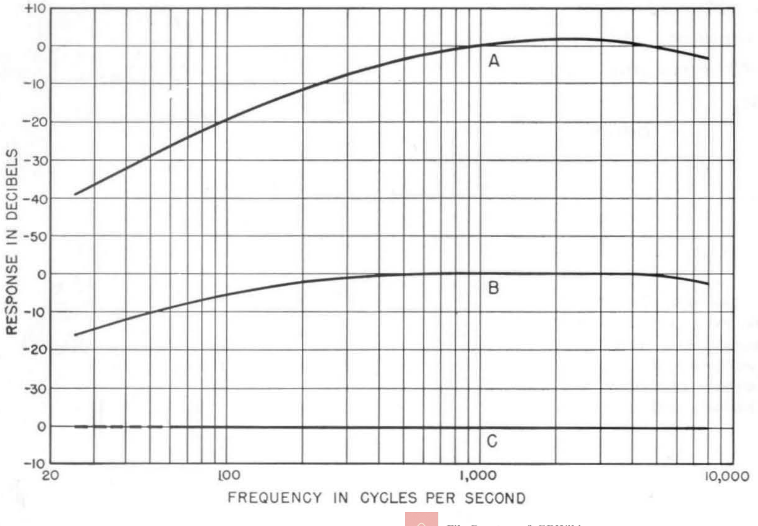
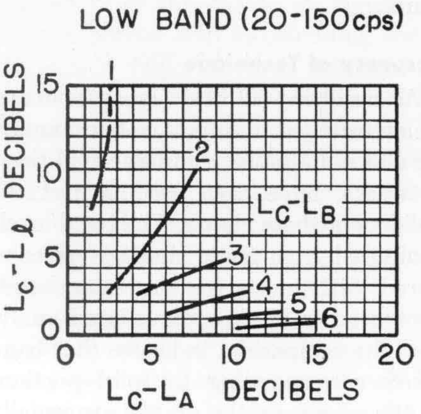
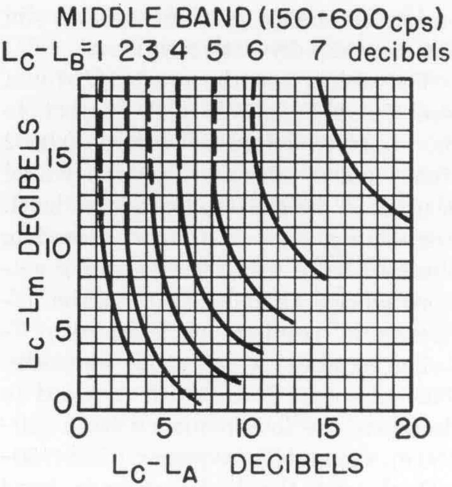



Figure 2. Frequency response characteristics for sound-level meters. *American Standard for Sound-Level Meters, Z24.3-1944.*

File Courtesy of GRWiki.org




*L*C = Level reading obtained when using the C-weighting network = *Over-all Level.*
*L*C — *L*A = Difference in readings of level with C-weighting and *A*-weighting networks.
*L*C — *L*B = Difference in readings of level with C-weighting and *B*-weighting networks.
*L*C — *L*l = Level to be subtracted from the C-weighting level to obtain "Low-Band" (20–150 c.p.s.) level.
*L*C — *L*m = Level to be subtracted from the C-weighting level to obtain "Middle-Band" (150–600 c.p.s.) level.
*L*C — *L*h = Level to be subtracted from the C-weighting level to obtain "High-Band" (600–8,000 c.p.s.) level.

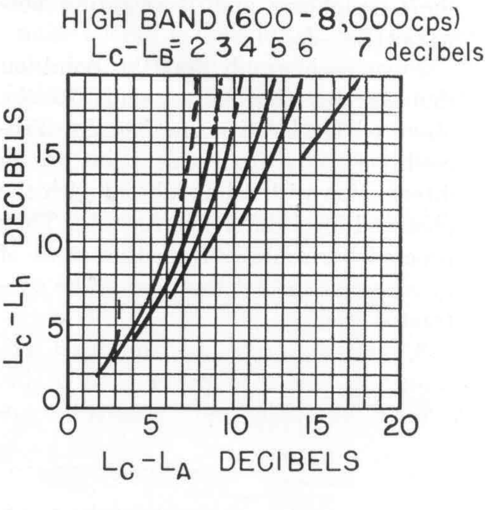



Figure 3. Curves for calculating an approximate frequency analysis in three bands from level readings taken when using the three sound-level meter weighting networks. The measured value of $L_C - L_A$ is entered at the abscissa of each graph, proceeding vertically to the curve labeled with the measured value of $L_C - L_B$, then horizontally to the ordinate value for each of the three bands corresponding to the difference between the individual band levels and the over-all level.

ings anything about the distribution within this broad band. Here is where an experienced engineer can use his subjective estimate of the noise to distinguish between a broad-band hiss and a narrow-band, pitched noise. Frequently, he can in this way make a good estimate of how the noise energy is distributed in this high-frequency band.

Incidentally, the directivity characteristics of the microphone at high-frequencies can also be helpful in making this estimate, but a discussion of that procedure will not be attempted here.

## Description of Charts

The charts of Figure 3 were prepared by a method of successive approximations from the characteristics of the three weighting networks. This method used experimental data taken on industrial noise spectra to make the final adjustment of the curves. The distri-

File Courtesy of GRWiki.org

bution of energy in these spectra did not vary rapidly with frequency.

The charts use the symbol $L$ for a level in decibels (all with respect to the standard reference level of 0.0002 $\mu$bar), and a subscript on this symbol is used to designate a particular level. For example, $L_C$ is the level reading obtained when using the weighting network labeled $C$, and $L_C - L_A$ is the difference in readings of level with $C$-weighting and $A$-weighting networks. The subscripts $l$, $m$, and $h$ are used to designate the low-frequency band (20–150 c), the middle-frequency band (150–600 c), and the high-frequency band (600–8000 c), respectively.

The charts are used as follows:

1. Obtain the difference in readings of level with the $C$-weighting and $A$-weighting networks ($L_C - L_A$) and with the $C$-weighting and $B$-weighting networks ($L_C - L_B$).

2. On each graph find the point on the abscissa that corresponds to the observed level difference $L_C - L_A$. Proceed vertically from this point to an intersection with a line labeled with the observed level difference $L_C - L_B$. Then proceed horizontally from this point of intersection to find the level to be subtracted from $L_C$.

3. Subtract from $L_C$ the level obtained in this fashion on each of the three graphs. The result is then the approximate level in each of the three bands.

## Accuracy of Technique

A number of field measurements, which included both octave-band analyses and sound-level readings on all three networks, have been used to test the validity of these charts. The band levels computed from these charts were compared with levels for the same bands computed from the octave-band analyses. The comparison indicates that band levels corresponding to solid portions of the curves on the graphs are usually accurate to ±3 db. There is a significant percentage of irregular cases, however. For example, if the noise energy is concentrated in a narrow band, which is true for a pure tone, or if the noise fluctuates markedly in level with time, larger errors than ±3 db can be expected. If the $A$, $B$, and $C$ readings cannot be repeated within 0.5 db, good accuracy cannot be expected.

Certain noises in which the energy is localized at one end or the other of the lower and middle bands cannot be analyzed by this method. Usually this type of spectrum will result in $L_C - L_A$ values that do not fall on the $L_C - L_B$ curves. Here, again, an experienced observer can sometimes use a subjective estimate of the noise to guide him in estimating the spectrum when the charts fail, but little confidence should be attached to extrapolation of these curves. Similarly, the dotted portions of the curves are regions of poor accuracy.

## Examples of Use

An analysis of the frequency distribution of the noise energy is usually essential for the satisfactory solution

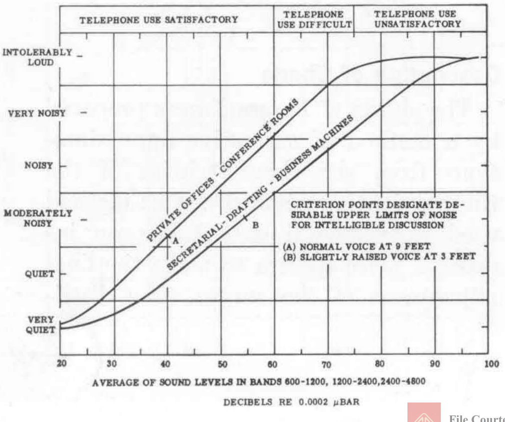



Figure 4. Rating chart for office noises. (Courtesy Beranek and Newman)

File Courtesy of GRWiki.org

of a noise problem. The analysis obtained from the charts of Figure 3 is only a partial step in providing the information required for a solution, but it usually gives a better idea of the magnitude of the problem than one can obtain from a single sound-level reading. In addition, subsequent measurements and analyses can be more adequately planned after the preliminary survey has been made.

In order to interpret the band levels given by this partial analysis, it is usually helpful to convert the levels into values similar to those used for the octave-band analyzer. For example, the speech-interference level[2, 3] is a useful reference value that can be obtained from an octave-band analysis. With slightly less accuracy than the band charts have, this speech-interference level is approximately equal to the level in the high-frequency band less 6 db (speech-interference level $= L_h - 6$). If this speech-interference level is high, the ability to converse will be seriously interfered with. For example, if you are trying to give involved instructions to a workman two feet away, your voice will have to be very loud to be heard satisfactorily when the noise produces a speech-interference level of 70 db.

Another use of speech-interference level is in rating office noises[2] as shown in Figure 4. These curves can be used to determine the desirability of noise control.

An analysis of the noise is also important for planning the steps necessary for reducing noise levels, since the most suitable control measures depend on the frequency spectrum of the noise. For example, the ordinary acoustic treatment has little effect at low frequencies. Because this simple three-band analysis does indicate how the noise energy is distributed, one can use the results of the analysis as a guide in selecting the noise reduction technique to be tried in a given situation.

—J. R. Cox, Jr.

[2] Leo L. Beranek, "Noise Control in Office and Factory Spaces," *Transactions* of Chemical-Engineering Conferences, Bulletin No. 18, 1950, Industrial Hygiene Foundation, Mellon Institute, pp. 26–33.

[3] H. O. Parrack, "Physiological and Psychological Effects of Noise," *Proceedings* of the Second Annual Noise Abatement Symposium, October 5, 1951, pp. 21–38.

**Figure 5. Determining noise level and speech-interference level in a business office with the Type 1551-A Sound-Level Meter.**

File Courtesy of GRWiki.org

# TWO-TERMINAL DIELECTRIC MEASUREMENTS OVER A WIDE TEMPERATURE RANGE

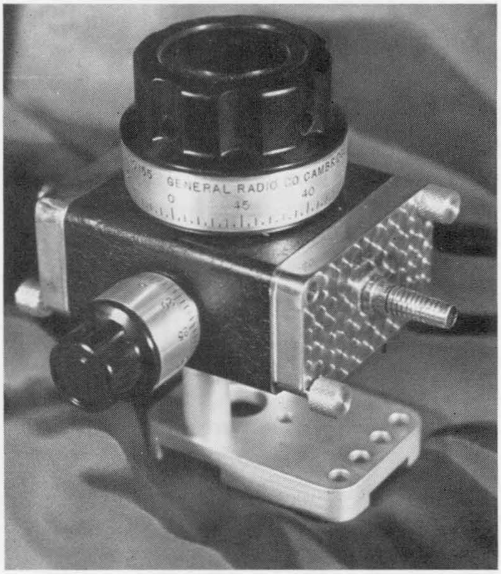



Figure 1. View of the modified dielectric sample holder with the special cover plates installed.

To simplify the measurement of solid dielectric samples over a considerable range of temperature, the Research Laboratories of the Tennessee Eastman Company, Division of Eastman Kodak Company, have developed an interesting modification of the Type 1690-A Dielectric Sample Holder. This modification avoids the long leads usually associated with a conditioning oven, which ordinarily requires a three-terminal system to eliminate the effects of lead capacitance.

As indicated in Figure 1, the removable covers at the ends of the main body of the sample holder have been replaced by specially designed covers fitted with tubular connections to permit the circulation of heated or cooled air through the holder.

The covers, which are shown in detail in Figure 2, are hollow chambers. Air is fed into the tubular intake and exhausted at lower velocity into the sample compartment through a slot of five times the intake area. Air leaves the sample compartment through the slot in the other cover. The entire cell is thus a plenum chamber in which the pressure is maintained well above atmospheric level. The location of the slots (intake at the bottom of the cover, outlet at the top) produces sufficient turbulence to avoid hot spots.

The compressed air supplied to the cell is heated by passage through a spiral copper tube in intimate contact with an electrically heated aluminum block. This modified sample holder has been used successfully at temperatures up to 110°C.

The complete measurement setup, consisting of a Type 716 Capacitance Bridge, a Type 1231 Amplifier and Null Detector, and a Type 722 Precision Condenser, is shown in Figure 3.

Although used by Tennessee Eastman at audio frequencies, the arrangement described has particularly interesting possibilities at higher frequencies. The measuring circuits may be used in a normal manner, obviating the problems of placing the specimen holder or the

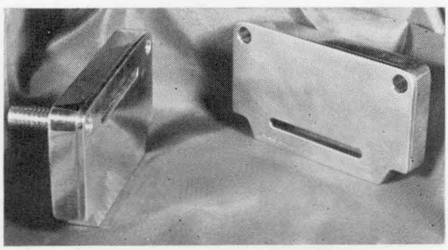


Figure 2. Close-up view of the covers, showing the slots through which air is pumped into, and exhausted from, the sample compartment.

File Courtesy of GRWiki.org

measuring circuits themselves in a conditioning chamber.

**Editor's Note:**

The information on which the foregoing article is based was furnished by Mr. R. G. Devany of the Research Laboratories, Tennessee Eastman Company. The covers for the sample holder were made by Mr. Blake Chapman of the Instrument Development Shop, Tennessee Eastman Company, Kingsport, Tenn.

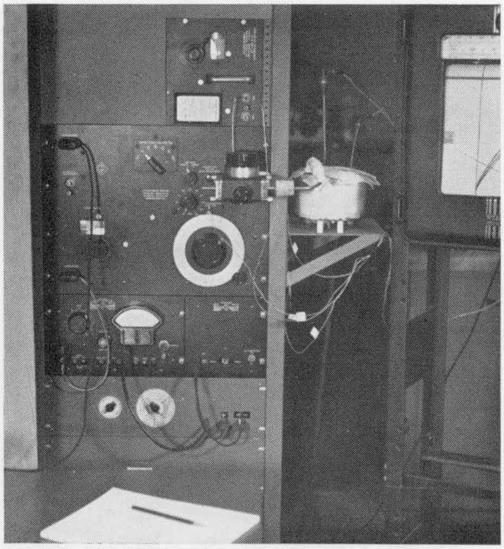


Figure 3. View of the measuring assembly at the Tennessee Eastman Company laboratories, showing the modified sample holder connected to a Type 716 Capacitance Bridge.

# A CLIP-TYPE LOCK FOR TYPE 874 CONNECTORS

General Radio Type 874 Connectors have been designed for best electrical performance and greatest convenience in use in the laboratory. The screw lock found on most coaxial connectors has, therefore, been omitted, because the sliding friction between mated connectors is sufficient under ordinary conditions to prevent accidental opening.

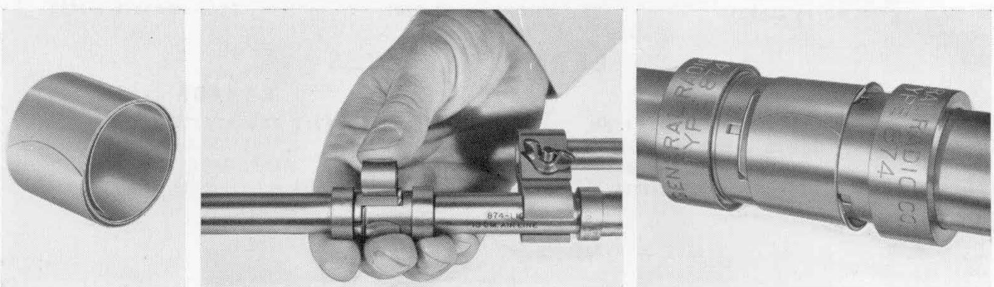
In setups where line length must be adjusted frequently, some kind of lock between connectors may be desirable. The flared ends on the outer conductors of the Type 874 Connectors make it possible to use an extremely simple locking device.

The Type 874-Y Cliplock, designed for this purpose, consists of a flat, stainless-steel spring, which is easily rolled over the joint of two connectors to produce a compact, neat, locked joint. The edges of the spring fit between the overlapping flanges of a mated connector pair and prevent it from pulling apart. To increase the holding power of the lock, the spring has been pre-stressed to make it a Negator.[1]

[1] W. J. Cook and P. C. Clark, *Product Engineering*, July, 1949; H. Mankonen, *Instruments*, 1952; F. A. Votta, Jr., Paper No. 51-F-11, The American Society of Mechanical Engineers, June, 1951.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **874-Y** | **Cliplock** | COAXLOCKER | 10 for **$1.75** |

The Cliplock before installation. To install, simply roll the spring around the mated connectors. Spring clings tightly to connectors, holding them firmly together.



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# MISCELLANY

## SUMMER CLOSING

**Vacation** — During the weeks of July 27 and August 3 most of our employees will be vacationing. Manufacturing departments will be closed, and other departments will be manned by a skeleton staff. Every effort will be made to take care of urgent business, but repairs cannot be made, except in hardship cases. Our Service Department requests that shipments of material to be repaired be scheduled either to reach us well before this vacation period or delayed until afterward.

**Recent Visitors** to the General Radio Plant and Laboratories — Mr. Harold Page, Head of Radio Section, Research Department, British Broadcasting Corporation; Dr. Otto Brune, Principal Research Officer, National Physical Laboratory, Pretoria, South Africa; and Dr. Tatsuo Hayashi, Director, Radio Precision Corporation, Osaka-Fu, Japan.

## ERRATA

Our attention has been called to an error in the diagram on page 7 of the March issue of the *Experimenter*, in the article entitled, "Portable Test Autotransformers."

In the leads to the selector switch, the lead to the switch arm shown as 230V should have no markings; the lead shown as 270V should be 230V; the lead to the other point on the switch should be marked 270V.

On page 1 of the March issue, the date of publication of Mr. Giacoletto's article (footnote 2, page 1) should have been given as March, 1953.

