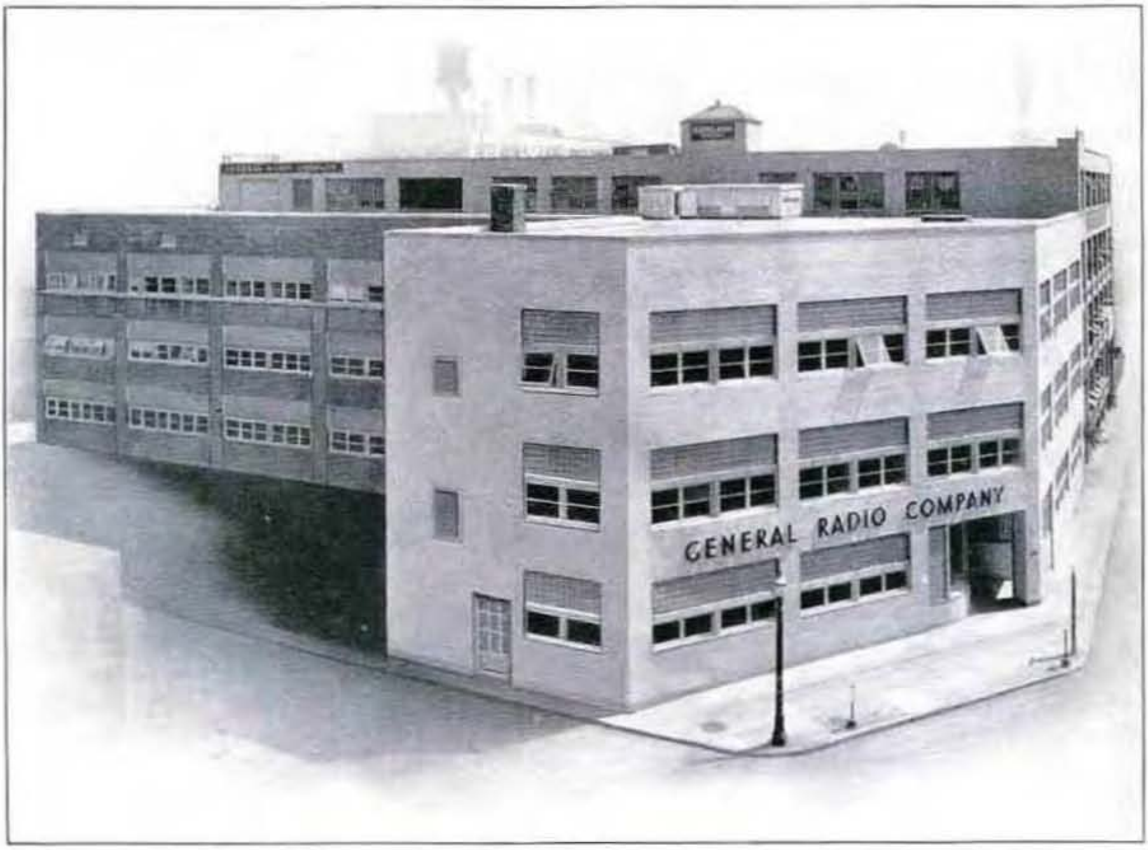
CATALOG M

GENERAL RADIO

COMPANY · CAMBRIDGE, MASS. U.S.A.

QUICK INDEX



We Sell Direct . . .

To develop the type of product manufactured by the General Radio Company requires a large staff of engineers, each a specialist in one or more phases of the work involved. One of the functions of this staff is to assist the customer in the selection of instruments in order that the correct equipment may be purchased with a minimum expenditure.

There has always been close contact between our engineering staff and our customers. The technical nature and the manifold uses of our product make the maintenance of this contact essential. For this reason, the General Radio Company maintains no sales agencies in the United States, but distributes its products directly to the consumer on a net, no discount, basis. The Company maintains factory branch offices in several major cities of the U.S. which are staffed by skilled, factory-trained engineers.

In order that customers outside the United States may receive equivalent technical service, exclusive distributors have been appointed in many foreign countries, each capable of giving technical and commercial information regarding General Radio products. For a list of foreign distributors, see the inside back cover of this catalog. In all matters regarding General Radio apparatus the customer should communicate with the appropriate distributor. Prices listed in the catalog are for domestic use only. Costs in foreign countries, where import duty and freight must be added, can be obtained from the distributors in those countries.

GENERAL RADIO COMPANY

CATALOG M

OCTOBER, 1951

GENERAL RADIO COMPANY

CAMBRIDGE 39, MASSACHUSETTS

NEW YORK CHICAGO LOS ANGELES

U. S. A.

SUGGESTIONS FOR ORDERING

ORDER BY TYPE NUMBER

Always order by catalog type number, and whenever possible mention name of item, ranges, or other significant specifications as protection against misunderstanding.

Be sure to include orders for any accessories desired or for calibrations which must be made before shipment. If minor modifications in the parts or instruments to be ordered would make the equipment more useful, our Sales Engineering Department would be glad to discuss the details.

TELEGRAPH AND CABLE ORDERS

We have direct telegraph printer connections with Western Union for the prompt handling of messages.

Use Bentley's code and the code words accompanying each catalog description. Our cable address is GENRADCO BOSTON.

SHIPPING INSTRUCTIONS

Unless specific instructions accompany the order, we shall use our best judgment as to the method of shipment. Repair parts or other items needed quickly can be shipped Air Express if requested. The following table shows approximate costs of this service in continental United States.

Air Miles	*2 lbs.*	*5 lbs.*	*25 lbs.*	*40 lbs.*	*75 lbs.*	*100 lbs.*
249	$2.50	$2.50	$3.25	$4.00	$5.75	$7.00
349	2.50	2.50	4.05	5.28	8.15	10.20
549	2.50	2.73	5.65	7.84	12.95	16.60
1049	2.61	3.53	9.65	14.24	24.95	32.60
2349	3.44	5.61	20.05	30.88	56.15	74.20
Over 2350	3.51	5.77	20.85	32.16	58.85	77.40

PACKING

There is no charge for our regular domestic or export packing and no charge for shipping containers or cases. Cases are not returnable.

TERMS

Net 30 days. All prices are F.O.B. Cambridge, Massachusetts. Unless credit has already been established, shipments are made C.O.D.

When full payment accompanies an order for equipment, except for repairs, we pay transportation charges to any point in the continental United States, except Alaska.

REMITTANCES

Should be made payable at par in Boston or New York funds.

PRICE CHANGES

All prices are subject to change without notice. Formal price quotations remain open for 30 days.

Prices shown will be increased by the amount of any applicable sales, use, excise, or similar taxes that are now in effect or that may hereafter be imposed by Federal, State, or local governments.

NO TRADE OR EDUCATIONAL DISCOUNTS

Our prices are made on a direct-to-consumer basis which permits of no special discounts.

QUANTITY DISCOUNTS

When 10 or more identical parts (not instruments), are ordered at the same time for single shipment to a single destination, the following quantity discounts are allowed:

10–19 . . . . 5 per cent
20–99 . . . . 10 per cent
100 or more . . . . 15 per cent

Questions regarding the applicability of quantity discounts to any item in this catalog will be answered promptly by our Sales Engineering or Commercial Departments.

SUGGESTIONS FOR ORDERING

SPECIFICATION CHANGES

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

WARRANTY

We warrant each new instrument manufactured and/or sold by us to be free from defects in material and workmanship; our obligation under this warranty being limited to repairing or replacing any instrument or part thereof, except tubes and batteries, which shall, within one year after shipment to the original purchaser, prove after our examination to be thus defective.

REPAIR PARTS

When ordering repair parts, be sure to describe completely the parts required, also referring to the symbol numbers and description from the parts list, and give the type number and serial number from the panel of the instrument.

SHIPMENTS TO GENERAL RADIO

When returning instruments for repair, recalibration, or for any other reason, please ask our Service Department for Return Material Tag and shipping instructions. Please state type number and serial number of instrument and date of purchase.

DOMESTIC SALES AGENCIES

Because of the Company's direct sales policy no general sales agencies are appointed. Complete stocks are carried only at the factory warehouse. A partial stock is maintained at Los Angeles.

OTHER GENERAL RADIO PUBLICATIONS

In addition to this catalog we publish a number of bulletins of interest to technical and professional workers in specialized fields, and a monthly magazine, the *General Radio Experimenter*, for free distribution among interested persons. The *Experimenter* contains technical and semi-technical engineering articles which are contributed, for the most part, by our engineering staff. To be placed on the mailing list, merely fill in, clip, and mail the coupon below; or supply ALL of the information requested.

TO: General Radio EXPERIMENTER, 275 Massachusetts Ave., Cambridge 39, Mass.
Enter my free subscription to the G-R EXPERIMENTER.

Name (print)..

Company Name..

Company Address...
Street City and Zone No. State

Type of Business.................................Your Title......................

IMPORTANT!
PLEASE FILL IN *COMPLETELY*.

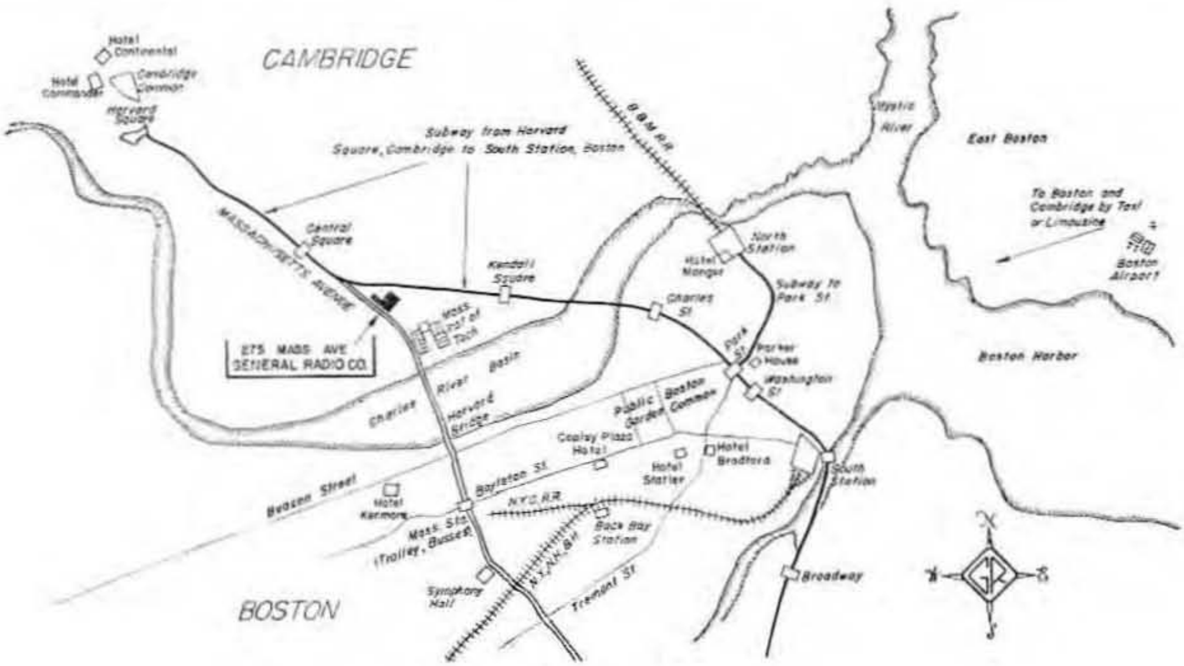
VISIT OUR LABORATORIES AND FACTORY

We cordially invite you to visit our engineering laboratories and factory the next time that you are in the vicinity of Cambridge.

Our plant is located in Cambridge (across the Charles River from Boston) at 275 Massachusetts Avenue. This is half way between the Massachusetts Institute of Technology and Central Square, Cambridge.

The accompanying map gives details for reaching the plant by public transportation or automobile.

HOURS FOR VISITORS: 10:00 A.M. to 4:00 P.M. every day except Saturdays, Sundays, and holidays.



PATENTS

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

1. "Certain vacuum-tube amplifier devices, electric wave filters, vacuum-tube oscillators, and sound-level meters are licensed by Western Electric Company, Inc., under all United States Letters Patent owned or controlled by American Telephone and Telegraph Company, or Western Electric Company, Inc., and any or all other United States patents with respect to which Western Electric Company, Inc., has the right to grant a license, solely for utilization in research, investigation, measurement, testing, instruction, and development work in pure and applied science, including engineering and industrial fields."
2. "This apparatus uses inventions of United States Patents licensed by Radio Corporation of America. Patent numbers supplied upon request. Licensed only for use in measuring or testing electronic devices, electron tube circuits, parts of such devices and circuits, and elements for use in such devices and circuits."
3. Patent 2,125,816.
4. Patent 2,548,457.
5. Licensed under all patents and patent applications of Dr. G. W. Pierce pertaining to piezo-electric crystals and their associated circuits.
6. Licensed under designs, patents and patent applications of Edgerton, Germeshausen and Grier.
7. Patent 2,294,941.
8. Patent 1,967,185.
9. Patent 2,173,427.
10. Patent 2,367,681.
11. Patent 2,009,013.
12. Patent 2,069,934.
13. Patent 2,376,394.
14. Patents D 142,777 and D 143,807.
15. Patent 1,983,447.
16. Patent 1,967,184.
17. Patent 2,012,497.
18. Patent 2,012,291.
19. Patent 1,999,869.
20. Patent 2,173,426.
21. Patent 2,298,177.
22. Patent 2,362,503.
23. Patent 2,020,358.
24. Patent 2,354,718.
25. Patent 2,025,775.
26. Patent 2,374,248.
27. Patent 2,160,588.
28. Patent 2,101,336.
29. Patent D 161,030.

INDUSTRIAL INSTRUMENTS

General Radio industrial instruments are electrical and electronic devices designed to meet the testing requirements of plants and laboratories in a wide variety of industries. They consist of (1) Stroboscopes, (2) Sound and Vibration Measuring Instruments, (3) a Polariscope, (4) Motor Speed Controls, and (5) VARIAC® Autotransformers.

STROBOSCOPES

The STROBOSCOPE permits rotating or reciprocating objects to be viewed intermittently and produces the optical effect of slowing down or stopping motion. For instance, an electric fan revolving at 1800 rpm will apparently be standing still if viewed under a light that flashes uniformly 1800 times per minute. At 1799 flashes per minute, the fan will appear to revolve at 1 rpm. and at 1801 flashes, it will rotate backward at 1 rpm. Because the eye retains images for an appreciable fraction of a second, no flicker is seen except at very low speeds. The apparent slow motion is an exact replica of the original higher-speed motion, so that the motion of a high-speed machine can be analyzed with the stroboscope under normal operating conditions.

The stationary image that is seen when the flash and rotational speeds are equal makes possible very precise speed settings, and when the flash rate control is calibrated in rpm. as in the STROBOTAC®, the stroboscope can be used as a tachometer.

The STROBOLUX® is an auxiliary light source that can be flashed from the Strobotac, for applications where more light is needed. The STROBOLUME is a high-intensity light source, flashed from a Strobotac or from a contactor, for low-flashing-rate applications, such as looms and printing presses. The CONTACTOR is a device for attachment to a crankshaft or other machine shaft to flash a stroboscope one or more times for each revolution of the shaft. It can be used with either the Strobotac or the Strobolume. The MICROFLASH is an ultra-high-speed light source for single-flash photography of rapidly moving objects such as bullets and projectiles.

The applications of General Radio Stroboscopes are more completely discussed in the booklet "Eyes for Industry," a copy of which will gladly be sent on request.

SOUND AND VIBRATION

Instruments in this group provide means for measuring objectively the noise generated in machines, appliances, and similar equipment, as well as general noise levels in offices, buildings, streets, etc. The SOUND-LEVEL METER and the SOUND SURVEY METER measure the level of the noise in terms of accepted standards; the SOUND ANALYZER measures each pitch component in the noise, the VIBRATION METER and VIBRATION ANALYZER measure solid-borne vibrations in the same way that the sound-measuring instruments measure air-borne vibrations. The OCTAVE-BAND ANALYZER permits the sound energy in successive octaves in the spectrum to be measured individually. A random noise generator, useful in many types of acoustic work, is also available, see page 153. This equipment and its uses are more completely described in "The Noise Primer." Write for a copy.

POLARISCOPE

The POLARISCOPE represents a new approach to the problem of stress analysis in photoelastic models. With the STROBOLUME light source, exposure time is reduced to a few millionths of a second, which greatly reduces the size and weight of the assembly, gives a large, 8-inch field, and also permits the photography of dynamic patterns.

MOTOR SPEED CONTROLS

General Radio VARIAC® SPEED CONTROLS provide smooth and continuous control of speed in d-c motors, operating from the a-c line. They combine a Variac and a rectifier to provide an armature voltage that can be adjusted over a wide range without deterioration of normal shunt-motor regulation. Ratings are 1/12 hp, 1/3 hp, and 3/4 hp.

VARIAC®

The VARIAC, a continuously adjustable autotransformer, gives smooth, continuous manual control of a-c voltage from zero to 17% above input line voltage. Available in single units and combinations in ratings from 170 va to 25 kva, these units are used in all types of industry for controlling voltage, heat, light, motor speed, and other voltage-sensitive quantities.

TYPE 631-B STROBOTAC®

(STROBOSCOPIC TACHOMETER)

DESCRIPTION: The Strobotac is a small, portable stroboscope calibrated to read speed directly in revolutions per minute. The light source is a neon Strobotron lamp mounted in a parabolic reflector. The frequency of a self-contained electronic pulse generator determines the flashing speed, which can be adjusted by means of a direct-reading dial.

Two models are available, the TYPE 631-B, with a range of 600 rpm to 14,400 rpm, and the TYPE 631-BL, which includes an additional range of 1/10th the scale values, i.e., 60 rpm to 1440 rpm, selected by throwing a switch, and useful for observational work.

Speeds below 900 or above 14,400 rpm, up to about 100,000 rpm, can be measured by using flashing rates that are simple multiples or submultiples of the speed to be measured. Below 600 rpm, the TYPE 631-BL model can be used for observations and control purposes, but, as the speed decreases, flicker becomes pronounced, owing to the inability of the human eye to retain successive images long enough to give the illusion of continuous motion.

The light flash from the Strobotron is extremely short and can effectively "stop" motion at subject speeds up to several times the scale values.

USES: The Strobotac is used for measuring the speed of rotating, reciprocating, or vibrating mechanisms and for observing their operation in slow motion. In the design and testing of machines and high-speed mechanisms, the Strobotac is invaluable. The operation of motors, fans, pulleys, gears, cams, and other machine elements can be examined in slow motion. Speed measurements for overload and underload tests can be made. It is ideally suited for rapidly adjusting the speeds of a number of machines intended to operate at the same speed, as, for instance, textile spindles. In production testing, it provides a means of rapidly aligning mechanisms that operate under close tolerances. It is approved for use in checking the calibration of aircraft tachometers.

FEATURES: ➔ Requires no contact with mechanism being measured, and hence absorbs no power. Therefore, it can be used to measure the speeds of very low-power devices.
➔ Short flash gives sharp images.
➔ High accuracy — ±1% when standardized by comparison with the power-line frequency.
➔ Can be used in places inaccessible to conventional tachometers.
➔ Easy to set — easy to read.
➔ Where more light is required, auxiliary light sources are available — see Strobolux (page 3) and Strobolume (page 4).

SPECIFICATIONS

Range: TYPE 631-B, 600 to 14,400 rpm on dial; can be used to measure speeds up to 100,000 rpm. TYPE 631-BL, 600 to 14,400 rpm and 60 to 1440 rpm.
Accuracy: ±1% of dial reading above 900 rpm on standard range for both models.
Flash Duration: 5 to 10 millionths of a second.
Power Supply: 105 to 125 volts, 60 cycles. Prices quoted on request for other voltages and frequencies.
Power Input: 35 watts, maximum.
Vacuum Tubes: One TYPE 631-P1 Strobotron, one 6X5-GT/G and one 6N7-GT/G are required. A complete set of tubes is furnished with the instrument.
Accessories Supplied: Seven-foot power cord, plug to fit contactor jack, and spare fuses.
Mounting: Metal cabinet with carrying handle.
Dimensions: 7½ x 8¾ x 9⅞ inches, over-all.
Net Weight: 9½ pounds.

Type		*Code Word*	*Price*
631-B	Strobotac (600 to 14,400 rpm)	BRAVO	$140.00
631-BL	Strobotac (60 to 14,400 rpm)	BRUIN	170.00
631-P1	Replacement Strobotron	SENNA	7.50

PATENT NOTICE. See Note 6, page vi.

TYPE 648-A STROBOLUX®
(AUXILIARY LIGHT SOURCE)

USES: The Strobolux is an auxiliary white-light source for use with the Strobotac in applications where the areas to be illuminated are larger than the Strobotac can cover, or where greater light intensity is required. Although its flash is not as short as that of the Microflash (page 6), it can be used as a light source for single-flash photography.

DESCRIPTION: Type 648-A Strobolux consists of a power supply and lamp, capable of producing brilliant light flashes at speeds up to 6000 per minute. The flashing source is a Type 631-B Strobotac and consequently can be controlled by (1) the self-contained pulse generator in the Strobotac, (2) the a-c line, (3) an external contactor (Type 1535), or (4) an external oscillator, preferably one which can supply square wave pulses.

The lamp, filled with a rare gas, furnishes a white light about one hundred times as powerful as that of the Strobotac.

FEATURES: The combination of the Type 631-B Strobotac and Type 648-A Strobolux has all the advantages of the Strobotac itself plus the feature of high illumination. No appreciable duplication of facilities is involved, so that the purchase of the Type 648-A Strobolux is an economical solution to problems requiring greater illumination than is provided by the Strobotac.

SPECIFICATIONS

Range: Up to 100 flashes per second (6000 per minute). Single flashes for photography can also be obtained.

Duration of Flash: Between 15 and 50 microseconds, depending upon flashing speed and upon the setting of the SPEEDS range switch. The shorter flash is obtained at the higher speeds.

Accuracy: The accuracy is that of the source controlling the flashing speed. (See specifications for Type 631-B Strobotac, page 2.)

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles.

Power Input: 125 watts, maximum.

Vacuum Tubes: One 5Z3 Rectifier and one Type 648-P1 Lamp, both of which are furnished with the instrument.

Mounting: Sheet metal case with black wrinkle finish. Lamp and its 9-inch reflector are mounted in one side of case, the power supply in the other. The removable lamp assembly is provided with a ¼ x 20 tapped hole for tripod mounting.

Accessories Required: A Strobotac is necessary to operate the Strobolux.

Accessories Supplied: Seven-foot power cord, cable for connection to Strobotac, extension cable for lamp, spare fuses.

Dimensions: 13⅝ x 11⅝ x 13½ inches, over-all.

Net Weight: 31¾ pounds.

Type		*Code Word*	*Price*
648-A	**Strobolux**	SCALY	**$225.00**
648-P1	**Replacement Lamp**	SURLY	**17.50**

PATENT NOTICE. See Note 6, page vi.

(*Left*) Adjusting electric shaver cutters with the Strobotac — photo courtesy Remington Rand. (*Right*) Type 631-B Strobotac with Type 648-A Strobolux.

TYPE 1532-B STROBOLUME
(HIGH-INTENSITY LIGHT SOURCE)

USES: The Strobolume produces a brilliant, white, light flash that is well suited for studying motions of machines operating at relatively low speeds. Two important applications are the analysis and adjustment of shuttle motion in textile looms and of color register in printing.

The Strobolume is designed to be flashed from an external contactor such as the TYPE 1535-A (page 5), and hence is particularly useful where the motion to be examined is related to angular position of a shaft, such as a crankshaft, camshaft, or countershaft, on one end of which a contactor is held or clamped. It can also be flashed from a Strobotac. It is adaptable as a light source for single- and multiple-flash photography in research projects, where the motion of the subject is often too fast to be stopped by conventional "speedlights."

DESCRIPTION: The elements of the Strobolume are a high-voltage transformer and rectifier; a capacitor, which is charged to about 2500 volts from the rectifier; and a lamp through which the capacitor is discharged to produce the flash. The discharge is initiated by a special Strobotron tripped by an external impulse. Either of two values of capacitance can be used, as selected by a switch. The larger is for flashing rates up to 1200 per minute with intense light for short periods, the smaller for rates up to 3000 with about 1/20th as much light. The Strobolume operates from a 115-volt a-c line, 50 to 60 cycles. The entire assembly is mounted in a small metal case with handle.

FEATURES: → Brilliant, high-intensity, white flash.

→ Short flash — about 40 microseconds at high-intensity position; 20 microseconds at low intensity position.

→ Flashing rates up to 3000 per minute.

→ Overload breaker opens on high-intensity range, when maximum safe operating time is reached for any speed.

→ Compact, light, portable assembly.

→ Lamp and its housing are removable from power supply and are provided with a 10-foot extension cable.

→ Lamp housing is provided with tripod socket.

→ Sealed-beam lamp is easily removed for replacement.

SPECIFICATIONS

Flashing Speed Range: High intensity — continuous. 60 flashes per minute, maximum; intermittent, or for short periods, up to 3000 per minute. Low intensity — continuous up to approximately 1200 per minute.

Duration of Flash: Approximately 40 microseconds with intensity switch at HIGH; approximately 20 microseconds with switch at LOW.

Flashing Control: TYPE 1535-A Contactor or TYPE 631 Strobotac with TYPE 1532-P2 Transformer Cable.

Tubes:
- 1 Rectifier — TYPE 816
- 1 Strobotron — TYPE 0A5
- 1 Flash Lamp — TYPE 1532-P1 (GE Type FT-220)

Accessories Supplied: Power cord with ground terminal, flash control cord with push button, and a plug to which a contactor can be connected.

Other Accessories Required: None, if lamp is to be flashed manually by push button. For stroboscopic work, a TYPE 1535-A Contactor, or a TYPE 631 Strobotac with TYPE 1532-P2 Transformer Cable is needed.

Mounting: Metal case with rounded top; lamp is removable; storage space for lamp cable is provided in case. Tripod mounting thread (1/4-20) is provided in lamp housing.

Power Supply: 105 to 125 volts, 50 to 60 cycles.

Power Input: At HIGH intensity, 105 watts at 60 flashes per minute; 500 watts at 1200 flashes per minute. At LOW intensity, 120 watts at 3000 flashes per minute.

Dimensions: 13 x 7½ x 11 inches, over-all.

Net Weight: 18½ pounds. Lamp only, 2 pounds.

Type		*Code Word*	*Price*
1532-B	**Strobolume**	TITLE	**$265.00**
1532-P1	**Replacement Lamp**	TOWEL	**30.00**
1532-P2	**Transformer-Cable**	TULIP	**12.00**

PATENT NOTICE. See Note 6, page vi.

TYPE 1535-A CONTACTOR

USES: The TYPE 1535-A Contactor is used to flash a stroboscope in synchronism with a rotating shaft, so that the motion of some other machine part can be observed stroboscopically as a function of shaft angular position. It is particularly useful in the examination of relatively low-speed machinery with the TYPE 1532-B Strobolume in such applications as the timing of loom shuttles and the adjustment of register in printing. It can be used equally well with the Strobotac or with the combination of Strobotac and Strobolux at speeds below 5000 rpm.

DESCRIPTION: The basic elements of the Contactor are a rotating electrical contact which engages successively 6 fixed contacts spaced at equal angles around its periphery. Hence, combinations of 1, 2, 3, or 6 equally spaced contacts per revolution can be used. Adjustment of the angular position of the contacts can be made over 360° and relative position is indicated on a scale calibrated in 5° intervals.

The rotor attaches to the shaft of a machine by a magnetic clutch at the end of an 18-inch flexible shaft. Two angular position controls are available, one at the end of an 8-foot flexible cable, the other a knob mounted on the contactor body. The assembly is mounted on a large diameter 4-foot rod, which is secured in a heavy cast iron base. The contactor may be located at any point on this rod and is locked in position by a thumbscrew.

FEATURES: ➔ Magnetic clutch uses a powerful multipole Alnico magnet, gives positive clutch action on iron and steel without the necessity of drilling and tapping the shaft.

Closeup of alternative coupling devices. Exploded assembly is for permanent coupling to shafts. Steel disc in foreground is for attaching clutch to nonmagnetic or small shafts.

➔ Can be easily attached and removed from machine while in motion.

➔ Remote control shaft is removable.

➔ Clutch has spring-loaded centering device.

➔ Ball bearings are used on rotating parts.

➔ Flexible drive shaft can be bent through 90° angle for work in crowded locations.

➔ Auxiliary coupling device is furnished for use in applications where permanent coupling to shaft is preferable, or where shaft is nonmagnetic.

➔ Contactor can be removed from stand and mounted permanently on machine.

SPECIFICATIONS

Speed Range: 0 to 5000 rpm.

Contacts per Revolution: 6, equally spaced. Combinations of 1, 2, 3, or 6, equally spaced, can be used. As shipped, contactor is connected for single contact per revolution.

Range of Phase Adjustment: 360°.

Range of Height Adjustment: 6 inches to 4 feet.

Diameter of Base: 18 inches.

Accessories Supplied: Auxiliary coupling devices for connection to shaft in which hole has been drilled.

Other Accessories Required: When the Contactor is used with a Strobotac, a TYPE 1535-P1 Adaptor Cable is needed for connection to the Strobotac.

Net Weight: 17 pounds.

Type		*Code Word*	*Price*
1535-A	Contactor	CROOK	$140.00
1535-P1	Adaptor Cable	CROOKCABLE	5.50

PATENT NOTICE. See Note 6, page vi.

TYPE 1530-A MICROFLASH®

USES: The Microflash is a light source for single-flash, ultra-high-speed photography. It provides a high-intensity light flash whose duration is approximately 2 millionths of a second, capable of arresting extremely rapid motion and recording it with conventional camera equipment.

Photographs of objects moving at extremely high speeds are possible with the Microflash, and it finds many applications in engineering and the physical sciences, particularly in such fields as ballistics, hydraulics, kinematics, and industrial chemistry.

Among these are studies of wear or abrasion, of turbulence in liquids, of fractures in solids, of mechanical distortion at high rotational speeds, and of the atomization of liquid fuels.

DESCRIPTION: The elements of the Microflash are a power supply, a gas-filled lamp, and a trigger circuit. A high-voltage transformer and rectifier, operating from the a-c power line, charge a capacitor across the lamp terminals. An electrical impulse, which may be derived in any one of several ways from the phenomenon to be photographed, ionizes the gas in the lamp, and the energy stored in the capacitor is dissipated in a discharge through the lamp, producing a short brilliant flash. A minimum of 10 seconds is required between flashes for the capacitor to become fully charged.

Typical Microflash photograph.

The trigger circuit includes an amplifier, so that the flash can be tripped with a conventional crystal microphone, if desired. The flash can also be triggered by a make or break contact.