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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

# A SIMPLIFIED SYSTEM OF WAVE ANALYSIS FOR PRODUCTION TESTING

*Also* IN THIS ISSUE

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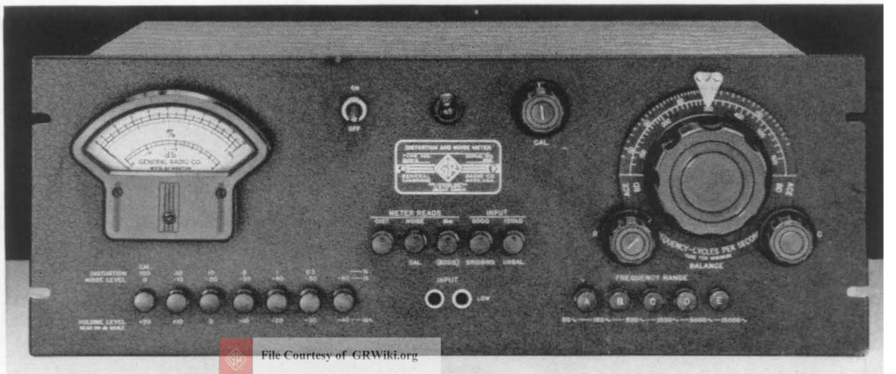
| General Radio at Wescon 1953 | 8 |

● **ALTHOUGH DESIGNED** principally for measuring distortion and noise in broadcast systems, the Type 1932-A Distortion and Noise Meter has also been found to be an indispensable laboratory tool for making quickly and accurately any adjustment that affects the distortion, hum, or noise output of communications apparatus. Properly used, this instrument provides a rapid, visual, complete, and continuous analysis of the undesirable by-products appearing in the output of such equipment.

In the General Radio Standardizing Laboratory, the Type 1932-A is used for testing audio oscillators, amplifiers, power supplies, and, in conjunction with suitable demodulating equipment,[1] signal generators of all frequencies. It is also used as a voltage indicator in attenuator and filter measurements, as a null indicator for audio-frequency bridge work, and as a frequency meter. Because of its reliability and its ease of operation, it has, wherever applicable, completely supplanted other types of wave analyzing equipment.

[1]The Type 1931-A Modulation Meter is used from .5 to 60 megacycles, the Type 874-VR Voltmeter Rectifier plus a simple *L-C* filter at VHF and UHF.

Figure 1. Panel view of the Type 1932-A Distortion and Noise Meter.



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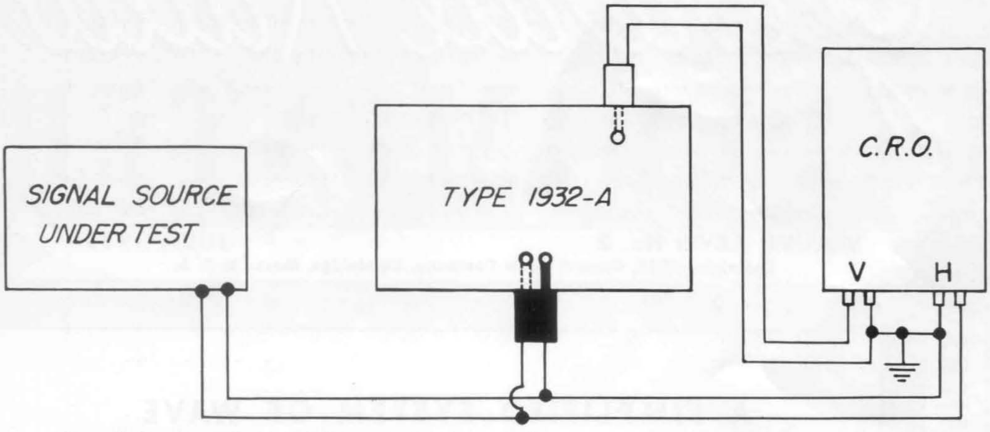


Figure 2. Test Setup for Visual Wave Analysis (top view).

The procedure is as follows: Set the signal source to any frequency in the range of 50 cycles to 15 kilocycles, and to any output within the range of 1.5 to 100 volts; calibrate the Type 1932-A, using its 100 KΩ input;[2] adjust the CRO gain controls to give a 1:1 Lissajous pattern (a diagonal line at most frequencies); cut in the null network of the Type 1932-A, and adjust it to eliminate the fundamental frequency component of the signal; set the push-button attenuator to give an on-scale meter indication. The distortion and noise by-products of the signal will now be presented graphically on the CRO in a form that can readily be analyzed, as well as being numerically summed up by the panel meter of the Type 1932-A.

[2]The 600-ohm input is a bridging (transformer) input, intended for broadcast use on program lines. It should be used only when a balanced input is required, for it restricts somewhat the frequency and distortion range of the instrument. *It is not a matching network for 600-ohm systems.*

The Type 1932-A Distortion and Noise Meter consists of a high-gain amplifier with an R-C interstage coupling unit that balances to a sharp null, a calibrated attenuator for adjusting the sensitivity, and a vacuum-tube voltmeter. The null network, which is continuously adjustable in frequency, eliminates the fundamental of the audio-frequency signal, and the distortion products that remain are indicated on the panel meter. The null network is switched out of the circuit for noise and hum measurements, so that the instrument operates as a highly sensitive voltmeter.

When the null network is tuned to the fundamental frequency of a signal in the frequency range of 50 cycles to 15 kilocycles, the meter indicates the *total* value of *all* by-products present: harmonics, hum, and noise. The simple expedient, however, of connecting an oscilloscope to plot these by-products versus the total input signal enables the user to recognize, to evaluate, and, if necessary, to correct for whatever distortion or noise components happen to predominate. The only special skill required of the operator is the ability to recognize a few simple Lissajous patterns.

## ANALYSIS OF WAVE FORMS

The Lissajous pattern appearing on the CRO will contain two components, the one stationary, the other in motion. The stationary component comprises the distortion, stationary because of the synchronism between x-axis and y-axis signals; the moving component comprises the noise (usually hum), moving because a non-synchronous or random relationship exists.[3] In a given noise-distortion test, therefore, a glance at the CRO pattern immediately resolves the problem into either one of distortion or one of noise.

[3]In the special case where the signal itself is derived from, and harmonically related to, the power frequency, no distinction between hum and distortion can, of course, be made.

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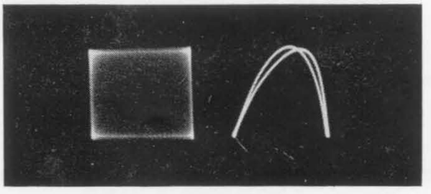
Assume the problem is one of distortion. Since this test procedure is limited to communications equipment, or rather to nominally sine-wave signals, the only harmonics that need be considered are the second and the third. The only Lissajous patterns, therefore, that enter into the analysis of the distortion, *regardless of the fundamental frequency involved*, are the simple 2:1 pattern, the simple 3:1 pattern, and various combinations of the two in which, generally, one or the other will predominate. Hence the principal skill required of one who uses this method of analysis is to be able to discern whether the Lissajous pattern is primarily 2:1 or 3:1. Having determined this (at a glance), he will know what corrective action to take—whether to shift an operating point or bias (second harmonic), or to replace a component with limited dynamic range (third harmonic). Furthermore, the *total* effect of any such action will appear immediately. Typical distortion patterns are illustrated in Figure 3.

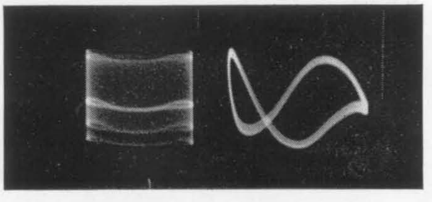
When the problem is primarily one of noise, the moving part of the pattern will be larger than the stationary part (see Figure 3). Where noise (hum) adjustments are provided, they can be set to minimize this component. Should analysis of the noise be desired, the horizontal axis of the CRO can be switched to the power frequency to "stop" the hum components (see Figure

**Figure 3. Typical distortion and hum patterns. In each case the pattern on the left is produced with power-line-frequency synchronization, the pattern on the right with signal-frequency synchronization.**

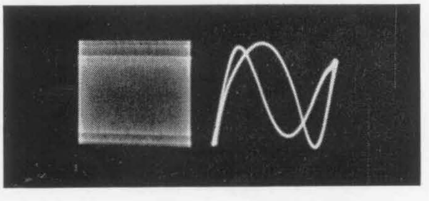
(1) 5 kc fundamental
Second harmonic 5 times third
Negligible hum



(2) 5 kc fundamental
Second and third harmonics about equal
Hum (second harmonic) about 10% of total



(3) 5 kc fundamental
Third harmonic 10 times second
Negligible hum



(4) Line-frequency hum predominant
Distortion same as in (2) above
This pattern was produced by introducing line voltage into the grid circuit of the oscillator under test

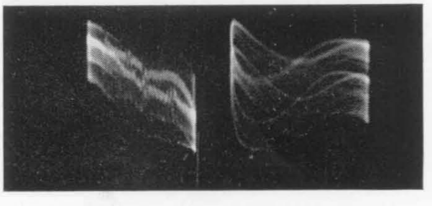


Figure 3 (*continued on page 4*)

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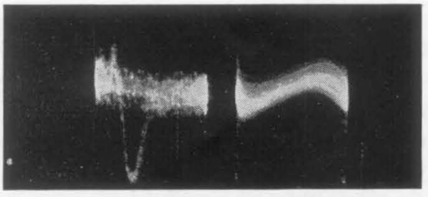
3). If in a given problem both distortion and hum are appreciable factors, both horizontal axes can be supplied simultaneously by means of an electronic switch.

Thus a single setup, with one quick adjustment, supplies all the information required to adjust bias controls, drive controls, B+ voltages, hum-bucking controls, and any other variables that may affect the linearity and hum-content of the equipment under test. The effects of such adjustments are monitored instantly, continuously, and completely. From the standpoint of speed as well as of thoroughness and accuracy, the system leaves little to be desired.

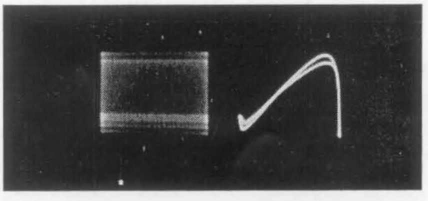
A serious limitation can occur when one attempts to measure very low values of distortion and noise, unless the normal test procedure is modified. The residual distortion and hum of the distortion meter itself can be as high as 0.1% on some ranges, if operated in the normal

Figure 3 (*continued*)

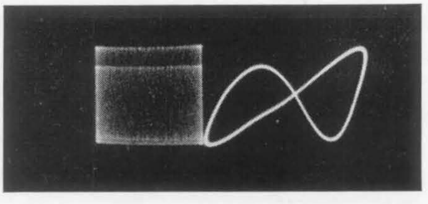


(5) 1 kc fundamental
Power supply ripple predominates because plate voltage regulator is not functioning properly. Total distortion is 1.5%; third harmonic is twice second. Relative hum amplitudes are:

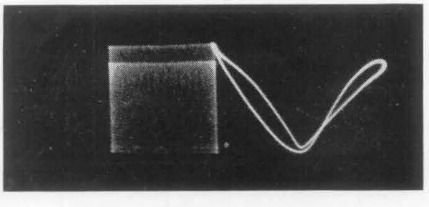
| Frequency | 60 | 120 | 180 | 240 | 300 |
|---|---|---|---|---|---|
| Amplitude | 100 | 100 | 60 | 80 | 50 |



(6) 1 kc fundamental
Second harmonic 8 times third
Negligible hum



(7) 1 kc fundamental
Second harmonic 12 times third
Negligible hum



(8) Second harmonic 2 times third, plus higher-order harmonics

(9) 1 kc fundamental
All hum and distortion products about equal. This is the output of a TYPE 1301-A Low-Distortion Oscillator at optimum adjustment.
Total noise and distortion at this frequency was 0.05%.

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manner. Hence, in evaluating distortion and hum in the order of .5% or less, the user can be misled as to both the quantity and the nature of the undesired signal by-products. Means are provided on the distortion and noise meter, however, both to determine the magnitude of the residual voltages and to make them negligible as a factor in measurements of .1% or less.[4]

Residual hum (in the distortion-measuring circuit) causes a residual meter indication when no input signal is present, and is therefore easily recognized. It is most pronounced on the lowest frequency range and on the lowest (most sensitive) attenuator position. An adjustment is provided to minimize it, but it is still an important factor in making noise-distortion measurements of the order of .1% or less. To minimize error in analyzing the hum content of such signals, the hum should be evaluated at a signal frequency above 150 cycles, if possible, and with the TYPE 1932-A calibrated at its normal (1.5 volts) input level. In any event, whenever the distortion pattern exhibits a high hum content, the input signal should be disconnected momentarily to determine whether the hum is residual or is a signal by-product.

Residual distortion can be virtually eliminated simply by operating at a signal level 10 db below the 1.5-volt normal input. In practice, this consists merely of using a different attenuator setting from that normally used, and a corresponding meter scale. All General Radio TYPE 1301-A Low-Distortion Oscillators (rated at not more than .1% total distortion and noise) are tested by this method.

[4]The residual hum described here applies only to *distortion* measurements, because it is introduced in the distortion-measuring circuits of the TYPE 1932-A. In *noise* measurements, when the noise constitutes the total signal being measured, this circuit is not used, and consequently residual noise and hum are negligible (more than 80 db below zero dbm level).

A further limitation must be considered when measurements are attempted in the presence of r-f voltages, as in demodulated carrier signals, beat-frequency oscillator outputs, and the like. No provision for radio-frequency filtering is made in the TYPE 1932-A, and such filtering, if necessary, must be inserted ahead of the input. The same considerations apply as for any high-gain audio-frequency amplifier.

## SOME EXAMPLES OF USES OF VISUAL ANALYSIS

A typical example of the usefulness of this system of wave analysis is the laboratory adjustment of the TYPE 1302-A (R-C) Oscillator. In this instrument nineteen variables must be set correctly to give the desired operating conditions at all frequencies. To adjust them by conventional methods at one time required a great deal of painstaking, point-by-point analysis of circuit behavior. When the test procedure was modified to employ the visual-analysis system described above, it was quickly learned that all information necessary to make the adjustments appeared on the CRO distortion pattern at certain settings of the panel controls, and that adjustments optimized by eye (visual analysis), even without regard to the numerical values involved, always resulted in a level of performance that was well within specifications. Currently, using this method, the average test time on this instrument is half what it formerly was.

Even in the design and development field, this system has proved valuable. A recently developed audio oscillator incorporated a push-pull output circuit supplied by a direct-coupled driver. Conventional methods of wave analysis indicated that the circuit, as first set up,

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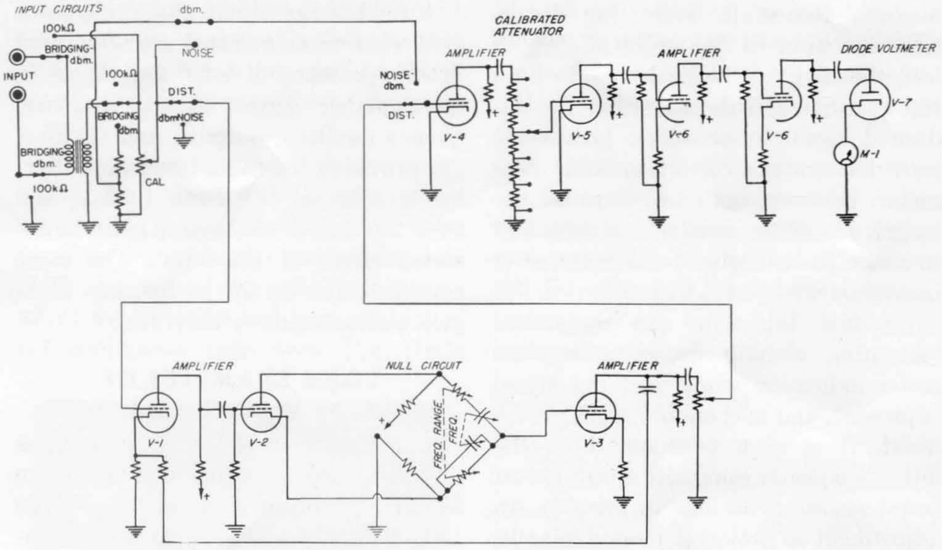


Figure 4. Elementary schematic circuit diagram of the distortion and noise meter.

would develop, at best, almost .5% distortion at rated output. Examination of the distortion by-products by visual analysis, however, indicated that something was wrong; to achieve *minimum* distortion required an abnormal, seriously unbalanced bias in the push-pull stage. Upon further investigation, a circuit error was located and corrected. The revised circuit developed rated output with greater efficiency and with less than half the distortion originally present. The conventional wave analysis had, of course, correctly measured the distortion of the original circuit, but had *failed to indicate optimum circuit conditions.*

## SO MUCH INFORMATION, SO FAST!

To sum up, therefore:

The Type 1932-A Distortion and Noise Meter, when used in conjunction with a CRO so connected as to plot its output versus its input, supplies the following useful information concerning a nominally sinusoidal signal supplied to it:

1. An approximately rms summation of the distortion and noise by-products of the signal, in per cent or in db below some reference.

2. A distinction between distortion and noise, immediately apparent to the eye.

3. A distinction between second harmonic and third harmonic distortion when one or the other predominates. Only two basic Lissajous patterns apply.

4. An indication of optimum conditions, whenever adjustments are made that affect distortion or noise.

When the x-axis of the CRO is switched to a voltage of line frequency, further information is supplied regarding the hum components present. If the x-axis switching is done continuously, as with an electronic switch, all of the above information is supplied instantly and continuously, as adjustments are made.

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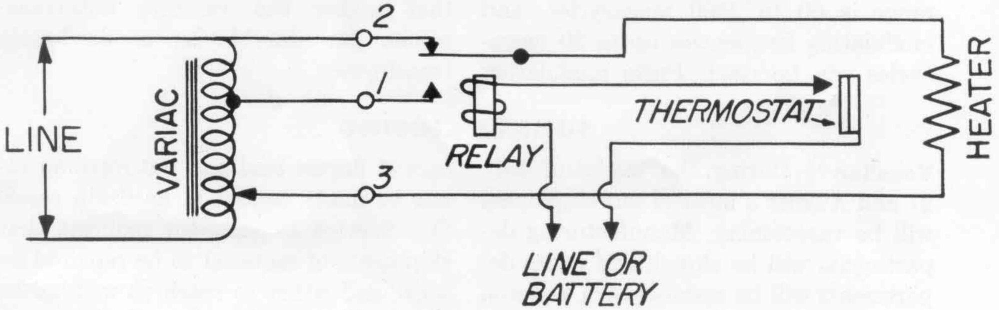
While precise numerical values of these various frequency components are not defined, their *relative* magnitudes are accurately portrayed. Wherever this amount of information is adequate for the purposes at hand, as, for instance, in production testing, the system leaves little to be desired.