FEATURES: The outstanding feature of the Microflash is its high-intensity, very short flash. During the flash, an object moving at 1000 feet per second would be displaced only about two hundredths of an inch. Consequently, sharp records can be obtained of bullets and other projectiles in flight.

SPECIFICATIONS

Duration of Flash: Approximately 2 microseconds.

Guide Number: The so-called guide number (Distance in feet x aperture) for the Microflash is about 25 with moderately fast film, and with the subject several feet from the lamp.

Temperature and Humidity Effects: Temperature and humidity variations (32 to 100° F, 0 to 95% R.H.) have no appreciable effect upon the operation of the instrument.

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles.

Power Input: 70 watts.

Tubes:

1 — 5U4-G 1 — FG-17 (GE)
1 — 2V3-G 1 — 6AC7 (1852)
1 — TYPE 1530-P1 (General Radio)

Accessories Supplied: Microphone with cable, tripod, all tubes, 2 spare flash lamps TYPE 1530-P1, plug for connection to contactor-trip jack, power cable, and spare fuses.

Mounting: The power supply and trigger circuits are assembled in one metal case, the lamp in another. The two cases lock together for transportation, completely protecting the lamp and controls.

Dimensions: 24½ x 13¼ x 11¾ inches, over-all.

Net Weight: 72 pounds.

Type		*Code Word*	*Price*
1530-A	**Microflash**	TAFFY	**$750.00***
1530-P1	**Replacement Flash Lamp**	TONIC	**27.50***

*Includes 25% Federal tax.
PATENT NOTICE. See Note 6, page vi.

TYPE 1534-A POLARISCOPE

USES: The General Radio Polariscope is intended for the study of static and dynamic stresses in transparent, photoelastic models of structural members by means of the fringe patterns that they exhibit under polarized light when stressed. It is best adapted to the study of two-dimensional stresses such as are set up by tension, compression, and bending in members of uniform thickness, viewed normal to the stressed axis. Because the photographic exposure time is extremely short, it can be used for dynamic as well as static observations. It is suitable for the study of both isoclinic and isochromatic patterns.

The Polariscope has many applications in physics and mechanical engineering, among them the study of the effects of fillets and other stress-relieving contours.

DESCRIPTION: The view of Figure 1 shows the elements of the TYPE 1534-A Polariscope. The incandescent lamp unit shown is used for adjustment and focussing and is supplied with the polariscope. For photographing the stress patterns, this lamp is replaced by a Strobolume (see price list page 8), which emits a brilliant flash of approximately daylight quality, lasting not more than 40 microseconds (40 millionths of a second), so that dynamic patterns can be arrested for photographing. The Polariscope with the Strobolume lamp is shown in Figure 2.

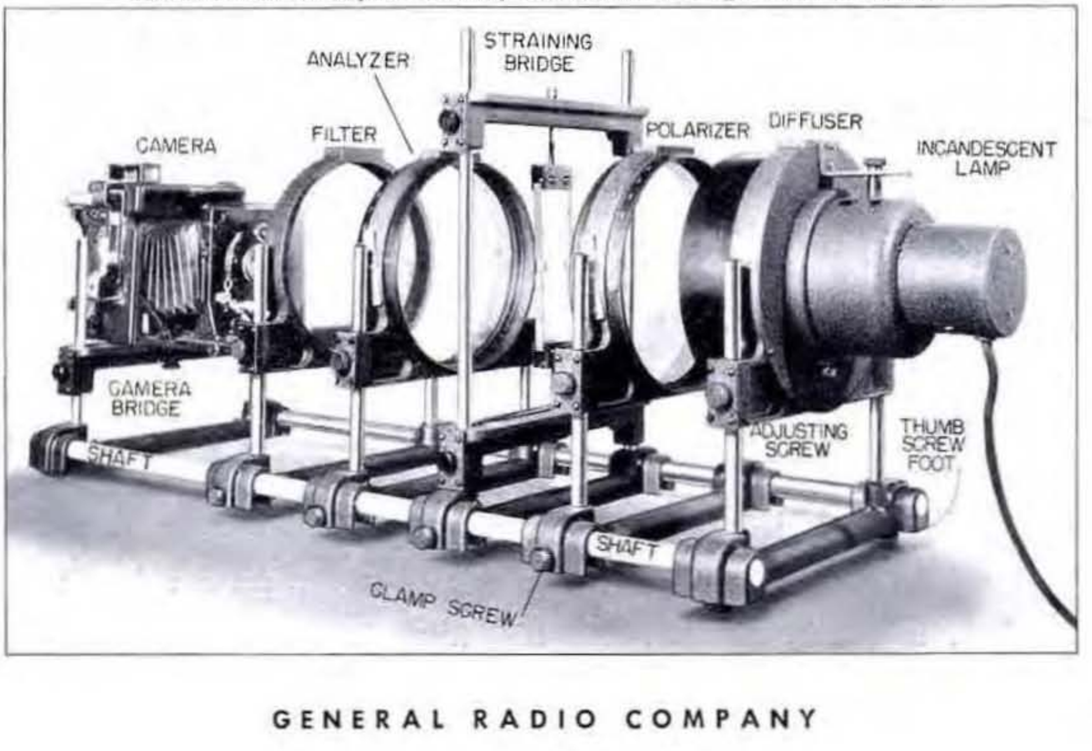
The blue-richness of the Strobolume spectrum permits the use of a filter, peaked in the blue-green at 4800 Angstroms, to give essentially monochromatic light.

The polarizer and analyzer assemblies are identical, each mounting a plane polarizer with a degree scale calibrated from zero to both plus and minus 90° for isoclinic (loci of equi-directional stresses) determination. A quarter-wave retardation plate, removable without tools, rotatable, and registering for right- or left-hand circular polarization, permits isochromatic (loci of equal net intensity stresses) patterns to be observed. Optical field is 8 inches in diameter.

All elements are horizontally adjustable along the 36-inch shafts and vertically adjustable over about 12 inches. Vee and flat ways insure optical alignment. Thumbscrews hold desired settings. Bases of all components are provided with mounting holes for use when the shafts are not required.

The Straining Bridge furnished with the instrument will serve for simple set-ups, but is not intended to be an accurately calibrated straining frame. Such equipment can be devised by the user to fit his particular requirements. Similarly, for dynamic stress analysis, both the straining means and the flash-tripping circuits should be tailored for the job by the user.

FIGURE 1. View of complete Polariscope with incandescent light source and camera.



POLARISCOPE

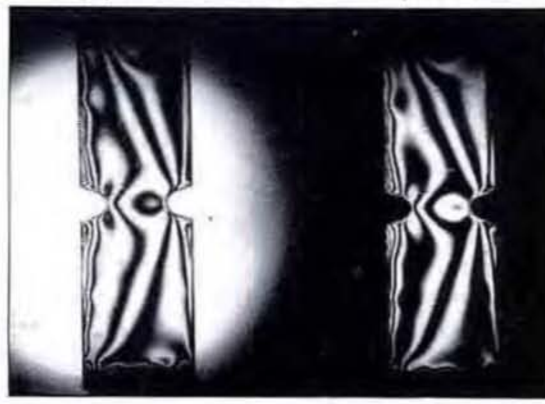
FEATURES: ➔ Light weight and low cost, resulting from the use of a high-speed flash and its consequent elimination of long photographic exposure requirements.
➔ High photoelastic sensitivity, resulting from use of light of very short wavelength.
➔ Photographic records can be made without darkening the room.
➔ Can be used in drafting room as easily as in laboratory.
➔ Convenient and simple to use.
➔ Large, 8-inch optical field.
➔ Uses conventional camera equipment; $f/4.5$ aperture with slow film is adequate.
➔ Dynamic stresses can be studied.
➔ Brings photoelastic measurements within reach of the laboratory with a modest budget and limited space.

SPECIFICATIONS

Components Supplied:
1 Type 1534-P1 Polarizer
1 Type 1534-P1 Analyzer
1 Type 1534-P2 Diffuser
1 Type 1534-P3 Strain Bridge
1 Type 1534-P4 Camera Bridge
1 Type 1534-P5 Filter
1 Type 1534-P6 Incandescent Light Source
2 Type 1534-P7 Shafts (36 inches long)

Optical Field: 8-inch diameter.
Vertical Adjustment: 12 inches.
Accessories Required: Type 1532-B Strobolume, camera with ground glass and lens of f 4.5 or faster. Camera Bridge has captive ¼-20 thumbscrew to fit tripod socket on camera.
Other Accessories Recommended: Wratten No. 75 front-of-lens filter. This permits camera shutter to be opened for short periods in artificial light without danger of fogging.
Film: Process film is recommended for optimum results.
Model Material: Water-white Catalin is recommended. Models contour-cut from sheets cast between plate-glass surfaces require no further finishing.
Dimensions: 36 x 14½ x 18 inches, over-all.
Net Weight: 32 pounds.

Light- and dark-field photographs of specimen, illustrating fringe patterns shown under circular polarization.



Type		*Code Word*	*Price*
1534-A	**Polariscope**	FOCUS	**$490.00**

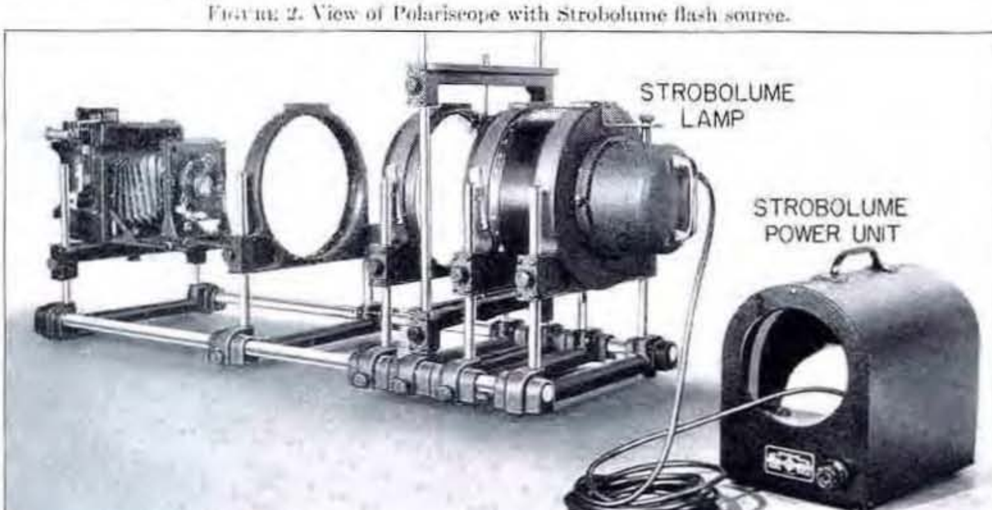
STROBOLUME

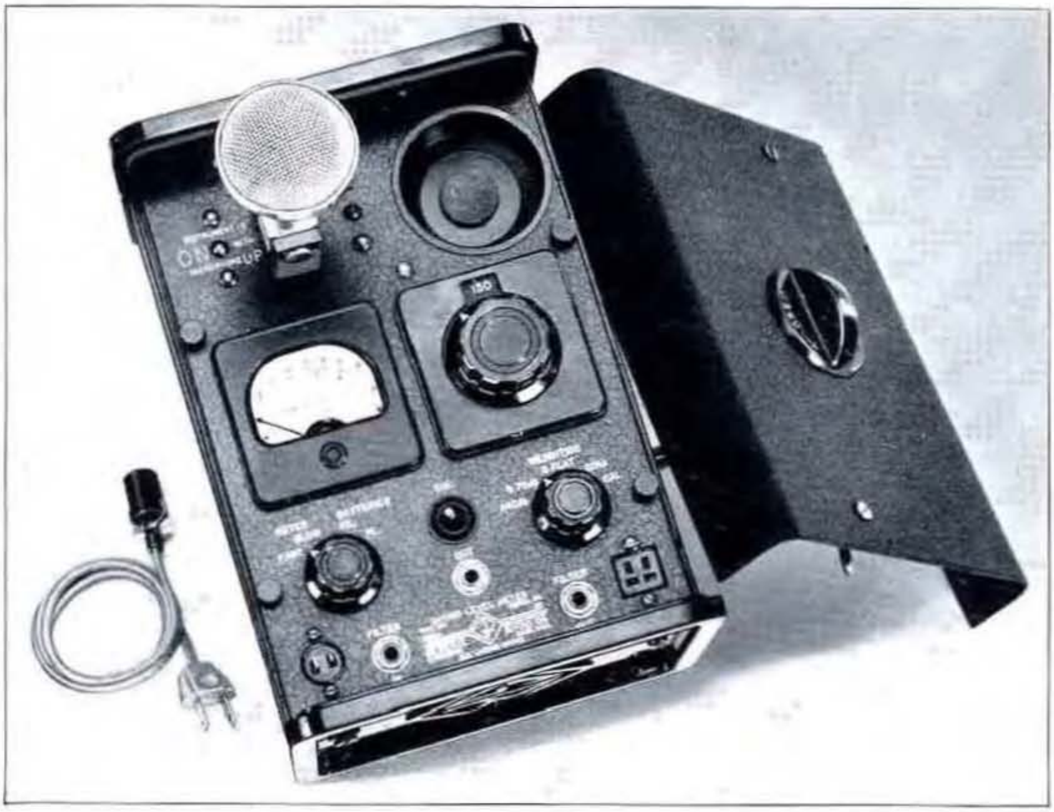
The Type 1532-B Strobolume is described on page 4.

Type		*Code Word*	*Price*
1532-B	**Strobolume**	TITLE	**$265.00**

PATENT NOTICE. See Note 6, page vi.

Figure 2. View of Polariscope with Strobolume flash source.





TYPE 1551-A SOUND-LEVEL METER

USES: The Type 1551-A Sound-Level Meter is a new instrument, of advanced design, for the general measurement of sound fields. It is ideally suited to the sound-measuring problems of commerce and industry. Manufacturers of machines and appliances use it for measuring product noise both in the development laboratory and in production. For such plants, it provides a means of establishing noise standards, of accepting or rejecting products on the basis of noise tests, and of analyzing and correcting trouble in the rejected units.

Acoustical engineers also use the sound-level meter for determining noise levels from engines, machinery, and other equipment, and for investigating the acoustical properties of buildings, structures, and materials.

Industrial hygienists and psychologists use it in surveys of the psychological and physiological effects of noise and for the establishment of acceptable noise levels and the determination of satisfactory noise environments in factories and offices.

The high-quality amplifier and attenuator used in this instrument have a wide frequency response, low internal noise level, low distortion, and wide dynamic range. Consequently the meter can be readily used with accessory equipment, such as frequency analyzers, graphic-level recorders, and magnetic-tape recorders.

It is also suitable for use as a portable amplifier for laboratory standard microphones, and, with accessory high-fidelity microphone, for measurements on high-fidelity sound systems.

Although the low-cost microphone supplied with the Type 1551-A Sound-Level Meter is satisfactory for the majority of applications, special microphones can be used to full advantage. Among these are the Altec M-11 for high-fidelity work, the Western Electric 640-AA where a reproducible standard is desired, and the Type 759-P25 Dynamic for use at the end of a long cable.

DESCRIPTION: The Type 1551-A Sound-Level Meter is an accurate, portable, low-priced meter for reading, in terms of a standard reference level, the sound level at its microphone.

It consists of a non-directional microphone, an amplifier, a calibrated attenuator, and an indicating meter. The amplifier uses sub-miniature tubes in a negative feedback circuit and has a frequency response range of 20 cycles to 20 kilocycles.

The complete instrument, including batteries, is mounted in an aluminum case with an easily removed cover which protects the microphone and panel meter when the instrument is carried about. The microphone is mounted on a bracket and folds down into a panel recess when not in use. In this storage position of the microphone, batteries are automatically turned off. An a-c power supply unit is available.

FEATURES: ➔ Small, compact, and easily portable — weighs only 11 pounds with batteries.

➔ Simple to operate, even for non-technical personnel.

➔ Meets all standards of the American Standards Association, the American Institute of Electrical Engineers, and the Acoustical Society of America.

➔ Separate output systems for panel meter and output terminals. When a sound analyzer is used, panel meter can be used for monitoring.

➔ Two-speed meter movement permits measurement of either steady or rapidly fluctuating sounds.

➔ Wide range — from 24 to 140 db.

➔ Sub-miniature tubes in negative feedback amplifier circuits provide excellent stability.

➔ Batteries are readily available.

➔ Amplifiers and panel meter have wide frequency response, 20 cycles to 20 kilocycles.

➔ Low distortion.

➔ Low internal noise level.

➔ Wide dynamic range.

➔ Internal calibration system for standardizing amplifier gain.

SPECIFICATIONS

Sound-Level Range: From 24 db to 140 db above the standard sound pressure reference level of 0.0002 microbar (a pressure of 0.0002 dyne per square centimeter) at 1000 cycles.

Frequency Characteristics: Any one of 4 response characteristics can be selected by means of a panel switch. The first and second of these are, respectively, the 40 and 70 db equal-loudness contours in accordance with the current standard specified by the American Standards Association. The third frequency response characteristic gives a substantially equal response to all frequencies within the range of the instrument and its microphone. This characteristic is used when measuring extremely high sound levels, when measuring sound pressures, or when using the instrument with the TYPE 760-B Sound Analyzer, the TYPE 736-A Wave Analyzer, or the TYPE 1550-A Octave-Band Noise Analyzer. The fourth frequency response characteristic provides an amplifier which has essentially flat response from 20 cycles to 20 kilocycles, so that full use can be made of extremely wide range microphones such as the W.E. 640-AA or the Altec 21-B Condenser Microphones.

Microphone: The microphone is of the Rochelle-salt, crystal-diaphragm type with an essentially non-directional response characteristic.

Sound-Level Indication: The sound level is indicated by the sum of the readings of the meter and an attenuator. The meter has a range of 16 db, and the attenuator has a range of 100 db in 10 db steps.

Output Terminals: A jack is provided, which supplies an output of 1 volt across 20,000 ohms when the panel meter reads full scale. This output is suitable for use with the TYPE 760-B Sound Analyzer, the TYPE 736-A Wave Analyzer, the TYPE 1550-A Octave-Band Noise Analyzer, a graphic level recorder, or a magnetic tape recorder.

A SLOW-FAST switch makes available two meter speeds. With the control switch in the FAST position the ballistic characteristics of the meter simulate those of the human ear and agree with the current standards of the American Standards Association. In the SLOW position, the meter is heavily damped for observing the average level of rapidly fluctuating sounds.

Calibration: A means is provided for standardizing the sensitivity of the instrument in terms of any a-c power line of approximately 115 volts.

The absolute level of all microphones is checked at several frequencies against a standard microphone, whose calibration is periodically checked by the National Bureau of Standards.

TYPE 1552-A Sound-Level Calibrator (page 12) is available for making periodic checks on the over-all calibration, including microphone.

Accuracy: The frequency response curves A, B, and C of the TYPE 1551-A Sound-Level Meter fall within the tolerances specified by the current ASA standards. When the amplifier sensitivity is standardized, the absolute accuracy of sound-level measurements is within ±1 decibel for average machinery noises in accordance with the ASA standards.

Temperature and Humidity Effects: Readings are independent (within 1 db) of temperature and humidity over the ranges of room conditions normally encountered.

Batteries: Two 1½-volt size D flashlight cells, (Eveready 950 or equivalent); one Eveready 467 B or equivalent battery. Batteries are supplied. An a-c power unit is available if a-c operation is desired.

Tubes: Four CK-512-AX and three CK-533-AX are required. A complete set is supplied with the instrument.

Accessories Supplied: Power Cord (for calibration check), telephone plug.

Other Accessories Available: See pages 12 and 13.

Case: Shielded carrying case of aluminum construction.

Dimensions: The over-all dimensions are approximately (height) 6⅝ x (length) 10¹³⁄₁₆ x (width) 8⅞ inches.

Net Weight: 11 pounds, with batteries.

Type		*Code Word*	*Price*
1551-A	**Sound-Level Meter**	MIMIC	**$360.00**

PATENT NOTICE. See Note 1, page vi.

TYPE 1555-A SOUND-SURVEY METER

USES: This pocket-size, inexpensive, sound-survey meter, of good accuracy, is designed for the many applications where the nature of the measurements does not require the accuracy of the TYPE 1551-A Sound-Level Meter. The TYPE 1555-A Sound-Survey Meter is well suited to a wide variety of general survey measurements, many of which are economically practical only with a low-cost meter.

This handy, versatile device can be used for checking the level of reproduced sound from theatre systems, public-address systems, and other sound systems; and, on high-fidelity sound systems, for determining the response characteristics through the cross-over point and for measuring the dynamic range. It is also useful for checking levels at rehearsals and in speech and singing classes; for determining an acoustic reference level when recording; for preliminary field surveys by sales engineers for acoustical materials; for acoustic experiments in physics classes; for measuring the sine-wave response characteristics of loudspeakers and rooms; for preliminary surveys to determine noise levels in homes, offices, factories, and other buildings, in streets and subways, and in vehicles; for determining levels from appliances, machinery, and office equipment; and for preliminary checks of noise levels for estimating the possible long-time effect on hearing of operating personnel.

When industrial and commercial product-acceptance tests for noise are required or when analysis of the noise is desired, or both, the TYPE 1551-A Sound-Level Meter and its accessory instruments are recommended.

DESCRIPTION: The TYPE 1555-A Sound-Survey Meter is a small, inexpensive meter for indicating the level of noise and other sounds in terms of a standard reference level. It consists of a non-directional microphone, a cali-

brated attenuator, an amplifier, and an indicating meter. The amplifier uses sub-miniature tubes in a negative feedback circuit.

The entire assembly, including microphone and batteries, is mounted in a simple, two-piece, aluminum case, and measures 6 x $3\frac{1}{8}$ x $2\frac{1}{2}$ inches, over-all. The controls for the attenuator and the weighting network selector are finger-tip-control discs.

FEATURES:

- ➔ Small enough to fit in trousers pocket.
- ➔ Weighs only 1 pound, 14 ounces with batteries.
- ➔ Indicating meter is conveniently located and easily read.
- ➔ Only two controls, both on face of instrument.
- ➔ Can be used when set on a bench or table, when mounted on tripod or when held in hand.
- ➔ Miniature in size, yet it uses standard and well-tested components.
- ➔ Meter can be read for either horizontal or vertical orientation of microphone.

SPECIFICATIONS

Range: From 40 db to 136 db above the standard sound-pressure reference level of 0.0002 μbar.

Frequency Characteristic: Three different frequency characteristics can be selected by the main control switch. In the *C* and *C* +30 db weighting positions substantially equal response to all frequencies between 40 and 8000 cps is obtained. This characteristic is ordinarily used for all levels above 85 db.

The *B* weighting position is used for levels between 55 and 85 db. Its response follows the 70 db contour established as the standard of weighting for sound-level meters. The *A* weighting position is usually used for levels between 40 and 55 db. Its response follows approximately the 40-db contour established for sound-level meter weighting. In addition to providing means for making the usual weighted level measurement, these characteristics permit one to estimate, by comparative measurements with different weighting characteristics, the relative importance of low-frequency components in the sound being measured.

Microphone: The crystal diaphragm-type microphone cartridge is mounted at the top of the instrument. Proximity of microphone to tube grid reduces the temperature coefficient to the order of 0.02 db per degree F.

Meter and Attenuator: For levels below 100 db the noise level is given by the sum of the readings of the meter and attenuator. For most sounds it is convenient to adjust the attenuator so that the level fluctuates equally about the zero-db meter reading, and then the level is given directly by the reading of the attenuator. In some other cases, particularly at low levels, it is more convenient to set the attenuator at one of the marked multiples of 10 and add the observed meter reading. For levels above 100 db the main control switch is set to "C +30 db." Then the noise level is given by the sum of the readings of the attenuator and the meter plus 30 db.

The ballistic characteristics of the rectifier-type meter simulate those of the human ear and agree with those for standard sound-level meters.

Stability: The amplifier and level indicator are stabilized by feedback. The change in gain with battery voltages is thereby reduced to moderate values.

The behavior of the instrument is not noticeably affected by temperature and humidity over the ranges of room conditions normally encountered. The maximum safe operating temperature is 115° F. Temperatures above 130° F will permanently damage the Rochelle salt crystal in the microphone cartridge.

Accuracy: The gain of the amplifier is set initially so that the sensitivity of the instrument is correct at 1000 cps within ±1 db. The *B* and *C* frequency characteristics are essentially within the tolerances allowed by the American Standards Association specification on Sound-Level Meters. The *A* frequency characteristic is similar to that required by the ASA specification, but it provides only the low-frequency roll-off below 1000 cps.

When the *B* and *C* weighting are used, the reading of this meter, for almost all types of sounds, agrees with that of a meter meeting the ASA specification on sound-level meters to within the tolerances allowed by the standard but increased by 1 db.

Batteries: One 1½-volt size C flashlight battery (Eveready 935 or equivalent) and one 30-volt hearing-aid battery (Eveready 413E or equivalent) are supplied.

Tubes: Two CK-512-AX and two CK-533-AX tubes are supplied.

Case: Aluminum, with standard ¼-20 threaded mount for tripod.

Dimensions: 6 x 3⅛ x 2½ inches, over-all.

Net Weight: 1 pound, 14 ounces, with batteries.

Type		*Code Word*	*Price*
1555-A	**Sound-Survey Meter**	MISER	**$125.00**

PATENT NOTICE. See Note 1, page vi.

STANDARD ACCESSORIES FOR THE TYPE 1551-A SOUND-LEVEL METER

The following accessories are available for use with the TYPE 1551-A Sound-Level Meter to increase its field of application and to adapt for specialized types of measurement. These accessories can also be used with the older 759-B Sound-Level Meter.

VIBRATION PICKUP AND CONTROL BOX

The TYPE 759-P35 Pickup and TYPE 759-P36 Control Box have been designed for use with General Radio Sound-Level Meters.

The TYPE 759-P35 Vibration Pickup is an inertia-operated crystal device which generates a voltage proportional to the acceleration of the vibrating body. By means of integrating networks in the control box, voltages proportional to velocity and displacement can also be delivered to the sound-level meter. The desired response is selected by means of a three-point switch on the control box.

The low-frequency response of the sound-level meter is sufficiently good to permit vibration measurements at frequencies down to 20 cycles. Such measurements include the fundamental and harmonic frequency vibrations, of machines rotating at 1200 rpm or higher, as well as many structural resonances.

The vibration pickup and control box plug into the sound-level meter in place of the microphone, as shown in the photograph above.

SPECIFICATIONS

Calibration: The db readings of the sound-level meter can be converted into absolute values of displacement, velocity, or acceleration by means of calibration data.

Range: The range of measurement of the pickup and control box when used with the TYPE 1551-A or the TYPE 759-B Sound-Level Meter is approximately as follows:

R-m-s Amplitude — 30 micro-inches (minimum).

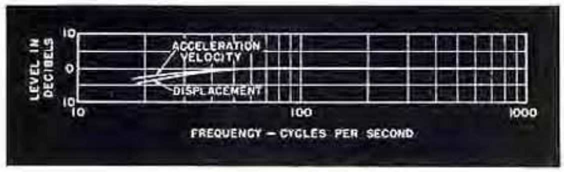
R-m-s Velocity — 1000 micro-inches per second (minimum). The upper limit of velocity and displacement measurements is dependent on the frequency and is determined by the maximum acceleration permissible before non-linearity occurs (10 g).

R-m-s Acceleration — 0.3 to 3900 in./sec/sec (10 g).

Frequency Characteristic: See plot. For frequencies below 20 cycles the TYPE 761-A Vibration Meter should be used.

Mounting: Both control box and pickup are housed in metal containers, finished in black lacquer.
Net Weight: Type 759-P35 Vibration Pickup, 8 ounces (pickup only); pickup plus cable and tips, 1 pound; Type 759-P36 Control Box, 1 pound, 6 ounces.

Type		*Code Word*	*Price*
759-P35	**Vibration Pickup**	NOSEY	**$40.00**
759-P36	**Control Box**	NANNY	**50.00**



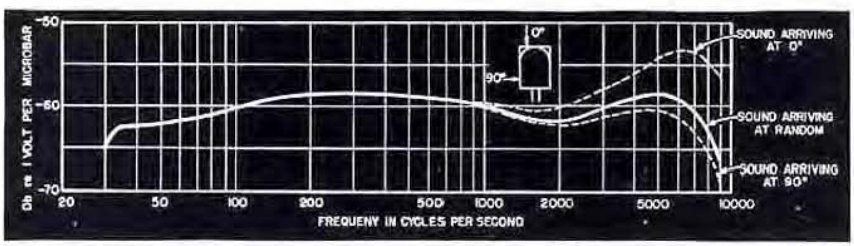
Over-all frequency response characteristic of the vibration pickup, control box, and sound-level meter.

DYNAMIC MICROPHONE ASSEMBLY

For some measurements, particularly where a long cable must be used between microphone and meter, or where large ranges of temperature and humidity are encountered, a dynamic microphone is preferable. The Type 759-P25 Dynamic Microphone Assembly includes, in addition to the microphone, a 25-foot cable, an input transformer, and a tripod. The transformer plugs into the Sound-Level Meter in place of the standard microphone, and the microphone cable plugs into the transformer.

SPECIFICATIONS

Frequency Response: When the sound-level meter and dynamic microphone are adjusted to the correct level, the combination will meet the ASA specifications above 50 cycles. The procedure for making this adjustment is described in the instruction book. A typical response curve is shown below.
Sensitivity: Open-circuit output of typical microphone is 90 db below one volt per microbar, and of microphone plus transformer is 60 db below one volt per microbar. This sensitivity is satisfactory for use with both the Type 1551-A and the Type 759-B Sound-Level Meters.
Calibration: Output level is checked in our laboratories at several frequencies against a standard microphone that is calibrated periodically by the National Bureau of Standards. The level at 400 cycles is supplied.
Maximum Safe Sound Pressure Level: Sound pressure levels above 140 db can damage the microphone.
Cable Correction: No correction is necessary for the 25-foot cable supplied or the Type 759-P22 100-foot cable.
Net Weight: 4⅝ pounds.



Typical response curves of Type 1551-A Sound-Level Meter with Type 759-P25 Dynamic Microphone and Accessories.

Type		*Code Word*	*Price*
759-P25	**Dynamic Microphone Assembly**	NABOR	**$150.00**
759-P22	**Extra 100-foot cable**	NASAL	**30.00**

TRIPOD AND EXTENSION CABLE

For measurements where the microphone must be located at a distance from the meter, the Type 759-P25 Dynamic Microphone is recommended (see below). However, a 25-foot extension cable and a tripod for mounting the Rochelle salt crystal microphone can be supplied. With this cable a correction curve is furnished, giving the cable correction as a function of temperature.