— W. P. Buuck

# VARIAC CONTROL OF HEATERS

The Variac® autotransformer offers a convenient means of controlling the input to electrical heaters. The Variac circuit shown here can be used in automatic control to maintain constant temperature in ovens and baths, and is particularly useful where an adjustable thermostat is used to obtain successive temperature settings.




# MISCELLANY

**Papers** — By Harold B. Richmond, Chairman of the Board, General Radio Company: "Incentives as a Tool of Management," at the May 7 meeting of the Professional Group on Engineering Management, Washington, D. C., Section, Institute of Radio Engineers; and "Patents and Licenses," at the Electronics Group Meeting, Scientific Apparatus Makers' Association, White Sulphur Springs, West Virginia, May 25. Since neither of these papers has been prepared for publication, copies are not available for distribution.

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# GENERAL RADIO AT WESCON 1953

General Radio products will be on display in Booths 913 and 914 at the Western Electronic Show and Convention to be held in the Civic Auditorium, San Francisco, August 19, 20 and 21.

Among the General Radio instruments shown will be:

*Type 1217-A Unit Pulse Generator* — a small, compact, inexpensive generator of pulses, with rise time as short as 0.05 microsecond and repetition rates between 30 and 100,000 cps.

*Type 1000-P7 Balanced Modulator* — a crystal-diode modulator designed to operate on the output of standard-signal generators to produce 100% amplitude modulation without incidental frequency modulation. Carrier frequency range is 60 to 2500 megacycles, and modulating frequencies up to 20 megacycles can be used. Pulse modulation can also be applied, with rise times as short as 0.02 microsecond.

*Limit bridges* for measuring d-c resistance and for comparing resistors, capacitors, and inductors at audio-frequencies.

*Sound-measuring equipment* — a complete line of sound-level meters, analyzers, and accessories for the measurement of noise and other sounds.

*Type 1602-B U-H-F Admittance Meter*, with a full line of accessories, set up to measure television transmitting antennas.

*Variac® autotransformers* with General Radio's new Duratrak contact surface that stands up under punishing overloads — an outstanding development that makes the variable autotransformer as durable as a fixed-ratio transformer.

## SUMMER CLOSING

**Vacation** — During the weeks of July 27 and August 3 most of our employees will be vacationing. Manufacturing departments will be closed, and other departments will be manned by a skeleton staff. Every effort will be made to take care of urgent business, but repairs cannot be made, except in hardship cases. Our Service Department requests that shipments of material to be repaired be scheduled either to reach us well before this period or delayed until afterward.


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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

# IMPROVED ACCURACY AND CONVENIENCE OF MEASUREMENTS WITH TYPE 1602-B ADMITTANCE METER IN VHF AND UHF BANDS

*Also* IN THIS ISSUE

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MEASUREMENTS ON 75-OHM LINES WITH THE ADMITTANCE METER ........... 7

● **IN ITS THREE YEARS** of field use, the TYPE 1602-A Admittance Meter[1] has proved to be a valuable and flexible instrument for the measurement of impedance and admittance at frequencies between 20 and 1500 Mc.

Its inherent utility has been greatly increased by the availability of accessories[2]

[1]W. R. Thurston, "A Direct-Reading Impedance Measuring Instrument for the U-H-F Range," *General Radio Experimenter*, Vol. 24, No. 12, May, 1950.

[2]"New Coaxial Accessories — Adaptors, Line Stretcher, Component Mount, Balun, Terminations, and Insertion Unit," *General Radio Experimenter*, Vol. 27, No. 5, October, 1952.

Figure 1. Close-up of the Type 1602-B U-H-F Admittance Meter.

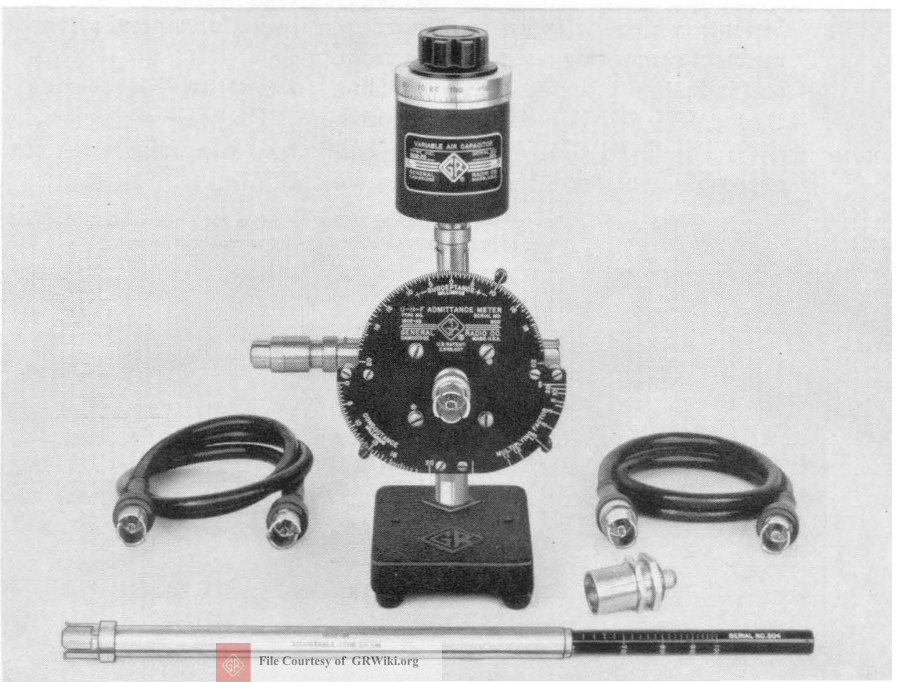


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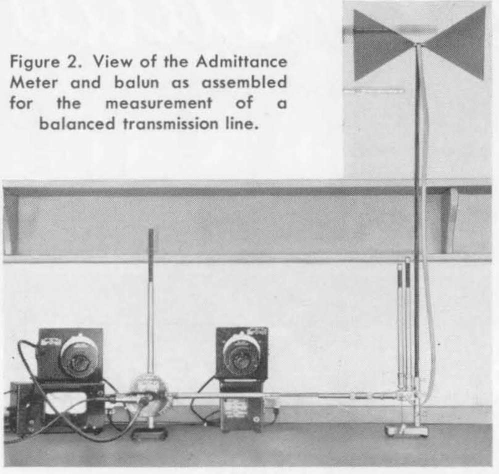
Figure 2. View of the Admittance Meter and balun as assembled for the measurement of a balanced transmission line.



to eliminate corrections and to facilitate the measurement of components, antennas, and balanced circuits. These accessories include:

(1) The TYPE 874-LK Constant-Impedance Adjustable Line, which can be adjusted to a half- or a quarter-wavelength to make the Admittance Meter direct reading in the admittance or impedance at the point where the unknown impedance is connected, without the use of Smith charts to correct for line length.

(2) The TYPE 874-M Component Mount, which provides a convenient means of connecting resistors, capacitors, and inductors to the 50-ohm coaxial line through which the impedance is measured.

(3) The TYPE 874-LB Balun, a balanced-to-unbalanced impedance transformer, which makes possible the measurement of impedance and VSWR of balanced 300-ohm circuits and of UHF receiving antennas.

(4) Low-reflection adaptors to most of the commonly used types of coaxial connectors, to facilitate connections to equipment fitted with connectors other than the General Radio TYPE 874. Adaptors are also available for connection to VHF and UHF television transmitting antenna systems.[3]

## RECENT IMPROVEMENTS

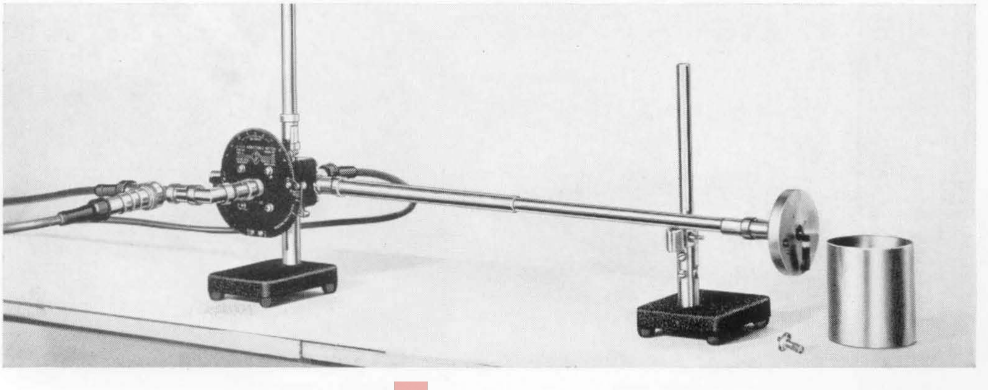
Since the original model was introduced, several methods of adding to the operating convenience and accuracy have been developed. One of these improvements eliminates the effect of the junction inductance, which causes errors at the higher frequencies; another one makes possible higher accuracy when multipliers larger than unity are used; and a third extends the direct-reading, low-frequency range and also eliminates the need for the long awkward stub. The type number of the improved instrument has been changed to the TYPE 1602-B Admittance Meter to avoid confusion with previous models.

### Junction Inductance

The basic principle behind the method used to eliminate the effect of junction

[3]To be described in a future issue of the *Experimenter*.

Figure 3. View of the Admittance Meter as set up for measurement of a resistor, showing the line stretcher and component mount.



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inductance is similar to that used on the Type 1601-A VHF Bridge to compensate for the capacitance of the unknown terminals. However, the applicability of this principle to the Admittance Meter was first realized and suggested by Messrs. G. D. Monteath and P. Knight of the British Broadcasting Corporation. The understanding of the method used to compensate for the junction inductance requires a knowledge of the principle of operation of the Admittance Meter. For convenience it will be briefly reviewed in the following paragraphs.

In the Admittance Meter, the currents flowing in three branch coaxial lines, fed from a common voltage source at a common junction point, are sampled by three independently adjustable loops, which couple to the magnetic field in each line as shown in Figure 4. One of the branch lines is connected to a conductance standard, one to a susceptance standard, and one to the unknown circuit. The outputs of the three loops are connected in parallel, and the coupling of each loop to its respective branch line is adjusted by rotating the loop until a null is obtained. At a null the settings of

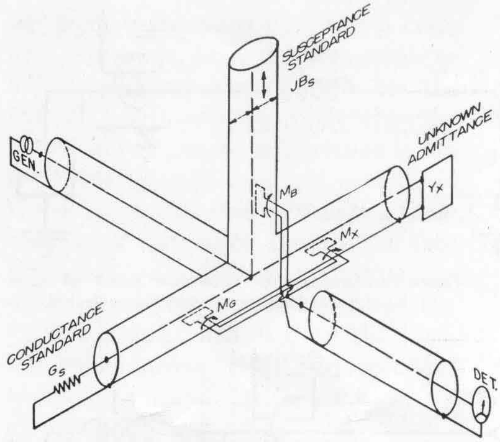
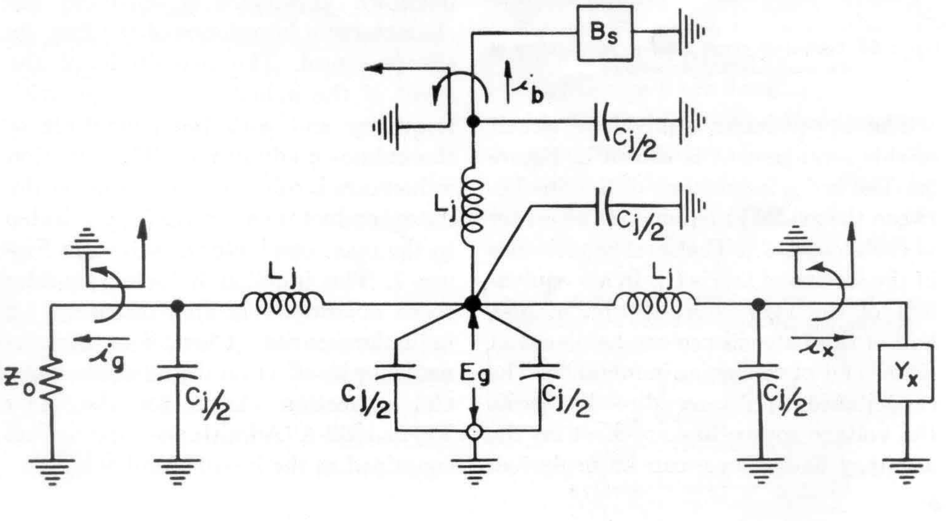



Figure 4. Schematic diagram of the Admittance Meter, showing the arrangement of coupling loop.

the loops are direct indications of the magnitudes of the conductance, the susceptance, and a multiplying factor.

The basic principle of operation assumes that the voltage at a point under the center of the coupling loop on each branch line is the same. However, in the practical case, the loops must be located at least a short distance from the actual common junction point and, hence, a short length of line exists between the common junction point and the center of each pickup loop as shown in Figure 4.

Figure 5a. Equivalent circuit of the junction.

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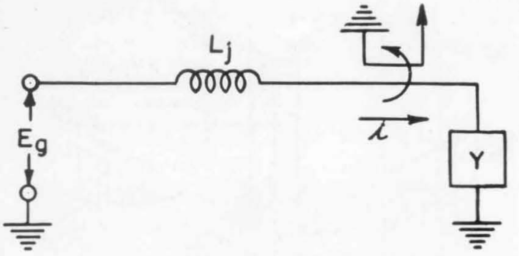


Figure 5b. Approximate equivalent circuit of each branch with junction capacitance neglected.

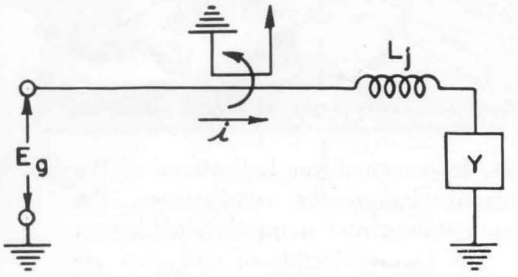


Figure 5c. Revised circuit of Figure 5b, with junction inductance shifted to the load side of the coupling loop.

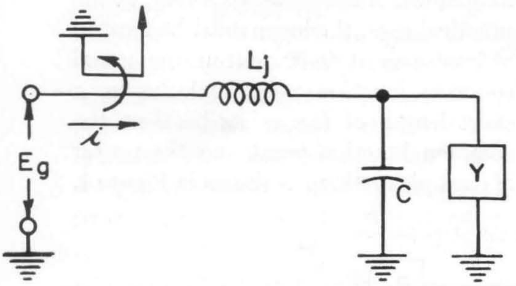


Figure 5d. Equivalent circuit showing the location of the compensating capacitance.

The approximate equivalent circuit of this arrangement is shown in Figure 5a. The series inductance of the line between the actual junction and the center of each loop is $L_j$. The total capacitance of the section of line is $C_j$. In a $\pi$ equivalent of the very short section of line, half of this capacitance can be placed at either end of the series inductance. The capacitance appearing directly across the voltage source has no effect on the accuracy and, hence, can be neglected.

The current flowing through the capacitance on the load side of the junction line does not induce a voltage directly into the loop since it does not flow in the line under the loop. This current does, however, produce a voltage drop when it flows through the junction inductance and, hence, has an effect on the voltage applied to the unknown circuit. In the actual instrument, the capacitive reactance is so large compared to the inductive reactance that the voltage drop caused by the capacitive current can be neglected and, hence, $C_j$ can be eliminated from the circuit.

The current flowing to the unknown circuit passes through the junction inductance and causes a voltage drop which can have an appreciable effect on the measurements when the measured admittance is large compared to 20 millimhos.

Since the pickup loop responds only to the current flowing in the line under the loop, the junction inductance can be shifted to the unknown side of the coupling loop without affecting the performance as shown in Figure 5c.

The same junction inductance appears in each branch, and, hence, when the unknown impedance is equal to the characteristic impedance of the line, its effects cancel. The magnitude of the effect of the inductance increases with frequency and with the magnitude of the unknown admittance. This junction inductance is minimized by bringing the outer conductor as close as is practicable to the inner conductor as shown in Figure 7. The junction inductance under these conditions is approximately 1.2 millimicrohenries. Correction can be made for its effect on the measurements, and correction charts for the older Type 1602-A Admittance Meters are contained in the instruction book.

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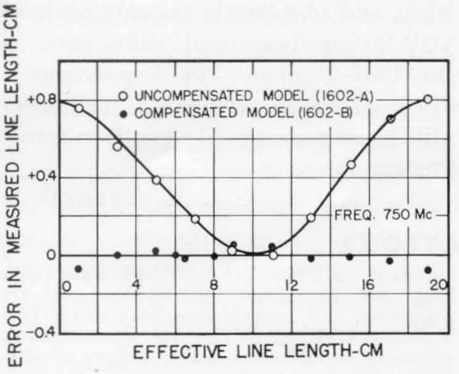



**Figure 6. Curves showing the error in measured length of a short-circuited line as a function of its electrical length when the junction inductance is ignored, as measured by both the older, uncompensated Type 1602-A Admittance Meter and the new Type 1602-B compensated model.**

The errors caused by ignoring the junction inductance in determinations of electrical line length from admittance measurements with the line short-circuited are shown in Figure 6. As previously mentioned, corrections can be made for this effect, but its elimination would be preferable. The effect can be eliminated by adding a shunt capacitance of the proper value to form, with the inductance, a short section of artificial transmission line, having the same characteristic impedance as the true line. For reactances small compared to the characteristic impedance, the inductance and capacitance are related by the equation:

$$Z_o = \sqrt{\frac{L}{C}}$$

The capacitance must be added on the unknown side of the coupling loop so the capacitive current will flow through the line under the loop.

In the new model, the desired additional capacitance is obtained by adding a polystyrene bead to the line, as shown in Figure 7. The electrical length of line between the unknown and the measuring point is increased by about 0.7 cm. as a result but, since the corrections or adjustments are always made for the over-all length of 50-ohm line when the actual impedance or admittance is desired, the increase does not complicate the situation, but does eliminate a time-consuming correction. Besides the simplification in correction procedure obtained when admittance is measured, the VSWR is now unaffected by the junction inductance as VSWR is independent of line length and, hence, a greater accuracy is obtained.

The compensation is independent of frequency as long as the length of line added is short compared to a wavelength. Figure 6 shows the results of measurements of electrical line lengths with a compensated instrument.

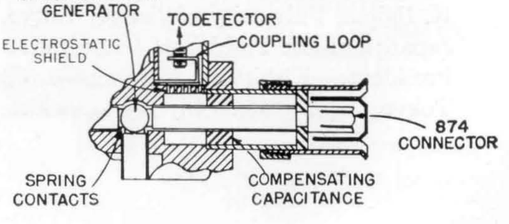
## Improvements to Multiplying Factor Scale

Another improvement that has been made in the Admittance Meter is the addition of several calibrated points on the multiplying-factor scale as shown in Figure 1. The additional points make greater accuracy possible in many cases by permitting the use of a lower multiplier setting.

## A New Low-Frequency Susceptance Standard

A new susceptance standard has been designed for use at the lower frequencies to replace the long adjustable stub. The new standard is a small, shielded, variable air capacitor, shown in Figure 1,

**Figure 7. Sketch of modified junction showing the location of one of the compensating capacitances.**




File Courtesy of GRWiki.org

which is calibrated directly in frequency from 41 to 150 Mc. Measurements at low frequencies will be facilitated by the extended frequency range and small size of the new standard.

The Admittance Meter has earned a deserved reputation for speed, convenience, and accuracy in measurements of VSWR impedance and admittance in the U-H-F range. The improvements discussed above increase still further its utility and acceptability for these measurements.

— R. A. Soderman

## SPECIFICATIONS

**Range:** Theoretically, zero to infinity; practically, the lower limit is determined by the smallest readable increment on the scale which is 100 micromhos (0.1 millimho). The upper limit is 1000 millimhos. Range is the same for both conductance and susceptance, but susceptance can be either positive or negative, i.e., the susceptance dial is calibrated from −20 to +20 millimhos. Multiplying factors from 1 to 20 are provided, and factors from 20 to 100 can be determined approximately.

**Frequency Range:** 41 to 1000 Mc, direct reading. Range can be extended downward to 20 Mc, if a frequency correction is applied to the susceptance reading, and upward to about 1500 Mc.

**Accuracy:** For both conductance and susceptance (up to 1000 Mc):

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 Mc, errors increase slightly and, at 1500 Mc, the basic figure of 3% in the expression above becomes 5%. For comparing impedances, the accuracy is ±3% up to 2000 Mc.

**Accessories Supplied:** One Type 1602-P4 50-Ω Termination, for use as conductance standard, and one Type 1602-P1 Adjustable Stub and one Type 1602-P3 Variable Air Capacitor, for susceptance standards; two Type 874-R20 Patch Cords for connections to generator and detector; and one Type 874-PB Panel Connector for installation on detector. A wooden storage case is furnished.

**Additional Accessories Required:** Generator and detector. Generator should cover desired frequency range and deliver between 1 volt and 10 volts. Type 1208-A (65 to 500 Mc), Type 1215-A (50 to 250 Mc), and Type 1209-A (250 to 920 Mc) Unit Oscillators are recommended. The Type 1021-AU and AV Standard-Signal Generators are also satisfactory.

Detector sensitivity should be better than 10 microvolts. Recommended detector is a heterodyne system consisting of the Type 874-MR Mixer Rectifier with a low-frequency receiver or an i-f amplifier and a second unit oscillator to provide the heterodyning signal.

**Other Accessories Available:** Type 874-Q Coaxial Adaptors, Type 874-LK Constant Impedance Adjustable Line, Type 874-UB Balun, Type 874-M Component Mount.

**Terminals:** All terminals are Type 874 Coaxial Connectors. Adaptors are available for other coaxial systems.

**Dimensions:** 7½ x 5½ x 5½ inches, without standards and unknown connected.

**Net Weight:** 8¼ pounds.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **1602-B** | **U-H-F Admittance Meter** | HONEY | **$295.00** |

U. S. Patent Nos. 2,125,816 and 2,548,457.

## MISCELLANY

**RECENT VISITORS FROM OVERSEAS** to our plant and laboratories — Mr. Virgilio Floriani, President and Technical Director, Telettra, Milan, Italy; Dr. Fred Bahli, University of Rangoon, Rangoon, Burma; Professor K. Iigima, University of Tokyo, Tokyo, Japan; and Mr. Yoshinori Chatani, Vice-President, Kishimoto Shoten, Ltd., Tokyo, Japan; Mr. Chiyoe Yamonaka, Department of Electrical Engineering, Osaka University, Osaka, Japan.

**PAPERS** — "A Balanced Crystal-Diode Modulator for UHF," by William F. Byers, Engineer, at the 1953 National Conference on Airborne Electronics, Dayton, Ohio, May 12, 1953. No copies of this paper are as yet available, but an abstract appears in the *Conference Proceedings*.

File Courtesy of GRWiki.org

# MEASUREMENTS ON 75 OHM LINES WITH THE ADMITTANCE METER

In many television receiving systems, 72- or 75-ohm transmission lines are used. The impedance or VSWR of the line can be easily measured, using either the old or new model of the Admittance Meter. Means must be devised, however, for connecting the 75-ohm line to the Admittance Meter, which is equipped with 50-ohm connectors. One solution to this problem is to fit the 75-ohm line with a General Radio TYPE 874 Connector. TYPE 874-C8 Cable Connectors are suitable for use with RG 11/U Cable and TYPE 874-C62 Cable Connectors are suitable for use with RG 59/U Cable. The TYPE 874 Connectors are 50-ohm connectors, and the junction between the 50-ohm line and 75-ohm line is made at the point indicated in Figure 1. There is a slight discontinuity at the junction due to stray reactances, but in most cases the effect is negligible.

The effect of the 50-ohm line in the connectors and the Admittance Meter can be eliminated by adjusting it to a half- or quarter-wavelength by means of a TYPE 874-LK Constant Impedance Adjustable Line. To obtain the proper half-wavelength adjustment, the 50-ohm line should be open-circuited at the 75-ohm line junction, the Admittance Meter set to balance at zero admittance, and the line length adjusted until a null is obtained. For a quarter-wavelength adjustment, the same procedure is used with the exception that the line is short-circuited at the junction. In the practical case, it is difficult to open-circuit or short-circuit the line at the proper point, but the TYPES 874-WO or WO-3 Open-Circuit Terminations and 874-WN or WN-3 Short-Circuit Terminations can be used to advantage for this purpose. These units do not produce an open-circuit exactly at the desired point, but minor adjustments of the line length can be made to compensate for the difference.

In this application, the termination is connected to the end of the adjustable line in place of the line under test, and the line length is adjusted as outlined above. Then, if the TYPE 874-WO Open-Circuit Termination or TYPE 874-WN Short-Circuit Termination is used, the adjustable line should be decreased in length 2.6 cm, and if the TYPE 876-WO3 Open-Circuit Termination or TYPE 874-WN3 Short-Circuit Termination is used, the length of the adjustable line should be increased 0.6 cm. If the termination is removed and the line under test connected, the length of 50-ohm line between the measuring point and the point at which the 75-ohm line is connected is now exactly a half- or quarter-wavelength long. For the half-wavelength adjustment, the admittance measured by the instrument is the admittance seen looking into the 75-ohm line at the junction. For the quarter-wavelength adjustment, the unknown series resistance and reactance are equal to the indicated conductance and susceptance respectively, multiplied by 2.5.

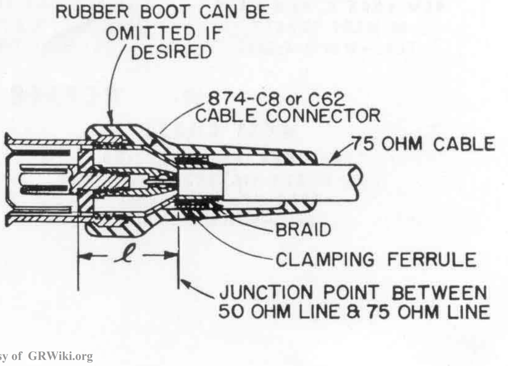



**Figure 1. Sketch of Type 874-C63 Cable Connector with a 75-ohm cable attached.**

File Courtesy of GRWiki.org

The VSWR on the 75-ohm line can be calculated from the measured admittance, using the equation or Smith chart as outlined in the instruction book. Reflection coefficient and, hence, VSWR can also be measured directly by a voltage-ratio method similar to that outlined for 50-ohm lines in the instruction book.

For this measurement, the 75-ohm line under test with its associated adjustable line should be connected to the branch line usually connected to the conductance standard. The branch line usually connected to the unknown should be open-circuited and the multiplier set at infinity. These connections are the reverse of those used when measuring 50-ohm lines and are necessary because the coupling to the unknown must be adjusted to be a specific value less than unity to compensate for the difference in characteristic impedance, and the conductance coupling is more finely calibrated than is the multiplier coupling and hence can be set more accurately.

The over-all 50-ohm line length should then be adjusted to be a quarter-wavelength, using the method previously described with the exception that the conductance indicator is set to maximum coupling, or 20, and the multiplier left at infinity. The susceptance standard is then removed and replaced by the conductance standard, the conductance indicator set at $20 \times \frac{50}{Z_0}$, where $Z_0$ is the characteristic impedance of the line under test.[3, 4] The ratio of the detector voltages obtained with the susceptance indicator first set to $-20$ and then to $+20$ is equal to the reflection coefficient $\Gamma$ on the 75-ohm line, and

$$\text{VSWR}_{75} = \frac{1 + \Gamma}{1 - \Gamma}.$$

— R. A. Soderman

[3]This method was suggested by Mr. B. Parzen of Federal Telecommunication Laboratories.

[4]This method can be used for any line having a characteristic impedance greater than 50 ohms. For lines having characteristic impedances less than 50 ohms, the same method can be used with the length of 50-ohm line set at a half-wavelength, and the conductance indicator set at $20 \times \frac{Z_0}{50}$.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **874-C62** | **Connector for RG62/U Cable** | COAXCANDOR | **$1.70** |


## GENERAL RADIO COMPANY

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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

# A UNIT OSCILLATOR FOR THE 0.5- TO 50-MC RANGE

*Also* IN THIS ISSUE

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●**THE TYPE 1211-A** Unit Oscillator, latest addition to the rapidly growing line of General Radio Unit Oscillators[1], extends the frequency range covered by the versatile units downward by a factor of 100.

This new oscillator has a frequency span of 0.5-50 Mc, which is covered in two logarithmic ranges. The output power is well over one

[1]Eduard Karplus, "V-H-F and U-H-F Unit Oscillators," *General Radio Experimenter*, Vol. 24, No. 12, May, 1950.

A. G. Bousquet, "A New Unit Oscillator — 50 to 250 Mc," *General Radio Experimenter*, Vol. 27, No. 8, January, 1953.

Figure 1. View of the Type 1211-A Unit Oscillator.


File Courtesy of GRWiki.org

watt over the 0.5-to-5 Mc range and is at least 200 milliwatts over the 5-to-50 Mc range. The frequency is indicated directly on a six-inch dial, and approximate increments of frequency expressed in percentage are given on a 3¼-inch slow-motion-drive dial.

To avoid the necessity of frequent range switching, the tuning ranges have been made as wide as possible. The span of each of the two ranges in the TYPE 1211-A Oscillator is 10 to 1. This wide frequency range is obtained by varying simultaneously the capacitance and the inductance as the frequency dial is turned. A frequency change of about 5 to 1 is due to the variable capacitor, and the remaining 2 to 1 frequency change results from inductance variation.

## Electrical Circuit

The TYPE 1211-A Unit Oscillator uses a Hartley circuit with a TYPE 5763 oscillator tube. This tube type was selected because it can handle all the power provided by the TYPE 1203-A Unit Power Supply. The output circuit is coupled inductively to the oscillator tuned circuit and includes a voltage divider as output control.

An audio oscillator can be connected to terminals in series with the plate supply for direct amplitude modulation of the oscillator. A convenient audio source is the TYPE 1214-A Unit Oscillator which yields about 25 per cent modulation at 400 or 1000 cycles. The envelope distortion at this modulation level is around two to four per cent, depending on the carrier frequency.

Since modulation is accomplished directly in the oscillator circuit, some unwanted frequency modulation is unavoidable. Amplitude modulation practically free of frequency modulation can be obtained at carrier frequencies above 10 Mc by using the TYPE 1000-P6 Crystal Diode Modulator.

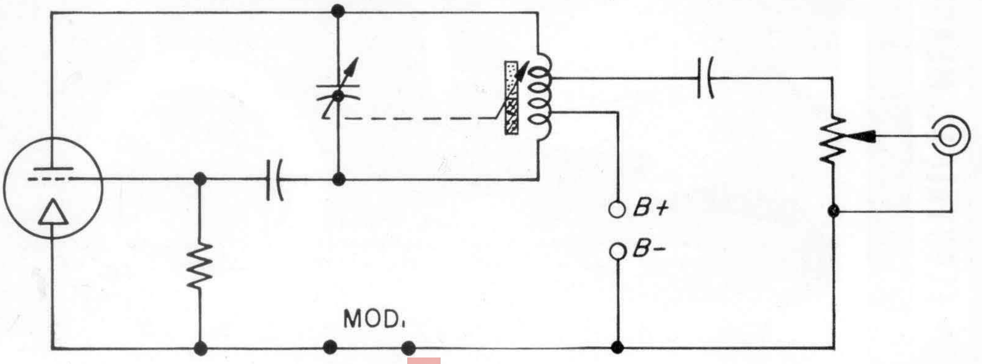
## Construction

The oscillator circuit is assembled on an aluminum casting with filtering components mounted within the casting. A spun-aluminum cylindrical cover completes the shielding much more effectively than would a conventional rectangular dust cover. The output control and the coaxial output connector are at the rear of the cover; the entire assembly is mounted on an L-shaped panel and base.

The tuning capacitor and the switch contacts are the same as those used in the TYPE 1001-A Signal Generator and TYPE 1330-A Bridge Oscillator.

The 0.5- to 5-Mc and the 5- to 50-Mc oscillator coils are arranged in a plane perpendicular to the tuning capacitor shaft, and range selection is obtained by switching in the appropriate coil by means of a rocker arm on the panel. The

Figure 2. Elementary Schematic Diagram of the Type 1211-A Unit Oscillator.




File Courtesy of GRWiki.org

frequency ranges are engraved at the arm extremities, and the main frequency dial shields one end of the arm so that only the range selected is indicated.

The core assembly, which helps to produce the wide frequency span, is concentric with the coils and is mounted to turn with the capacitor shaft. This assembly consists of a dust core and an aluminum core, both of a sickle shape, to produce a smooth transition from full iron-dust core for maximum inductance through a minimum of core to a full aluminum core for minimum inductance. The cores and the tuning capacitor plates are shaped to yield an approximate logarithmic response of frequency with angular rotation over the 10-to-1 frequency span. (See Figure 3.) The iron-dust core increases the circuit $Q$, while the aluminum core reduces it.

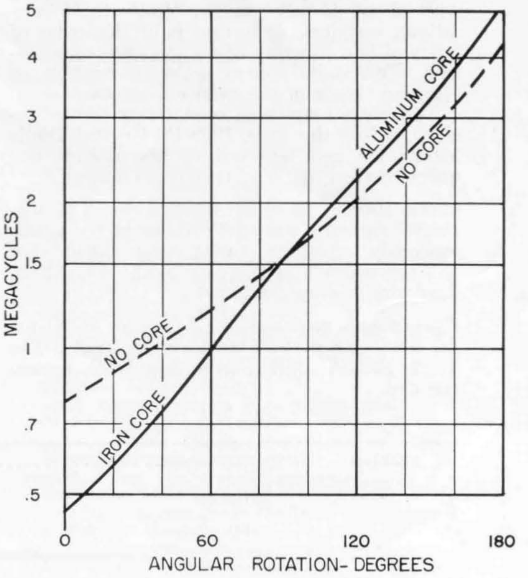



Figure 3. Frequency versus rotation angle showing the effect of the metal cores.

### Features

The major features of this oscillator are the compact unit design, the 10-to-1 frequency range for each switch position, and the approximately logarithmic frequency response of the main dial with a smaller auxiliary dial indicating frequency increments of 0.2% per division. The 874-type coaxial output system and the effective shielding add appreciably to the usefulness of the instrument. All power leads are carefully filtered, and the dial shaft is enclosed within a grounded capsule inside the main knob.

The shielding is entirely adequate for use of the oscillator as a power source in bridge measurements. The 874-type coaxial output connector permits extension of the shield system to the bridge.

Since all leads to the power unit are carefully filtered, batteries can be used as the power supply for field applications. For general laboratory operation, the Type 1203-A Unit Power Supply is recommended.

— A. G. Bousquet

## SPECIFICATIONS

**Frequency Range:** 0.5 to 50 Mc in two ranges.

**Frequency Calibration Accuracy:** 2% at no load.

**Frequency Controls:** A two-position range switch. A 6-inch dial with calibration approximately logarithmic against angular rotation. A slow-motion vernier dial to indicate frequency increments of 0.2% per dial division.

**Output System:** The oscillator output is available at a coaxial connector at the rear of the instrument. An adjacent ground terminal also permits connection by means of a Type 274-M Plug. The output is controlled by a small dial calibrated in arbitrary units.

**Output Power:** At least 200 milliwatts into a 50-ohm load at any frequency within the range. For the 0.5-5 Mc range, the output power is of the order of 2 watts.

**Modulation:** Direct amplitude modulation over the audio-frequency range can be obtained with an external audio oscillator. The impedance at the modulation terminals is about 8000 ohms, and 25% modulation is obtained

File Courtesy of GRWiki.org

with about 45 volts audio. Under these conditions, envelope distortion is of the order of 3% and is a function of carrier frequency setting. The audio source must be capable of carrying the dc of the carrier oscillator.

To obtain amplitude modulation free of incidental f-m, the TYPE 1000-P6 Crystal Diode Modulator can be used at the carrier frequencies above 10 Mc, at reduced output.