Type		*Code Word*	*Price*
759-P21	**Tripod and Extension Cable**	KIMBO	**$18.50**

TYPE 1552-A SOUND-LEVEL CALIBRATOR

USES: The Sound-Level Calibrator provides a means of making an over-all acoustic check of the Sound-Level Meter calibration, including the microphone. It can be used to calibrate the TYPE 1551-A, TYPE 759-B, and TYPE 759-A Sound-Level Meters, as well as other types that use the 9898-type, the BR2S-type or the TYPE 759-P25 (633A) microphones.

In conjunction with the internal calibration check on electrical circuits that is provided in the Sound-Level Meter the Sound-Level Calibrator makes it possible to detect and to evaluate any long-period change in over-all sensitivity and to locate it either in the microphone or the electrical circuits. Such a check is invaluable where a series of measurements are to be taken over a long period, or where several meters are to be intercompared.

This calibrator can also be used to make acoustic checks on the TYPE 1555-A Sound-Survey Meter, which has a built-in microphone, and to calibrate the TYPE 1550-A Octave-Band Noise Analyzer when it is used directly with dynamic microphone input.

DESCRIPTION: The calibrator consists of a small, stabilized, and rugged loudspeaker, mounted in an enclosure which fits over the microphone of the Sound-Level Meter. The enclosure is so designed that the speaker is always located at the correct distance from the microphone diaphragm. A standard 400-cycle voltage is required to operate the calibrator (see specifications below).

SPECIFICATIONS

Input: 2.0 volts, 400 cycles; total harmonics must not exceed 5%.

Output: When in position on the 9898-type microphone used on TYPES 1551-A and 759-B Sound-Level Meters, the calibrator produces a sound pressure of 85 ±1 db (above a reference level of 0.0002 microbars, i.e., 0.0002 dynes per square centimeter) at the microphone diaphragm for rated input as specified above.

Terminals: Input terminals are TYPE 938-W Binding Posts.

Accessories Required: 400-cycle oscillator, output control, and voltmeter. TYPE 813-B Audio Oscillator (see below), TYPE 301-A, 500-ohm potentiometer (see page 43), and TYPE 728-A or TYPE 1803-A Vacuum-Tube Voltmeter (see pages 176 and 172) are satisfactory. A Weston, Model 301, 0-3 volt rectifier-type, a-c voltmeter, 2000 ohms per volt, can also be used.

Dimensions: (Length) 4½ x (diameter) 2¼ inches, over-all.

Net Weight: 12 ounces.

Type		*Code Word*	*Price*
1552-A	Sound-Level Calibrator	NATTY	$45.00
813-B	Audio Oscillator, 400 cycles	AMUSE	85.00
301-A	Rheostat, 500 ohms	RIVAL	2.25
1803-A	Vacuum-Tube Voltmeter	ABOOM	155.00

TYPE 1550-A OCTAVE-BAND NOISE ANALYZER

USES: The Octave-Band Noise Analyzer makes possible the simple and rapid analysis of noises having complex spectra. Operating from the output of a sound-level meter (page 9), it is more convenient than the Sound Analyzer for those applications where a knowledge of the individual frequency components is not required; and, in addition, is particularly suited for noise measurements on aircraft, vehicles, and machinery, for the analysis of office noise, where speech interference level is the significant factor and for determination of the possible damaging effects of noise on hearing. Another important application is in determining the acoustical characteristics of rooms. It is particularly valuable in production testing and for noise-level acceptance tests.

DESCRIPTION: The analyzer consists of a set of band-pass filters with selection by means of a rotary switch, followed by an attenuator and an amplifier, which drives both an indicating meter and a monitoring output.

The filter is isolated by a resistance pad, which makes the filter characteristics independent of the source, provided the source impedance either is small compared to the 20,000-ohm analyzer impedance or is constant

over the audio-frequency range.

FEATURES:
→ Small, compact, lightweight.
→ Excellent attenuation characteristics.
→ Monitoring output is provided.
→ Operates from output of the Type 1551-A or the Type 795-B Sound-Level Meter as well as other sound-level meters with outputs adequately free from noise and distortion.
→ Can be used directly with microphone for high sound levels.
→ Amplifier input jack permits amplifier to be used alone.
→ A-C power supply can be substituted for batteries for laboratory use.

SPECIFICATIONS

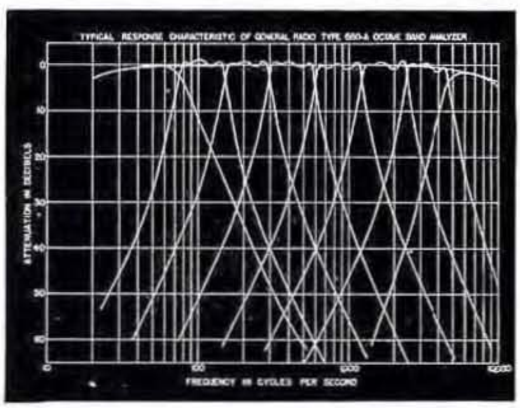
Range: 20 cycles to 10,000 cycles in 8 bands.

20 c to 75 c (low pass)	600 c to 1200 c
75 c to 150 c	1200 c to 2400 c
150 c to 300 c	2400 c to 4800 c
300 c to 600 c	4800 c to 10,000 (high pass)

In addition, a band with a flat characteristic from 20 c to 10 kc is available at two switch positions for convenience in calibration against the sound-level meter.

Input Level: Between 1 and 10 volts for normal range. Levels below one volt reduce the range of reading; those higher than 10 volts overload the filters.

Input Impedance: 20,000 ohms. Input is isolated by a resistance pad, so that performance is independent of source if source impedance is constant over audio range or is small compared to 20,000 ohms.



Source: Sound-level meter supplying analyzer input must have low hum, low internal noise, and low distortion. The Type 1551-A or the Type 759-B Sound-Level Meter is recommended.

Direct Use with Microphone: Type 759-P25 Dynamic Microphone is recommended if the band levels exceed 70 db.

Level Indication: Meter calibrated in decibels from −6 to +10 db; attenuator covers 50 db in 10 db steps. Level is sum of meter and attenuator readings.

Attenuation: Except for the lowest and highest bands, at least 30-db attenuation is obtained at one-half the lower nominal cut-off frequency and twice the upper nominal cut-off frequency; at least 50-db attenuation is obtained at one-fourth the lower nominal cut-off frequency and at four times the upper nominal cut-off frequency. The 75-cycle low-pass filter has at least 30-db attenuation at 200 c and 50 db at 400 cycles. The 4800-cycle high-pass filter has at least 30-db attenuation at 2400 cycles and 50 db at 1200 cycles.

Tubes: Three 1U4 and one 1T4, all furnished.

Power Supply: Battery, Burgess 6TA60. Battery is included in price. For a-c operation, Type 1261-A Power Supply (page 101) fits battery compartment.

Accessories Supplied: Shielded cable and plug assembly for connecting analyzer to sound-level meter.

Dimensions: (Width) 11⅝ x (height) 12$\frac{9}{16}$ x (depth) 9 inches, over-all.

Net Weight: 27 pounds including battery.

Type		*Code Word*	*Price*
1550-A	**Octave-Band Noise Analyzer**	ABEAM	**$535.00**
	Replacement Battery for above	ABEAMADBAT	**5.79**

TYPE 760-B SOUND ANALYZER

USES: This instrument has been designed particularly for analyzing the noises produced by electrical and mechanical equipment, such as airplane and automobile engines, industrial machinery, and household appliances. It operates from the output of the Sound-Level Meter and measures the amplitude of each individual frequency component, or pitch, in the noise. This information is valuable in tracing and locating the sources of noise.

In the electrical laboratory, the Sound Analyzer can be used as a harmonic analyzer and as a selective bridge balance indicator.

DESCRIPTION: The circuit is that of a three-stage degenerative selective amplifier having a bandwidth that is a constant percentage of the operating frequency, followed by a voltmeter. The frequency to which the amplifier is tuned is indicated by a single dial and push-button multiplier. The amplitude of the selected component is indicated directly on the meter scale.

FEATURES: → External magnetic fields do not affect readings.

→ Constant-percentage bandwidth is an advantage for measurements on machines whose speeds fluctuate.

→ Dial can be rotated continuously in either direction, so that the analyzer can be adapted for automatic recording.

SPECIFICATIONS

Frequency Range: From 25 to 7500 cycles per second, direct reading. This total range is covered in five complete turns of the tuning knob, the ranges on the various dial rotations being 25 to 75, 75 to 250, 250 to 750, 750 to 2500, and 2500 to 7500 cycles. A push-button switch allows immediate change of the main control to any one of these ranges.

Frequency Calibration Accuracy: ±1.5% of the frequency to which the dial is set or ±1.5 cycles per second, whichever is the larger.

Input Voltage Range: 1 millivolt to 10 volts for usable indications. The meter scale is calibrated for reading directly component tones down to 1% of the sound pressure (or voltage) of the fundamental or loudest component. Hence the input voltage at the loudest component or fundamental should be 0.1 volt or higher.

Input Impedance: Between 20,000 and 30,000 ohms, depending upon the setting of the sensitivity control. A blocking capacitor is in series with the input.

Frequency Response: Flat within ±2 db over the entire range. At points where two ranges overlap, the sensitivity is the same on either range, within ±1 db.

Band Width: Relative attenuation is 3 db at 1% off the peak to which the analyzer is tuned.

Temperature and Humidity Effects: Under very severe conditions of temperature and humidity slight shifts in calibration, sensitivity, and bandwidth may occur.

Meter: The indicating meter is calibrated in two ranges. For convenience in use the meter scale is calibrated with the 0 located 2 db below full scale on the meter, so that actual meter scales are +2 to −30 db and −12 to −40 db. Auxiliary percentage ranges of 0 to 120% and 0 to 24% are provided.

Output: A jack is provided on the panel for plugging in a pair of head telephones, in order to listen to the actual component of the sound to which the instrument is tuned. This is also useful when the analyzer is used as a bridge-balance indicator.

Tubes: Three 1L4-type and one 1U4-type are used, together with a neon pilot light (NE-48). All are supplied.

Batteries: The batteries required are four Burgess No. 2FBP 1.5-volt batteries, or the equivalent, and three Burgess No. Z30NX 45-volt batteries, or the equivalent. A battery compartment is provided in the case of the analyzer. Batteries are supplied with instrument.

Accessories Supplied: A shielded cable-and-plug assembly for connecting the analyzer to the sound-level meter.

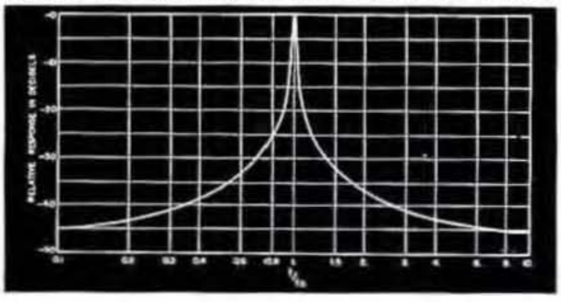
Case: Shielded carrying case of airplane-luggage construction.

Dimensions: (Length) 18 x (width) 10 x (height) $11\frac{1}{2}$ inches, over-all.

Net Weight: $36\frac{1}{2}$ pounds, with batteries; $29\frac{3}{4}$ pounds, without batteries.

A heterodyne type of analyzer, TYPE 736-A, with constant bandwidth in cycles, is described on page 162.

Typical normalized response curve for the TYPE 760-B.



Type		Code Word	Price
760-B	Sound Analyzer	ATTAR	$495.00
Set of Replacement Batteries for above		ATTARADBAT	12.02

PATENT NOTICE. See Note 20, page vi.

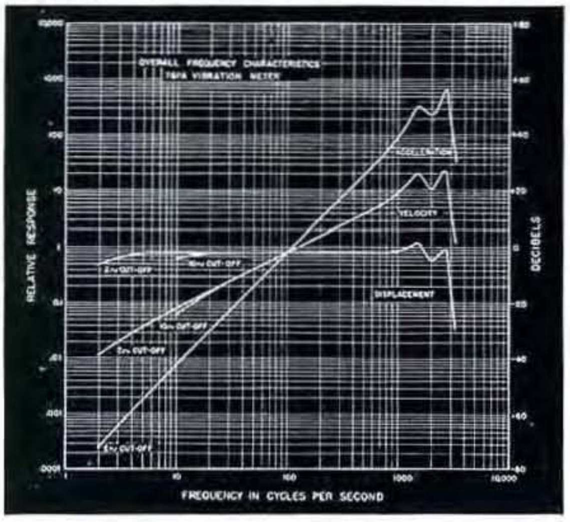
TYPE 761-A VIBRATION METER

USES: Vibrations in machines and structures can be measured quickly and easily with this instrument. For the manufacturer of machinery and equipment, the TYPE 761-A Vibration Meter is extremely useful in research, design, and production testing. Maintenance engineers will find it useful for checking the operating condition of bearings, gear trains, and other mechanisms. Excessive vibrations due to improper adjustment or to structural resonances can be located and measured.

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

A frequency analysis of the measured vibration can be made with the TYPE 762-B Vibration Analyzer (page 18).

DESCRIPTION: The TYPE 761-A Vibration Meter consists essentially of a vibration pickup, adjustable attenuator, an amplifier, and a direct-reading indicating meter. The pickup is of the inertia-operated crystal type, which delivers a voltage proportional to the acceleration of the vibratory motion. An integrating network converts this output, when desired, to a voltage proportional to velocity or displacement. The type of response is selected by push-button switches.



The basic units in which the instrument is calibrated are inches and seconds, and calibrations are in root-mean-square values.

FEATURES:
- ➔ Portable and self-contained.
- ➔ Simple to operate.
- ➔ Direct reading.
- ➔ Reads three response characteristics, acceleration, velocity, and displacement.
- ➔ Low-frequency response down to 2 cycles per second (120 per minute).
- ➔ Independent output system for panel meter and output terminals.

SPECIFICATIONS

RANGES: The vibration meter is direct-reading in the units shown in the range table below.

Vibration Quantity	*Range*
Displacement	16 micro-inches to 30 inches, rms.
Velocity	160 micro-inches per second to 300 inches per second, rms.
Acceleration	0.160 inch per second per second to 3900 inches per second per second, rms.

RESPONSE CHARACTERISTICS: The response follows theoretical curves of the quantity measured, vs. frequency within the following tolerances.

Quantity	*Range*	*Tolerance*	*Frequency Range*	
Acceleration	0.160 in./sec/sec to 3900 in./sec/sec	±10%	4 to 500 cps	Down 25% at 2 cps
Velocity	1600 μin./sec to 300 in./sec	±10%	5 to 500 cps	Down 40% at 2 cps
Velocity	Below 1600 μin./sec	±15%	20 to 500 cps	Down 25% at 10 cps
Displacement	160 μin. to 30 in.	±10%	10 to 500 cps	Down 50% at 2 cps
Displacement	Below 160 μin.	±15%	20 to 500 cps	Down 25% at 10 cps

Above 500 cps the error increases and may reach ±30% at 1000 cps. This is caused by the differences in response of individual pickups near resonance.

Pickup Unit: Inertia-operated, Rochelle-salt-crystal type. Non-linearity occurs at 10 g or 3900 inches per second per second. Point and ball tips and an 8-inch extension rod are supplied.

Meter: Scale reads directly in the quantity being measured — root-mean-square micro-inches for displacement, root-mean-square micro-inches per second for velocity, and root-mean-square inches per second per second for acceleration.

Attenuators: A 10-step attenuator changes the meter scale calibration over a range of 30,000 to 1. Additional multipliers indicate the correct units of measurement and multiplying factors for each response characteristic.

Calibration: Connection to any a-c power line makes it possible to check the over-all calibration excluding pickup.

Terminals: A jack is provided on the panel for plugging in a pair of head telephones in order to listen to the vibrations being measured, for connecting the TYPE 762-B Vibration Analyzer, or for connecting a cathode-ray oscillograph.

Tubes: One CK533AX, two 1N5-GT tubes and one 1D8-GT tube are required. A complete set of tubes is supplied.

Battery: A single self-contained battery unit, BA48, Burgess 6TA60, which supplies the necessary plate and filament voltages, is included.

Accessories Supplied: Power cable for calibration check, spare pilot lamp, and plug for output jack.

Case: Shielded carrying case of airplane-luggage construction.

Dimensions: (Height) $12\frac{1}{2}$ inches x (length) $13\frac{1}{2}$ inches x (width) $9\frac{1}{2}$ inches.

Net Weight: $22\frac{3}{4}$ pounds with battery; $17\frac{1}{4}$ pounds without battery.

Type		*Code Word*	*Price*
761-A	**Vibration Meter**	VIRUS	**$490.00**
761-P1	**Replacement Pickup**	NOSEY	**40.00**
Replacement Battery for above		VIRUSADBAT	**5.79**

TYPE 762-B VIBRATION ANALYZER

USES: The TYPE 762-B Vibration Analyzer makes possible the analysis of vibration phenomena having fundamental frequencies as low as 2.5 cycles per second. It is intended primarily for use with the TYPE 761-A Vibration Meter but can also be used for general harmonic analysis of very-low-frequency voltages in the laboratory.

Its range includes practically all frequencies normally encountered in vibration studies, from the fundamental vibrations of ships and other large structures to the unbalance vibrations of high-speed centrifuges.

DESCRIPTION: The analyzer is similar in all essential characteristics of performance, construction, operation, and appearance to the TYPE 760-B Sound Analyzer (page 14) except that the frequency has been lowered by a factor of 10, the output meter has a single logarithmic range, and provision has been made for operation with broad selectivity if desired. The latter arrangement is particularly useful in identifying components in the two lowest frequency ranges (2.5 to 25 cycles per second) and in making analyses involving components that vary slightly about a mean frequency.

SPECIFICATIONS

Frequency Range: 2.5 to 750 cycles, covered in five ranges as follows: 2.5 to 7.5, 7.5 to 25, 25 to 75, 75 to 250, 250 to 750.

Band Width: For the sharp selectivity position, the relative attenuation is approximately 30% (3 db) at a frequency differing by 1% from that to which the analyzer is tuned. For the broad selectivity position, the attenuation is at least 30% for a frequency difference of 5%. At one octave from the peak, the relative attenuations are at least 98% (35 db) and 90% (20 db), respectively.

Frequency Calibration: Sharp selectivity network, $\pm 1\frac{1}{2}\%$ or $\pm 1\frac{1}{2}$ cycles, whichever is the larger, over the three highest ranges (25 to 750 cycles); on the two lower ranges (2.5 to 25 cycles), the accuracy is ±5% or ±0.2 cycle, whichever is the larger. The frequency as determined with the broad selectivity network deviates on the average by less than ±2% from that determined with the sharp selectivity network.

Frequency Response: The response of the sharp selectivity network is flat within ±2 db over the entire range. At points where two ranges overlap, the sensitivity is the same on either range within ±1 db. The sensitivity of the broad selectivity network is the same as that of the sharp selectivity network within ±2 db.

Net Weight: $34\frac{1}{4}$ pounds, with batteries; $27\frac{1}{2}$ pounds, without batteries.

For other specifications see TYPE 760-B, page 16.

Type		*Code Word*	*Price*
762-B	**Vibration Analyzer**	AWARD	**$540.00**

PATENT NOTICE. See Note 20, page vi.

VARIAC® SPEED CONTROLS
FOR OPERATING D-C MOTORS FROM A-C SUPPLY

VARIAC Speed Controls are compact, moderately priced motor speed controls, designed to operate d-c shunt, compound, and series motors from an a-c line. The motors are operated with constant field excitation and adjustable armature voltage, obtained from a Variac and rectifier, so that shunt motor regulation characteristics are obtained.

These controls are made in three sizes, 1/15, 1/3, and 3/4 hp. The 1/15 hp controls, TYPES 1701-AK and AU, are suitable for a wide range of laboratory applications and are described below.

The larger controls include 1/3 hp TYPES 1700-AH and AL using gas tube rectifiers and TYPES 1700-B and 1702, 1/3 and 3/4 hp, respectively, using selenium rectifiers. The latter require no time delay on starting and are simple and rugged controls, having good regulation and are particularly suited to shop installation. They have given excellent performance in a wide range of machine tool and industrial applications. Specifications and prices will be furnished on request.

TYPE 1700-AL Variac Speed Control in use on a bench lathe.

TYPE 1701-A VARIAC SPEED CONTROL

TYPE 1701-AK Variac Speed Control.

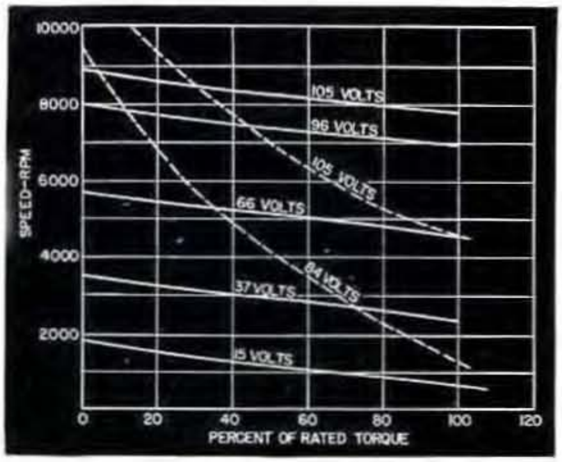
USES: The TYPE 1701-A Variac Speed Control, available in two models, has been designed for applications requiring up to about 1/15 hp output. The TYPE 1701-AK is used with shunt motors, while the TYPE 1701-AU is used with series or universal motors converted by reconnection for operation at constant field excitation. The TYPE 1701-AU Control permits the high operating speeds of series motors to be obtained with the good regulation characteristics of shunt motors, and also permits existing equipment powered by universal motors to be converted to adjustable constant-speed operation without changing the motor.

The power rating of the TYPE 1701-A Control is ample for many process applications, including photographic developing and printing machines, blueprinting machines, etc.

The combination of adjustable speed with reversibility makes the control particularly adapted to positioning applications of various kinds.

Other applications include high-speed drill presses, lathe feed, jeweler's lathes, centrifuges, and oscillographic chart speed control.

DESCRIPTION: Separate full-wave selenium bridge rectifiers are used for the armature and field. The adjustable output voltage of a VARIAC feeds the armature through one of the rectifiers and a choke, which serves to reduce ripple and improve regulation. All the control components are mounted in a small metal cabinet which can be fastened permanently by means of screw holes in the back and in the base, or can rest on a bench for complete portability.



Speed-torque curves for 1/15 hp converted universal motor used with TYPE 1701-AU Control, compared with a-c operation (dashed lines).

FEATURES: ➔ Continuously adjustable speed ranges up to 100 : 1 are obtainable with high speed series or universal motors, and up to 30 : 1 from 1725 rpm shunt motors.

➔ Shunt motor regulation characteristics from converted series motors.

➔ Speed regulation up to 10 : 1 better than obtainable from simple adjustable voltage or resistive controls.

➔ *No warmup, instant starting.*

➔ Heavy short-time overload capacity.

➔ High starting torque.

➔ Excellent reversing characteristics.

➔ Compact and convenient.

➔ Very low ripple in armature current waveform giving increased efficiency and *negligible torque pulsations.* Full rated output is obtained from standard motors.

SPECIFICATIONS

	Type 1701-AK	*Type 1701-AU*
Supply Frequency / Supply Voltage	60 c, 105-125 v; 50 c, 105-120 v	60 c, 105-125 v; 50 c, 105-120 v
D-C Output Armature Voltage	0-115 v	0-115 v
D-C Output Armature Current	0.8 a. max.	0.8 a. max.
D-C Output Field Voltage	38 v, 115 v	10 v or 16 v
D-C Output Field Current	0.2 a.	1.25 a.

Speed Range: Motor rated speed down to zero at constant torque. A working range of 30 : 1 can be satisfactorily employed with motors of 1725 rpm base speed and up to 100 : 1 or more when the TYPE 1701-AU Control is used with a converted universal motor having a speed rating of 5000 rpm or higher. Two speed ranges, one up to rated speed and one at reduced field excitation up to approximately twice rated speed, are provided in the TYPE 1701-AK Control. Only a single range is provided in the TYPE 1701-AU Control because of the higher rated speeds of universal motors.

Motor: The TYPE 1701-AK Control can be used with any 1/15 hp, 115-volt d-c shunt motor or with motors of somewhat higher rating when the current consumption is within the rating of the control.

The TYPE 1701-AU Control can be used with universal motors up to about 1/15 hp when the current consumption does not exceed 0.8 ampere. When operating at its rated current, the motor will furnish rated torque at up to 150 per cent or more of its rated speed, giving output power substantially greater than the normal rating. Motors of the four-wire reversible type can be used without modification. Uni-directional motors must be provided with separate field leads. Bodine type NSE-12 motors 1/15 hp, 8800 rpm, for reversing service are stocked as listed below. Motors of other ratings or with built-in gear reduction can be obtained from the manufacturer.

Overload Protection: No protection for starting load or momentary overload is required. A slow-blow fuse is provided only as a protection against damage from stalling when starting an excessively heavy load.

Reversal: Motors with brushes set on neutral give excellent reversing performance with either control. Sparking at the commutator may occur if it is attempted to reverse motors having brushes set for a single direction of rotation.

Mounting and Wiring: The control can be mounted either through the bottom or the back and can be used unmounted on a laboratory bench. Mounting must permit ventilation through the side louvers. A $5\frac{1}{2}$ foot power cord and a $3\frac{1}{2}$ foot four-conductor motor cord are permanently attached to the control.

Dimensions: Height $6\frac{13}{16}$ inches, width $5\frac{11}{16}$ inches, depth $4\frac{5}{8}$ inches, over-all.

Weight: Six pounds for either model.

Type		*Code Word*	*Price*
1701-AK	**Variac® Speed Control,** 115 v, 50-60 cps, for D-C Shunt Motor	WINDY	**$75.00**
1701-AU	**Variac® Speed Control,** 115 v, 50-60 cps, for Converted Universal Motor	WEARY	**75.00**
MOD-5	**Bodine Model NSH-34** Sleeve-Bearing, Reversible, D-C Shunt Motor, 1/15 hp, 1750 rpm, for use with TYPE 1701-AK Control	MOTOR*	**28.55**
MOD-4	**Bodine Model NSE-12** Sleeve-Bearing, Reversible Universal Motor, 1/15 hp, 8800 rpm, for use with TYPE 1701-AU Control	MOTOR*	**14.26**

*To order speed control with motor, use compound code word, WINDYMOTOR or WEARYMOTOR.

PATENT NOTICE. See Note 11, page vi.

VARIAC®

USES: The VARIAC is a manual voltage control that finds applications in the shop and laboratory wherever a-c voltage must be adjusted smoothly and continuously. A few of its uses are:

A-C voltage control in testing and development work.

Heat control on electric heaters and ovens in the laboratory and pilot plant.

Overvoltage and undervoltage tests.

Output voltage control in transformer-rectifier power supplies.

Voltage control on aging racks for lamps, vacuum-tubes, and dry-disc rectifiers.

Illumination control in auditoriums, theatres, photographic studios and darkrooms.

Motor speed control.

Voltage control in the calibration of voltmeters and ammeters.

Phase-angle controls in the calibration of wattmeters, power-factor meters.

Torque adjustment control on 3-phase motors.

Although VARIACS are built for 115- and 230-volt circuits, they can be used on circuits of higher or lower voltage in conjunction with fixed-ratio auxiliary transformers. Ganged units are available for parallel, series, and polyphase connections (see pages 25 and 26).

DESCRIPTION: The VARIAC is a continuously variable autotransformer supplying an output voltage from zero to 17% *above* line voltage. It consists of a single-layer winding on a toroidal iron core. As the dial is rotated a carbon-brush contact traverses the winding, "tapping off" a portion of the total voltage across the winding. The brush is always in contact with the winding, and the voltage between turns is always less than 1 volt, even in the largest models, while in the smallest model it is only about 0.3 volt. The actual increments of voltage obtained as the dial is turned are always less than the voltage between turns, the action of the carbon brush being such that the change in voltage is practically continuous. The resistance of the brush is so chosen that excessive heating does not occur in the turns bridged by the brush.

Core material is high-grade silicon steel. Smooth, uniform windings are put on by automatic machines. Windings are banked on the inside circumference of the toroid, single layer on the outside circumference. Aluminum structural parts in V-models assure minimum weight.

FEATURES: ➔ Compared to resistive methods of voltage control, the VARIAC has the advantages of high efficiency, smooth control, good voltage regulation, and comparatively small size.

➔ Because the VARIAC is a transformer, output voltage is essentially independent of load and the VARIAC is equally effective on any load within its rated capacity.

➔ A linear variation of voltage with dial rotation is obtained.

➔ VARIACS also furnish output voltages above line voltage, making it possible to compensate for undervoltage lines.

➔ Dial has large, easily read numerals and indicates output volts directly.

➔ Brush is designed for constant contact pressure, and brush holder cannot contact winding if brush fails.

➔ Shaft reversal to convert from panel to table mounting is easily accomplished.

➔ Terminals on V-models have both screw and solder connections, easily accessible and logically arranged.

➔ Extra terminals for mid-winding taps on V-models facilitate the use of auxiliary transformers. On 230-volt models, tap for 115-volt input is provided.

➔ V-models have attractive case with rounded contours, no sharp edges.

➔ Durable black finish — wear and abrasion resistant.

GENERAL SPECIFICATIONS

Frequency: Specifications are for 50-to-60-cycle service. For 25-cycle service, see page 27.

Rated Current: Can be drawn from the VARIAC at any dial position. When the overvoltage connection is used, the load should not take more than *rated current* at maximum output voltage.

Rated Current should not be exceeded for continuous 24-hour-per-day duty.

Maximum Current can be drawn at the input line voltage when the line-voltage connection is used. The VARIAC will control at any *lower* setting a load drawing no more than maximum current at line voltage.

Output Voltage is the range of voltage available at the output terminals with rated input voltage applied to the input terminals. Dials read directly in output voltage for this condition.

KVA Rating is the *maximum current* multiplied by *normal input line voltage*. A VARIAC can handle, at any *lower* setting, a constant-impedance load that draws at input voltage a current no greater than the *maximum current*.

Temperature Rise: The ratings of VARIACS are based on operation at ordinary room temperatures with an average temperature rise of not more than 50° Centigrade. When ambient temperature exceeds 40° Centigrade, kva ratings should be decreased approximately 20% for every 10° C increase in the ambient temperature.

No-Load Loss is measured at 60 cycles with rated input voltage. The values quoted in the table are the guaranteed maxima.

Driving Torque is the torque required to turn the VARIAC shaft.

Terminals (see also **Mounting** below): TYPE 200-B is furnished with threaded terminal studs and soldering lugs. TYPES V-5, V-10, and V-20 have combined soldering and screw-type terminals; TYPE 50 models have self-locking terminals, and provision for attaching armored cable or conduit.