**Circuit:** Hartley oscillator coupled direct to output. Frequency tuning is obtained by simultaneously changing the tuning capacitance and the position of the core in the coils (iron-dust core to aluminum core).

**Power Supply Requirements:** 300 volts at 50 ma dc, 6.0 volts at 0.75 amperes ac or dc. The TYPE 1203-A Unit Power Supply is recommended.

**Tube:** TYPE 5763 Miniature VHF Beam Power Amplifier, which is supplied with the instrument.

**Mounting:** The oscillator is mounted on an aluminum casting and is shielded with a spun-aluminum cover. The assembly is mounted on an L-shaped panel and chassis, finished in black-crackle lacquer.

**Accessories Supplied:** TYPE 874-R21 Patch Cord, TYPE 874-Q2 Adaptor and TYPE CDMS-466-4 Multipoint Connector.

**Accessories Available:** TYPE 1000-P6 Crystal Diode Modulator, TYPE 1214-A Unit Oscillator, TYPE 1203-A Unit Power Supply, TYPE 1204-B Unit Variable Power Supply, and the TYPE 874 Coaxial Elements.

**Dimensions:** 7 x 8 x 12 inches over-all.

**Net Weight:** 11½ pounds.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **1211-A** | **Unit Oscillator** | ATLAS | **$295.00** |

U. S. Patents 2,125,816 and 2,548,457.

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# GENERAL RADIO AT N. E. C. 1953

General Radio products will be on display in Booths 87 and 88 at the National Electronics Conference to be held in the Hotel Sherman, Chicago, September 28, 29, and 30.

Among the General Radio instruments shown will be:

*Type 1217-A Unit Pulse Generator* — a small, compact, inexpensive generator of pulses, with rise time as short as 0.05 microsecond and repetition rates between 30 and 100,000 cps.

*Type 1000-P7 Balanced Modulator* — a crystal-diode modulator designed to operate on the output of standard-signal generators to produce 100% amplitude modulation without incidental frequency modulation. Carrier frequency range is 60 to 2500 megacycles, and modulating frequencies up to 20 megacycles can be used. Pulse modulation can also be applied, with rise times as short as 0.02 microsecond.

*Limit bridges* for measuring d-c resistance and for comparing resistors, capacitors, and inductors at audio-frequencies.

*Sound-measuring equipment* — a complete line of sound-level meters, analyzers, and accessories for the measurement of noise and other sounds.

*Type 1602-B U-H-F Admittance Meter*, with a full line of accessories, set up to measure television transmitting antennas.

*Variac® autotransformers* with General Radio's new Duratrak contact surface that stands up under punishing overloads — an outstanding development that makes the variable autotransformer as durable as a fixed-ratio transformer.

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


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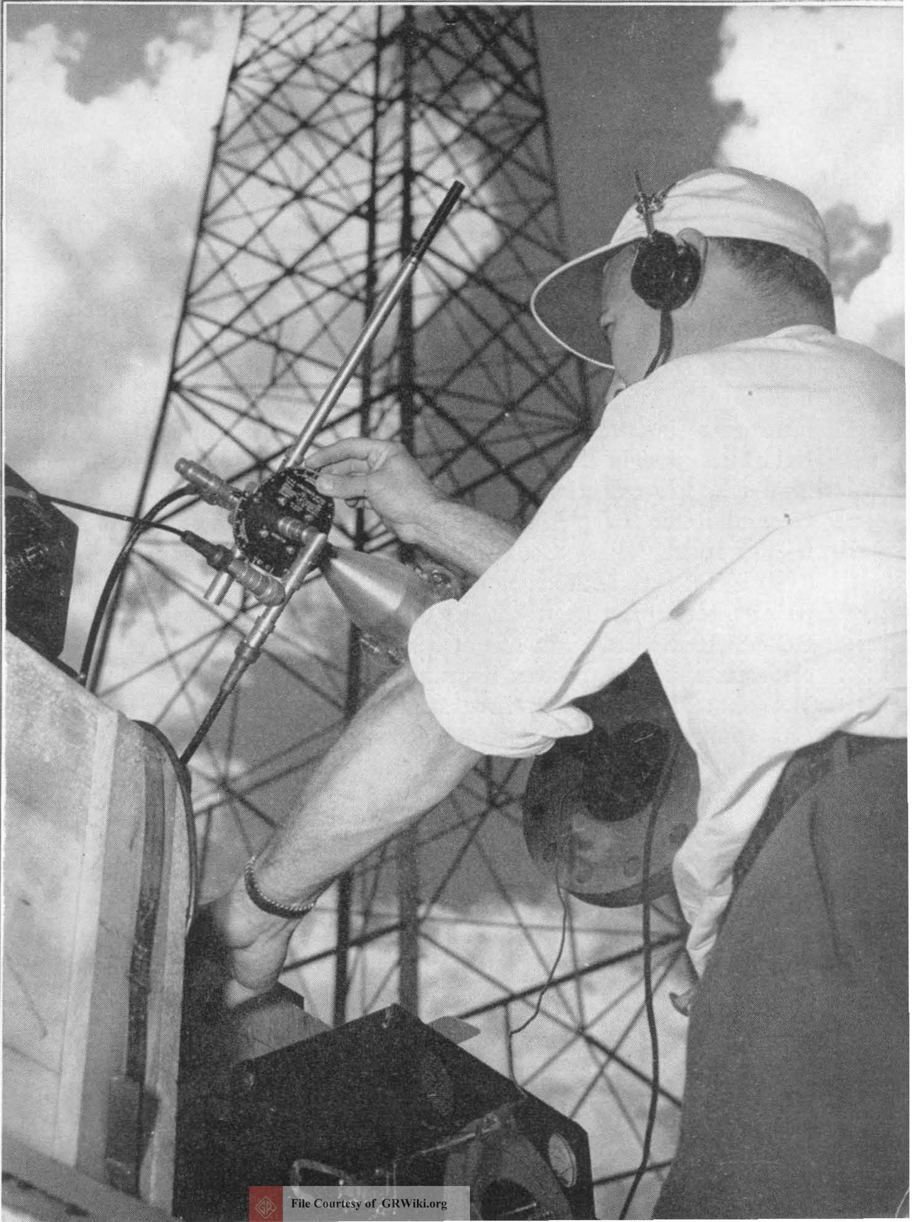
ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS



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# NEW ADAPTORS FOR VHF- AND UHF-TV COAXIAL TRANSMISSION LINES

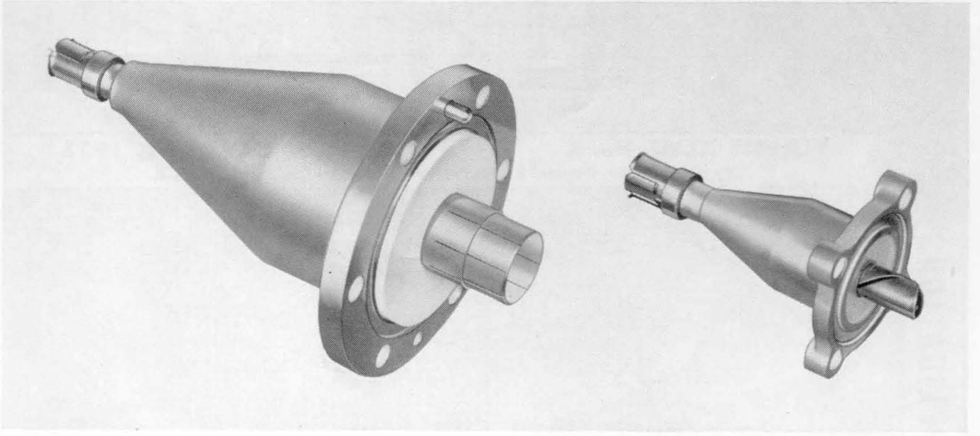

Figure 1. (*Left*) Type 874-QU3 Adaptor to 3⅛-inch rigid line, and (*right*) Type 874-QV2A Adaptor to 1⅝-inch rigid line.

For measurements of the standing-wave ratio and impedance of television transmitting antennas, adaptors are necessary to connect general-purpose measuring instruments to the large rigid lines used in the antenna system. Two new low-reflection adaptors from General Radio Type 874 Coaxial Connectors to 1⅝″ VHF Coaxial Line and 3⅛″ UHF Coaxial Line now make it possible to utilize the advantages of the General Radio Type 874 line of coaxial elements and of associated instruments in both VHF- and UHF-TV transmitting applications. With these adaptors, the Type 874-LB Slotted Line and the Type 1602-B Admittance Meter can be used for impedance and standing-wave ratio measurements, the Type 1021-A Standard Signal Generators for bandwidth and attenuation measurements, the Type 1208-A and 1209-A Oscillators for low-power excitation of circuits and antennas, and the various combinations of Type 874 components for matching transformers, diplexers, detectors, etc. The low-reflection and hermaphroditic features of the Type 874 Connectors and the electrical smoothness of these new adaptors make them well suited for use in television transmitting measurement applications where very low VSWR's are required to prevent ghosts.

## UHF ADAPTOR

The Type 874-QU3 UHF Adaptor is designed to make the connection be-

## COVER PHOTO

Measuring standing-wave ratio on a u-h-f television transmitting antenna (Channel 56) with the Type 1602-B U-H-F Admittance Meter. The base of the admittance meter has been removed in order to mount the instrument directly on the Type 874-QU3 Adaptor.

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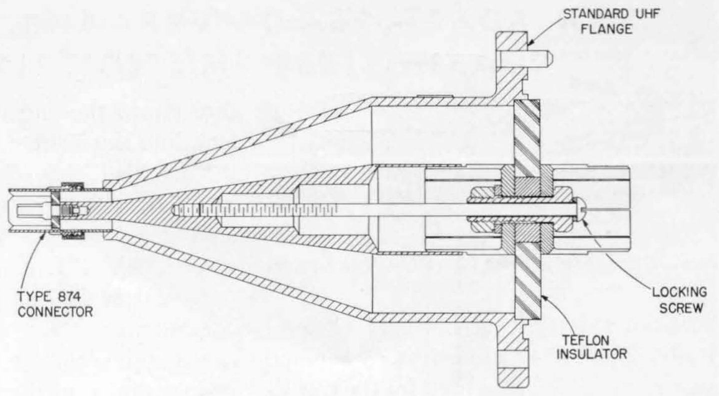



Figure 2. Cross section of Type 874-QU3 Adaptor to 50-ohm, 3⅛-inch rigid line.

tween circuits fitted with General Radio Type 874 Connectors and standard 3⅛″ 50.0-ohm UHF coaxial transmission line. The transition between the two lines is made by means of a tapered section of line as shown in Figure 2. This adaptor is provided with a RETMA standard flange and anchor terminal as shown in Figure 1, and the anchor terminal is made captive to the tapered inner conductor by means of a 4″ screw whose head is visible at the center of the anchor terminal. The anchor terminal can be removed and the adaptor used as female element if the locking screw is removed. However, caution must be exercised when the adaptor is used in this connection, as the long tapered section is then supported at one end only.

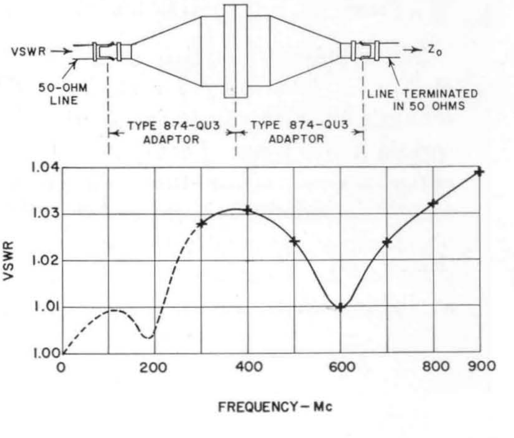
The electrical characteristics of this adaptor are excellent. Figure 3 shows the standing wave introduced into a flat 50 ohm line by a pair of typical adaptors connected back to back. The measured values include the effects of the two pairs of Type 874 Connectors shown in the sketch in the figure.

For standing-wave-ratio and impedance-measurement applications, the best results are obtained with the measuring instrument connected directly to the adaptor terminals, since reflections produced by intermediate sections of line and connectors are eliminated. In field applications of the Type 1602-B UHF Admittance Meter, the instrument can be completely supported by the adaptor as shown if the base of the admittance meter is removed (*see cover photo*).

## VHF ADAPTOR

In the VHF band, the old standard 51.5-ohm 1⅝″ coaxial line is still widely used. The Type 874-QV2A Adaptor, shown in Figure 1, makes the transition

Figure 3. Voltage-standing-wave ratio of Type 874-QU3 Adaptor as a function of frequency.

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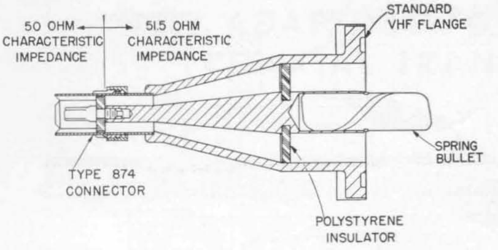


Figure 4. Cross section of the Type 874-QV2A Adaptor to 51.5 ohm, 1⅝-inch rigid line.

between this type of line and General Radio Type 874 Connectors. A tapered section of line is again used for the transition element. However, since the Type 874 line has a 50.0-ohm characteristic impedance and the VHF line has a 51.5-ohm characteristic impedance, a small reflection is produced at the junction. In the adaptor, the change in characteristic impedance is made directly behind the polystyrene insulator in the Type 874 Connector, as shown in Figure 4.

When the Type 1602-B Admittance Meter is used to measure either admittance or standing-wave ratio, using the null method with the meter connected directly to the end of the adaptor, the length of the 50 ohm line is so short that it has a negligible effect on the measurements over the VHF-TV band (less than .015 effect on the VSWR at 200 Mc when the VSWR is near unity and proportionately less at lower frequencies). Measurements can also be made with maximum accuracy using the voltage-ratio method with minor modifications.

The reflection introduced by the adaptor in addition to that introduced by the change in characteristic impedance produces less than a 1.02 VSWR on a flat line over the VHF-TV band.

The adaptors just described enable the television engineer to make wider applications of a large number of very useful existing devices and thus simplify his measurement problems.

—R. A. Soderman

## SPECIFICATIONS

**Net Weight:** Type 874-QU3, 5¼ pounds. Type 874-QV2A, 1¼ pounds.

**Over-all Length:** Type 874-QU3, 9⅛ inches. Type 874-QV2A, 4¾ inches.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **874-QU3** | **Adaptor to U-H-F, 3⅛″, 50.0 ohm Rigid Line** | COAXYULTRA | **$87.00** |
| **874-QV2A** | **Adaptor to V-H-F, 1⅝″, 51.5 ohm Rigid Line** | COAXYVERRA | **46.00** |

# BRIDGE MEASUREMENTS IN THE COLLEGE LABORATORY

The efficient operation of a college electronics laboratory for student use requires the permanent installation of certain major items of equipment. Such apparatus as vacuum-tube bridges, Q meters, impedance bridges, and the like, which are so frequently required as accessories to experiments, should be available without the necessity of setup.

This does not mean that a student should be deprived of the opportunity to make his own setups. It does mean that a worthwhile experiment, whose subject is a vacuum-tube bridge, may require assembling the necessary components but, when a certain amplifier experiment requires a knowledge of tube parameters, a bridge should be available

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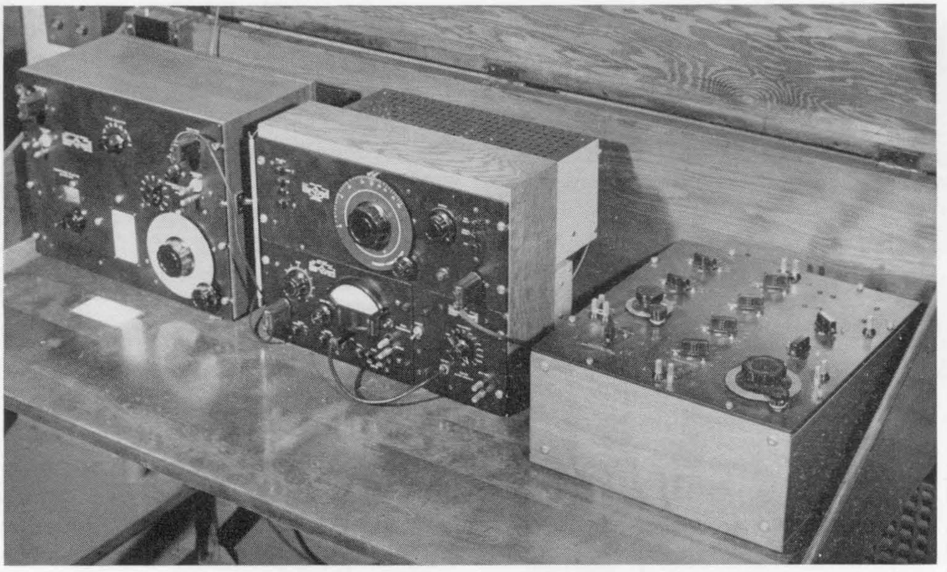


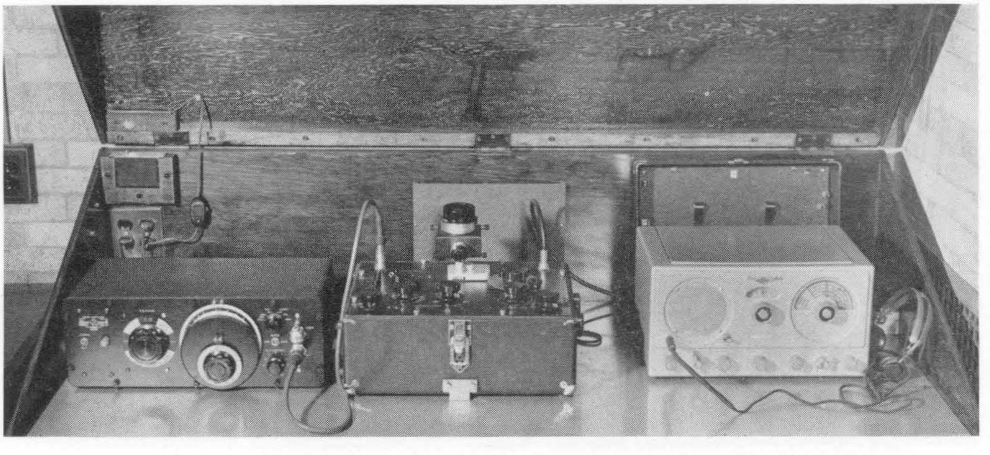
Figure 1. View of audio-frequency capacitance and inductance bridges with generator and detector in the Electronics and Communication Laboratory at The Cooper Union.

already set up with power supplies, tone source, and detector.