Dial: A reversible dial, reading in output voltage for the overvoltage connection, is provided on all "V" models. One side is used for table mounting with rotating dial, the other for panel mounting, with fixed dial and rotating pointer. Dials can be supplied on special order marked for maximum voltage equal to line voltage, if the overvoltage connection is not to be used. The total angle of rotation is 320°.

The TYPES 50-A, 50-B, and 200-B are supplied with reversible dials, one side of which is marked for the overvoltage connection and one side for maximum voltage equal to line voltage.

Panel Thickness is the maximum thickness of panel on which the VARIAC can be mounted, with the shaft supplied.

Mounting: See photographs on pages 22 and 23. TYPE 200-B is supplied without case, for panel mounting. TYPE V-20 models are always supplied with case. TYPES V-5 and V-10 can be ordered either with or without case (the M-models have cases). A terminal box cover, cord, and plug are provided on the MT-models. On special order, they can also be supplied without case, but with terminal box and line cord.

Dimensions: Over-all dimensions are given on the drawings, pages 22 and 23. Complete dimensional sketches and drilling templates can be furnished on request.

Net Weight: See table on page 24.

PATENT NOTICE. See Note 11, page vi; also Note 27 for TYPE 50 only.

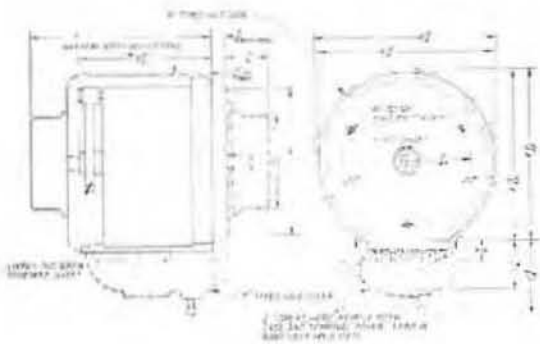
TYPE V-5

TYPE V-5M

TYPE V-5 VARIACS

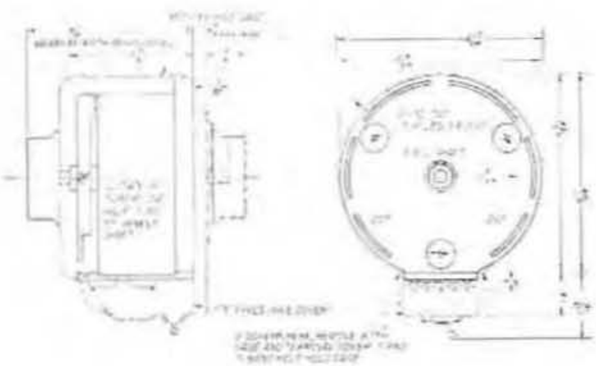
Rated at 5 amperes for 115-volt service, 2 amperes for 230-volt service (H-models), TYPES V-5 and V-5H have terminal plate and are uncased; TYPES V-5M and V-5HM have terminal plate and case; TYPES V-5MT and V-5HMT have case, terminal box, power cord, and switch.

TYPE V-5MT



TYPE V-10 VARIACS

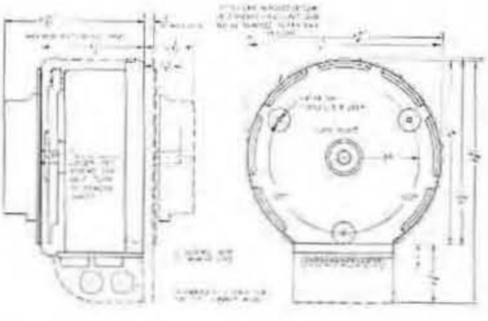
Popular 10-ampere size for 115-volt service (230-volt models have 4-ampere rating). Available in the same three basic models as TYPE V-5, above.



TYPE V-10MT

TYPE V-20 VARIACS

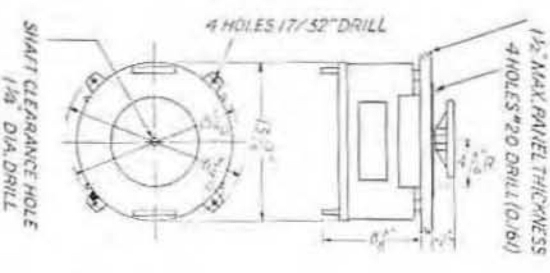
For either 115-volt or 230-volt service. 115-volt model is rated at 20 amperes, 230-volt model at 8 amperes. Both models have case and terminal box with knockouts for armored cable or conduit.



TYPE V-20M

TYPE 50 VARIACS

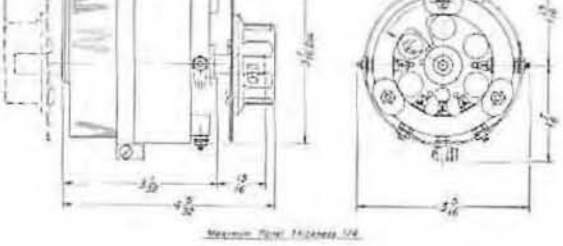
Largest size VARIAC rated at 40 amperes for 115-volt model, TYPE 50-A, and 20 amperes for 230-volt model, TYPE 50-B. Both models have case and terminal plate with cover. Terminals are brought out at two opposite sides of the assembly for convenience in wiring.



(*Left*) TYPE 50-B

TYPE 200-B VARIAC

One-ampere model, supplied without case, for panel mounting and for 115-volt service. A small, compact unit, ideal for building into low-power equipment.



SPECIFICATIONS

Type	Mounting (See also photographs and dimension sketches on pages 22 and 23)	Rated Input Voltage	Rated Output Current in Amperes	OUTPUT — Line-Voltage Connection (Note D): Output Voltage Range	Maximum Output Current in Amperes (Note A)	Output kva at Maximum Output Voltage (Note A)	OUTPUT — Overvoltage Connection: Output Voltage Range	Rated Current in Amperes (Note B)	60-Cycle No-Load Loss in Watts	Driving Torque in Inch-Ounces	Net Weight in Pounds	Code Word	Price
200-B	Uncased, with terminal strip	115	1	0–115	1.5	0.17	0–135	1	3	10–20	2 7/8	BALSA	**$ 12.50**
V-5	Uncased, with terminal strip	115	5	0–115	7.5	0.86	0–135	5	9	15–30	6 3/4	COBRA	**18.50**
V-5M	With case and terminal strip	115	5	0–115	7.5	0.86	0–135	5	9	15–30	7	COPAL	**20.50**
V-5MT	With case, terminal box, line cord, plug and switch	115	5	See Note C			0–135	5	9	15–30	7 5/8	CORAL	**25.00**
V-5H	Uncased, with terminal strip	230 115	2 1	0–230	2.6	0.60	0–270 0–270	2 1	9	15–30	6 1/2	CULPA	**21.00**
V-5HM	With case and terminal strip	230 115	2 1	0–230	2.6	0.60	0–270 0–270	2 1	9	15–30	6 3/4	CUMIN	**23.00**
V-5HMT	With case, terminal box, line cord, plug and switch	230	2	See Note C			0–270	2	9	15–30	7 3/8	CUPID	**27.50**
V-10	Uncased, with terminal strip	115	10	0–115	13	1.5	0–135	10	17	30–60	12	HAZEL	**33.00**
V-10M	With case and terminal strip	115	10	0–115	13	1.5	0–135	10	17	30–60	12 1/4	HEAVY	**35.50**
V-10MT	With case, terminal box, line cord, plug and switch	115	10	See Note C			0–135	10	17	30–60	13 1/8	HELOT	**40.00**
V-10H	Uncased, with terminal strip	230 115	4 2	0–230	5.2	1.2	0–270 0–270	4 2	17	30–60	10 5/8	HINNY	**34.00**
V-10HM	With case and terminal strip	230 115	4 2	0–230	5.2	1.2	0–270 0–270	4 2	17	30–60	11 1/2	HOARY	**36.50**
V-10HMT	With case, terminal box, line cord, plug and switch	230	4	See Note C			0–270	4	17	30–60	11 1/2	HOBBY	**41.00**
V-20M	With case and terminal box	115	20	0–115	26	3.0	0–135	20	27	55–110	22	JEWEL	**55.00**
V-20HM	With case and terminal box	230 115	8 4	0–230	10.4	2.4	0–270 0–270	8 4	27	55–110	21	JIMMY	**55.00**
50-A	With case and terminal box	115	40	0–115	45	5	0–135	40	60	250–500	79	TOKEN	**140.00**
50-B	With case and terminal box	230 115	20 10	0–230	31	7	0–270 0–230	20 10	75	250–500	76 1/2	TOPAZ	**140.00**

NOTES

A. Maximum current can be drawn at max. voltage for the line-voltage connection only. Max. output voltage = line input voltage. KVA as listed = normal input line voltage × maximum current.

B. Rated current should not be exceeded for the overvoltage connection. Output kva for overvoltage connection = output voltage × *rated current.*

C. -MT models are shipped with overvoltage connections, but can be supplied with line-voltage connections on special order.

D. All models are shipped with overvoltage dials unless line-voltage dials are specified in order.

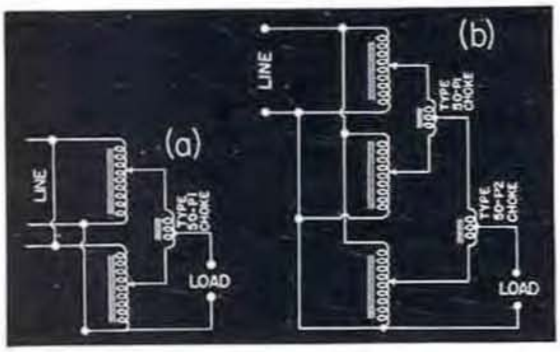
GANGED VARIAC® ASSEMBLIES

(FOR PARALLEL, SERIES, AND THREE-PHASE OPERATION)

Two- and three-gang VARIAC assemblies are available for controlling several circuits from a single dial, or for controlling 3-phase circuits in the same manner that one VARIAC controls a single-phase circuit.

In polyphase circuits a large variety of input and output voltage combinations is possible. The wye and open-delta connections listed are most frequently used.

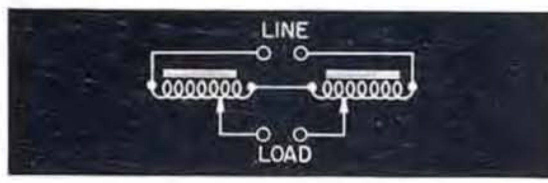
PARALLEL COMBINATIONS



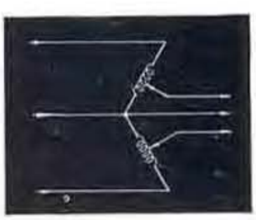
The larger-size VARIACS (V-20 and Type 50) can be operated in parallel if a Type 50-P1 Choke is used to limit circulating current, as shown in circuit (a) at left. Load rating of two identical VARIACS in parallel is twice that of a single VARIAC. Parallel operation is not recommended for smaller VARIACS, because the use of the next larger size VARIAC is economical. Where a load rating in excess of two Type 50 units is needed, a third unit can be added by using a Type 50-P2 Choke, as shown in circuit (b).

SERIES OPERATION

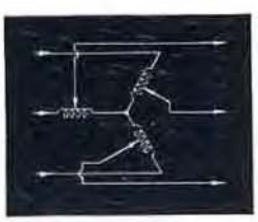
The series connection is useful in operating 115-volt units on 230-volt lines and 230-volt units on 460-volt lines. This circuit cannot be used, however, when a common connection is required between line and load, as, for instance, when the load is grounded.



THREE-PHASE COMBINATIONS



A three-phase arrangement of VARIACS in the open-delta circuit.



A Wye-connected three-phase arrangement of VARIACS.

Three-gang VARIACS can be operated in a wye on three-phase circuits, and two-gang units in an open delta.

With the wye connection, 115-volt VARIACS can be used on 230-volt lines, and 230-volt units on 460-volt lines. Load rating for a three-gang wye is about 3.5 times the rating of a single VARIAC.

The open delta connection makes it necessary to de-rate the VARIACS slightly. The load rating of a two-gang open delta is 1.732 times that of a single VARIAC.

PHASE-CHANGING CIRCUITS

A three-gang, or closed, delta is not suitable for voltage control, although it has some application in phase-changing circuits. A VARIAC, connected to a three-phase line as shown here will give a single-phase output with a phase control range of 120°.

Type 50-P1 Choke

SPECIFICATIONS FOR GANGED UNITS

ASSEMBLIES FOR 230-VOLT‡ THREE-PHASE SERVICE

		Line-Voltage Connection			Overvoltage Connection				
Input Three-Phase Line Volts	Rated Output Line Amp.	Output Voltage Range	Max. Output Line Amperes	Output KVA	Output Voltage Range	Output KVA	Circuit	Type of Assembly	Price*
230	2	0-230	2.6	1	0-270	.94	Open Delta	V-5HG2	$ 54.00
230	4	0-230	5.2	2	0-270	1.9	Open Delta	V-10HG2	81.00
230	5	0-230	7.5	3	Not recommended†		Wye	V-5G3	68.50
230	8	0-230	10.4	4	0-270	3.8	Open Delta	V-20HG2	126.00
230	10	0-230	13	5.2	Not recommended†		Wye	V-10G3	113.00
230	20	0-230	26	10.4	Not recommended†		Wye	V-20G3	182.00
230	20	0-230	31	12.5	0-270	9.3	Open Delta	50-BG2	310.00
230	40	0-230	45	18	Not recommended†		Wye	50-AG3	460.00

‡On 208-volt circuits, current ratings remain unchanged, but voltage range and kva ratings are reduced in proportion to the voltage.
†On 208-volt circuits, overvoltage connection may be used.

ASSEMBLIES FOR 460-VOLT THREE-PHASE CIRCUITS

460	2	0-460	2.6	2	Not recommended	Wye	V-5HG3	$ 76.00
460	4	0-460	5.2	4	Not recommended	Wye	V-10HG3	116.00
460	8	0-460	10.4	8	Not recommended	Wye	V-20HG3	182.00
460	20	0-460	31	25	Not recommended	Wye	50-BG3	460.00

*See price list on next page for code words and net weights.

ASSEMBLIES FOR SINGLE-PHASE 115-VOLT SERVICE

		Line-Voltage Connection			Overvoltage Connection					
Input Line Volts	Rated Output Amperes	Output Voltage Range	Max. Output Amperes	KVA at Max. Volts	Output Voltage Range	Rated Output Amperes	Type of Assembly	Connection	Chokes Required	Total Price,* including Chokes
115	40	0-115	52	6	0-135	40	V-20G2	Parallel	One Type 50-P1	$138.00
115	60	0-115	78	9	0-135	60	V-20G3	Parallel	One Type 50-P1 One Type 50-P2	206.00
115	80	0-115	90	10	0-135	80	50-AG2	Parallel	One Type 50-P1	322.00
115	120	0-115	135	15	0-135	120	50-AG3	Parallel	One Type 50-P1 One Type 50-P2	484.00

ASSEMBLIES FOR SINGLE-PHASE 230-VOLT SERVICE

230	5	0-230	7.5	1.7	0-270	5	V-5G2	Series†	None	$49.00
230	10	0-230	13	3	0-270	10	V-10G2	Series†	None	79.00
230	16	0-230	20.8	4.8	0-270	16	V-20HG2	Parallel	One Type 50-P1	138.00
230	20	0-230	26	6	0-270	20	V-20G2	Series†	None	126.00
230	40	0-230	62	14	0-270	40	50-BG2	Parallel	One Type 50-P1	322.00
230	60	0-230	93	21	0-270	60	50-BG3	Parallel	One Type 50-P1 One Type 50-P2	484.00

ASSEMBLIES FOR SINGLE-PHASE 460-VOLT SERVICE

460	2	0-460	2.6	1.24	0-540	2	V-5HG2	Series†	None	$54.00
460	4	0-460	5.2	2.4	0-540	4	V-10HG2	Series†	None	81.00
460	8	0-460	10.4	4.8	0-540	8	V-20HG2	Series†	None	126.00
460	20	0-460	31	14	0-540	20	50-BG2	Series†	None	310.00

*See price list on next page for net weights and code words.
†Cannot be used where a common connection exists between input and output, as for instance, when load is grounded.

VARIAC ASSEMBLIES

Type	*Description*	*Net Weight in Pounds*	*Code Word*	*Price**
V-5G2	2-Gang V-5	16½	COBRAGANDU	$ 49.00
V-5G3	3-Gang V-5	24	COBRAGANTY	68.50
V-5HG2	2-Gang V-5H	16	CULPAGANDU	54.00
V-5HG3	3-Gang V-5H	22	CULPAGANTY	76.00
V-10G2	2-Gang V-10	27	HAZELGANDU	79.00
V-10G3	3-Gang V-10	37½	HAZELGANTY	113.00
V-10HG2	2-Gang V-10H	27	HINNYGANDU	81.00
V-10HG3	3-Gang V-10H	36¾	HINNYGANTY	116.00
V-20G2	2-Gang V-20	48½	JEWELGANDU	126.00
V-20G3	3-Gang V-20	69½	JEWELGANTY	182.00
V-20HG2	2-Gang V-20H	46½	JIMMYGANDU	126.00
V-20HG3	3-Gang V-20H	68	JIMMYGANTY	182.00
50-AG2	2-Gang 50-A	180	TOKENGANDU	310.00
50-AG3	3-Gang 50-A	245	TOKENGANTY	460.00
50-BG2	2-Gang 50-B	175	TOPAZGANDU	310.00
50-BG3	3-Gang 50-B	256	TOPAZGANTY	460.00
50-P1	Choke	1¼	PARALLCHOK	12.00
50-P2	Choke	1¼	TRIPLECHOK	12.00

*Prices of Ganged Assemblies do not include Chokes.

Type V-10G3

VARIACS FOR 25-CYCLE SERVICE

H-Type VARIACS, designed for 60-cycle service, can be used on 25-cycle supply at one-half their 60-cycle voltage and load ratings.

Type	Rated Input Volts	Rated Output Amperes	Line Voltage Connection			Overvoltage Connection	
			Output Voltage Range	Max. Output Amperes	KVA at Max. Output Voltage	Output Voltage Range	Rated Output Current in Amperes
V-5H V-5HM V-5HMT	115	2	0-115	2.6	.3	0-135	2
V-10H V-10HM V-10HMT	115	4	0-115	5.2	.6	0-135	4
V-20HM	115	8	0-115	10.4	1.2	0-135	8
50-B	115	20	0-115	31	3.5	0-135	20

For other specifications and prices, see page 24.
When ordering, please specify that VARIAC is for 25-cycle service, in order that proper dial may be furnished.

TYPES V-5 AND V-10 VARIACS WITH SPECIAL-PURPOSE OUTLET BOXES

Type V-5MTC

Type V-5 and V-10 VARIACS are available with special-purpose outlet boxes for applications where the standard terminal box shown on page 1 is not suitable. Two models in each VARIAC size are stocked, (1) V-5MTC and V-10MTC, with holes for armored cable or conduit, and (2) V-5MTE and V-10MTE, equipped with 3-wire female plug, 3-wire power cord and plug, and on-off switch.

Type V-5MTE

Type		*Code Word*	*Price*
V-5MTC	**V-5 VARIAC with knockouts in terminal box**	COAST	$24.00
V-5MTE	**V-5 VARIAC with 3-wire terminal box, cord, and switch**	COMET	33.50
V-10MTC	**V-10 VARIAC with knockouts in terminal box**	HERON	39.00
V-10MTE	**V-10 VARIAC with 3-wire terminal box, cord, and switch**	HILLY	48.50

TYPE 60-A VARIAC® FOR 400-CYCLE TO 2600-CYCLE SERVICE

TYPE 60-AM

TYPE 60-AU

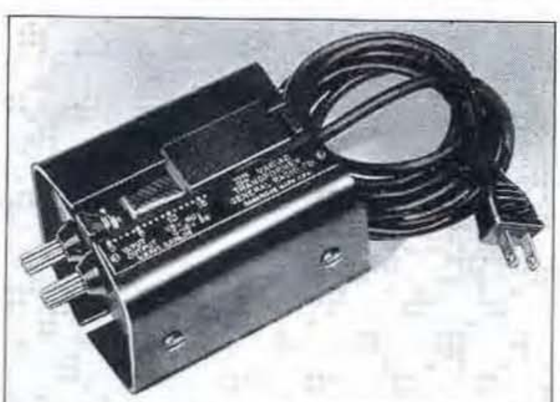
TYPE 60-A VARIAC is the high frequency equivalent of the 60-cycle TYPE V-5. Load rating is the same, but over-all height is much less, owing to the higher operating frequency, which permits a smaller core.

Load Rating: 860 va.
Input Voltage: 115 volts.
Frequency: 400 to 2600 cps.
Output Voltage: 0 to 115 or 0 to 135.
Load Current: 5 amperes, rated; 7.5 amperes maximum at input line voltage for line-voltage connection.

No-Load Loss: 7 watts at 400 cycles.
Dimensions: Over-all height for table mounting, 4⅛ inches; depth behind panel for panel mounting, 3 inches; over-all diameter of base, 5½ inches.
Net Weight: TYPE 60-AU, 3 pounds, 2 ounces; TYPE 60-AM, 3½ pounds.

Type		*Code Word*	*Price*
60-AU	**VARIAC, uncased**	BEGOT	**$28.00**
60-AM	**VARIAC, with case**	BEFOG	**30.00**

TYPE 71-A VARIAC® TRANSFORMER



The TYPE 71-A Variac Transformer is a step-down transformer with secondary voltage adjustable by a sliding brush. Case is simple, rugged, attractive, and easily mounted for either laboratory or built-in use. A seven-foot power cord is permanently attached, and the low-voltage output is available at binding posts on standard ¾-inch spacing.

The output has no direct connection with the input power line, and is adjustable from zero to 13 volts at 5 amperes.

Input Voltage: 115 volts.
Output Current: 5 amps maximum.
Output Voltage: 0-16 volts open circuit.
0-13 volts at 5 amps.
No Load Loss: Less than 5 watts.
Dimensions: (Length) 5½ x (width) 3⅝ x (height) 3¼ inches, over-all.
Net Weight: 4 pounds.

Type		*Code Word*	*Price*
71-A	**Variac Transformer**	POPPY	**$18.50**

RESISTORS

RESISTORS designed for use at electrical communication frequencies differ from those intended for use only at direct current in that low reactance and constancy of resistance as the frequency is varied are of considerably more importance than extreme accuracy of adjustment. Inevitably, resistors have capacitance and inductance associated with them, and these residual impedances become increasingly important as the frequency is raised, acting to change the terminal resistance from its low-frequency value.

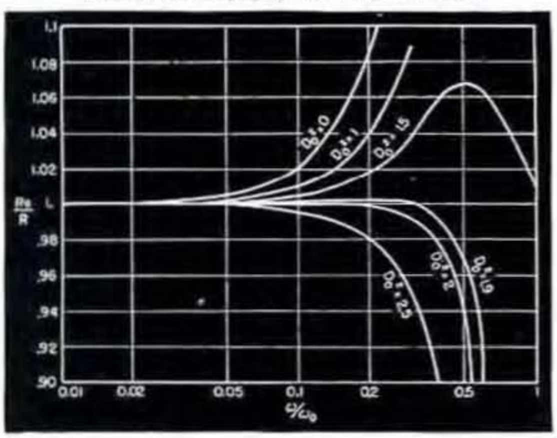
For frequencies where the resistance and its associated residual impedances behave as lumped parameters, the equivalent circuit of a resistor can be represented as shown in Figure 1. The inductance L is the equivalent inductance in series with the resistance, while the capacitance C is the equivalent capacitance across the terminals of the resistor.

To analyze the behavior of the equivalent circuit as frequency is varied, it is necessary to differentiate clearly between the concepts of equivalent series and equivalent parallel circuits. The two-terminal circuit of Figure 1 can be described as an impedance, $R_s + jX_s$, or as an admittance, $G + jB\left(=\frac{1}{R_p} + \frac{1}{jX_p}\right)$, wherein the parameters are a function of frequency. This distinction between series and parallel components is more than a mathematical exercise — the use to which the resistor is put will frequently determine which component is of principal interest.

The expressions for the effective series resistance (R_s) and the effective series reactance (X_s) of Figure 1 are:

$$R_s = \frac{R}{\left[1 - \left(\frac{\omega}{\omega_0}\right)^2\right]^2 + (R\omega C)^2} \qquad (1)$$

Figure 2. General normalized curves of resistance as a function of frequency for a fixed resistor.



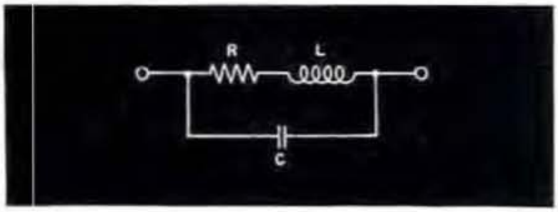


Figure 1. Equivalent circuit of a resistor showing the residual impedances associated with the resistance.

$$X_s = \frac{\omega\left\{L\left[1 - \left(\frac{\omega}{\omega_0}\right)^2\right] - R^2C\right\}}{\left[1 - \left(\frac{\omega}{\omega_0}\right)^2\right]^2 + (R\omega C)^2} \qquad (2)$$

where

$$\omega_0 = \frac{1}{\sqrt{LC}} \quad \text{and} \quad \left(\frac{\omega}{\omega_0}\right)^2 = \omega^2 LC \qquad (3)$$

The effective parallel components are given by:

$$G = \frac{1}{R_p} = \frac{1}{R\left[1 + \omega^2\left(\frac{L}{R}\right)^2\right]} \qquad (4)$$

$$B = -\frac{1}{X_p} = \omega C - \frac{1}{\omega L\left[1 + \frac{1}{\omega^2}\left(\frac{R}{L}\right)^2\right]} \qquad (5)$$

At frequencies sufficiently low so that the terms in ω^2 may be neglected, the network behaves like a resistance, R, in series with an inductance, $L - R^2C$, or in parallel with a capacitance, $C - \frac{L}{R^2}$. It is apparent that for high values of resistance the *capacitance* dominates, while for low values of resistance *inductance* is the controlling effect.

At higher frequencies the behavior can best be demonstrated by normalizing the expressions and plotting against $\frac{\omega}{\omega_0}$ with the dissipation factor at resonance, $D_0 = \frac{R}{\sqrt{L/C}}$, as a parameter. This is done for R_s and X_s in Figures 2 and 3.

For values of D_0^2 less than 2, the resistance increases with frequency to a maximum and then decreases to zero. For values of D_0^2 of 2 or greater, the resistance never rises above unity. The same sort of behavior occurs for reactance, except that the value of D_0^2 is 1 for the monotonic condition.

Dielectric losses in the lumped portion of the shunt capacitance C of Figure 1 are equivalent to a resistance

$$R_0 = \frac{1}{D\omega C} \qquad (6)$$

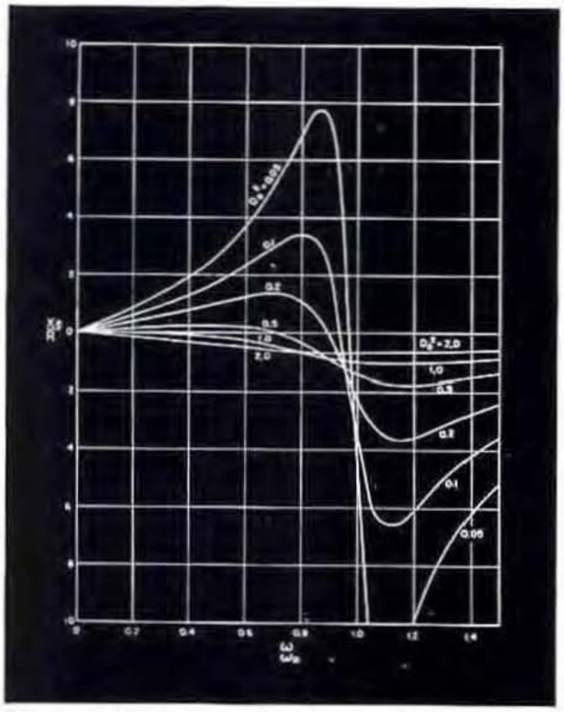


Figure 3. General normalized curves of reactance as a function of frequency for a fixed resistor.

which decreases with increasing frequency and causes even the parallel resistance to decrease rapidly beyond a certain frequency. That portion of the shunt capacitance C which is distributed causes a similar rapid decrease in resistance, even if its dielectric loss is negligible. These effects together are called the Boella effect. Its outstanding characteristic is that, when the ratio of a-c to d-c resistance (normalized parallel resistance) is plotted against the product fR of frequency and d-c resistance, all points for any one type of resistor fall approximately on the same curve, regardless of the resistance value. The decrease in resistance will amount to 1% for wire-wound resistors and the poorer composition-type resistors when the product fR is 0.01 (Mc, MΩ) and for the best composition-type resistor when fR is 10 (Mc, MΩ).

For any given resistance value there will be a combination of residual parameters that will give best performance over the widest frequency range. Proper proportioning of the residual parameters determined by the mechanical construction will lead to the best compromise design for a line of fixed resistors. An example of this kind of design is the Type 663 Resistor, in which a fine, straight wire is used as the resistive element in order to reduce skin effect. The inductance is held at a low value by clamping the wire to flat metal fins, which also aid in power dissipation. This produces a comparatively large shunt capacitance, and the element is so proportioned that $\sqrt{L/C}$ is of the same order of magnitude as the resistance, a condition which minimizes the changes of both inductance and capacitance with frequency. Resistors of this type exhibit only 1% change in resistance at frequencies as high as 30 megacycles.

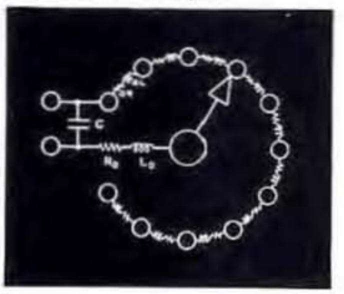
Wire-wound resistors of the card type exhibit a negligible frequency error in resistance up to about 500 kc, for values of resistance up to 500 ohms, and only moderate errors at one megacycle.

When assembled into decades, these resistors have added to their own residual impedances those of the switches, wiring, and cabinet. The equivalent circuit is then that of Figure 4, which represents a single decade of the 510 type. For assemblies of such decades in the Type 1432 Decade Resistor the same circuit is still valid. The incremental inductances of the several decades in the circuit are additive, but the capacitance is approximately that of highest decade in use. Typical values of the residual impedances for the various types of General Radio resistors are given in the specifications for each type.

It should be noted that the effect of the residual reactance depends greatly upon the way the resistor is connected into a circuit. Reactances can often be tuned out, particularly in parallel circuits. This is a particularly important consideration with the higher valued resistors of 10,000 ohms and above. When the resistor is used as a parallel circuit element, the upper limit of frequency for a given error is some 10 times higher than for the series connection.

All General Radio precision resistors in sizes above 100 ohms are wound with wire of a newly developed alloy which has many desirable characteristics. Chief among these are a smaller temperature coefficient of resistance, +0.001% per degree C as against ±0.002%, than is found in manganin, and a negligible thermal emf to copper. Moisture has no appreciable effect on its resistance, and there is little, if any, drift in resistance as a result of strains put in the wire when it is wound on a card. Its greater tensile strength is an advantage in winding, making it possible to produce better and more uniform resistors than can be made with other alloys.

Figure 4. Equivalent circuit of a resistance decade, showing location and nature of residual impedances.



TYPE 1432 DECADE RESISTOR

USES: Accurate decade resistors are extremely valuable wherever electrical measurements are made. They are constantly used in circuits where a wide range of resistance values is required or where variable dummy generator and load resistances are needed. The accuracy of Type 1432 Decade Resistors easily meets the requirements of these applications and also permits them to be used as laboratory standards and as ratio arms for direct- and alternating-current bridges.

Although designed primarily for direct-current and audio-frequency work, many of the models are useful well into the radio-frequency range.

DESCRIPTION: The Type 1432 Decade Resistor is an assembly of Type 510 Decade-Resistance Units in a single cabinet. Mechanical as well as electrical shielding of the units is provided by the rugged aluminum cabinet and panel, which completely enclose both the resistance units and switch contacts. The resistance elements have no electrical connection to the cabinet and panel, for which a separate shield terminal is provided.

Three-, four-, and five-dial decade assemblies are available. Each decade has eleven contact studs and ten resistance units, so that the dial values overlap. Positive detent mechanisms in conjunction with bar-type knobs permit the operator to sense the position of the switches without looking at the panel.

FEATURES: ➔ Low zero resistance — less than 0.003 ohm per decade.

➔ High accuracy — 0.05% for most decades.

➔ Low temperature coefficient of resistance.

➔ Negligible thermal emf to copper.

➔ Resistors are adjusted to specified values at their own terminals rather than at the box terminals, so that resistance *increments* are always correctly indicated.

➔ Residual impedances are small and are given in the specifications so that approximate frequency characteristics can be computed.

➔ Maximum current for each decade based on 40° C temperature rise is engraved on panel.

SPECIFICATIONS

Frequency Characteristics: Similar to those of individual Type 510 Decade Resistance Units, modified by the increased series inductance, L_0, and shunt capacitance, C, due to the wiring and the presence of more than one decade in the assembly. At total resistance settings of approximately 1000 ohms or less, the frequency characteristic of any of these decade resistors is substantially the same as those shown for the Type 510 Decade-Resistance Units in the plot on page 33. At higher settings, shunt capacitance becomes the controlling factor, and the effective value of this capacitance depends upon the settings of the individual decades. See *Residual Impedances* below.

Residual Impedances:

Zero Resistance (R_0)**:** 0.002 to 0.003 ohms per dial at dc; 0.04 ohms per dial at 1 Mc; proportional to square root of frequency at all frequencies above 100 kc.

Zero Inductance (L_0)**:** 0.10 μh per dial.

Effective Shunt Capacitance (C)**:** This value is determined largely by the highest decade in use. With the LOW terminal connected to shield, a value of 15 to 10 μμf per decade may be assumed, counting decades down from the highest. Thus, if the third decade from the top is the highest resistance decade in circuit (i.e., not set at zero) the shunting terminal capacitance is 45 to 30 μμf. If the highest decade in the assembly is in use, the effective capacitance is 15 to 10 μμf, regardless of the settings of the lower-resistance decades.

Temperature Coefficient of Resistance: Less than ±0.002% per degree Centigrade at room temperatures, except for the 0.1 Ω decade, where the box wiring will increase the over-all temperature coefficient.

Type of Winding: See specifications for Type 510 Decade-Resistance Units, page 33.

Accuracy of Adjustment: All cards are adjusted within ±0.05% of the stated value between card terminals, except the 1-ohm cards, which are adjusted within ±0.15%, and the 0.1-ohm units which are adjusted within ±0.5%.

Maximum Current: See specifications for Type 510 Decade-Resistance Units, page 33. Values for 40° C rise are engraved on panels directly above switch knobs.

Terminals: Jack-top binding posts set on General Radio standard ¾-inch spacing. Shield terminal is provided.

Mounting: Aluminum panel and cabinet.

Dimensions: Width, 4⁵⁄₁₆ inches; height, 4¹¹⁄₁₆ inches; length, 10⁵⁄₁₆ inches for 3-dial, 13 inches for 4-dial, and 15¾ inches for 5-dial box.

Net Weight: Type 1432 — A, C, F, 4 pounds, 2 ounces; Type 1432 — J, K, L, Q, 5 pounds, 4 ounces; Type 1432 — M, N, P, 6 pounds, 5 ounces.

Type	*Resistance*	*No. of Dials*	*Type 510 Decades Used*	*Code Word*	*Price*
1432-F	**111 ohms, total, in steps of 0.1 ohm**	**3**	**A, B, C**	DELTA	**$56.00**
1432-K	**1,111 ohms, total, in steps of 0.1 ohm**	**4**	**A, B, C, D**	DEFER	**75.00**
1432-C	**11,100 ohms, total, in steps of 10 ohms**	**3**	**C, D, E**	DEBAR	**65.00**
1432-J	**11,110 ohms, total, in steps of 1 ohm**	**4**	**B, C, D, E**	DEBIT	**83.00**
1432-N	**11,111 ohms, total, in steps of 0.1 ohm**	**5**	**A, B, C, D, E**	DEMON	**99.00**
1432-L	**111,100 ohms, total, in steps of 10 ohms**	**4**	**C, D, E, F**	DECAY	**87.00**
1432-M	**111,110 ohms, total, in steps of 1 ohm**	**5**	**B, C, D, E, F**	DEMIT	**107.00**
1432-A	**1,110,000 ohms, total, in steps of 1000 ohms**	**3**	**E, F, G**	DEMUR	**96.00**
1432-Q	**1,111,000 ohms, total, in steps of 100 ohms**	**4**	**D, E, F, G**	DEPOT	**113.00**
1432-P	**1,111,100 ohms, total, in steps of 10 ohms**	**5**	**C, D, E, F, G**	DETER	**133.00**

TYPE 510 DECADE-RESISTANCE UNIT

USES: Because of their accuracy, compactness, and sturdy construction the Type 510 Decade-Resistance Units are ideal for assembly into production test instruments, bridges, and other experimental and permanent equipment. They are particularly useful in applications where only one or two decades are needed, or where a Type 1432 Decade Resistor cannot be mounted conveniently. In many cases the use of these units will release for general laboratory work relatively more expensive decade resistors, that would otherwise be tied up for long periods of time in experimental equipment.

DESCRIPTION: Winding methods are chosen to reduce the effects of residual impedances. The 1-, 10-, and 100-ohm steps are Ayrton-Perry wound on molded phenolic forms especially shaped and heat treated to minimize aging effects. The 0.1-ohm steps are bifilar wound with ribbon, while the 1000-, 10,000-, and 100,000-ohm steps are unifilar wound on thin mica cards.

Each decade is enclosed in an aluminum shield, and a knob and etched-metal dial plate are supplied. The mechanical assembly is also available complete with shield, blank dial plate, switch stops, and knob, but without resistors, as the Type 510-P3 Switch.

FEATURES: ➔ High accuracy — ±0.05% for most units.

➔ Excellent stability — newly developed stable resistance alloys, with final resistance adjustment after artificial aging at high temperatures.

➔ Good frequency characteristics — most Type 510 Decades can be used at frequencies as high as several hundred kilocycles, as well as at dc.

➔ Low temperature coefficient.

➔ Negligible thermal emf to copper.

➔ Unaffected by high humidity — even the high resistance units can be exposed to high humidity for long periods of time without significant change in resistance.

SPECIFICATIONS

Accuracy of Adjustment: Resistors are adjusted to be accurate at card terminals within the tolerances given in Table I.

Maximum Current: See Table I below.

Frequency Characteristics: The equivalent circuit of a decade resistance unit is shown on page 30. The values of the residual impedances are listed in Table I.

The accompanying plot shows the maximum percentage change in effective series resistance of all seven decades as a function of frequency. For TYPES 510-A and 510-B the error is due almost entirely to skin effect and is independent of switch setting. For TYPE 510-C the error changes slowly with dial setting and is a maximum at maximum resistance setting, while for TYPE 510-D a broad maximum occurs at the 600-ohm setting. For all the higher resistance units, the error is due almost entirely to the shunt capacitance and its losses and is approximately proportional to the square of the resistance setting.

The high-resistance decades (TYPES 510-E, 510-F, and 510-G) are very commonly used as parallel resistance elements in resonant circuits, in which the shunt capacitance of the decades becomes part of the tuning capacitance. The parallel resistance changes by only a fraction, between a tenth and a hundredth, of the amount indicated in the plot as the series-resistance change, depending on frequency and the insulating material in the switch.

Switches: Quadruple-leaf, phosphor-bronze brushes bear on lubricated bronze contact studs 3/8 inch in diameter. These brushes are bent so as not to be tangent to the arc of travel, thus avoiding cutting and affording a good wiping action. A cam-type detent is provided. There are eleven contact points (0 to 10 inclusive). The switch resistance is between 0.002 and 0.003 ohm. The effective capacitance of the switch is of the order of 5 μμf, with a dissipation factor of 0.06 at 1 kc for the standard cellulose-filled molded phenolic switch form, and 0.01 for the mica-filled phenolic form used in the TYPE 510-G Unit.

Temperature Coefficient of Resistance: Less than ±0.002% per degree Centigrade at room temperature.

Terminals: Soldering lugs are provided.

Mounting: Each decade is complete with dial plate and knob and can be mounted on any panel between 1/4 inch and 3/8 inch in thickness. A template is furnished with each unit.

Dimensions: Over-all diameter, 3 1/16 inches; depth behind panel, 3 1/16 inches; template and dimension sketch mailed on request.

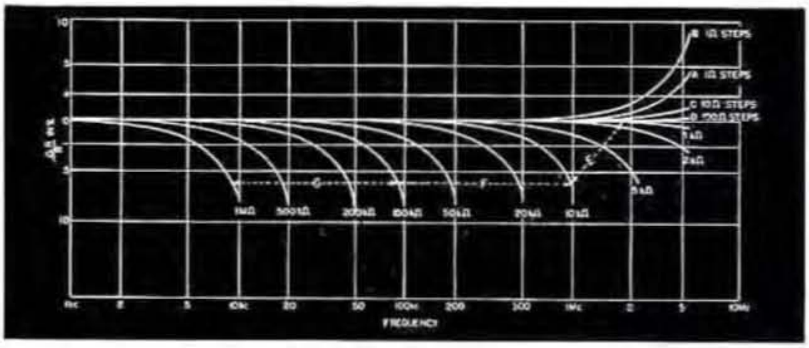
Net Weight: TYPE 510 Units, 11 ounces; TYPE 510-P3, 9 1/2 ounces.

TABLE 1

Type	*Resistance per Step (ΔR) Ohms*	*Accuracy*	*Maximum Current 40° C Rise*	*Power per Step watts*	*ΔL μh*	*C* μμf*	*L_0 μh*
510-A	0.1	±0.5%	1.6 a	.25	0.014	7.7-4.5	0.023
510-B	1	±0.15%	800 ma	.6	0.056	7.7-4.5	0.023
510-C	10	±0.05%	250 ma	.6	0.11	7.7-4.5	0.023
510-D	100	±0.05%	80 ma	.6	0.29	7.7-4.5	0.023
510-E	1,000	±0.05%	23 ma	.5	3.3	7.7-4.5	0.023
510-F	10,000	±0.05%	7 ma	.5	9.5	7.7-4.5	0.023
510-G	100,000	±0.05%	2.3 ma	.5	—	7.7-4.5	0.023

*The larger capacitance occurs at the lowest setting of the decade. The values given are for units without the shield cans in place. With the shield cans in place, the shunt capacitance is from 10 to 20 μμf greater than indicated here, depending on whether the shield is tied to the switch or to the zero end of the decade.

Type	*Resistance* Total	*Resistance* Per Step	*Code Word*	*Price*
510-A	**1 ohm**	**0.1 ohm**	ELATE	**$12.00**
510-B	**10 ohms**	**1 ohm**	ELDER	**14.00**
510-C	**100 ohms**	**10 ohms**	ELEGY	**14.00**
510-D	**1,000 ohms**	**100 ohms**	ELBOW	**16.50**
510-E	**10,000 ohms**	**1,000 ohms**	ELECT	**18.50**
510-F	**100,000 ohms**	**10,000 ohms**	ELVAN	**21.00**
510-G	**1,000,000 ohms**	**100,000 ohms**	ENTER	**40.00**
510-P3 Switch only (Black Phenolic Frame)			ENVOY	**7.50**
510-P3L Switch only (Low-Loss Phenolic Frame)			ESTOP	**8.50**



Maximum percentage change in resistance as a function of frequency for TYPE 510 Decade-Resistance Units.

TYPE 670-F COMPENSATED DECADE RESISTOR

USES: The TYPE 670-F Compensated Decade Resistor is intended for use in a-c measurements where non-reactive increments of resistance are desired. Inductance-compensated decade resistors are useful in tuned-circuit substitution measurements, as variable resistance elements in antenna measuring circuits, and, in general, for any use where the variation in inductance of the conventional type of decade resistor cannot be tolerated.

DESCRIPTION: The TYPE 670-F Compensated Decade Resistor is an assembly of TYPE 668 Compensated Decade-Resistance Units, described on the next page.

FEATURES: ➔ Inductance remains constant within 0.1 microhenry regardless of resistance setting of the TYPE 670-F Compensated Decade Resistor.

➔ Total inductance is about one microhenry and can usually be balanced out in preliminary adjustment.

SPECIFICATIONS

Type of Winding: The 10-ohm and 1-ohm steps are Ayrton-Perry resistance cards, while the 0.1-ohm steps are bifilar ribbon units.

Accuracy of Adjustment: Resistance increments are correct within ±0.1% for the 10-ohm steps, ±0.25% for the 1-ohm steps, and ±1% for the 0.1-ohm steps.

Zero Resistance: D-C, about 0.04 ohm; at 1 Mc, about 0.3 ohm; above 100 kc, proportional to square root of frequency.

Inductance: 1.05 microhenry, within 0.1 microhenry regardless of resistance setting.

Switches: See specifications for TYPE 668.

Terminals: Standard ¾-inch spacing is used on the terminals. A ground post connected to shield and panel is also provided.

Maximum Current: See specifications for TYPE 668 Compensated Decade-Resistance Unit on page 35. Values for 40° Centigrade rise are engraved on the panel directly above the switch knobs.

Frequency Characteristics: Similar to those of the TYPE 668 Units, described on the next page. However, the box wiring and cabinet shield affect these characteristics by adding series inductance and shunt capacitance.

Temperature Coefficient: See specifications for TYPE 668 Compensated Decade-Resistance Unit.

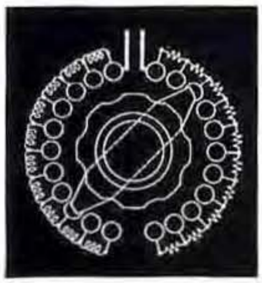
Mounting: The decade units are mounted on aluminum panels in copper-lined walnut cabinets.

Dimensions: Panel, (length) 13 x (width) 5 inches. Cabinet, (height) 5 inches, over-all.

Net Weight: 5½ pounds.

Interior of TYPE 670-F Compensated Decade Resistor.

In the compensated decade resistor opposite ends of the switch blade make contact with resistance or inductance windings, respectively. As a resistance step is added to the circuit, a compensating inductance step is removed, and vice versa.



Type	*Resistance*	*Type Units Used*	*Code Word*	*Price*
670-F	0 to 111 ohms, total, in steps of 0.1 ohm	668-A, -B, -C	ABYSS	$74.00

TYPE 668 COMPENSATED DECADE-RESISTANCE UNIT

USES: The Type 668 Compensated Decade-Resistance Unit is the basic unit for the Type 670-F Compensated Decade Resistor. It has found wide application as a component part in antenna measuring equipment and other general r-f impedance-measuring circuits. It is useful for any measurements where constancy of inductance is desired as resistance is varied.

DESCRIPTION: The Type 668 Compensated Decade-Resistance Unit is made with a double set of switch contacts, by means of which a copper winding is exchanged, step by step, for the resistance cards, thus keeping the total inductance constant regardless of resistance setting. This arrangement is shown in the diagram on the preceding page.

The units are mounted with an etched-metal dial plate, knob, and stops, but with no shield.

FEATURES: ➔ Low inductance, constant with setting.

➔ Good frequency characteristic.

➔ Accurately adjusted.

SPECIFICATIONS

Accuracy of Adjustment: Resistance increments are correct within ±1% for the 0.1-ohm steps, ±0.25% for the 1-ohm steps, and ±0.1% for the 10-ohm steps.

Zero Resistance: See Table I, below. The zero resistance at 1 Mc is about 8 times that at dc and at frequencies above 100 kc is proportional to the square root of the frequency.

TABLE I

Type	*D-C Zero Resistance in ohms*	*Inductance*	*Current in ma for 40° C Rise*
668-A	0.005-0.010	0.15 μh	1600
668-B	0.015-0.025	0.30 μh	500
668-C	0.010-0.020	0.50 μh	160

Inductance: See Table I. The inductance remains constant regardless of resistance setting within ±0.05 microhenry.

Temperature Coefficient: Less than ±0.002% per degree Centigrade at room temperature, except for the lower settings of Types 668-A and 668-B, where the temperature coefficient of the compensating windings may affect the over-all temperature coefficient.

Frequency Characteristics: Similar to those of Type 510 Decade-Resistance Units, page 33. Change in resistance with frequency results almost entirely from skin effect.

Although skin effect produces a positive change in resistance, the skin effect in the compensating winding is greater than that in the resistance cards. Accordingly there is a net negative change in resistance increments from this effect. That is, the increment in resistance between one switch point and the next higher one will be less at high frequencies than at low. This "negative skin effect," at one megacycle, is about −0.8% for the units decade and about −0.6% for the tens decade.

Maximum Current: See table, ratings are based on 0.25 watt per step.

Type of Winding: The 10-ohm and 1-ohm cards are Ayrton-Perry wound, while the 0.1-ohm steps are bifilar ribbon. Compensating windings are used on all decades to maintain constant inductance.

Switch: Double-leaf, phosphor-bronze brushes bear on lubricated bronze contact studs ¼ inch in diameter. These brushes are bent so as not to be tangent to the arc of travel, thus avoiding cutting and affording a good wiping action. A cam-type detent is provided, and there are eleven contact points (0 to 10 inclusive).

Terminals: Soldering lugs are provided.

Mounting: Interchangeable (except for switch stops) with Type 510 (see page 33). A combination dial plate and drilling template is furnished. Machine screws for attaching the decades to a panel are supplied.

Dimensions: Diameter, 3⅛ inches; depth behind panel, 3 inches, over-all; shaft diameter, ⅜ inch.

Net Weight: 7 ounces.

Type	*Resistance* *Total*	*Resistance* *Per Step*	*Code Word*	*Price*
668-A	1 ohm	0.1 ohm	GABLE	$14.50
668-B	10 ohms	1 ohm	GAILY	17.50
668-C	100 ohms	10 ohms	GALOP	17.50

TYPE 1450 DECADE ATTENUATOR

DESCRIPTION: The TYPE 1450 Decade Attenuator is an assembly of two or three TYPE 829 Decade Attenuator Units mounted on a single panel and housed in a metal cabinet. Each decade has eleven positions, 0 to 10 inclusive, so the decades overlap.

FEATURES: ➔ A wide range of attenuation values is possible in small steps.

➔ The accuracy of the boxes is maintained even at low radio frequencies.

➔ Decade-type switches make the boxes convenient to use. There are no stops on the 0.1- and 1-db-per-step decades, facilitating quick return from full to zero attenuation when making adjustments.

➔ Both T-type sections and balanced-H sections are available.

➔ An etched plate is attached to the case, indicating mismatch loss for terminations other than 600 ohms.

USES: The TYPE 1450 Decade Attenuator is useful in power-level measurements, transmission-efficiency tests, and in gain or loss measurements on transformers, filters, amplifiers and similar equipment. It can also be used as a power-level control in circuits not equipped with other volume controls.

SPECIFICATIONS

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

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

Accuracy: Each individual resistor is adjusted within ±0.25% of its correct value. The low-frequency error in attenuation is less than plus 0.008 db (HA), 0.004 db (TA), 0.012 db (HB), or 0.006 db (TB) ±0.25% of the indicated db value, provided the attenuator is terminated by a pure resistance of 600 ohms. When properly terminated, the input impedance is 600 ±3 ohms.

Frequency Discrimination: Less than ±1% of the indicated value at frequencies below 200 kc.

Maximum Input Power: Determined by the highest values decade in circuit. In general, 1 watt. See specifications for TYPE 829 Units.

Switches: See TYPE 829. Stops are provided on the highest decade only (10 db per step).

Mounting: The decade units are mounted on an aluminum panel in a metal cabinet. Each decade is individually shielded, and all shields are connected to the panel and the "G" terminal. Relay-rack mounting is available on special order at an additional charge. See price list below.

Terminals: Jack-top binding posts with ¾-inch spacing; common terminal of T units grounded to chassis; common terminal of H units not grounded; ground terminal provided.

Dimensions: 1450-HA and 1450-TA, 10 x 5¾ x 12¼ inches, over-all; 1450-HB and 1450-TB, 12 x 5¾ x 12¼ inches, over-all.

Net Weight: 1450-HA, 11¼ pounds; 1450-TA, 10¾ pounds; 1450-HB, 15¼ pounds; 1450-TB, 14½ pounds.

Type	*Range*	*Impedance*	*Type of Section*	*Code Word*	*Price*
1450-HA	**110 db in steps of 1 db . . .**	**600 ohms**	**Balanced-H**	NETWORKHAT	**$270.00**
1450-TA	**110 db in steps of 1 db . . .**	**600 ohms**	**T**	NETWORKTAM	**190.00**
1450-HB	**111 db in steps of 0.1 db. .**	**600 ohms**	**Balanced-H**	NETWORKHUB	**395.00**
1450-TB	**111 db in steps of 0.1 db. .**	**600 ohms**	**T**	NETWORKTUB	**275.00**

For relay rack mounting (19-inch) add $10.00 to above prices and add R to type number (TYPE 1450-HAR, for example).

TYPE 829 DECADE ATTENUATOR UNITS

USES: These decade units have been designed as convenient attenuators which can be built into speech circuits, recording channels or other equipment where definitely known amounts of attenuation are required. They provide, for attenuation, the analogue of decade resistors for resistance. The tapered units are useful for changing impedance levels either up or down.

DESCRIPTION: The resistors used in each decade are mounted in compartments in a cast aluminum housing, which is completely shielded by the addition of aluminum covers. Each decade consists of four pads series-connected by cam-operated switches, arranged with positive detents. All cams are mounted on a control shaft which is provided with ball bearings. Each pad is completely shielded, and a shield is interposed between the input and output elements of each pad.

FEATURES: ➔ Accurately known attenuation over a wide frequency range is possible because of careful shielding, the construction of the resistance cards, and the use of capacitance compensation.

→ Decade-type switches which can be arranged for continuous rotation make the TYPE 829 Decade Attenuator Unit very convenient to use.

→ Tapered units for changing impedance levels are also available in both T and balanced-H sections.

SPECIFICATIONS

Attenuation Range: Three decade ranges are listed in the price table below. The two tapered units, TYPES 829-HT and 829-TT, introduce an exact insertion loss, as follows:

Matching Ratio	600Ω to 600Ω	150Ω to 600Ω	75Ω to 600Ω	50Ω to 600Ω	30Ω to 600Ω
Attenuation ...	0db	12db	15db	17db	20db

Characteristic Impedance: 600 ohms both directions except for the tapered units, which are 600 ohms in one direction and either 30, 50, 75, 150, or 600 ohms in the other direction to accommodate microphones, coaxial lines, high-fidelity telephone lines, etc. Either end can be used as input.

Accuracy: Each individual resistor is adjusted within ±0.25% of its correct value. The low frequency error in attenuation is less than plus 0.002 db (T decades) or 0.004 db (H decades) ±0.25% of the indicated db value, provided the unit is terminated by the nominal value of pure resistance. Impedance matching within ±0.5% will exist.

Maximum Voltage: Based on 1-watt dissipation in any single resistor, the maximum RMS values of input voltage are as follows:

Load Resistance	600 Ω	∞	0
TYPE 829-TA	117 volts	114 volts	3.8 volts
TYPE 829-TB	46	39	11.7
TYPE 829-TC	25	25	25
TYPE 829-HA	83*	80*	2.6*
TYPE 829-HB	32*	28*	8.3*
TYPE 829-HC	18*	18*	18*

Input Impedance	TYPE 829-TT	TYPE 829-HT
30 Ω	5.9 volts	4.1 volts*
50	7.4	5.2*
75	9.0	6.4*
150	13.4	9.5*
600	25	17.5*

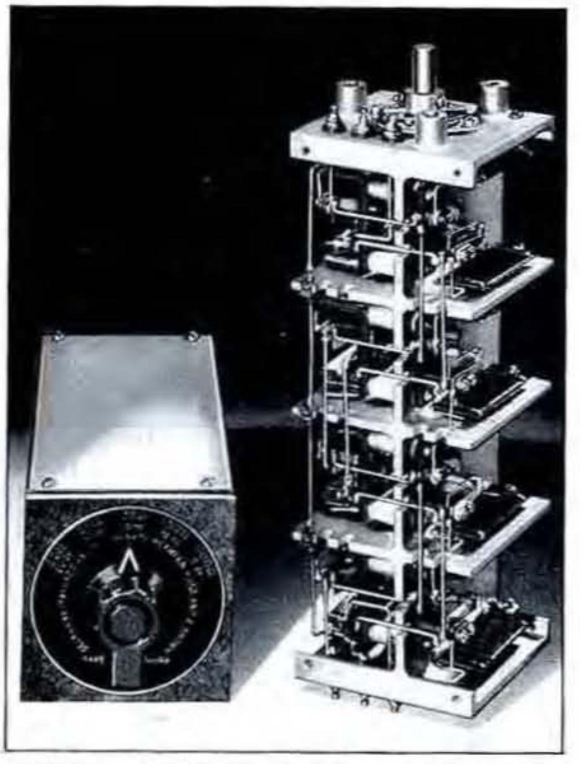
* Voltages across each side of balanced input.

Frequency Discrimination: Less than ±1% of the indicated value.

At 1 Mc for the TA, TB, and TC units.

At 200-500 kc for the HA, HB, HC, TT, and HT units.

Type of Section: Both balanced-H and T-type sections are available.



(*Left*) TYPE 829-HT Decade Attenuator Unit (tapered model), and (*right*) typical internal construction of the TYPE 829 Decade Attenuator Units.

Type of Winding: All resistance elements use Ayrton-Perry windings except the shunt elements of 829-HA and 829-TA, which are unifilar cylindrical windings. Resistors are capacitance-compensated in the TA, TB and TC units. Compensation is impractical in H-type units.

Switches: Cam-type switches are used with twelve positions covering 360°. The dials are numbered from "0" to "10" inclusive (except on tapered models) and the twelfth point is also connected to "0." No stops are provided in the switch mechanism to prevent complete rotation, but spacers, which are provided, can be used under the mounting screws to act as stops for the knob.

Terminals: External input and output soldering terminals on opposite ends; common terminal of T units grounded to chassis; common terminal of H units not grounded.

Mounting: The resistors and switches are housed in compartments of an aluminum casting, which is enclosed by aluminum covers. A dial and knob are furnished, and decades may be panel mounted from one end by three mounting screws which are provided.

Dimensions: 3⅛ x 3⅛ inches, extending 9¾ inches behind panel.

Net Weight: 3¼ pounds.

Type	*Range*	*Type of Section*	*Code Word*	*Price*
829-HA	**1 db in steps of 0.1 db**	**Balanced-H**	TENUTORHAG	**$125.00**
829-HB	**10 db in steps of 1 db**	**Balanced-H**	TENUTORHUB	**125.00**
829-HC	**100 db in steps of 10 db**	**Balanced-H**	TENUTORHIC	**125.00**
829-HT	**(See Specifications above)** ...	**Balanced-H**	TENUTORHUT	**125.00**
829-TA	**1 db in steps of 0.1 db**	**T**	TENUTORTAD	**85.00**
829-TB	**10 db in steps of 1 db**	**T**	TENUTORTUB	**85.00**
829-TC	**100 db in steps of 10 db**	**T**	TENUTORTIC	**85.00**
829-TT	**(See Specifications above)** ...	**T**	TENUTORTOT	**75.00**

TYPE 654-A DECADE VOLTAGE DIVIDER

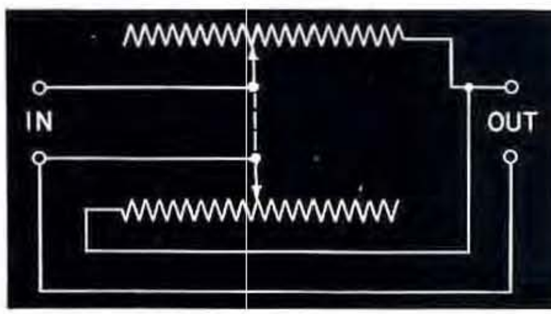
USES: The Type 654-A Decade Voltage Divider will supply exact voltage ratios between 0.001 and 1.000 in steps of 0.001 and is useful on the input of amplifiers and similar high-impedance circuits for reducing the input voltage by a definitely known ratio, which can be varied in very small steps.

DESCRIPTION: This instrument is equivalent to a pair of Type 1432 Decade Resistors connected in series and so manipulated that as resistance is taken out of one box it is added to the other to maintain the total resistance constant at 10,000 ohms. This action is accomplished by using five Type 510 Decade-Resistance Units, two of which are connected back-to-back to two similar units by means of a chain drive.

FEATURES: ➔ 1000 different ratios from 0.001 to 1.000, each one known within ±0.1%.
➔ Constant input resistance.
➔ Negligible thermal emf to copper.