The accompanying photographs show some of the permanent installations which have been found useful in the Electronics and Communication Laboratory of the Electrical Engineering Department at The Cooper Union. The severe dust and dirt conditions of a metropolitan location have led to the use of the hinged, counterbalanced wooden covers which also provide mechanical protection of the enclosed equipment.

The apparatus in Figure 1 consists of the General Radio Type 716-C Capacitance Bridge, Type 667-A Inductance Bridge, Type 1302-A Oscillator, and Type 1231-BRFA Amplifier and Null Detector with Filter. In Figure 2 are the Type 821-A Twin-T Impedance-Measuring Circuit, Type 1330-A Bridge

Figure 2. The Type 821-A Twin-T Impedance Measuring Circuit at The Cooper Union. A metal shield covers the table top, and equipment is protected from dust and other damage by the hinged cover.



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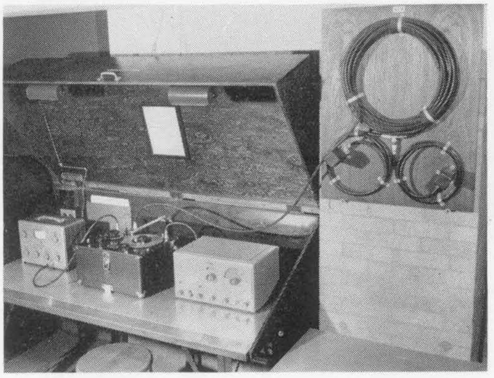


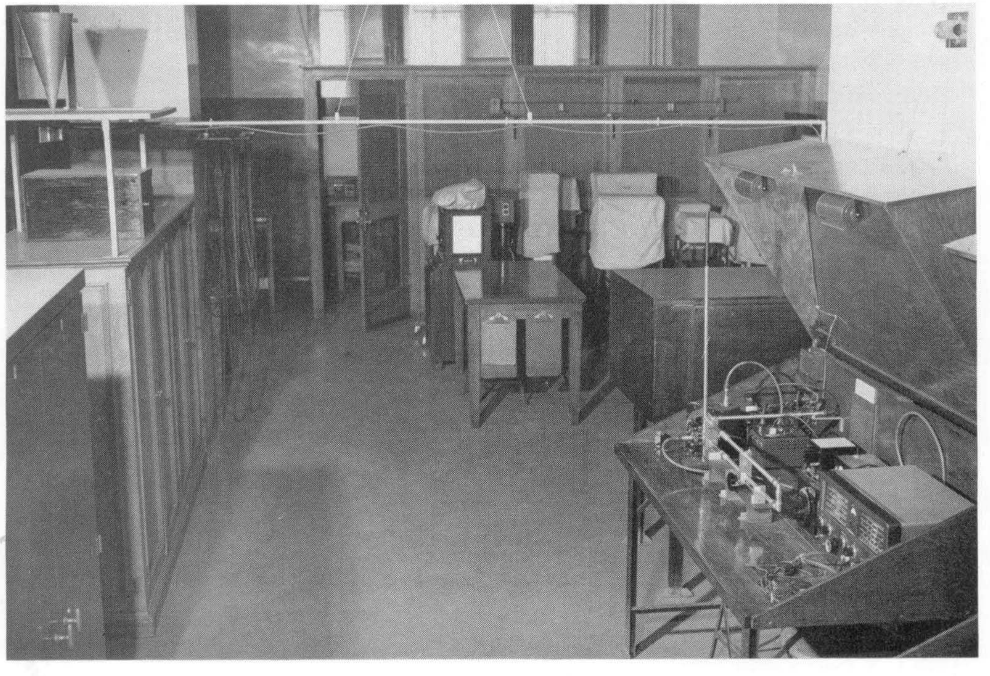
Figure 3. View of equipment for the measurement of cable characteristics at 12 Mc with the Type 916-A Radio-Frequency Bridge.

Oscillator, and National NC-57 Receiver used as null detector. Among the uses to which the 716-C and 821-A are put is the measurement of dielectric constant and dissipation factor by means of the TYPE 1690-A Dielectric Sample Holder which appears in Figure 2.

Shown in Figure 3 are the General Radio TYPE 916 Radio-Frequency Bridge, RCA WR-67A Oscillator, and National NC-57 Receiver. This inexpensive oscillator has, with occasional calibration, been satisfactory for this bridge. One experiment performed with this equipment makes use of the cable circuit attached to the wall. This consists of a long line of RG-8/U which branches at a tee junction to two short lengths of RG-11/U, one terminated by a capacitive-resistive and the other by an inductive impedance. The circuit is matched at the tee at 12 Mc. The sending-end impedance is measured over a substantial range centered about this frequency. The cable characteristics are measured on samples, and verifying computations performed from this information and the termination constants.

Figure 4 shows an installation built

Figure 4. The setup for antenna measurements at very-high and ultra-high frequencies with the Type 1602-A U-H-F Admittance Meter. The cone antenna under measurement is shown at the extreme upper left of the photograph. The special adjustable line can be seen at the front of the test bench.



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around the TYPE 1602-A U-H-F Admittance Meter. The usual unit oscillators, mixer, and the like are provided, with a Hallicrafters receiver as 30-Mc detector. It was desired particularly to use this equipment for antenna impedance measurement. For this purpose, a ground plane of moderate size was mounted above an instrument cabinet at a sufficient height so that antennas under test are little affected by persons moving about the laboratory. A special connector constructed from a TYPE 874-EL Ell is inserted at the center of the ground plane. This connector includes a solenoid-operated switch for remotely short-circuiting the transmission line at the base of the antenna. The line is made of brass tube and rod with the central conductor supported by polystyrene screws.

A useful accessory to this equipment is the special constant-impedance adjustable line which can be seen to the right of the admittance meter. This is built up of two TYPE 874-LK Units. The principal purpose of this device is to increase the adjustable length for use between 100 and 500 Mc. A rack-and-pinion drive makes its operation particularly convenient, and the dangling patch cord of the single unit is eliminated.

Various antenna models equipped with banana plugs can be conveniently connected. Typical student data taken on a cone antenna are reproduced in Figure 5.

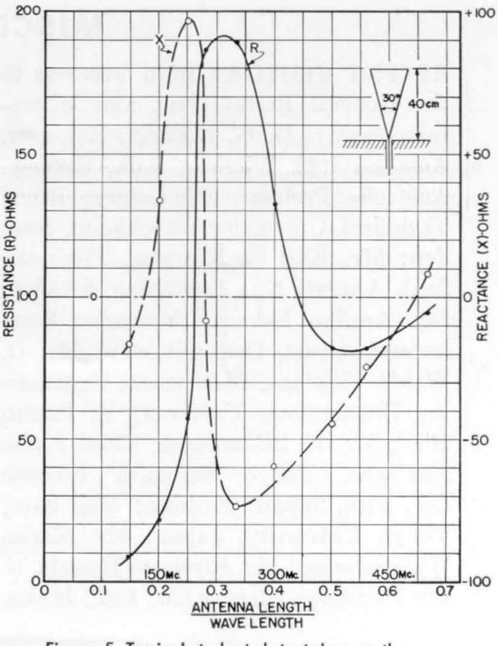


Figure 5. Typical student data taken on the cone antenna of Figure 4.

In the conduct of this experiment as with many others performed in this laboratory, the student is provided with a minimum outline of instruction. An adequate analysis of results is considered the real essential of his laboratory report, and he is expected to a considerable extent to decide for himself just what matters are worthy of analysis. This is in accord with a general Department philosophy which attempts to avoid leading the student through his work "by the nose," and makes a modest effort to anticipate the day close by when the student will no longer have a patient instructor at his elbow.

—JESSE B. SHERMAN

*The author of the foregoing article is Professor of Electrical Engineering at The Cooper Union. We are grateful to Professor Sherman for his courtesy in making this material available to* EXPERIMENTER *readers.*

—EDITOR

File Courtesy of GRWiki.org

# MISCELLANY

**RECENT VISITORS** from overseas to the General Radio plant and laboratories — Mr. D. G. Lindsay, Engineer, Amalgamated Wireless, Ltd., Sydney, Australia; Professor Eric Lofgren, Royal Technical University, Stockholm, Sweden; Mr. Karl G. Roström, Engineer, Saab Aircraft Co., Linköping, Sweden; Mr. Arnfinn Lykaas, Forsvarets Forskningsinstitutt, Oslo, Norway; Mr. O. Waldo Villafant, Mechanical Engineering Department, University of Puerto Rico; Mr. N. Shimomura, Chief Radio Engineer, Tokyo Shibaura Electric Co., Ltd., Japan; Professor Koji Sato, Tokyo University, Japan; Mr. Karno Watanabe and Mr. Kirokuro Hosada, of the Furukawa Electric Co., Ltd., Japan.

**SPEAKERS** — At the National Electronics Conference Luncheon, Chicago, September 30, H. B. Richmond, Chairman of the Board, General Radio Company, on "Opportunities and Responsibilities of Employment in the Electronics Field."

At the West Coast I.R.E. Convention, San Francisco, August 21, R. A. Soderman, Engineer, on "Measurement Problems in V-H-F and U-H-F Antenna Systems."

At the August 24th meeting of the Portland, Oregon, Section, I.R.E., Paul K. McElroy, Design Engineer, on "What Does Current Standardization Mean to You?"

## LEWIS M. LYONS

It is with great regret that we note the death, following a long illness, of Mr. Lewis Lyons, a partner of the firm of Claude Lyons, Ltd., who have represented us in Great Britain for many years. Mr. Lyons managed the Liverpool offices and warehouse of the firm with an efficiency and effectiveness that will be missed both by ourselves and our friends overseas. His place is being taken by Mr. A. G. Kneen, the secretary and a director of the firm.

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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

File Courtesy of GRWiki.org

# A LABORATORY AMPLIFIER FOR AUDIO AND ULTRASONIC FREQUENCIES

The TYPE 1206-B Unit Amplifier, newest member of the General Radio family of Unit Instruments,[1] is a high-quality amplifier, designed for general laboratory use. Its maximum output power of 3 watts is adequate for driving low-power transducers, and its wide frequency range (up to 250 kc) makes it useful as an amplifier for the output of such oscillators as the TYPE 1301-A and the TYPE 1302-A or for pulses with rise times as short as one microsecond. In conjunction with a pair of earphones, it has sufficient gain for use as a null detector in bridge measurements.

The General Radio unit construction makes possible a low price and a small compact assembly, which can be bolted to the TYPE 1203-A Unit Power Supply to form a single unit.

## Circuit Details

This amplifier takes advantage of the desirable characteristics of the single-ended push-pull circuit to obtain low distortion over a wide frequency range.

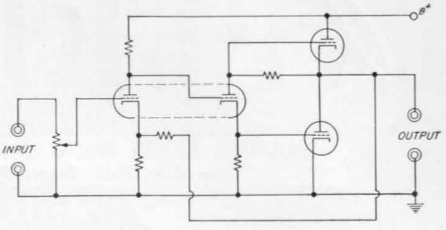


Figure 1. Elementary schematic circuit diagram of the Type 1206-B Unit Amplifier.

This type of circuit has been discussed in previous articles[2,3] and is shown in basic form in Figure 1. Note that the upper output tube is driven from grid to cathode, not grid to ground, and that the a-c currents of both tubes add in the load, while the grid voltages are of opposite phase. Therefore it has true push-pull operation and single-ended output without the use of an output transformer. In a conventional push-pull circuit, the frequency range is severely limited by the output transformer.

The unit amplifier was designed for use with the TYPE 1203-A Unit Power

[1]For other Unit Instruments, see the *General Radio Experimenter* for May, 1950; July, 1951; February, 1952; February, 1953, and September, 1953.

[2]A. P. G. Peterson, "A New Push-Pull Amplifier Circuit," *General Radio Experimenter*, October, 1951, pp. 1-7.

[3]A. P. G. Peterson and D. B. Sinclair, "A Single-Ended Push-Pull Amplifier," *Proc. I.R.E.*, January, 1952, pp. 7-11.

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## COVER PHOTO

In the production of textile yarns, the speeds of the processing machinery are extremely important. Constant speed assures uniform quality and fewer defects in the cloth woven from the yarn, while the maintenance of rated speeds is necessary for efficient production.

The stroboscopic method of speed measurement is widely used in textile plants, because there is no mechanical contact between machine and tachometer, so that the speed of the machine is not affected. In spinning and twisting operations, a complete frame of spindles can be checked quickly for proper speed and, at the same time, defects in the operation of the machine can be spotted by means of the slow-motion effect.

This photograph shows the General Radio Strobotac® being used to measure the speeds of spindles on an Atwood twister and to observe the shape of the yarn balloons.

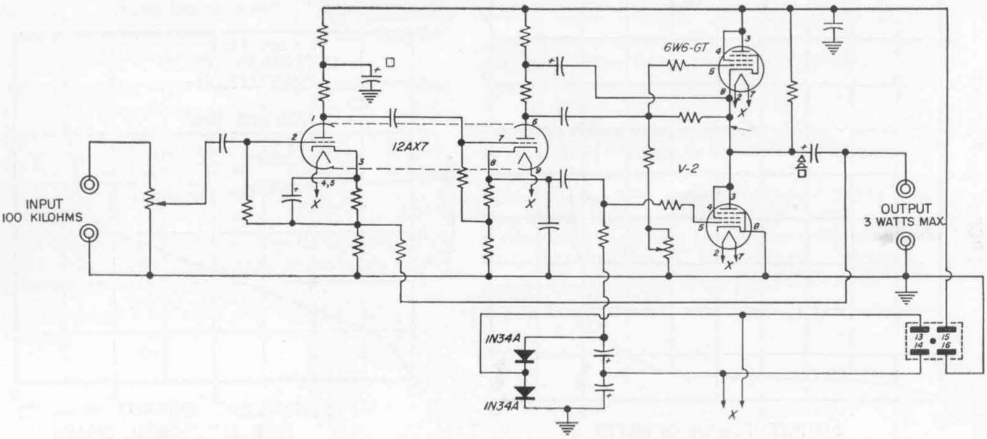
File Courtesy of GRWiki.org


Figure 2. Panel view of the amplifier.

Supply, whose output necessarily limits the maximum output power of the amplifier and the choice of tube types. Of the available tube types that could be operated from the power supply, a pair of triode-connected 6W6-GT's gave the best results.

A 12AX7 miniature twin triode is used in the input stage and phase inverter since it combines the economy of a single envelope with the desirable features of high gain and low cathode-heater power. It will be noted from Figure 3 that the phase-inverter plate supply is taken from B+ through a resistor to enable this stage to handle larger signals. A capacitor connects the phase-inverter plate resistor to the output, so that for a-c signals the circuit is equivalent to that of Figure 1. The

Figure 3. Complete circuit diagram.




File Courtesy of GRWiki.org

first stage has a gain of about 50, and the phase inverter and output stage have an over-all gain of about 3.5 when loaded with 600 ohms. Feedback reduces this gain by a factor of 4. Full output is obtained with an input signal of slightly less than 1 volt. With no load, the gain is approximately 50.

## OPERATING CHARACTERISTICS

Output power vs. load for a total distortion of 1% is shown in Figure 4 for a typical instrument. It can be seen that the optimum load is slightly more than 600 ohms. The output impedance would be about 400 ohms with no feedback, and it is 100 ohms with feedback.

Figure 5 shows harmonic distortion as a function of output power for a typical instrument at 1 kc. At 20 cycles and 40 kc, the distortion is slightly higher. These curves are taken with the amplifier supplied from a Type 1203-A Unit Power Supply operating from a line voltage of 115 volts. The voltage output for a given distortion and load is roughly proportional to the line voltage.

The intermodulation distortion in this amplifier is essentially independent of the component frequencies over the audio range. At 3-watts output, the

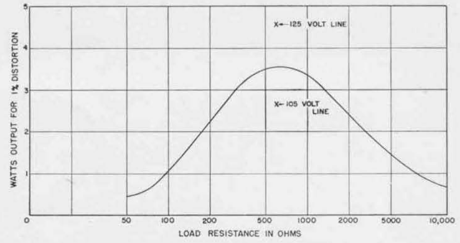
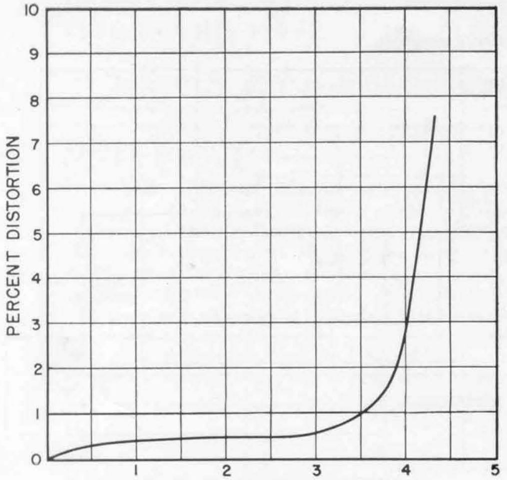



Figure 4. Output power as a function of load resistance for a total harmonic distortion of 1%, with the power supply operating from a 115-volt line. Points are also shown for 105-volt and 125-volt lines.

CCIF[4] quadratic intermodulation distortion is about 0.25%, and the cubic is about 0.6%. The SMPTE intermodulation is shown in Figure 6 as a function of output power. Up to 3 watts, the distortion is well below the 5% intermodulation limit usually set for high-quality amplifiers.

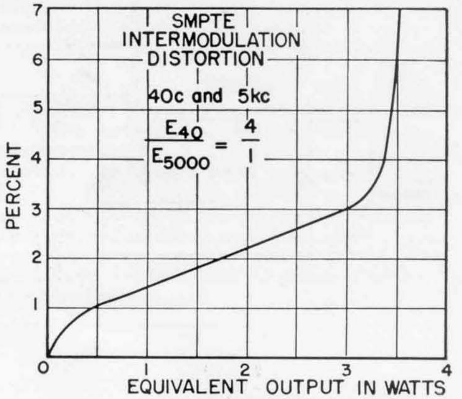
The frequency characteristics of the amplifier are given in Figures 7 and 8 for a 600-ohm load and no load. The solid curves are the output (measured with a peak-reading voltmeter) for a constant input level. At the frequency extremes, distortion occurs owing to the relatively limited frequency response of the phase inverter. The dashed curves give the maximum output for an output waveform that is not visibly distorted on a cathode-ray oscillograph.