SPECIFICATIONS

Voltage Ratio Range: 0.001 to 1.000 in steps of 0.001.
Accuracy: ±0.1% or better.
Frequency Characteristics: If the external capacitance which is placed across the output terminals is less than 20 $\mu\mu$f, the frequency error is less than 0.1% for all frequencies below 10 kc.
Input Impedance: 10,000 ohms. This value is engraved on the panel.
Internal Output Impedance: 10 ohms to 10,000 ohms, i.e., 10,000 times the voltage ratio setting. For rated accuracy, load impedance must be at least 1000 times the internal output impedance.
Maximum Input Voltage: 230 volts for a 40° Centigrade temperature rise. This value is engraved on the panel.
Temperature Coefficient: Less than ±0.002% per degree Centigrade at normal room temperature.
Terminals: Jack-top binding posts are provided, on standard ¾-inch spacing. The shield is connected to one terminal of both input and output, which is marked *G*.
Mounting: Aluminum panel and shielded walnut cabinet.
Dimensions: Panel, (length) 13 x (width) 7 inches. Cabinet, (depth) 5¼ inches, over-all
Net Weight: 8 pounds.



Type		*Code Word*	*Price*
654-A	**Decade Voltage Divider**	ABACK	**$105.00**

TYPE 663 RESISTOR

USES: The Type 663 Resistors are designed to have an accurately known impedance at high frequencies. They are useful as standard resistors for the resistance-variation method of impedance measurement at radio frequencies, as circuit elements in bridges and similar equipment, as terminating resistors for matching radio-frequency transmission lines and, generally, as low-resistance standards in high-frequency applications.

DESCRIPTION: A straight piece of resistance wire is soldered to two flat metal plates, which are mounted close together on a strip of insulating material. A thin piece of mica insulates the wire from the plates, except at the soldered ends. This assembly is rigidly clamped together with a top piece of insulating material.

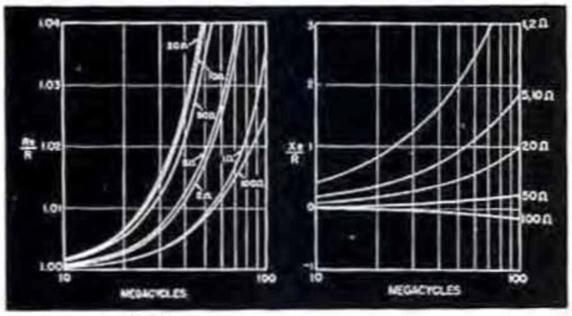
FEATURES: ➔ Very small residual inductance.
➔ Skin effect is kept at a minimum, and a value of $\sqrt{L/C}$ is maintained that minimizes the residual reactance as well as resistance change with frequency.
➔ Power dissipation is greatly aided by the terminal fins.

SPECIFICATIONS

Accuracy: All units are adjusted within ±1%.
Residual Inductance: See table below.
Skin Effect: Less than 1% below 50 Mc.
Temperature Coefficient: Less than ±0.002% per degree Centigrade.
Maximum Current: See table below.
Terminals: The flat metal plates to which the resistance wire is attached are used as terminals, and are both slotted and drilled for ¾-inch spacing.

(At right) Ratio of effective resistance, and equivalent series reactance, to d-c resistance versus frequency, for the TYPE 663 Resistors mounted ⅝ inch above a ¼-inch metal panel. One end was grounded to the panel, and the total capacitance approximated the rather high value of 6.5 μμf, which could have been reduced if a low-capacitance mounting were used.

Dimensions: (Length) 2¼ x (width) 1¼ inches. Overall height ⅝ inch. **Net Weight:** 2 ounces.



Type	*Resistance in Ohms*	*Inductance in Microhenrys*	*Current in Amperes for 40° C Rise*	*Maximum Allowable Dissipation in Watts*	*Code Word*	*Price*
663-A	1	0.0065	1.4	2.0	PANIC	$8.50
663-B	2	0.013	1.0	2.0	PARTY	8.50
663-C	5	0.015	0.5	1.25	PATTY	8.50
663-D	10	0.029	0.35	1.22	PEDAL	8.50
663-E	20	0.032	0.2	.80	PENAL	8.50
663-F	50	0.034	0.1	.50	PENNY	8.50
663-G	100	0.039	0.06	.36	PETTY	8.50

TYPE 500 RESISTOR

USES: The TYPE 500 Resistors are particularly recommended as resistance standards for use in impedance bridges and as secondary standards for laboratory use. The plug-type terminals make them readily interchangeable in experimental equipment. Screw terminals are also supplied for more permanent installations.

DESCRIPTION: This resistor is an accurately adjusted resistance card, sealed in a phenolic case to exclude moisture and to provide protection from mechanical damage.

FEATURES: ➔ Convenient and accurate.
➔ Negligible thermal emf to copper.
➔ Low temperature coefficient of resistance.
➔ Excellent high-frequency characteristics.

SPECIFICATIONS

Accuracy of Adjustment: ±0.05% at the terminals, except for the 1-ohm unit, which is adjusted within ±0.15%.

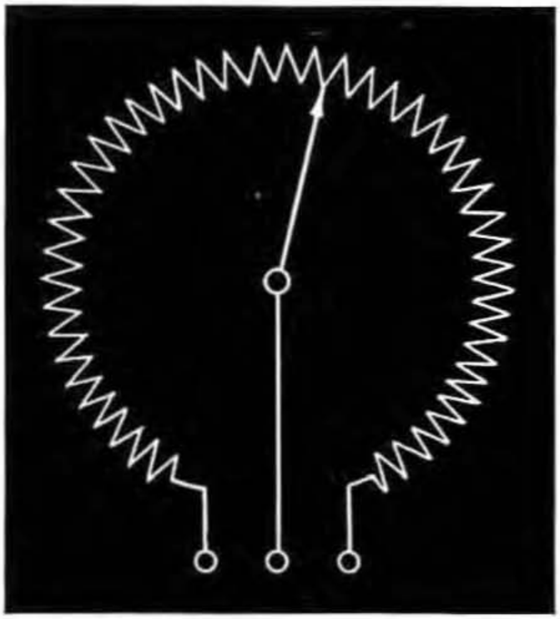
Frequency Characteristics: Similar to those of the TYPE 510 Decade-Resistance Units for resistance values up to 600 ohms; somewhat better for higher resistances, because of the relatively small shunt capacitance of an isolated resistor.

Maximum Power and Current: All units will dissipate one watt for a temperature rise of 40° Centigrade. The value of current for this rise is given in the table below and is engraved on each unit.

Temperature Coefficient: Less than ±0.002% per degree Centigrade at normal room temperature.
Type of Winding: Less than 200 ohms, Ayrton-Perry; 200 ohms and higher, unifilar on thin mica cards.
Terminals: Both terminal screws and plugs are supplied. Each terminal stud is recessed as a jack to accommodate a plug. Standard ¾-inch spacing is used.
Mounting: Black molded phenolic case sealed with high-melting-point wax. Two mounting holes are provided, spaced 2¼ inches, for No. 16 drill.
Dimensions: (Length) 2¾ x (width) 1⁵⁄₁₆ inches. Overall height, exclusive of plugs, 1 inch.
Net Weight: 2 ounces.

Type	*Resistance in Ohms*	*Maximum Current*	*Code Word*	*Price*
500-A	1	1.0 a	RESISTBIRD	$4.00
500-B	10	310 ma	RESISTDESK	4.00
500-K	20	220 ma	RESISTFILM	4.00
500-C	50	140 ma	RESISTFORD	4.00
500-D	100	100 ma	RESISTFROG	4.00
500-E	200	70 ma	RESISTGIRL	4.00
500-F	500	45 ma	RESISTGOAT	4.00
500-G	600	40 ma	RESISTGOOD	4.00
500-H	1000	30 ma	RESISTHYMN	4.00
500-L	2000	22 ma	RESISTBELL	4.00
500-M	5000	14 ma	RESISTPIPE	4.00
500-J	10,000	10 ma	RESISTMILK	4.00

RHEOSTATS AND VOLTAGE DIVIDERS



Variable resistors and voltage dividers are useful in assembling experimental equipment where tube voltages and circuit elements are to be varied until the final design is obtained. In standard equipment, such as oscillators, bridges, test equipment, and industrial instruments, many manufacturers find General Radio rheostats extremely useful as filament- and plate-supply controls, output controls, bridge arms, and as parts of almost any instrument where variable resistances are needed. Units with special resistance values or tolerances can be made to order. In addition to the ordinary linear models, certain tapered units of both the straight and logarithmic type can be made to satisfy particular requirements.

The resistance wire is wound on a strip of linen- or nylon-reinforced phenolic insulating material, which is then bent around and fastened to the molded supporting form.

Wires are wound as closely as possible in order to get the maximum number of turns and hence maximum fineness of setting for a given resistance.

Shafts are supplied in phenolic or stainless steel, depending upon the model. The phenolic material is chosen to have a high degree of surface hardness. All shafts are centerless ground. Shafts turn in accurately machined brass bushings which are molded into the phenolic form. Construction is so arranged that the shaft may extend through either or both ends of the rheostat.

All models are provided with mounting holes and with terminals which connect to both ends of the winding and to the contact arm. This arm is in continuous contact with the winding, and there is no "off" position.

General Radio rheostats and voltage dividers are manufactured in five basic models under several different types of construction. The essential features of each type of design are listed below.

GENERAL SPECIFICATIONS

Accuracy: All types are wound to an accuracy of ±5% of the nominal maximum-resistance values listed.

Maximum Current: The maximum current is the current which will produce the rated power dissipation when flowing through the entire winding. This current should not be exceeded in any portion of the winding.

Terminals: Screw terminals with tinned soldering lugs are provided on all models.

Accessories: All models are supplied with the necessary screws and nuts for mounting, a template for laying out the mounting holes, and pointer-type knob.

Mounting: All models can be arranged for either table or panel mounting.

Dimensions: Over-all size and mounting dimensions are shown on the sketches.

Power Rating: In the table below are given the approximate power ratings of the various models for a temperature rise of from 50 to 60 degrees Centigrade for open shelf or panel mountings. When units are mounted in enclosed spaces, slightly higher temperature rises or somewhat reduced ratings are to be expected.

Wire: Various kinds of resistance wire are used on the standard models. Their characteristics are listed in the table below.

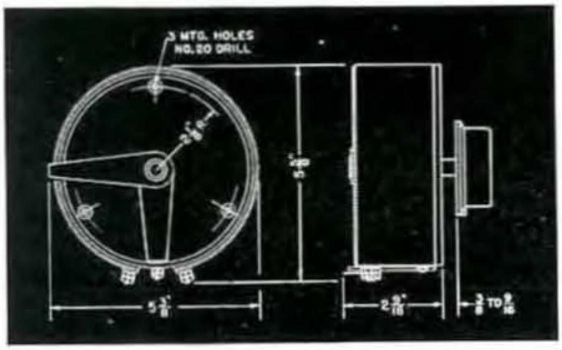
Wire	*Composition*	*Ohms per Circular Mil Foot*	*Temp. Coeff. of Resistance (20–100°C)*	*Thermal EMF to Copper*
A	Copper Nickel (Constantan)	294	±20 in 10^6	−43 μV/°C
L	Copper Nickel	60	+710	—
N	Nickel-Chromium-Iron	675	+170	+25
E	Nickel-Chromium (modified)	800	+ 20	+ 1
R	Chromium-Aluminum-Iron	800	+ 70	—

TYPE 433-A RHEOSTAT-POTENTIOMETER

The very high resistance (500,000 ohms) of this rheostat-potentiometer is made possible by the large (5-inch) winding form. Contact with the winding is made by a specially formed phosphor-bronze blade. A linen-bakelite strip protects the outer surface of the winding from mechanical damage.

The Type 433-AJ is equipped with a justifying mechanism which can be adjusted in terms of Wheatstone Bridge measurements to compensate for small variations in wire, and to produce a linear resistance variation.

Maximum Dissipation: 25 watts.
Maximum Current: 7 ma.
Winding Length: 14¼ inches.
Useful Angle of Rotation: 322°



Shaft: ⅜-inch phenolic.
Knob: Type KNSP-10.
Wire: E (see table under General Specifications).
Net Weight: Type 433-A, 18 ounces; Type 433-AJ, 1½ pounds.
Approximate Number of Turns: 4300.

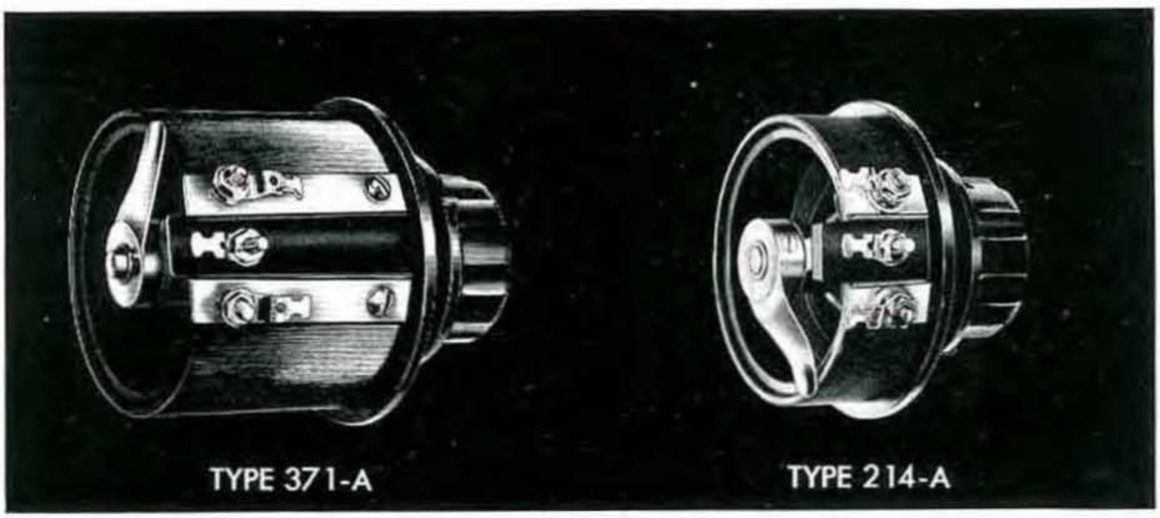
Type	*Maximum Resistance*	*Code Word*	*Price*
433-A	500,000 Ω	IMBUE	$16.50
433-AJ	(Type 433-A with Justifying Mechanism)	IMPEL	22.00

TYPE 371 AND TYPE 214

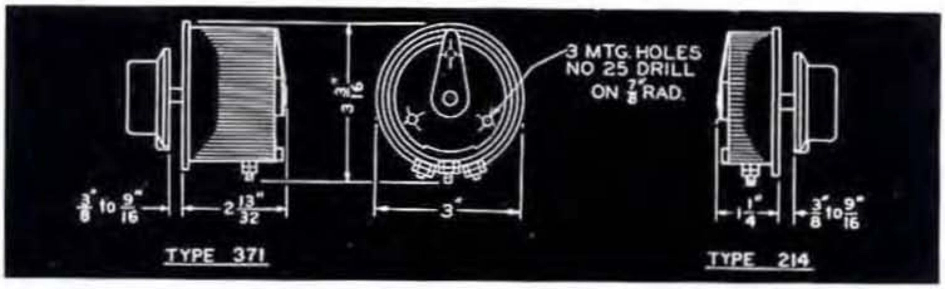
Type 371-A. The resistance wire is wound on a linen-phenolic strip, which is securely clamped to the supporting form. The contact arm is a specially formed single phosphor-bronze blade that provides smooth and firm contact with the edge of the winding.

Type 371-T. In this unit the resistance form is tapered linearly, so that the variation of resistance with angle of rotation follows a square law (the resistance-rotation derivative increasing with clockwise rotation of the knob in a panel-mounted unit).

Maximum Dissipation: Type 371-A, 15 watts (12 watts with protecting strip); Type 371-T, 8 watts.
Winding Length: 6¾ inches.
Useful Angle of Rotation: 303°.
Shaft: ¼-inch stainless steel.
Knob: Type KNSP-8.
Net Weight: 8 ounces.



TYPE 371-A TYPE 214-A



Type	*Maximum Resistance*	*Maximum Current*	*Approx. Turns*	*Wire*	*Code Word*	*Price*
371-A	**1,000 Ω**	120 ma	615	A	REDAN	**$5.00**
371-A	**2,000 Ω**	90 ma	765	A	REFIT	**5.00**
371-A	**5,000 Ω**	55 ma	990	A	ROTOR	**5.00**
***371-A**	**10,000 Ω**	34 ma	1185	A	ROWDY	**5.00**
***371-A**	**20,000 Ω**	24 ma	1020	N	RULER	**5.00**
***371-A**	**50,000 Ω**	16 ma	1525	N	SATYR	**5.00**
***371-A**	**100,000 Ω**	11 ma	1880	R	SEPOY	**5.00**
†*371-T	**10,000 Ω**	28 ma	1200	N	SULLY	**5.00**

* Supplied with linen-phenolic protecting strip.
† Tapered to give square-law variation of resistance with angle

Type 214-A. Similar to the Type 371-A in every respect except that the winding form is narrower. See dimension drawing above.

Maximum Dissipation: 10 watts
Knob: Type KNSP-8.
Net Weight: 6 ounces.

Type	*Maximum Resistance*	*Maximum Current*	*Approx. Turns*	*Wire*	*Code Word*	*Price*
214-A	**10 Ω**	1.0 a	200	A	RURAL	**$3.00**
214-A	**20 Ω**	0.7 a	250	A	RAZOR	**3.00**
214-A	**50 Ω**	450 ma	300	A	RAPID	**3.00**
214-A	**100 Ω**	320 ma	365	A	RIVET	**3.00**
214-A	**200 Ω**	220 ma	475	A	EMPTY	**3.00**
214-A	**500 Ω**	140 ma	600	A	ROSIN	**3.00**
214-A	**1,000 Ω**	100 ma	740	A	ENACT	**3.00**
214-A	**2,000 Ω**	70 ma	950	A	SYRUP	**3.00**
***214-A**	**5,000 Ω**	40 ma	1100	A	ROWEL	**3.00**
***214-A**	**10,000 Ω**	28 ma	1250	N	RUMOR	**3.00**

* Supplied with linen-phenolic protecting strip.

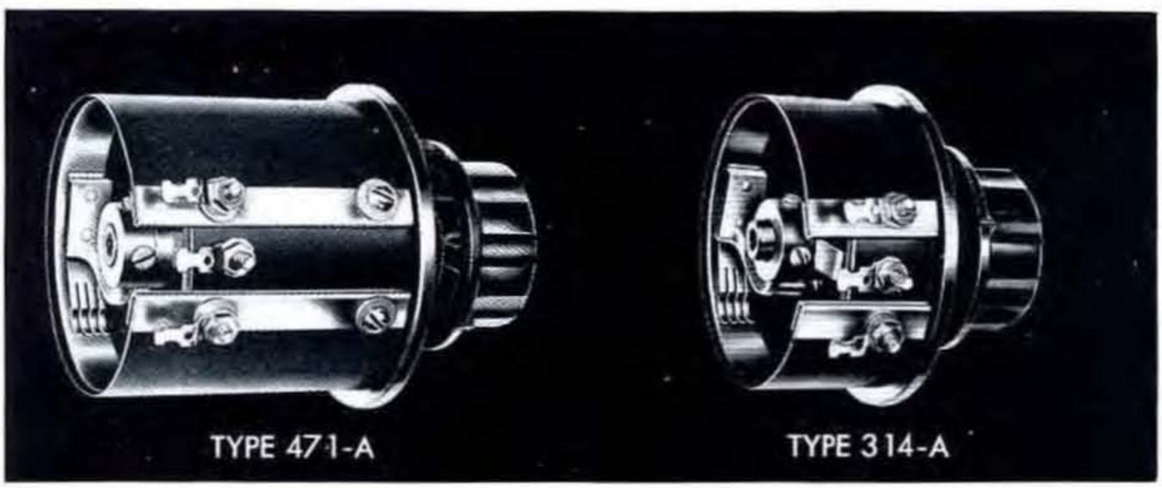
TYPE 471 AND TYPE 314

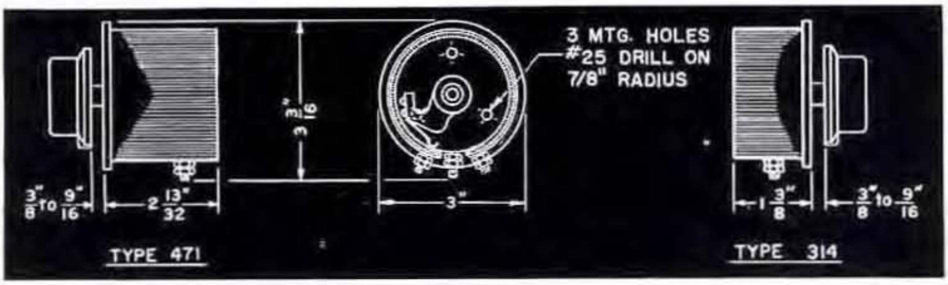
Type 471-A. A high grade unit suitable for use in high-impedance circuits.

Windings are protected from mechanical damage or disturbance by an external protecting strip of linen phenolic.

An inside contact arm, bearing four separate wiping fingers, insures extremely smooth operation

Maximum Dissipation: 12 watts
Winding Length: $6\frac{5}{8}$ inches.
Useful Angle of Rotation: 300°.
Shaft: $\frac{3}{8}$-inch phenolic.
Knob: Type KNSP-8.
Net Weight: 8 ounces.


TYPE 471-A TYPE 314-A



Type	Maximum Resistance	Maximum Current	Approx. Turns	Wire	Code Word	Price
*471-A	10,000 Ω	35 ma	770	N	ERECT	$7.00
*471-A	20,000 Ω	25 ma	1120	N	HUMAN	7.00
*471-A	50,000 Ω	15 ma	1450	N	ERODE	7.00
*471-A	100,000 Ω	10 ma	1620	R	ERUPT	7.00
*471-A	200,000 Ω	8 ma	2000	R	ESKER	7.00

* Supplied with linen-phenolic protecting strip.

Type 314-A. Similar to Type 471-A in every respect except that the winding form is narrower.

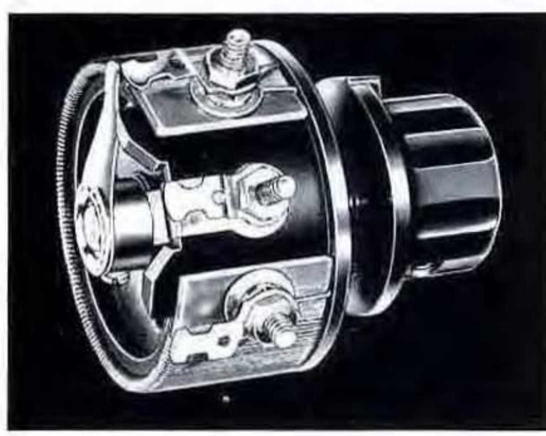
Maximum Dissipation: 8 watts.
Knob: Type KNSP-8.
Net Weight: 6 ounces.

Type	Maximum Resistance	Maximum Current	Approx. Turns	Wire	Code Word	Price
*314-A	1,000 Ω	90 ma	690	A	DIVAN	$5.00
*314-A	2,000 Ω	65 ma	860	A	ENEMY	5.00
*314-A	5,000 Ω	40 ma	1050	A	ENJOY	5.00
*314-A	10,000 Ω	28 ma	1200	N	DIVER	5.00
*314-A	20,000 Ω	20 ma	1460	N	ENROL	5.00
*314-A	50,000 Ω	13 ma	1640	R	DONAX	5.00
*314-A	100,000 Ω	9 ma	2000	R	DONGA	5.00

* Supplied with linen-phenolic protecting strip.

TYPE 301

Type 301-A. A small, compact unit similar in construction to the Type 214.
Maximum Dissipation: 4 watts without protecting strip (5 Ω–1,000 Ω). 3 watts with protecting strip (2,000 Ω–20,000 Ω).
Winding Length: 3¾ inches.
Useful Angle of Rotation: 258°.
Shaft: ¼-inch stainless steel.
Knob: Type KNSP-6.
Net Weight: 3 ounces.



Type	Maximum Resistance	Maximum Current	Approx. Turns	Wire	Code Word	Price
301-A	5 Ω	0.9 a	120	L	PALSY	$2.25
301-A	10 Ω	0.65 a	165	L	REMIT	2.25
301-A	20 Ω	450 ma	160	L	RENEW	2.25
301-A	50 Ω	280 ma	190	A	RIFLE	2.25
301-A	100 Ω	200 ma	235	A	RIGID	2.25
301-A	200 Ω	140 ma	300	A	REBUS	2.25
301-A	500 Ω	90 ma	375	A	RIVAL	2.25
301-A	1,000 Ω	65 ma	475	A	RAVEL	2.50
*301-A	2,000 Ω	39 ma	550	A	READY	2.50
*301-A	5,000 Ω	24 ma	630	N	ROMAN	2.75
*301-A	10,000 Ω	17 ma	780	N	CURRY	2.75
*301-A	20,000 Ω	12 ma	840	R	CRUMB	2.75

* Supplied with linen-phenolic protecting strip.

STANDARD CAPACITORS

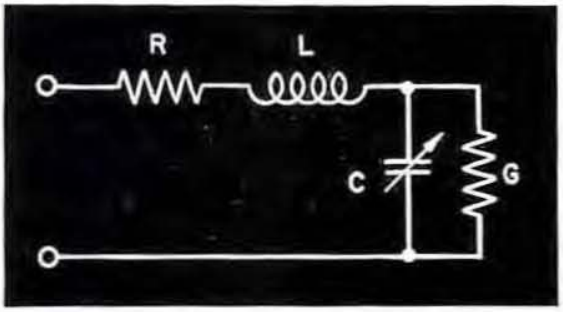


FIGURE 1. The equivalent circuit of a variable air capacitor C. R represents the series metallic resistance, L the inductance, and G the dielectric conductance.

1. AIR-DIELECTRIC CAPACITORS

The characteristics of a properly designed air capacitor approach very closely those of an ideal circuit element. Whether the capacitor is fixed or variable, a low temperature coefficient, low losses, and a high degree of stability can be achieved.

For many measurements, and over a wide range of frequency, such a capacitor can be considered as having a terminal impedance defined solely by its electrostatic capacitance. However, for the most accurate measurements at audio frequencies or for measurements at radio frequencies, the small deviations from ideal performance must be examined and evaluated. Figure 1 is an equivalent circuit showing the static capacitance and the residual impedances representing series (metallic) resistance, series inductance, and shunt (dielectric) conductance.

At low frequencies only the conductance (G) need be considered. This component represents (a) the dielectric losses in the supports, (b) the losses in the air dielectric, and (c) the d-c leakage conductance. The effect of the leakage conductance is negligible at frequencies above a few cycles, and is ordinarily of importance only when the capacitor is used at dc, i.e., for charge storage. The losses in the air dielectric are negligible under conditions of moderate humidity and temperature. The dielectric losses in the insulating structure give rise to an effective conductance component which ordinarily increases directly with frequency (i.e., the dissipation factor of the insulation is approximately constant with frequency).

The dissipation factor of the capacitor is defined as

$$D = \frac{G}{\omega C} \qquad (1)$$

It will be seen from (1) that $\frac{G}{\omega}$, the product of capacitance and dissipation factor, is independent of C. Accordingly, this product is a convenient figure of merit for variable air capacitors, as it is independent of the setting of the capacitor.

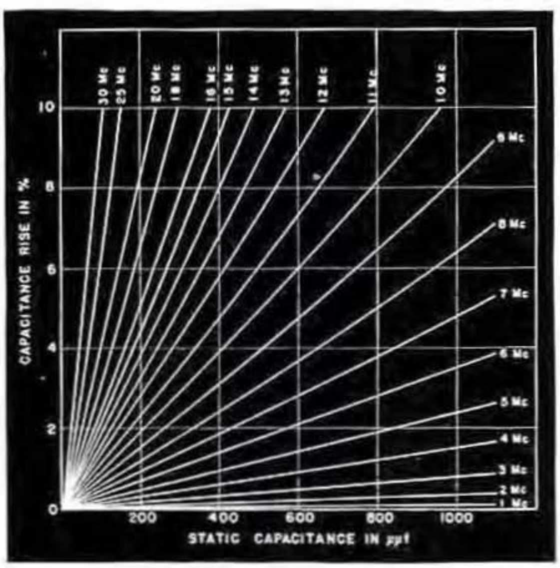
As frequency is progressively increased, the impedances of R and L become significant compared to the reactance of C and must be taken into account.

R represents the metallic resistance in the leads, stack supports, and plates. It ordinarily is not significant except at frequencies where skin effect is essentially complete, under which condition its value varies as the square root of frequency. The total dissipation factor of the capacitor when the resistance R is taken into account is

$$D = \frac{G}{\omega C} + R\omega C \qquad (2)$$

L represents the inductance of the current path between terminals. It is largely concentrated in the leads and supporting members, and as a consequence is nearly independent of setting in a variable capacitor. The variation

FIGURE 2. The amount by which the effective terminal capacitance of a precision capacitor differs from the low frequency values, plotted as a function of static capacitance (dial readings) for various frequencies. The plot shown is for TYPE 722-N, whose series inductance is approximately .024 μh. TYPES 722-D and 722-M have approximately three times as much series inductance. Their performance can be estimated from the plot by entering at three times the capacitance, or at 1.7 times the frequency.



in effective terminal capacitance caused by L is given by the expression

$$C_e = \frac{C}{1 - \omega^2 LC} \qquad (3)$$

Variations of C_e for a TYPE 722 Precision Condenser are given in Figure 2 as a function of frequency, for various settings.

2. FIXED SOLID-DIELECTRIC CAPACITORS

The same residual impedances shown in Figure 1 for air capacitors are present in solid-dielectric capacitors, but, because of a different mechanical structure and because the capacitance is concentrated in the solid dielectric, their relative magnitudes are different.

The effects of interfacial polarization in the dielectric are shown by the low-frequency portions of Figure 3, *a* and *b*. On these log-log plots the slope of the lines is characteristic of the dielectric material. At very low frequencies, the d-c leakage conductance adds a component to the dissipation factor, but does not affect capacitance. It is normally negligible, even at 10 cycles per second.

At high frequencies, the series residuals cause dissipation factor to increase as the 3/2 power of frequency, while the fractional change in capacitance increases as the square of frequency (See Equation 3).

Fractional change in capacitance and dissipation factor each have a minimum value, which occurs at a frequency that varies inversely with capacitance and that can be as low as 1 kc and as high as 10 Mc. For small capacitances, where the effect of series resistance appears only at very high frequencies, a residual polarization, having a dissipation factor constant with frequency, sets a minimum value for dissipation factor. It is also in this frequency range around 1 Mc that the effect of dipole polarization occurs. Dielectrics ordinarily used for capacitors rarely show the effects of this polarization.