Figure 5. Harmonic distortion as a function of output power at a frequency of 1 kc with 115-volt line.




[4]A. P. G. Peterson, "An Audio-Frequency Signal Generator for Non-Linear Distortion Tests," *General Radio Experimenter*, August, 1950.

Figure 6. Intermodulation distortion (SMPTE method) as a function of output power.

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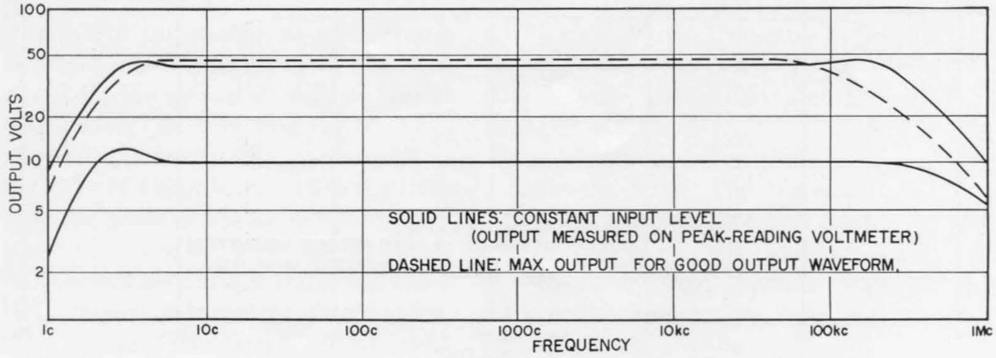


**Figure 7. Output voltage vs. frequency with 600-ohm load. Solid curves are for constant input level, dashed curves for good output waveform.**

## USES

The Type 1206-B Unit Amplifier has been designed to give full output with a maximum input of one volt, corresponding to the output voltage of many electro-acoustic and electro-mechanical measuring devices. Thus it can be used to amplify their outputs to a level sufficient to operate graphic recorders. Typical examples of these devices are the Type 1551-A Sound-Level Meter, the Type 760-B Sound Analyzer, the Type 1550-A Octave-Band Noise Analyzer, the Type 761-A Vibration Meter, and the Type 762-B Vibration Analyzer.

It is also useful in amplifying the output of the Type 1390-A Random-Noise Generator for audio-frequency tests.

For use with load impedances other than 600 ohms, the Type 941-A Toroidal Transformer[5] is an excellent impedance matching device. With this transformer, load impedances from 37.5 ohms to 9600 ohms can be matched to the 600-ohm amplifier impedance. Frequency response covers approximately four decades.

— Henry P. Hall

[5] Horatio W. Lamson, "Type 941-A Toroidal Transformer," *General Radio Experimenter*, September, 1950, pp. 5-8.

## SPECIFICATIONS

**Power Output:** With 300-volt plate supply and 600-ohm load:
- 3 watts from 20 cycles to 50 kc.
- 1.5 watts from 10 cycles to 100 kc.
- 0.5 watt at 250 kc.

**Distortion:** Less than 1% harmonic distortion with 2 watts output (2% with 3 watts) into 600 ohms from 20 cycles to 40 kc.

| **Pulse Response:** | No Load | 600Ω |
|---|---|---|
| Droop in 30-cycle square wave | 15% | 20% |
| Approx. Rise time: | | |
| 50 v peak-to-peak | 1 μsec. | 2 μsec. |
| 100 v peak-to-peak | 2 μsec. | 4 μsec. |
| Max output, peak-to-peak magnitude | 260 v | 120 v |

**Load Impedance:** 600 ohms optimum. Blocking capacitor is 100 μf. (Source impedance about 100 ohms.)

**Input Voltage:** Less than one volt for full power output.

**Input Impedance:** 100,000 ohms in parallel with 35 μμf.

**Frequency Response:** Essentially flat from 10 cycles to 100 kc (see power output specification).

**Voltage Gain:** Continuously adjustable. Maximum voltage gain is 50 (34 db), with no load.

**A-C Hum:** Maximum a-c hum in output with Type 1203-A Unit Power Supply is less than 15 mv, rms.

**Power Requirements:** 6.3 volts, 2.7a; 300 volts, 50 ma. Type 1203-A Unit Power Supply is recommended.

**Power Supply:** The amplifier plugs directly into the Type 1203-A or the Type 1204-B Unit Power Supply It can be permanently attached with bolts supplied to form a complete assembly.

**Accessories Supplied:** Multipoint connector.

**Tubes:** One 12AX7 and two 6W6-GT are supplied.

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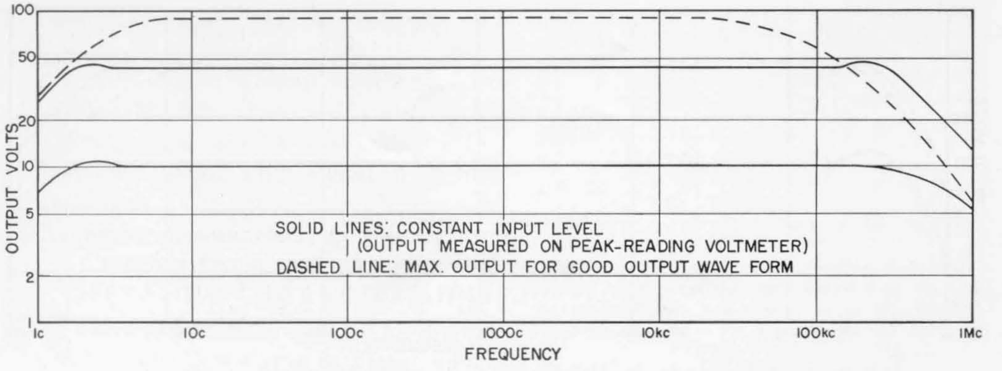



Figure 8. No-load output voltage as a function of frequency. Solid curves are for constant input voltage, dashed curves for good output waveform.

**Terminals:** Jack-top binding posts with standard ¾-inch spacing.

**Mounting:** Black-crackle finished panel and sides. Aluminum cover finished with clear lacquer.

**Dimensions:** (Width) 9⅞ x (height) 5¾ x (depth) 6¼ inches, overall.

**Net Weight:** 4 pounds.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **1206-B** | **Unit Amplifier** | ARBOR | **$85.00** |
| **1203-A** | **Unit Power Supply** | ALIVE | **40.00** |

Patent applied for. Licensed under patents of the A. T. and T. Co.

# "OSCILLATOR CONSIDERATIONS"

"With literally thousands of R-C band switch oscillators in use throughout the industry, we believe it is high time, particularly with the many younger engineers entering industry who may not have had experience with other types, to mention a few favorable words about the somewhat neglected, yet definitely deserving, beat-frequency audio oscillator.

> This article is one of the best and fairest summaries that we have seen of the relative performance of beat-frequency oscillators and resistance-capacitance oscillators. It is reprinted, with permission, from *Lab Notes*, published by Gawler-Knoop Company, Sales Engineers, and was prepared by Clough-Brengle Company, one of the manufacturers whose products are distributed by Gawler-Knoop.

"Basic advantages of the BFO as compared with the RCO might be summarized as follows:

"1. The BFO output amplitude is constant throughout a frequency range of usually 50 cps. to 10,000 cps. and within 0.5 db to 32 kc. It is not subject to discontinuity of output level resulting from band switching as is necessary with RC types, since no band switching is necessary.

"2. Because of insufficient overlap in band switching, the investigation of important network responses occurring at RCO dial extremes becomes an inconvenient task.

"3. Thermal and warm-up stability of the BFO is far superior to the RCO. At 1,000 cps., a typical drift figure for the BFO from a cold start is in the order of 10 cps. or 1%, but is corrected with

File Courtesy of GRWiki.org

simple zero adjustment, so such error is diminished to essentially zero. The RCO has about the same drift with no correction control. At 1,000 cps. the BFO calibration and readability accuracy is in the order of 1% or better, while the RCO is in the order of 2% or better. After a two-hour warm-up, both the BFO and RCO have substantially stabilized. Since BFO frequency drift is a constant value, not a constant percentage, the BFO will perform even better at higher frequencies.

"4. A well-designed BFO will not exhibit frequency change with output attenuator setting changes.

"5. The rated distortion value for the BFO is usually ½ of 1%, while the same figure for the RCO is usually 1%. These figures apply only above 100 cps., however.

"6. The BFO depends upon the stability of $L$ rather than $R$. It consequently exhibits a superior calibration permanence and can take advantage of the further inherent stability resulting from a low $L$- to $C$-ratio.

"7. Much has been said of the lock-in tendencies of the BFO at low frequencies (when both high-frequency oscillators are approaching the same frequency). This problem is one of the reasons for BFO's to be more useful above 25 to 50 cps. However, let it be said that a similar problem also exists with the RCO since the tuning capacitor must operate above chassis potential, which causes it to tend to 'lock in' at power line frequency and multiples thereof.

"8. Fairness in making a comparison such as this dictates the comment that the RC circuits are ideal for low-frequency applications, generally below 50 cps., where the design problems of the BFO are extremely severe.

"Beat-frequency audio oscillators are currently manufactured commercially by General Radio Company (who, by the way, hold the basic RC oscillator patent with 34 claims) and Clough-Brengle Co."

---

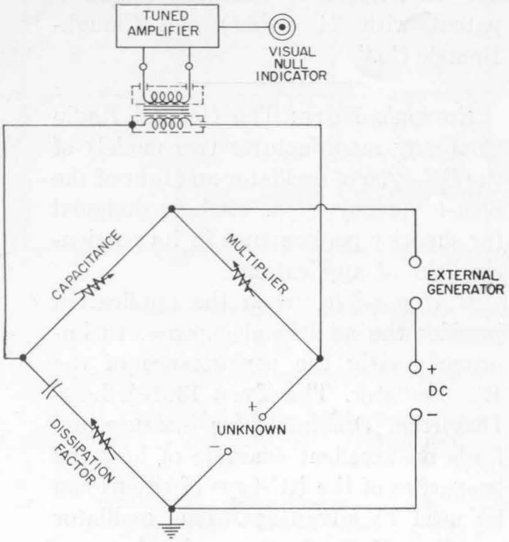
Editor's Note: The General Radio Company manufactures two models of the RC-type of oscillator and four of the beat-frequency type. Each is designed for superior performance in its particular field of application.

It is possible, when the application justifies the additional expense, to improve greatly the performance of the RC oscillator. The Type 1301-A Low-Distortion Oscillator, for instance, affords an excellent example of how the properties of the RC-type of circuit can be used to advantage. This oscillator supplies 27 fixed frequencies between 20 and 15,000 cycles for use as test tones in the measurement of harmonic distortion. Here, by careful design of the frequency- and amplitude-controlling circuits and through the use of high-quality components, a total harmonic distortion as low as 0.1% is obtained with a frequency drift of only 0.02% per hour.

The beat-frequency oscillator has an outstanding advantage for audio-frequency testing. The frequency-control dial can be made logarithmic in frequency over a range of three decades, thus permitting the drive to be coupled directly to a recorder for the automatic recording of frequency-dependent phenomena over a range of 20 to 20,000 cycles without range switching. The RC oscillator usually requires three bands to cover this range. This logarithmic, wide-range, single-dial control is a feature of the Type 1304 Beat-Frequency Oscillator, which is widely used for measuring the amplitude-vs.-frequency characteristics of audio-frequency equipment.

File Courtesy of GRWiki.org

# ELECTROLYTIC CAPACITOR TESTING AT 120 CYCLES




Current RETMA standards call for the measurement of electrolytic capacitors at 120 cycles. As a result, a number of our customers have requested modification of the TYPE 1611-A Capacitance Test Bridge to permit measurements at this frequency.

The inclusion of a 120-cycle source for use over the entire capacitance range of this bridge would require substantial and expensive alterations. Relatively minor and inexpensive changes, however, make possible the use of an *external* 120-cycle source for measurements with the upper four multipliers of the bridge. These multipliers cover the range from 1$\mu$f to 11,000 $\mu$f, and are thus appropriate for electrolytic capacitors.

As indicated in the accompanying schematic diagram, the 120-cycle measuring voltage is applied in series with the external d-c polarizing voltage normally required for electrolytic capacitor testing. Since the d-c supply is grounded, the test voltage must be supplied through an isolation transformer, which can also serve to match the low impedance of the bridge (from a few ohms to a few thousand ohms) to the 120-cycle source.

Tuning of the detector to 120 cycles is provided, as is a jack to permit connection of a resonant circuit externally, for measurements at frequencies other than 60 cycles or 120 cycles.

The dissipation factor range is directly proportional to the test frequency; thus at 120 cycles the range of the bridge becomes 0% to 120%. The dissipation factor accuracy is $\pm$ (2% of dial reading $+ 0.05\% \times \frac{f}{60}$).

The modification described is designated as TYPE 1611-AS2.

| *Type* | | *Code Word* | *Price* |
|---|---|---|---|
| **1611-AS2** | **Capacitance Test Bridge** | FAVOR | **$525.00** |

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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

# FIVE NEW VARIAC® SPEED CONTROLS ROUND OUT THE LINE

*Also*
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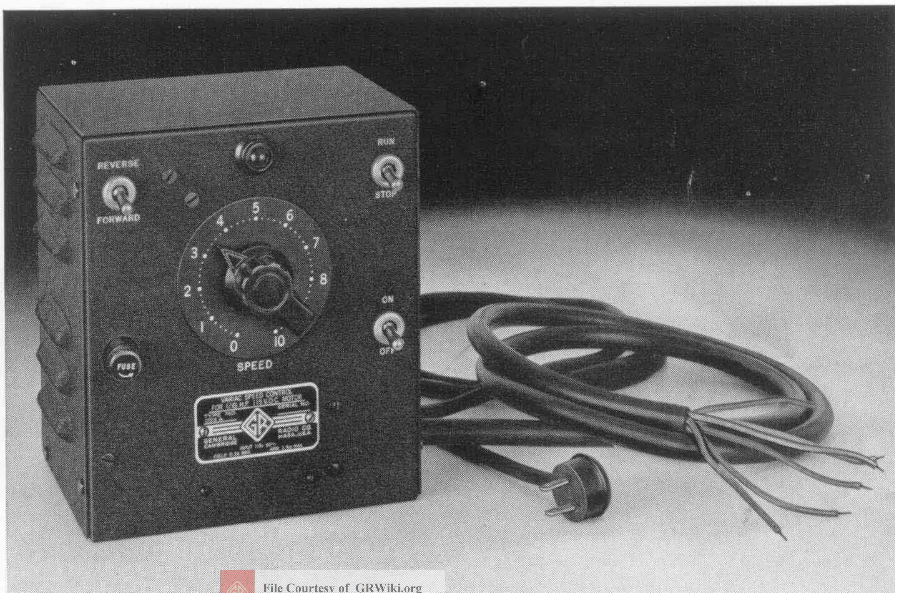
● **THE ADDITION** of the Types 1701-AM, 1703-A, 1702-M, 1704-A, and 1705-A Variac® Motor Speed Controls to the four previously announced brings to nine the models now available.

The Type 1703-A control, of 1/6-hp rating, fills the gap between the 1/15-hp controls, Types 1701-AK and AU, and the 1/3-hp control, Type 1700-B.

The Types 1704-A and 1705-A controls extend the line to higher ratings, 1 and 1½ hp, respectively.

The Type 1702-M is a new ¾-hp control for push-button operation, which is an alternative to the Type 1702-A.

Figure 1. The Type 1703-A One-Sixth Horsepower Control.




File Courtesy of GRWiki.org

The Type 1701-AM control is similar to the Type 1701-AK of 1/15-hp rating but has only a single-speed range and has an armature-circuit fuse accessible from the front panel. Comparative specifications and prices of the entire line of controls are given in the table on page 4.

The Variac Motor Speed controls, first announced in April, 1949,[1] provide adjustable constant-speed operation of d-c motors from a-c lines. Separate rectifiers supply field and armature power and a Variac® adjustable transformer, ahead of the armature rectifier, makes it possible to vary the armature voltage from the rated value down to zero smoothly and with good regulation. The superior performance of armature-voltage control is thus provided by particularly simple and reliable equipment.

### Advantages

This system, however, has advantages not common to other adjustable-armature-voltage systems, and it is becoming evident in the rapidly expanding field of applications that the control is basically a new device with a unique combination of characteristics. Selenium rectifiers are employed so that power conversion and control are accomplished without using either rotating machinery or electron tubes. Low-cost, simple installation, elimination of warm-up time, and long life with very much reduced maintenance are the result. The use of selenium rectifiers rather than tubes also greatly increases the short-period overload rating. This is particularly important in starting heavy loads or in repeated starting and stopping. The rectified armature voltage is reduced by changing the amplitude of the a-c input, rather than, as in a thyratron rectifier, by cutting out part of the cycle. The result is that it is relatively easy to filter the armature supply and so to obtain very low ripple content. This reduces both motor heating and torque pulsation in the motor output.

[1] W. N. Tuttle, "Variac Motor Speed Controls," *General Radio Experimenter*, Vol. 23, April, 1949, pp. 1-8.

The speed-torque characteristics of the control, providing about 15-25 per cent regulation at base speed, seem to be definitely superior to those of a very "stiff" drive for most applications. A drive with these characteristics yields enough to protect the work or tool when irregularities are encountered, but maintains constant speed under heavy load under ordinary conditions.

### Applications

With the Variac Motor Speed Control, it is possible to start delicate equipment or critical processes smoothly and slowly. On toroidal winding machines handling fine wire, for example, one user reports that wire breakage has been practically eliminated. On these machines, no other control had been satisfactory.

An application where the excellent starting characteristics of the control have proved of great value has been for the spindle drives of a battery of ten winding lathes for transformer coils in our own plant. Here, in order to obtain maximum production, over-voltage starting is employed with a special low-


Figure 2. Compact Control Station for Type 1702-M Three-Quarter Horsepower Control.

File Courtesy of GRWiki.org

inertia motor so that the spindle can be accelerated to more than 5000 rpm in about three seconds. Although the starting current peak is about seven times the full-load value, maintenance on the controls has been negligible and none whatever has been required on the motor brushes or commutators. The first installation of this group has been in operation almost five years. A similar application requiring frequent starting and stopping is on automatic condenser-winding machines.