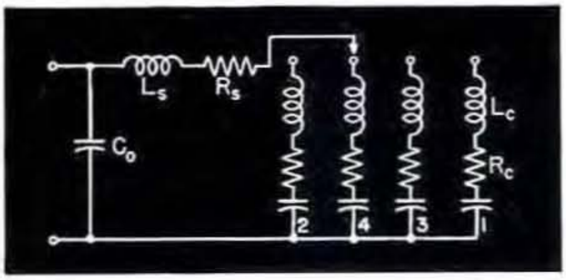


FIGURE 4. Equivalent circuit of a TYPE 380 Decade-Capacitor Unit showing the additional residual impedances produced by the switches and wiring.

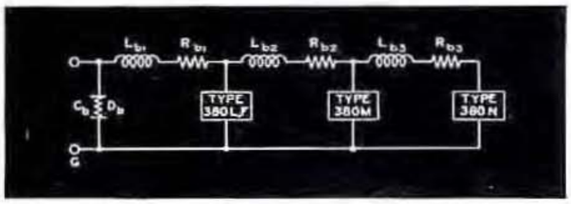
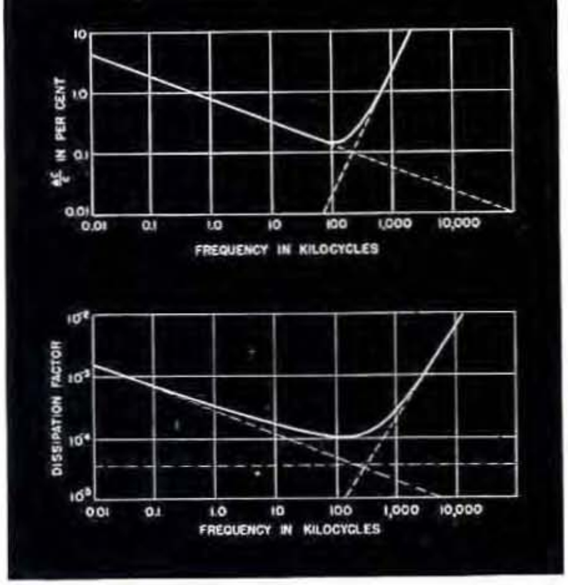


FIGURE 5. Equivalent circuit of a TYPE 219 Decade Condenser.

FIGURE 3. The variation, with frequency, of capacitance, *a* (*top*), and dissipation factor, *b* (*bottom*), of a fixed solid-dielectric capacitor.



When capacitors are assembled into decades, as in the TYPE 380 Decade-Capacitor Units, the series residuals are increased by the switch as shown in Figure 4. There is also a terminal capacitance with dielectric loss. The assembling of several decades into a TYPE 219 Decade Condenser adds more series residuals and more terminal capacitance, as shown in Figure 5. The solution of these more complicated networks is discussed in the *General Radio Experimenter*, Vol. XVII, No. 5, October 1942.

Because there is no frequency at which capacitance has reached a constant value, each General Radio capacitor is adjusted to have its nominal value of capacitance at 1 kc.

TYPE 722 PRECISION CONDENSER

Panel View of the TYPE 722-D Precision Condenser.

USES: The TYPE 722 Precision Condenser is a stable and precise variable air capacitor intended for use as a standard of capacitance.

It is widely used in a-c bridges, both as a built-in standard and as an external standard for substitution measurements. It is also used as a tuning capacitor in oscillators, frequency meters, and other instruments where highest accuracy and stability are important.

DESCRIPTION: The entire capacitor assembly is mounted in a cast frame, which gives the unit rigidity. This frame, the stator rods and spacers, and the rotor shaft are made of the best available alloys of aluminum, which combine the mechanical strength of brass with the weight of aluminum. The plates are of aluminum, so that all parts have the same temperature coefficient of linear expansion.

A worm drive is used to obtain the desired high precision of setting. In order to avoid the slight eccentricity that occurs when a worm gear is mounted on a shaft, the shaft and the worm are one accurately machined piece. The dial end of this worm shaft runs in a self-aligning ball bearing, while the other end is supported by an adjustable spring mounting. Sealed, self-lubricating ball bearings, lightly stressed, are used at both ends of the rotor shaft. Electrical connection to the rotor is made, not through the bearing, but by means of a phosphor-bronze brush running on a brass drum to assure a positive electrical contact.

The preliminary assembly of the frame, shaft, and gears is motor driven to grind in the gears before final assembly.

FEATURES: ➔ High stability.

➔ High precision of setting — one part in 25,000 of full scale.

➔ High accuracy.

➔ Low backlash.

➔ Low temperature coefficient of capacitance.

➔ Low dielectric losses.

➔ Direct reading in capacitance.

SPECIFICATIONS

Capacitance Range: Two stock models are available: TYPE 722-D, direct reading in capacitance over two ranges, 25 to 110 μμf, and 100 to 1110 μμf; TYPE 722-M, intended for bridge-substitution measurements and direct reading in capacitance *removed* from the capacitor over a range of 0 to 1000 μμf.

Rotor Plate Shape: Semicircular for all models, to give a linear capacitance characteristic.

Standard Calibration Accuracy:

Type 722-D: The capacitance, measured at 1 kc, of the HIGH section, 100 to 1100 μμf, is indicated directly in micromicrofarads by the dial and drum readings within ±1 μμf. The capacitance of the LOW section, 25 to 110 μμf, is indicated directly in micromicrofarads by one-tenth of the dial and drum readings within ±0.2 μμf.

Type 722-M: The capacitance at a reading of zero for the dial and drum is indicated on a calibration card mounted on the panel. This capacitance, about 1150 μμf is given to 0.1 μμf and is accurate within ±1 μμf. The capacitor is adjusted to indicate directly in micromicrofarads the capacitance *removed* from the circuit to an accuracy of ±1 μμf.

Both Types: In addition, a correction chart is supplied giving corrections to 0.1 μμf, at multiples of 100 μμf. By using these data the direct-reading accuracy which can be obtained for the HIGH section of the TYPE 722-D is ±0.1% or ±0.4 μμf, whichever is the greater, and capacitance differences can be measured to ±0.1% or ±0.5 μμf, whichever is the greater. For the LOW section of the TYPE 722-D an accuracy of ±0.1 μμf can be obtained for both direct capacitance and capacitance differences. Capacitance differences for the TYPE 722-M can also be obtained to ±0.1% or ±0.5 μμf, whichever is the greater.

The usable accuracy at the terminals may still be limited to approximately 1 μμf, unless a standard technique is used by the operator for connecting the capacitor into a measuring circuit. (See *General Radio Experimenter*, Vol. XXI, No. 12, May 1947, for a complete discussion of connection errors.)

Worm Correction Calibration: Corrections for the slight residual eccentricity of the worm drive can be supplied for both models at an extra charge indicated in the price list. Mounted charts are supplied, which give the corrections to at least one more figure than the guaranteed accuracies, which are stated below.

Type 722-D: When the worm correction is used, the capacitance of either section can be determined within ±0.1% or ±0.1 μμf, whichever is the greater, and capacitance differences can be measured to an accuracy of ±0.1% or ±0.2 μμf, whichever is the greater, with the HIGH section; and ±0.1% or ±0.04 μμf, whichever is the greater, with the LOW section.

Type 722-M: Capacitance differences, in capacitance removed, can be measured within ±0.1% or ±0.2 μμf, whichever is the greater.

Maximum Voltage: All models, 1000 volts, peak.

Dielectric Supports: Two bars of low-loss steatite support the stator assembly, and conical polystyrene bushings insulate the terminals from the panel. Quartz insulation, coated with a silicone resin to prevent formation of a water film, can be supplied on special order. (See price list.)

Dielectric Losses: The figure of merit, *DC* (dissipation factor times capacitance), when measured at 1 kc, is approximately 0.01 μμf for steatite insulation and 0.003 μμf for quartz.

Residual Parameters: Representative values of series inductance and series metallic resistance are given in the following table:

Type	*L*	*R at 1 Mc*
722-D		
high section	0.065 μh	0.02 Ω
low section	0.11 μh	0.03 Ω
722-M	0.060 μh	0.02 Ω

The series resistance varies as the square root of the frequency for frequencies above 100 kc.

Frequency Characteristic: See Figure 2, page 44, for plot of variation of capacitance with frequency.

Temperature Coefficient of Capacitance: Approximately +0.002% per degree Centigrade, for small temperature changes.

Backlash: Less than one-half division corresponding to .01% of full scale value. If the desired setting is always approached in the direction of increasing scale reading, no error from this cause will result.

Terminals: Jack-top binding posts are provided. Standard ¾-inch spacing is used. The rotor terminal is connected to the panel and shield.

Mounting: The capacitor is mounted on an aluminum panel finished in black crackle lacquer and enclosed in a shielded walnut cabinet. A wooden storage case with lock and carrying handle is supplied.

Dimensions: Panel, 8 x $9\frac{1}{8}$ inches; depth, $8\frac{1}{8}$ inches.

Weight: $10\frac{1}{2}$ pounds; $19\frac{3}{4}$ pounds with carrying case.

Type	*Capacitance Range*	*Code Word*	*Price*
722-D	**25 to 110 μμf** and **100 to 1100 μμf,** direct reading	CRUEL	**$205.00**
722-M	**0 to 1000 μμf,** direct reading in capacitance removed from circuit	COMIC	**175.00**
Worm-Correction Calibration for Type 722-M		WORMY	**50.00**
Worm-Correction Calibration for Type 722-D		WORMY	**70.00**

When ordering, use compound code word, CRUELWORMY, etc.

QUARTZ INSULATION

Any TYPE 722 Precision Condenser can be obtained with quartz insulation.

Type		*Code Word*	*Price*
722-MQ	**Type 722-M with Quartz Insulators**	COMICQUATZ	**$240.00**
722-DQ	**Type 722-D with Quartz Insulators**	CRUELQUATZ	**290.00**
722-NQ	**Type 722-N with Quartz Insulators**	BOXERQUATZ	**265.00**

TYPE 722-N PRECISION CONDENSER

(FOR USE AT RADIO FREQUENCIES)

USES: This capacitor has been designed particularly for use as a standard at radio frequencies in series- or parallel-resonance methods of impedance measurement. It is also useful as a variable capacitor in radio-frequency bridges.

DESCRIPTION: The frame, bearing, and drive mechanism of this capacitor are identical with those used on the other TYPE 722 Precision Condensers. The rotor and stator leads, however, are not brought out in the conventional manner. Connection is made at the center of both plate stacks to minimize residual inductance and resistance.

The rotor connection is made by spring-temper silver-alloy brushes bearing on a silver-overlay brass disc.

FEATURES: The important features of this capacitor are its low metallic resistance and low inductance. Both of these quantities are about one-third the magnitude of those in the TYPE 722-D. The accuracy of calibration is as good and the dielectric losses nearly as low as in the other TYPE 722 Condensers.

SPECIFICATIONS

Capacitance Range: 100 to 1100 μμf, direct reading.

Standard Calibration Accuracy: The capacitance, measured at 1 kc, is indicated directly in micromicrofarads by the dial and drum readings to ±1 μμf.

A correction chart is supplied giving corrections to 0.1 μμf at multiples of 100 μμf. By using these data the direct-reading accuracy is ±0.1% or ±0.4 μμf, whichever is the greater, and the accuracy for capacitance differences is ±0.1% or ±0.5 μμf, whichever is the greater.

Worm Correction Calibration: A worm correction can be supplied on special order. (See price list.) A mounted chart is supplied giving the corrections to at least one more figure than the guaranteed accuracy stated below.

When the worm correction is used, the capacitance can be determined within ±0.1% or ±0.1 μμf, whichever is the greater, and capacitance differences can be measured to an accuracy of ±0.1% or ±0.2 μμf, whichever is the greater.

Dielectric Supports: Two bars of steatite support the stator assembly, and a third bar insulates the high terminal from the panel. Quartz insulation can be supplied on a special order. See price list on preceding page.

Dielectric Losses: The figure of merit, *DC* (dissipation factor times capacitance), when measured at 1 kc, is approximately 0.05 μμf. (See discussion on page 44.)

Other Residual Parameters: The series metallic resistance is about 0.008 ohm at 1 megacycle and increases directly as the square root of the frequency. The dielectric and metallic losses are approximately equal at a setting of 1000 μμf and a frequency of 1 Mc.

The series inductance is approximately 0.024 μh. The increase in capacitance caused by this inductance reaches 10% at a setting of 1000 μμf and a frequency of 10 Mc.

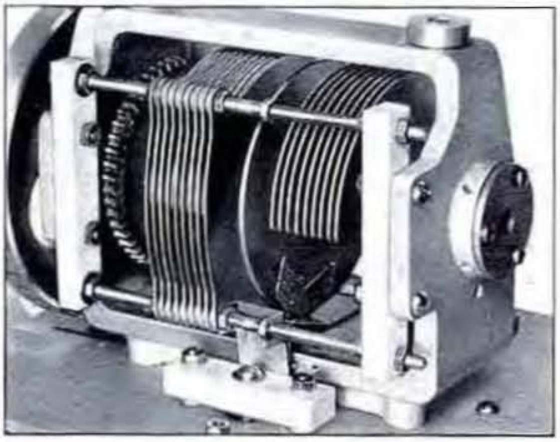
At smaller capacitance settings the effects of residual parameters are less. The equal division of losses occurs at 20 Mc for a setting of 100 μμf and the 10% capacitance rise occurs at 30 Mc for the same setting.

Frequency Characteristic: See Figure 2, page 44, for plot of variation of capacitance with frequency.

Dimensions: Panel, 8 x 9½ inches; depth, 8½ inches.

Net Weight: 11¼ pounds; 20½ pounds with carrying case.

Other specifications are identical with those of Type 722-D, page 46.



Interior photograph of a Type 722-N Precision Condenser with half the stator removed, showing the leads and the method of connection to the rotor.

Type		*Code Word*	*Price*
722-N	**100 to 1100 μμf,** direct reading	BOXER	**$180.00**
Worm-Correction Calibration		WORMY	**50.00**

When ordering, use compound code word, BOXERWORMY.

TYPE 1401 FIXED AIR CAPACITOR

USES: The Type 1401 Fixed Air Capacitor is an air dielectric fixed capacitor for use as a laboratory standard. It supplements the Type 509 series of fixed standard capacitors and provides a stable, low-loss standard in the low-capacitance range.

DESCRIPTION: The plate assemblies are supported from a low-loss end plate, which in turn is attached to an aluminum casting. The casting, together with a cylindrical aluminum case, provides a complete shield and dust-free enclosure. Six support rods are used for each of the plate assemblies, assuring a high degree of rigidity and stability.

FEATURES: → High accuracy. → Low losses. → Excellent stability. → Convenient size.

SPECIFICATIONS

Capacitance: Two sizes are available, 100 μμf (1401-A) and 1000 μμf (1401-D).

Accuracy of Adjustment: ±0.1% for the 1401-D; ±0.25% for the 1401-A. These accuracies apply when connection is made to the capacitors in a specified manner, using a fine wire perpendicular to the binding posts. For other methods of connection, further uncertainty, approaching 1 μμf, may be introduced.

Dissipation Factor: For Type 1401-A, less than 0.00004; for Type 1401-D, less than 0.00001, measured at 1 kc under ASTM standard laboratory conditions (23° C and 50% RH).

Maximum Voltage: Maximum peak voltage 1500 volts for 1401-A; 700 volts for 1401-D.

Terminals: Type 938 jack-top binding posts on standard ¾-inch spacing. A pair of doubled ended plugs is supplied, to permit connection to jack-top binding posts, with small and known connection capacitance.

Dimensions: Diameter, 3¼ inches, height, over-all, 4¼ inches.

Net Weight: 1401-A, 13 ounces; 1401-D, 1 pound.

Type	*Capacitance*	*Code Word*	*Price*
1401-A	**100 μμf**	HABIT	**$37.00**
1401-D	**1000 μμf**	HANDY	**42.50**

TYPE 505 CAPACITOR

USES: The Type 505 Capacitors are used as secondary laboratory standards and as high-quality circuit elements. An assortment of various sizes is a valuable addition to any communications laboratory.

DESCRIPTION: The capacitor unit consists of a mica and foil pile, which is held by a heavy metal clamp for mechanical rigidity. This clamp is not connected to either capacitor terminal but is left floating. After aging, the capacitor unit is placed in the low-loss phenolic case, surrounded by silica gel to provide perpetual dessication and ground cork to absorb shock, and then sealed with wax.

FEATURES: ➔ Small, convenient, and accurate.

➔ Has both screw- and plug-type terminals. Units can be stacked in parallel with only small cumulative connection errors.

➔ Dielectric is best, selected, India, ruby mica.

➔ Low temperature coefficient of capacitance.

➔ Units are heated to eliminate moisture before sealing and internal humidity held to low value by dessicant.

➔ Low-loss case to reduce dissipation factor and leakage conductance.

SPECIFICATIONS

Accuracy of Adjustment: ±1% or ±10 μμf, whichever is the larger.

Temperature Coefficient: Less than +0.01% per degree Centigrade between 10° and 50° Centigrade. Calibration is made at 25° C.

Dissipation Factor: Less than 0.0005 for all except the three smallest units, measured at 1 kc and at 25° Centigrade. For the Types 505-A, 505-B, and 505-E, less than 0.0010, 0.0008, and 0.0006, respectively. A change of about +5% of its value occurs in the dissipation factor for a temperature rise of 1° Centigrade.

Frequency Characteristics: See plots, page 50. Series inductance is approximately 0.055 μh for units in small case and 0.085 μh for large case. Series resistance at 1 Mc is approximately 0.03 ohm for small case and 0.05 ohm for large case, varying as square root of frequency above 100 kc.

Leakage Resistance: Greater than 100,000 megohms, when measured at 500 volts, except for the Types 505-U and 505-X, for which it is greater than 50,000 and 20,000 megohms, respectively.

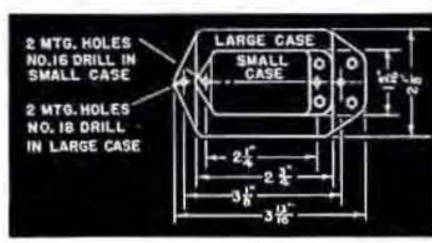
Maximum Voltage: In the table the voltages shown hold below the tabulated limiting frequencies. At higher frequencies the allowable voltage decreases and is inversely proportional to the square root of the frequency. These limits correspond to a temperature rise of 40° Centigrade for a power dissipation of 1 watt for the small case and 2.5 watts for the large case.

Terminals: Screw terminals spaced ¾ inch apart. Two Type 274-P Plugs are supplied with each capacitor.

Mounting: Mica-filled, low-loss phenolic cases.

Dimensions: See sketch. Over-all height, 1⅝ inches for large case, 1 inch for small case, exclusive of plugs.

Net Weight: See table.



Type	*Capacitance*	*Peak Volts*	*Frequency in kc*	*Weight in Ounces*	*Code Word*	*Price*
505-A	100 μμf	700	2000	4	CONDENALLY	$ 6.00
505-B	200 μμf	700	1000	4	CONDENBELL	6.00
505-E	500 μμf	500	1000	4	CONDENCOAT	6.50
505-F	0.001 μf	500	800	4	CONDENDRAM	6.50
505-G	0.002 μf	500	400	5	CONDENEYRE	6.50
505-K	0.005 μf	500	160	5	CONDENFACT	8.00
505-L	0.01 μf	500	80	5	CONDENGIRL	8.00
505-M	0.02 μf	500	40	6	CONDENHEAD	10.00
*505-R	0.05 μf	500	40	11	CONDENCALM	12.00
*505-T	0.1 μf	500	20	12	CONDENCROW	16.00
*505-U	0.2 μf	500	10	13	CONDENWIPE	23.00
*505-X	0.5 μf	500	4	15	CONDENWILT	35.00

*Mounted in large case

TYPE 509 STANDARD CAPACITOR

USES: These capacitors are fixed standards for laboratory use. When they are used in conjunction with a Type 722-D or a Type 722-M Precision Condenser in a parallel substitution method of measurement, precise measurements of capacitance up to several microfarads can be made. For capacitor manufacturers who maintain a capacitance stand-

ardization laboratory, a set of TYPE 509 Standard Capacitors used with a TYPE 716-C Capacitance Bridge, is recommended.

DESCRIPTION: Each TYPE 509 Standard Capacitor consists of two TYPE 505 Capacitor units which have been put through an additional aging process. The final accuracy and stability are thus increased markedly. The units are mounted in cast aluminum cases and are furnished with jack-top binding posts. Case is grounded to one terminal.

FEATURES: ➔ Stability within ±0.1% is obtained by carefully controlled aging.

➔ An accurate calibration, within ±0.1% is furnished with each unit.

➔ Plug-in terminals are arranged for convenience in using the capacitors. Several units can be stacked one upon the other without the use of leads and without cumulative error.

SPECIFICATIONS

Accuracy of Adjustment: Within ±0.25% of the nominal capacitance value engraved on the case.

Accuracy of Calibration: After each capacitor has been aged, adjusted, and mounted, its capacitance is carefully measured and the value of capacitance at 1 kc and 25° C, accurate within ±0.1%, is entered on a certificate of calibration which is packed with each unit.

Stability: Over reasonable periods of time (at least one year) each capacitor will maintain its calibrated value within ±0.1%.

Temperature Coefficient: Less than +0.01% per degree Centigrade between 10° and 50° Centigrade.

Dissipation Factor: Less than 0.0005 when measured at 1 kc and 25° Centigrade. See *D* curves below.

Frequency Characteristics: See plots below. Values of series inductance and series resistance at 1 Mc are given in the table below. This resistance varies as the square root of the frequency for frequencies above 100 kc.

Leakage Resistance: Greater than 100,000 megohms when measured at 500 volts, except for the TYPES 509-U, 509-X, and 509-Y, for which it is greater than 50,000, 20,000, and 10,000 megohms, respectively.

Maximum Voltage: 500 volts peak at frequencies below the limiting frequencies tabulated below. At higher frequencies the allowable voltage decreases and is inversely proportional to the square root of the frequency. These limits correspond to a temperature rise of 40° Centigrade for a power dissipation of 3 watts for the small case and 5 watts for the large.

Mounting: Cast aluminum cases with rubber feet.

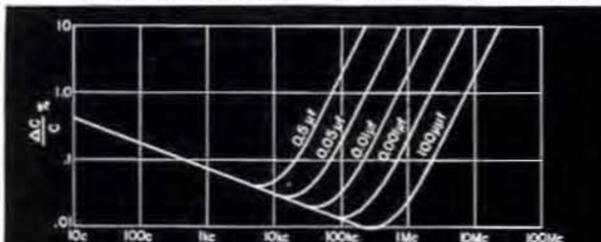
Terminals: Two jack-top binding posts spaced 3/4 of an inch apart are mounted on the case. One terminal is grounded, and the other one is insulated by means of a low-loss phenolic bushing.

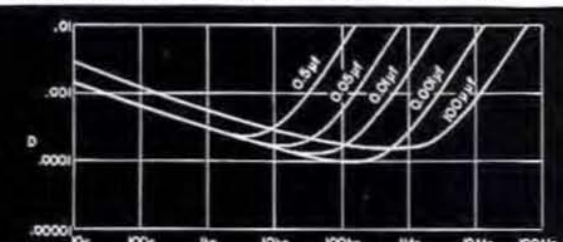
Dimensions: Small case, (length) 4 7/8 inches x (width) 2 1/2 inches x (height) 1 7/8 inches, over-all. Large case, (length) 6 inches x (width) 3 5/8 inches x (height 2 3/8 inches, over-all.

Type	*Capacitance in µf*	*Peak Volts*	*Frequency in kc*	*Series Inductance in µh*	*Resistance in ohms at 1 Mc*	*Weight in pounds*	*Code Word*	*Price*
509-F	**0.001**	500	2500	0.065	0.040	1 1/4	GOODCONBOY	**$30.00**
509-G	**0.002**	500	1250	0.065	0.040	1 1/4	GOODCONBUG	**30.00**
509-K	**0.005**	500	500	0.035	0.020	1 3/8	GOODCONCAT	**30.00**
509-L	**0.01**	500	250	0.035	0.020	1 3/8	GOODCONDOG	**30.00**
509-M	**0.02**	500	125	0.035	0.020	1 3/8	GOODCONEYE	**32.50**
***509-R**	**0.05**	500	80	0.040	0.025	2 3/4	GOODCONPIG	**35.00**
***509-T**	**0.1**	500	40	0.040	0.025	2 5/8	GOODCONROB	**39.00**
***509-U**	**0.2**	500	20	0.040	0.025	2 3/4	GOODCONSIN	**42.00**
***509-X**	**0.5**	500	8	0.040	0.025	3 1/4	GOODCONSUM	**54.00**
***509-Y**	**1.0**	500	4	0.050	0.030	3 5/8	GOODCONTOP	**78.00**

*Mounted in large case.

(*Left*) Change in capacitance as a function of frequency. These changes are referred to the values which the capacitors would have if there were neither interfacial polarization nor series inductance. Since the capacitors are adjusted to their nominal values at 1 kc, the 1-kc value on the plot should be used as a basis of reference in estimating frequency errors.
(*Right*) Dissipation factor as a function of frequency. Characteristics of TYPE 505 Capacitors are similar.





TYPE 219 DECADE CONDENSER

USES: The TYPE 219 Decade Condensers find uses in every laboratory as tuned circuit elements, bridge impedances, filter elements, or as components of any circuit where a wide-range variable capacitor is necessary.

DESCRIPTION: The TYPE 219 Decade Condensers are assemblies of three TYPE 380 Decade-Capacitor Units mounted in a shielded cabinet. Each decade has eleven positions, 0 to 10 inclusive, so that the decades overlap. A positive detent mechanism allows the switch to be set accurately.

FEATURES: ➔ A wide range of direct-reading capacitance values.

➔ Accuracy sufficient for most laboratory work.

➔ The zero capacitance has been kept at a minimum, and its value is marked on each box for ready reference.

➔ Dissipation factor has been held low by employing mica-dielectric capacitors on all decades except the 0.1-microfarad decade of the TYPE 219-M.

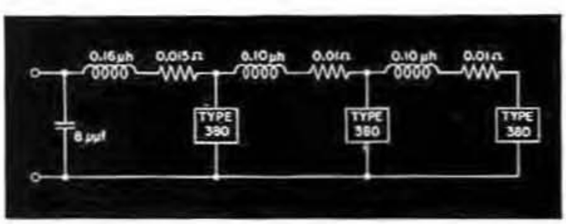
➔ Mica dielectric is used throughout the TYPE 219-K, which can therefore be used where the comparatively high losses of paper capacitors cannot be tolerated.

➔ Low-loss switches.

SPECIFICATIONS

Accuracy: All units are accurate for capacitance increments within ±1%, except the 0.1-microfarad decade of the TYPE 219-M which is within ±2%. The zero capacitance of the TYPE 219-K is 46 μμf and of the TYPE 219-M is 41 μμf.

Dissipation Factor: The dissipation factor for the individual decades is given in the specifications for the TYPE 380 Decade-Capacitor Units.



Residual impedances in the TYPE 219 Decade Condenser.

Maximum Voltage: These values for the different decades are given in the specifications for the TYPE 380 Decade-Capacitor Units. The limiting values for the different TYPE 219 Decade Condensers are engraved on the panel.

Frequency Characteristics: The variation of capacitance and dissipation factor with frequency is similar to that shown on page 53 for TYPE 380 Decade-Capacitor Units, modified by the additional residual impedances shown in the accompanying sketch. Detailed descriptions of these frequency characteristics are given in the *General Radio Experimenter*, Vol. XVII, No. 5, October 1942.

Terminals: Standard jack-top binding posts with a ¾-inch spacing are used. The shield is connected to the "G" terminal.

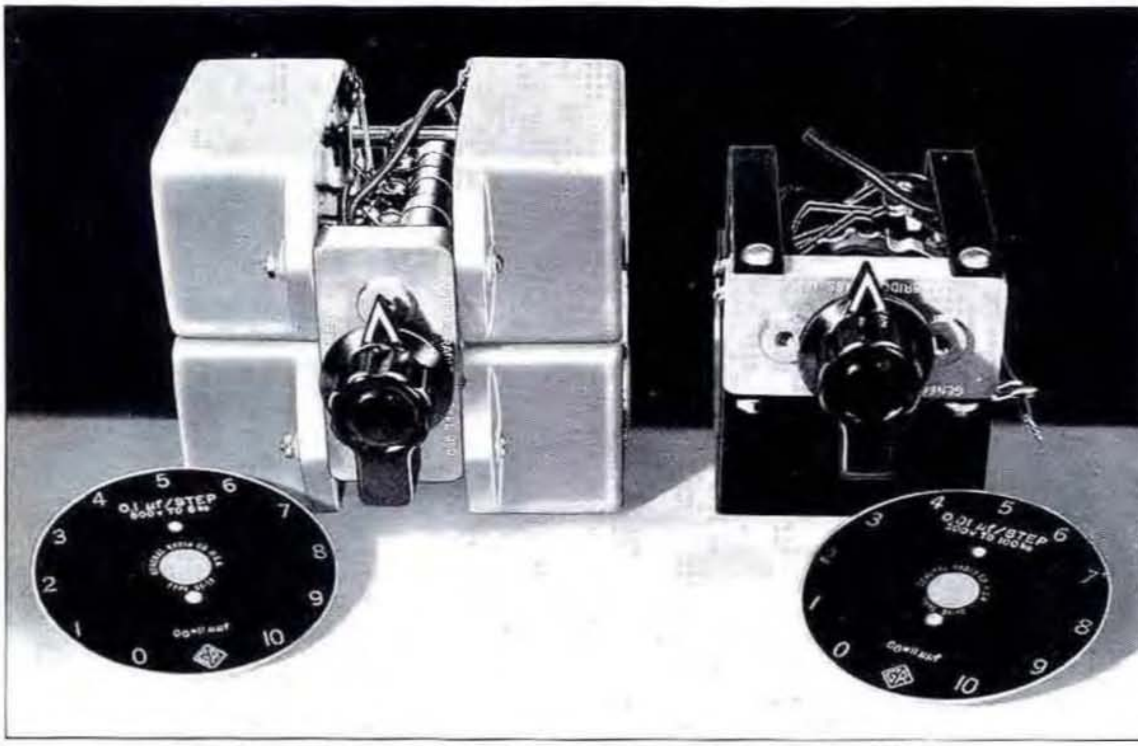
Mounting: The decades are assembled on an aluminum panel and mounted in a shielded walnut cabinet.

Dimensions: TYPES 219-K and 219-M, (length) 13¾ x (width) 5½ x (height) 5⅞ inches.

Net Weight: TYPE 219-K, 10¾ pounds; TYPE 219-M, 8⅝ pounds.