The virtual elimination of torque pulsation, resulting from the very low ripple content of the armature current, has proved particularly valuable in precision grinding work, and the control is being used increasingly for both grinder feeds and spindles and for similar applications.

The controls have proved highly versatile, and any listing of uses can only suggest the many fields where they can be used successfully. In machining plastics and in lens lapping, the ease and smoothness of adjustment have proved very valuable. In conveyors and in process work of various kinds, the constancy of speed has proved highly satisfactory in a large number of applications. The characteristics of the controls have been found particularly suited to rewinding and take-up drives of various kinds.

Descriptions of the new controls follow with a tabulation of specifications and prices for the complete line.

## The Type 1703-A One-Sixth Horsepower Control

As shown in Figure 1, this control is similar in appearance to the Type 1701 controls but has two and one-half times the output rating. It provides in addition two features previously available only in the larger models. These are dynamic braking and the superior starting characteristics of compound-wound motors. We have had many requests for a control of this rating, a typical application being for heavier feed drives than can be handled by the Type 1701 controls. A power cord and 3½-foot motor cable are included as with the Type 1701, and the control also requires no bottom ventilation, so can be used on a laboratory bench.

## The Type 1702-M Three-Quarter Horsepower Control

This new control is offered as an alternative to the Type 1702-A in cases where the cabinet of the latter is too large to be mounted within convenient reach of the operator of the driven machine, or where push-button control is preferred to the mechanically-operated switch. Control relays for starting, reversing, and dynamic braking are included in the cabinet, replacing the Variac and control switch; and the Variac, push buttons, and a pilot light are mounted in a separate, compact control station, illustrated in Figure 2. This is a dust-proof enclosure, which protects the Variac fully from metal

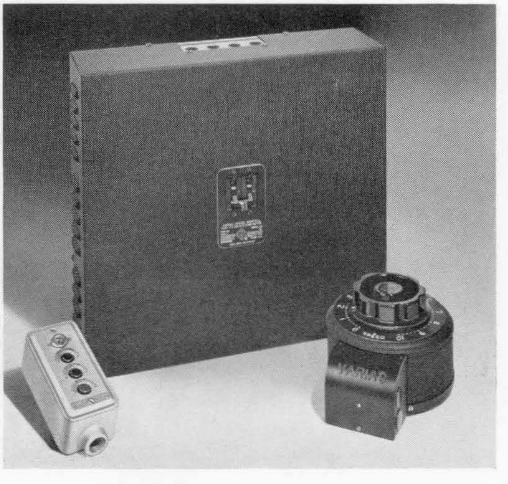


Figure 3. Cabinet, Variac, and Control Station for Types 1704-A and 1705-A Controls Rated One and One-Half Horsepower. The shallow cabinet takes very little room on the side of a machine.

File Courtesy of GRWiki.org

# VARIAC MOTOR SPEED CONTROLS

| Type No. | 1701-AK<br>1701-AM† | 1701-AU | 1703-A | 1700-B | 1702-A<br>1702-M | 1704-A | 1705-A |
|---|---|---|---|---|---|---|---|
| Motor Horsepower Range | 1/15 and less | 1/15 and less | 1/12 to 1/6 | 1/4 and 1/3 | 1/2 and 3/4 | 1 | 1 1/2 |
| Power Supply: (Single phase ac) volts | 115 | 115 | 115 | 115 | 115** | 230 | 230 |
| Full load amperes | 1.5 | 1.5 | 2.2 | 5 | 10 | 6.5 | 8.5 |
| Line voltage limits at 60 cycles | 105–125 | 105–125 | 105–125 | 105–125 | 105–125 | 210–250 | 210–250 |
| at 50 cycles | 105–120 | 105–120 | | No rating | No rating | No rating | No rating |
| Input Power — watts Full load | 175 | 175 | 255 | 560 | 1150 | 1500 | 1950 |
| Standby | None | None | 30 | 38 | 65 | 90 | 90 |
| Control Output — DC Armature — Amperes | 0.8 | 0.8 | 1.5 | 3.0 | 6.5 | 4.5 | 6.0 |
| Volts | 0–115 | 0–115 | 0–115 | 0–115 | 0–115 | 0–230 | 0–230 |
| Field — Amperes | 0.2 | 1.25 / 1.0 | 0.2 | 0.4 | 0.4 | 0.5 | 0.5 |
| Volts | 115 / 38 | 10 / 16 | 115 / 66 / 48 | 115 / 75 | 115 / 75 | 230 / 160 / 128 | 230 / 160 / 128 |
| Speed Range | 0 to rated / 0 to 2 rated† | 0 to rated | 0 to rated / 0 to 1.25 rated / 0 to 1.50 rated | 0 to rated / 0 to 1.15 rated | 0 to rated / 0 to 1.15 rated | 0 to rated / 0 to 1.12 rated / 0 to 1.25 rated | 0 to rated / 0 to 1.12 rated / 0 to 1.25 rated |
| Dynamic Braking | None | None | Automatic in Stop Position | Automatic in Stop Position | Automatic in Stop Position | Automatic in Stop Position | Automatic in Stop Position |
| Armature Overload Protection at | Slow-Blow Fuse<br>0.9–1.15 amps | Slow-Blow Fuse<br>0.9–1.15 amps | Slow-Blow Fuse<br>1.7–2.0 amps | Circuit Breaker<br>3.5–4.3 amps | Circuit Breaker<br>7.25–9 amps | Circuit Breaker<br>4.5–5.6 amps | Circuit Breaker<br>7.25–9 amps |
| Control Station | On cabinet | On cabinet | On cabinet | On cabinet | 1702-A — On cabinet<br>1702-M — Remote | Remote | Remote |
| Cabinet Dimensions — inches | 5 7/8×6 7/8×4 5/8 | 5 7/8×6 7/8×4 5/8 | 7 1/8×7 3/4×4 5/8 | 12 7/8×9 3/8×6 | 13 1/2×15×6 1/2 | 21×19 1/4×7 | 21×19 1/4×7 |
| Net Weight — pounds | 6 | 6 | 9 | 23 1/2 | 41 | | |
| Code Word | -AK WINDY<br>-AM WIDOW | WEARY | WEBBY | AFOOT | 1702-A AMAZE<br>1702-M WISTY | WEEDY | WAXER |
| Price | $75.00 | $75.00 | $97.50 | $170.00 | 1702-A $245.00<br>1702-M $350.00 | $470.00 | $495.00 |

**THESE MOTORS CAN BE SUPPLIED WITH VARIAC MOTOR SPEED CONTROLS**

| Type No. | 1701-AK<br>1701-AM† | 1701-AU | 1703-A | 1700-B | 1702-A<br>1702-M | 1704-A | 1705-A |
|---|---|---|---|---|---|---|---|
| Motor Ratings: Open dripproof, Reversible, 40 c. Rise Continuous Horizontal, Rigid Base | Shunt | Series or Universal with Armature and Field Leads Separate | Compound | Compound | Compound with Interpoles | Compound with Interpoles | Compound with Interpoles |
| Horsepower | 1/15 | 1/15 | 1/6 | 1/3 | 3/4 | 1 | 1 1/2 |
| Frame size | N-34 | N-12 | F-56 | H-56 | H-66 | N-203 | N-204 |
| Speed RPM | 1725 | 8800 | 1725 | 1725 | 1725 | 1750 | 1750 |
| Leads (brought out separately) | 4 | 4 | 6 | 6 | 6 | 6 | 6 |
| | | (3 1/2 foot motor cable furnished) | | | | | |
| Bearings | Sleeve | Sleeve | Sleeve | Sleeve | Sleeve | Ball | Ball |
| General Radio Designation | MOD-5 | MOD-4 | MOD-11 | MOD-3 | MOD-6 | MOD-9 | MOD-10 |
| Code Word | MOTOR* | MOTOR* | MOTOR* | MOTOR* | MOTOR* | MOTOR* | MOTOR* |
| Net Weight — pounds | 10 3/4 | 3 3/4 | 25 | 30 | 60 | 75 | 87 |
| Price | $33.00 | $17.50 | $41.00 | $51.00 | $84.00 | $170.00 | $195.00 |

*To order motor with Variac Speed Control, use compound code word, WINDYMOTOR, AMAZEMOTOR, etc. Motors are not sold separately.
†The Type 1701-AM is similar to the Type 1701-AK, except it has one speed range (0 to rated) and its armature fuse is accessible from the front panel.
**Type 1702-P1 Autotransformer is available for use on 230-volt lines; weight, 20 1/4 pounds; price, $27.50.





File Courtesy of GRWiki.org

chips and dirt. The relay control circuit has been carefully engineered, the prototype model having been in continual use on a lathe in our Experimental Shop for almost four years. We feel confident that this control will be particularly free of relay maintenance difficulties.

### The Types 1704-A and 1705-A Controls of One and One and One-Half Horsepower Rating

These larger controls are also for push-button operation, but differ from the smaller Type 1702-M in that a conventional push-button station is used and the Variac is mounted separately. Because of the size of the Type V-20 Variac, a single-unit control station is no longer feasible. With the large machines on which these controls would be used, there is usually room in the cabinet where the Variac can be placed, making the whole installation very simple and compact.

### Special Controls for Machine Manufacturers

Frequently, the user wants to combine a Variac speed control with other equipment in his own cabinet. For such applications, the basic elements of the control can be provided as a sub-assembly along with a separate Variac. For these cases, the user usually prefers to provide conventional contactors and overload protection as part of the complete control equipment for the machine or process. These sub-assemblies are not listed as standard controls but can be provided on order in most sizes if reasonable quantities are involved.

— W. N. Tuttle

# INK FLOW ON ROTATING ROLLERS

The accompanying photographs are the result of an interesting study of the physical properties of printing ink. The General Radio Type 1530 Microflash was used as a high-speed light source to make all of these photographs.

Attempts to correlate theoretical studies of physical properties of printing ink with actual press results observed are often unsuccessful for short, stiff inks and inks used for high-speed press operation. Mr. Lars H. Sjodahl of the International Printing Ink Division of Interchemical Corporation has studied this problem using an inkometer and the Microflash. The inkometer allows measurement of the torque required to split an ink film of predetermined thickness. It consists essentially of two inked roll-

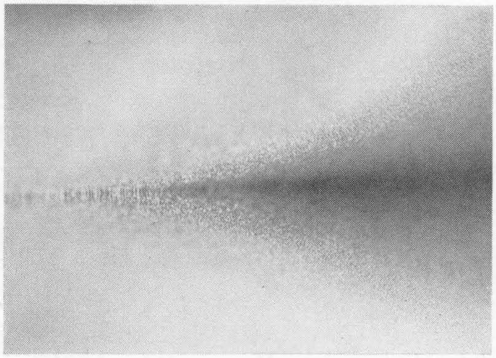


Figure 1. Filamentation of white offset ink with the Inkometer rollers turning at 300 feet per minute. The filaments reach a length of four-hundredths of an inch, forty times the thickness of the ink film. There is very little ink "mist."

File Courtesy of GRWiki.org

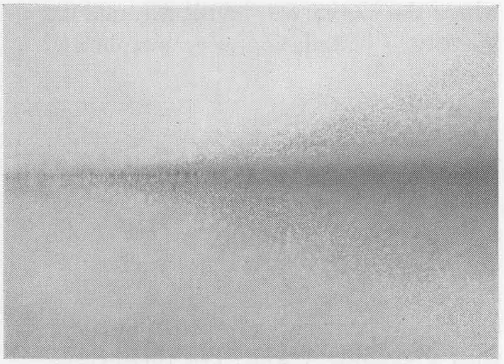


Figure 2. Same ink at 900 feet per minute. The filaments break closer to the "nip" because elastic forces are built up more rapidly at higher speeds.

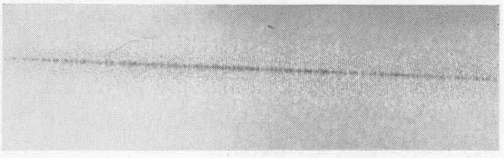


Figure 3. A head-on view of the same conditions shown in Figure 2. There are about 130 filaments per inch.

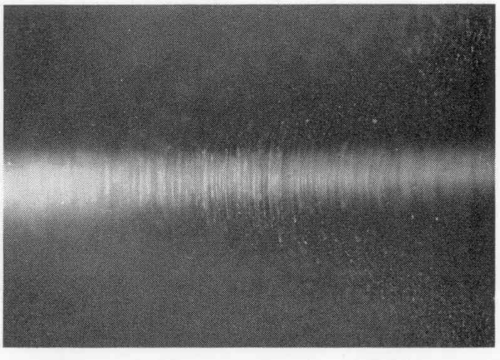


Figure 4. An ink which "flies" badly at a speed of 300 feet per minute. The filaments stretch out to one-eighth inch before breaking. Many free-floating ink particles are thrown off.

ers, the speed of which can be varied to simulate actual press condition. The Microflash allows high-speed photographs to be taken of the ink filaments that form as the ink film on the rollers separates.

Mr. Sjodahl's results indicate that previous calculations of the force necessary to break the filaments were too high, often by a factor of one hundred. These calculations had been based strictly on viscous flow equations. The lower force actually required is attributed to the effect of absorbed gases in the ink expanding as the ink moves away from the "nip" between the rollers.

These Microflash photographs show the length of the filaments under varying conditions and the ink "mist" that forms as the filaments break.

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From "Ink Flow on Rotating Rollers" by Lars H. Sjodahl, First Annual Meeting of the Technical Association of the Lithographic Industry, Chicago, April 15, 1949.

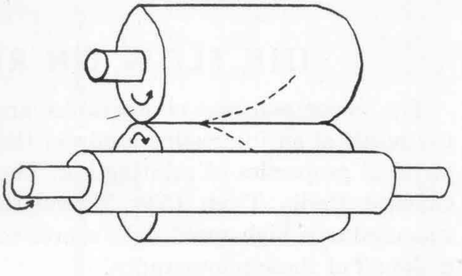


Figure 5. Sketch of Inkometer rollers showing line of focus for Figures 1, 2, and 4.

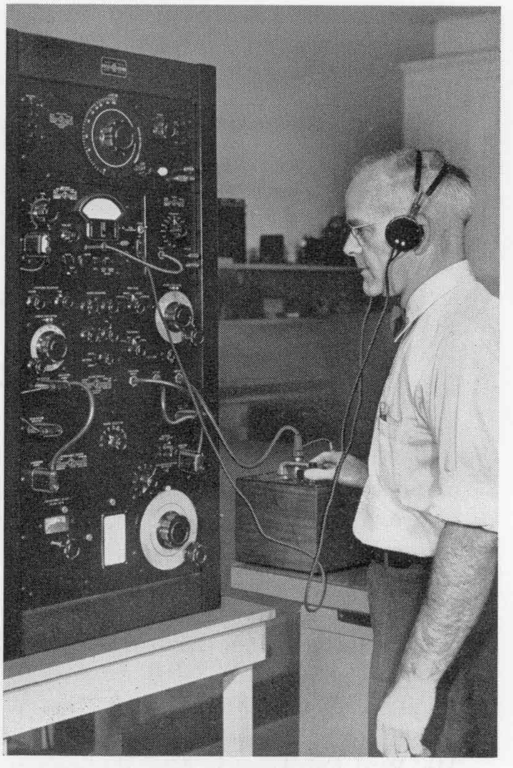
# A COMPLETE ASSEMBLY FOR CAPACITANCE MEASUREMENTS

The Type 1610-A Capacitance Measuring Assembly equipment is a well-integrated assembly of standard General Radio Company instruments mounted

File Courtesy of GRWiki.org

in a bench-type relay rack, complete with all interconnections. With this equipment, accurate two- or three-terminal measurements can be made of capacitance and dissipation factor over the frequency range from 60 cycles to 100 kc. The assembly is comprised of the following instruments: TYPE 716-CR Capacitance Bridge, TYPE 716-P4R Guard Circuit, TYPE 1231 BRFA Amplifier and Null Detector and Filter, and the TYPE 1302-A Oscillator. The assembly is operated from a 115 volt, 60 cycle, a-c power line.

The Capacitance Measuring Assembly, TYPE 1610-A, has been in use at the General Radio Standardization Laboratory and government research laboratories since it was first announced in the August, 1952, *Experimenter*. In addition, leading component and wire manufacturers, aircraft manufacturers, and petroleum companies have found that the packaged convenience and accuracy of the assembly add a new step in quality control to their manufacturing processes.



The guard circuit eliminates the effects of terminal capacitance by means of a three-terminal connection to the sample and makes possible accurate measurements of the direct capacitance of components and samples that may have large terminal capacitances to ground. One example of the use of this equipment is the measurement of components over wide ranges of temperature and humidity as required by JAN specifications and many present-day commercial applications. The conditioning chamber in which the sample must be placed is often at a distance from the bridge terminals, requiring shielded leads of considerable length whose capacitance, in a simple two-terminal measurement, would be in parallel with that of the sample. With the guard circuit, the same accuracy of measurement can be obtained under these conditions as would be obtained if a two-terminal sample were connected directly to the bridge terminals. Measurements of capacitance up to 1000 $\mu\mu$f are possible to $\pm 0.1\%$ or 0.8 $\mu\mu$f,[1] whichever is the larger, and of dissipation factor to $\pm 0.00005$ or $\pm 2\%$ for change in dissipation factor observed, when the change is less than 0.06.

For two-terminal measurements of solid dielectric samples, the Capacitance Measuring Assembly can be used with the TYPE 1690-A Dielectric Sample Holder, which is designed for use with standard ASTM two-inch discs.

For use solely in two-terminal capacitance measurements, the assembly is

[1]When a worm-correction calibration for the TYPE 716-C Capacitance Bridge is used, the accuracy can be improved to $\pm 0.1\%$ or $\pm 0.2 \mu\mu$f, whichever is larger.

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available without the guard circuit, which is replaced in the rack by a dummy panel. This assembly is the Type 1610-A2. Both assemblies are listed below.

| *Type* | | *Code* | *Price* |
|---|---|---|---|
| 1610-A | Capacitance Measuring Assembly | SEDAN | $1,930.00 |
| 1610-A2 | Capacitance Measuring Assembly, less Guard Circuit | SABER | 1,635.00 |
| 1690-A | Dielectric Sample Holder | LOYAL | 435.00 |
| | Worm-Correction Calibration | WORMY | 50.00 |

U. S. Patent 2,173,427. Licensed under patents of the American Telephone and Telegraph Company and patents of the Radio Corporation of America.

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