Type	*Capacitance*	*No. of Dials*	*Type 380 Decades Used*	*Code Word*	*Price*
219-K	1.110 μf in 0.001 μf steps . .	3	F, M, N	CROSS	$170.00
219-M	1.110 μf in 0.001 μf steps . .	3	L, M, N	BRIER	95.00

TYPE 380 DECADE-CAPACITOR UNIT



TYPE 380-F   TYPE 380-M

USES: The TYPE 380 Decade-Capacitor Units are extremely useful as elements in tuned circuits, wave filters, and other experimental or permanent equipment where a rather large variable capacitance is desired. They are also useful in oscillators, analyzers, amplifiers, and similar apparatus, especially during the preliminary design period when capacitance values are to be determined by experiment.

DESCRIPTION: Each decade is an assembly of four individual mica or paper capacitors of magnitudes in the ratio 1, 2, 3, 4. A selector switch is arranged to connect parallel combinations of the units so that any value between 1 and 10 may be obtained.

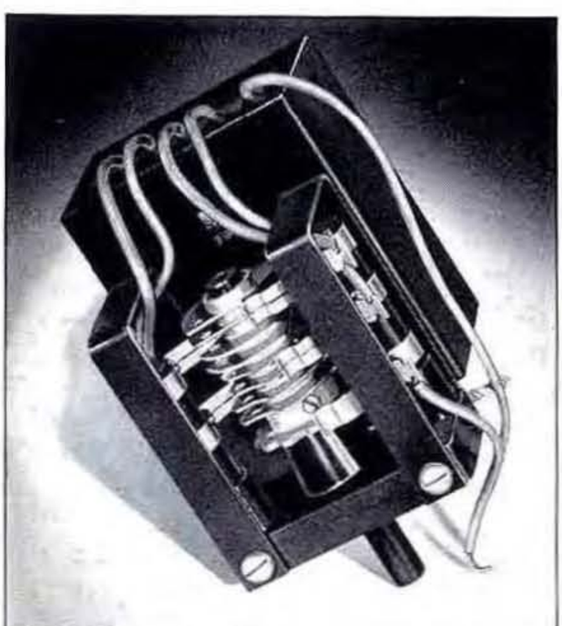
The switch is of rigid construction and carries a detent mechanism for positive location of the switch positions. A phenolic shaft is used, and contact is made by means of cams bearing on phosphor-bronze springs. A brass shaft bushing is molded in. This switch together with dial plate and knob is available separately as the TYPE 380-P3. (See price list.)

All standard units are furnished complete with knob, photo-etched dial plate with 30° detent positions, and stops.

FEATURES: ➔ Stability is obtained by careful selection and aging of the component capacitors.

➔ The TYPE 380-F is a high-quality decade employing TYPE 505 Capacitors.

➔ Thorough impregnation during winding, with molten ceresin, is given the paper capacitors used in the TYPE 380-L. A non-inductive



(*Left*) Rear view of TYPE 380-N.

type of winding is used, with the foil projecting at each end of the roll, thus avoiding the large increases in dissipation factor and capacitance that occur at high frequencies when only the one end of each foil is connected.

SPECIFICATIONS

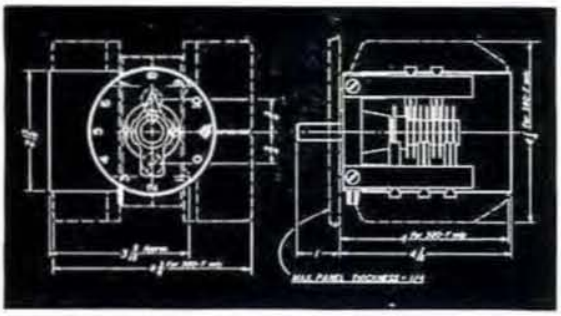
Accuracy: Capacitance increments on all units are within ±1% when measured at 1 kc except the Type 380-L, which is accurate within ±2%. The units are checked with the switch mechanism high, electrically, and the common lead and case grounded. The zero capacitance of all units is 11 μμf and must be added to the switch settings to give the total capacitance.

Dielectric: The Type 380-F is made up of Type 505 Capacitors which have mica as the dielectric. The Type 380-L uses ceresin-impregnated linen-paper capacitor units, while the Type 380-M and Type 380-N use mica capacitors molded in phenolic cases.

Dissipation Factor: The dissipation factor of the different units, when measured at 1 kc and 25° Centigrade, will be less than the values in the following table.

Frequency Characteristics: See plot below. The rise in both capacitance and dissipation factor is caused at low frequencies by interfacial polarization and at high frequencies by series inductance and resistance. Values for these residual parameters are given in the *General Radio Experimenter*, Vol. XVII, No. 5, October 1942.

Maximum Voltage: 500 volts peak for Type 380-F and 300 volts peak for all other units at frequencies below the limiting frequencies tabulated below. At higher frequencies the allowable voltage decreases and is inversely proportional to the square root of the frequency. These limits correspond to a temperature of 40° Centigrade for a power dissipation of 2.5 watts for the Type 380-F and 3.5 watts for all other units.



Over-all dimensions of Type 380 Decade-Capacitor Units. While all models use the same switch mechanism, the Type 380-F requires additional space because of the large capacitors which are mounted on both sides of the switch.

Terminals: Flexible, rubber-insulated leads are provided.

Mounting: Machine screws for attaching the decade to a panel are supplied.

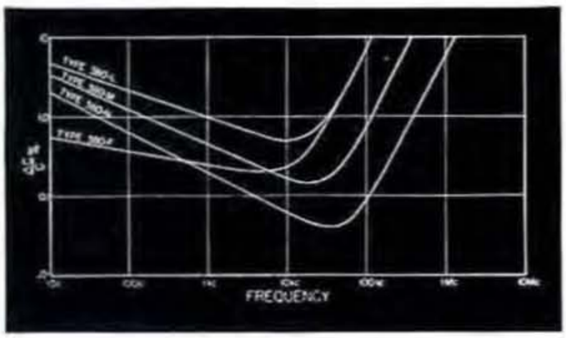
Dimensions: Type 380-F, panel space, 4¾ x 4¼ inches; behind panel, 4 inches. Types 380-L, 380-M, and 380-N, see accompanying sketch.

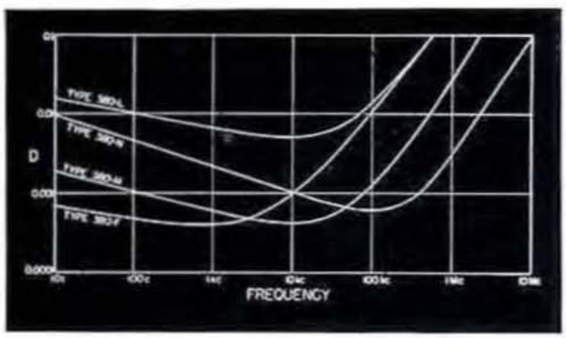
Net Weight: Type 380-F, 3 pounds, 12 ounces; Types 380-L and 380-M, 1½ pounds; Type 380-N, 1 pound, 6 ounces.

Type	*Capacitance*	*Dissipation Factor*	*Frequency Limit for Max. Voltage*	*Code Word*	*Price*
380-F	**1.0 μf in 0.1 μf steps**	0.0005	5 kc	ACUTE	**$95.00**
380-L	**1.0 μf in 0.1 μf steps**	0.010	1 kc	ADAGE	**22.00**
380-M	**0.1 μf in 0.01 μf steps**	0.001	100 kc	ADDER	**34.00**
380-N	**0.01 μf in 0.001 μf steps**	0.002	1000 kc	ADDLE	**24.00**
380-P3	**Switch only**			SWITCHFORD	**8.25**

(*Left*) Change in capacitance at maximum setting of each decade as a function of frequency. The capacitance curves are referred to the value the capacitor would have if there were no interfacial polarization and no series inductance. Since the capacitors are adjusted to their rated accuracy at 1 kc, the 1-kc value on the plots should be used as a basis of reference in estimating the frequency error.

(*Right*) Dissipation factor as a function of frequency.





STANDARD INDUCTORS

The desirable attributes of any inductor to be used as a laboratory standard include:

(1) High stability of inductance value.
(2) Small variation of inductance with frequency.
(3) Small variation of inductance with current.
(4) High ratio of inductive reactance to resistance at the desired operating frequency.
(5) Low temperature coefficient.
(6) Reasonable physical size.
(7) High degree of astaticity.

On the following pages are described a number of both fixed and variable inductors representing different economic compromises among the above factors.

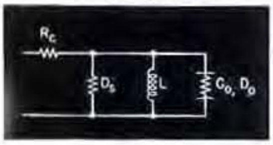


FIGURE A. Equivalent circuit of an air-cored inductor L.

AIR-CORED INDUCTORS

High stability and small variation of inductance with frequency and current are best met by air-cored inductors, as exemplified by the TYPE 106 Standard Inductors. In such an inductor, stability of inductance depends entirely upon the dimensional stability of the coil structure and, with proper design, constancy of inductance to a few hundredths per cent can be expected over a period of years. Except for small and usually negligible variations due to skin effect the only change of inductance with frequency is produced by the distributed capacitance, C_0, of the coil, which causes the effective *series* inductance to increase above the geometric or "zero frequency" value, L, as the natural frequency, f_0, is approached. At resonance the product $\omega_0^2 LC_0$ is unity. For frequencies below resonance, the effective inductance is

$$L_e = \frac{L}{1-\left(\frac{f}{f_0}\right)^2} = \frac{L}{1-\omega^2 LC_0}$$

and the fractional increase is approximately

$$\frac{\Delta L}{L} \approx \left(\frac{f}{f_0}\right)^2 = \omega^2 LC_0$$

No variation of inductance with current occurs, and an air-cored inductor can be considered as an ideally linear circuit element.

The losses in an air-cored inductor are (a) an "ohmic" or I^2R, loss from the series resistance of the winding, (b) a loss in the copper caused by eddy currents, and (c) dielectric losses in the insulation. An equivalent circuit taking these losses into account is shown in Figure A.

The effects of the various loss components are most easily represented by the plot of dissipation factor against frequency, Figure B. In logarithmic coordinates, the three dissipation factor components of an air-core inductor can all be represented by straight lines as shown. The component, D_c, caused by the d-c resistance of the winding, varies inversely with frequency, while D_s due to eddy-current loss in the copper (and associated with skin-effect) is directly proportional to the frequency. The dissipation factor, D_0, of the distributed capacitance of the winding produces D_d which is proportional to the square of the frequency within the significant range where D_0 is independent of frequency. Note that D_d reaches the value D_0 at f_0. The total dissipation factor, D, is the sum of these three components and has a minimum value which occurs well below the natural frequency, f_0, of the inductor.

It will be observed that at low frequencies the dissipation factor, D, is determined entirely by series resistance, while at high frequencies the eddy current and dielectric losses predominate.

The minimum value of dissipation factor obtainable depends upon the geometry of the coil and upon the diameter of the wire. Insulated stranded wire (Litzendraht) is frequently employed to reduce D_s by using small individual wire diameters.

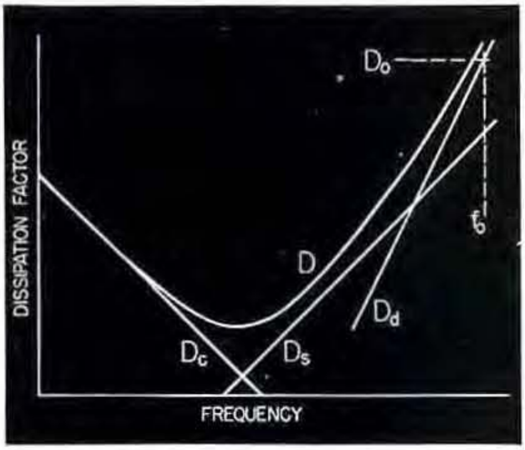
IRON-CORED INDUCTORS

A larger inductance can be obtained in a given volume or with a given amount of copper if a core material of high permeability is used. The term "iron" is used loosely and generically to identify such ferromagnetic materials, although these materials are highly developed special alloys, in sheet, strip, or bonded granular form.

The economy in coil construction resulting from the use of "iron" cores is obtained with some sacrifice of performance in an inductor used as a calibrated standard. Stability is ordinarily reduced, since the inductance depends not only on geometry but also on the permeability of the core material. This permeability will vary somewhat with current, because of its inherent change with magnetizing force, and may also be subject to a slight aging. By proper design and choice of core material, as exemplified by the TYPES 940, 1490, and 1481, inductors satisfactory as secondary standards and as adjustable decade elements can be realized.

In an iron-cored inductor, lower values of D_c and D_s can be obtained, due to the increase of effective permeability, while D_0 remains unchanged and f_0 is reduced somewhat. Three other linear *core* components of dissipation factor must be added to the *winding* components shown in Figure B. Eddy currents in the core produce a component, D_e, which, like D_s, is directly proportional to the frequency and which is minimized in a dust core made by molding fine iron powder in an insulating binder. However, by the use of fine wire, D_s can be made negligible compared to D_e. The hysteresis component of dissipation factor, D_h, is independent of frequency but, since it is proportional to the magnetizing force, it becomes vanishingly small as the operating level approaches zero (initial permeability). The relatively small component, D_r, caused by residual losses in the iron is constant with frequency and, like D_h, would be represented by a horizontal line in Figure B.

FIGURE B. Dissipation factor variation with frequency showing the relative contributions of the several loss components.



TYPE 106 STANDARD INDUCTOR

USES: The Type 106 Standard Inductor is an accurate standard of self-inductance for use in bridge and other measurements at audio frequencies.

DESCRIPTION: A partially astatic form of mounting is used wherein two D-shaped coils are mounted parallel to each other. The coils are form wound, bound with tape, and impregnated with wax before being mounted. A minimum of metal is used in the mounting, thus minimizing variations in inductance with frequency.

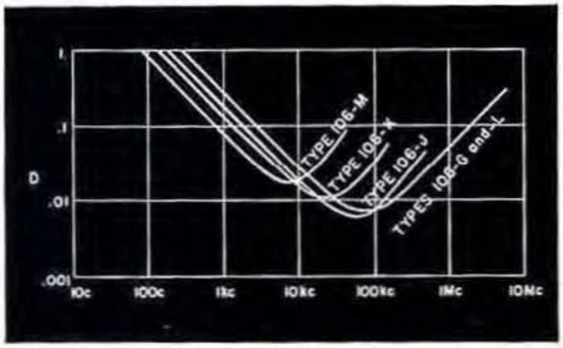
FEATURES: ➔ Low and nearly constant resistance at audio frequencies is insured by the use, wherever practicable, of stranded wire in which the separate strands are insulated from one another.
➔ Inductance independent of applied voltage.
➔ Inductance capable of precise adjustment.
➔ A serviceable set of primary standards.

SPECIFICATIONS

Type	*Nominal D-C Resistance*	*Maximum Power*	*Maximum Current*	*Natural Frequency*
106-L	0.11 Ω	5 w	6.7 a	6000 kc
106-G	0.94 Ω	5 w	2.3 a	2000 kc
106-J	12.8 Ω	5 w	0.62 a	500 kc
106-K	95 Ω	5 w	0.23 a	150 kc
106-M	570 Ω	13 w	0.15 a	35 kc

Accuracy: ±0.1% at 1 kc.

Resistance: The resistance at 1 kc is the same as the d-c resistance. This resistance, together with the temperature, is entered on a certificate mounted on the bottom of the cabinet when the inductor is measured in the Standardizing Laboratory. The nominal values are given in the table above.



Dissipation factor ($D = 1/Q$) versus frequency for Type 106 Standard Inductances.

Temperature Coefficient: The temperature coefficient of inductance is less than ±0.004% per degree Centigrade.

Maximum Power and Current: See table.

Losses: The maximum value of the storage factor $Q = \frac{X}{R}$ and the frequency for which it occurs for each size are given in the table. The change of dissipation factor $D = \frac{1}{Q}$ with frequency is shown in the accompanying plot.

Frequency Error: The fractional increase in inductance with frequency is f^2/f_0^2 where f is operating frequency and f_0 the natural frequency. At one-tenth the natural frequency, therefore, the error is 1%.

Terminals: Jack top binding posts, ¾-inch spacing.

Mounting: All units are assembled in walnut cabinets with phenolic panels. Inductor is not shielded.

Dimensions: Panel, 5⅞ x 5⅞ inches. Cabinet, (height) 3½ inches, over-all, except Type 106-M which is 5⅝ inches, over-all.

Net Weight: Approximately 2⅝ pounds, except Type 106-M which is 5 pounds.

Type	*Inductance*	*Code Word*	*Price*
106-L	0.1 mh	INNER	$36.00
106-G	1 mh	INERT	36.00
106-J	10 mh	IRATE	36.00
106-K	100 mh	ISLET	36.00
106-M	1 henry	ISSUE	50.00

TYPE 107 VARIABLE INDUCTOR

USES: The Type 107 Variable Inductors find their greatest uses in the laboratory as adjustable standards of moderate accuracy for measurements of self and mutual inductance, and as circuit elements in bridges, oscillators, and similar equipment.

DESCRIPTION: Two coils, a rotor and a stator, are mounted concentrically. As the position of the rotor is changed the coupling between the two coils changes, and the inductance is varied.

In most models stranded wire is used, in which the separate strands are insulated from one another. The coils are impregnated and baked in a high-melting-point material before being securely mounted to the phenolic panel.

FEATURES: → Continuous adjustment of self or mutual inductance. Direct reading in inductance for the series connection of the coils. Inductance for the parallel connection is exactly one-fourth the value shown by the dial. Total inductance range of over 25 : 1.
→ Rotor and stator may be quickly connected in either series or parallel as a self-inductor, or used separately as a mutual inductor.
→ Rotor and stator inductances have been equalized so that losses are not appreciably increased by circulating currents when the parallel connection is used.

SPECIFICATIONS

Self-Inductance Range: See table below.

Mutual Inductance: See table below. Either positive or negative values of mutual inductance can be obtained. The exact formula for the mutual inductance is engraved on each individual instrument.

Calibration: The inductance for the series connection, measured at 1 kc and accurate within ±1% of full-scale reading, is engraved on the dial. The inductance for the parallel connection is within ±0.1% of one-fourth of the series inductance.

The mutual inductance accuracy is ±2.5% of the maximum mutual inductance value.

Frequency Error: The fractional increase in inductance with frequency will be f^2/f_0^2 where f is the operating frequency and f_0 the natural frequency. Full-scale values of f_0 are tabulated below. To a first approximation f_0 varies inversely as the square root of the scale setting. The change of dissipation factor $D = \frac{1}{Q}$ with frequency for full-scale setting, series connection, is shown in the plot below.

Maximum Power and Current: Current for 15 watts maximum dissipation, corresponding to a 40° C temperature rise, is given in the table below and is engraved on the nameplate.

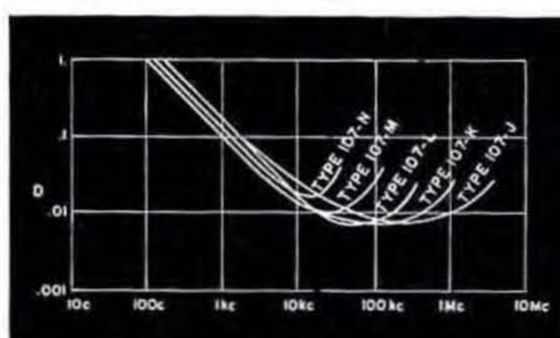
D-C Resistance: See table below. These series connection values are engraved on the nameplate. For parallel connections the resistance is closely ¼ the tabulated values.

Terminals: Standard ¾-inch spacing, jack-top binding posts are provided which allow separate connections to rotor and stator. Connecting links are supplied so that either a series or parallel connection of the rotor and stator can be made available at a third pair of binding posts.

Mounting: All units are mounted on phenolic panels and enclosed in non-shielded walnut cabinets.

Dimensions: 6½ x 6½ x 8¾ inches high, over-all.

Net Weight: 5 pounds, all ranges.



Dissipation factor ($D = 1/Q$) versus frequency for Type 107 Variable Inductors for the full-scale series connection.

Type	Self-Inductance Series	Self-Inductance Parallel	Mutual Inductance	Natural Frequency (kc)* Series	Natural Frequency (kc)* Parallel	D-C Resistance Ω	Maximum Current a	Code Word	Price
107-J	**8– 50 µh**	**2–12.5 µh**	0–10.8 µh	3700	6500	0.05	16.	HAREM	**$60.00**
107-K	**80–500 µh**	**20–125 µh**	0–110 µh	1100	1900	0.38	6.	HARPY	**60.00**
107-L	**0.8– 5 mh**	**0.2–1.25 mh**	0–1.1 mh	360	620	4.6	1.7	HARRY	**60.00**
107-M	**8– 50 mh**	**2–12.5 mh**	0–11 mh	120	210	32	0.65	HOTEL	**65.00**
107-N	**80–500 mh**	**20–125 mh**	0–110 mh	35	60	410	0.18	HOVER	**65.00**

* For full-scale setting.

TYPE 1481 STANDARD INDUCTOR

USES: The TYPE 1481 Inductors have higher values of storage factor Q than the TYPE 106 Standard Inductors and a higher degree of astaticism. They are useful at audio frequencies as standards of self-inductance, although their accuracy of adjustment is not so high as the TYPE 106 Inductors, and, for some uses, allowance must be made for their voltage coefficient of inductance.

DESCRIPTION: These inductors are uniformly wound toroidal units on molybdenum-permalloy dust cores, identical in construction with the toroids used in TYPE 940 Decade Inductor Units. The aluminum case affords an electrostatic shield.

FEATURES:
- → High storage factor Q — between 230 and 300, maximum.
- → Q is greater than 1 down to 6 cycles.
- → Inherently astatic.
- → Electrostatically shielded.

SPECIFICATIONS

Accuracy: See table below. Accuracy of adjustment is limited to the change produced by a single turn of the winding. Nominal value of inductance, with tolerance limits, and current for 0.25% change in inductance, are engraved on the case.

Storage Factor, Q: Maximum initial Q is between 230 and 300. The plot of Figure 1 shows the variation of dissipation factor $\left(D = \frac{1}{Q}\right)$ as a function of frequency for initial permeability, i.e., with no hysteresis loss. Hysteresis loss for an r-m-s current I in terms of I_1 (see table) will add approximately $.001 \frac{I}{I_1}$ directly to D.

Current Coefficient of Inductance: Per cent change in inductance as a function of $\frac{I}{I_1}$ is given in Figure 1, page 58, where I is the r-m-s operating current and I_1 the current that would produce a 0.25% linear increase in L.

Incremental Inductance: D-C bias will reduce the initial inductance as shown in Figure 1, page 58.

Frequency Characteristics: Per cent change in inductance with frequency is plotted in Figure 2, below.

Temperature Coefficient of Inductance: Approximately −0.0025% per degree C, between 16° and 32° C.

Safe Operating Limits: (1) Maximum terminal voltage, 500 volts, r-m-s or (2) maximum r-m-s current = 70 I_1, whichever limit is pertinent.

Distributed Capacitance: Between 28 μμf for the 1-mh unit and 33 μμf for the 5 h unit.

Mounting: Aluminum Case. External finish, black crackle.

Terminals: Jack top binding posts, one grounded to case. A pair of double-ended plugs is furnished, for connection to jack-top binding posts.

Dimensions: Case, (height) 3⅝ x (width) 3¼ x (depth) 1⅝ inches; over-all height, including terminals, 4⅝ inches. **Net Weight:** 14 ounces.

FIGURE 1. Initial D versus frequency for typical units ($D_h = 0$).

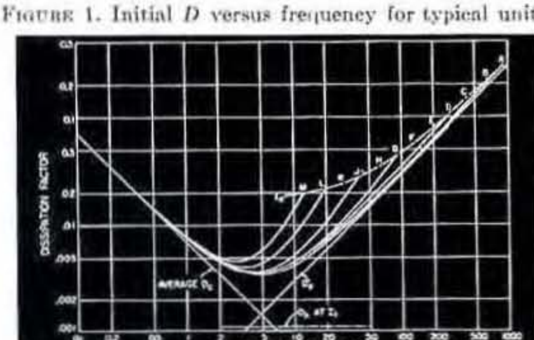
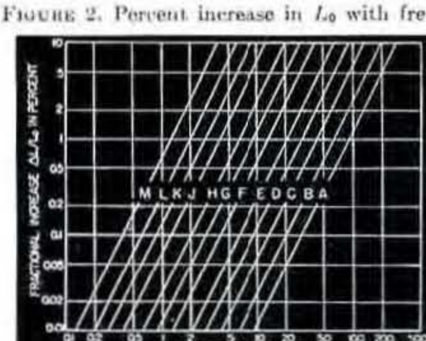


FIGURE 2. Percent increase in L_0 with frequency.



Type Inductor	*Nominal Inductance L*	*Accuracy %*	*R-M-S Current, I_1, for 0.25% increase in L_0 ma*	*Resonant Frequency f_0 kc*	*Approx. D-C Resistance Ω*	*Code Word*	*Price*
1481-A	**1 mh**	±1	39	940	0.043	INDUCTOSAP	**$24.50**
1481-B	**2 mh**	±1	28	660	0.15	INDUCTOSET	**24.50**
1481-C	**5 mh**	±1	17	420	0.25	INDUCTOSIG	**24.50**
1481-D	**10 mh**	±0.5	12	300	0.44	INDUCTOSOT	**24.50**
1481-E	**20 mh**	±0.5	8.7	210	0.95	INDUCTOSUM	**24.50**
1481-F	**50 mh**	±0.5	5.5	130	2.31	INDUCTOPAL	**24.50**
1481-G	**100 mh**	±0.25	3.9	91	4.3	INDUCTOPEG	**24.50**
1481-H	**200 mh**	±0.25	2.8	64	7.2	INDUCTOPIT	**24.50**
1481-J	**500 mh**	±0.25	1.7	40	22	INDUCTOPOD	**24.50**
1481-K	**1 h**	±0.25	1.2	28	40	INDUCTOPUB	**24.50**
1481-L	**2 h**	±0.25	0.87	20	91	INDUCTORAM	**24.50**
1481-M	**5 h**	±0.25	0.55	12.5	230	INDUCTORED	**27.50**

TYPE 940 DECADE-INDUCTOR UNIT

USES: The TYPE 940 Decade-Inductor Units are convenient elements for use in wave filters and tuned circuits throughout the audio and low radio-frequency range. As components in oscillators, analyzers, and similar equipment, they are especially useful during the preliminary design period when the ability to vary circuit elements over relatively wide ranges is necessary to determine optimum operating values. As moderately precise standards of inductance they have values of low-frequency storage factor Q which are much larger than can be obtained with air-cored coils.

DESCRIPTION: Each unit is an assembly of four toroids wound on molybdenum-permalloy dust cores. All four coils (relative values 1, 2, 2, 5) are connected in series, and the switch, a modified TYPE 920, short-circuits combinations of the coils to give the eleven successive values from 0 to 10. The switch blades are beryllium copper with silver stud contacts to decrease both contact and volume resistance.

FEATURES: ➔ High values of storage factor Q are obtained in all models, with maximum values above 200.

➔ Toroidal construction practically eliminates any external magnetic field, and makes it possible to stack the coils closely without errors from mutual inductance. The toroids are nearly astatic to external magnetic fields.

➔ Electrostatic shielding and mechanical protection are furnished by the aluminum frame and covers.

➔ Moisture is kept from the windings by wax impregnation.

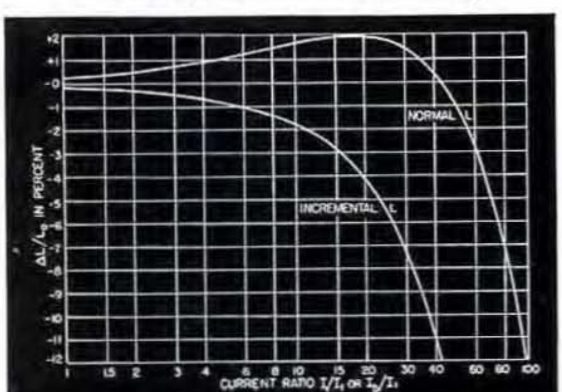
SPECIFICATIONS

Accuracy: Each unit is adjusted so that its inductance at zero frequency and initial permeability will be the nominal value within the accuracy tolerance given in the following table:

Inductance per step	1 mh	10 mh	100 mh	1 h
Accuracy	±2%	±1%	±0.5%	±0.25%

Frequency Characteristics: For any specific operating frequency, Figure 2 shows the percentage increase in effective series inductance (above the geometric value when $f = 0$) which is encountered with the extreme settings of each of the four Decade Inductor Units when the chassis is floating. Vertical interpolation may be used for intermediate settings.

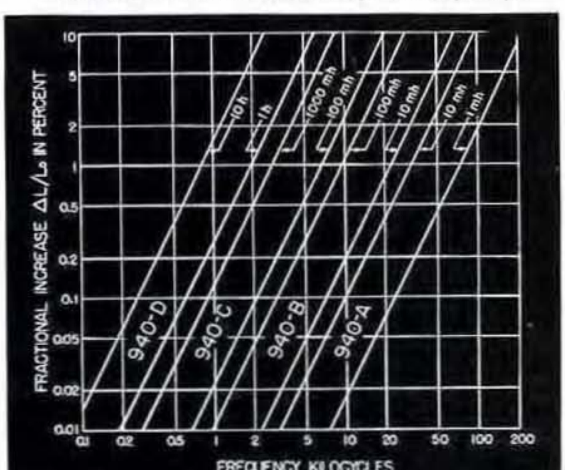
FIGURE 1. Percent change in normal and incremental inductance with a-c and bias current. Incremental curve is limited to an a-c excitation less than I_1.



Change in Inductance with Current: Fractional change in initial inductance with a-c current for each size of toroid is shown in the normal curve, Figure 1, in terms of the ratio of the operating current I, to I_1, the current for 0.25% change. For ratios below unity, inductance change is directly proportional to current. Values of I_1 listed below are approximate and are based on the largest inductor in circuit for each setting.

Switch Setting	RMS I_1 (ma) for 0.25% Increase			
	940-A	940-B	940-C	940-D
1	39	12	3.9	1.2
2, 3, 4	28	8.7	2.8	0.87
5, 6, 7, 8, 9, 10	17	5.5	1.7	0.55

FIGURE 2. Percent increase in L_0 with frequency.



Incremental Inductance: D-C bias current I_b will reduce the initial inductance as shown in the incremental curve, Figure 1.
Dissipation Factor: See Figure 3.
Resistance: 60 d-c ohms henry for TYPE 940-A, 45 d-c ohms henry for TYPES 940-B, C, D.
Temperature Coefficient: Approximately −0.0025% per degree C between 16 and 32° C.
Maximum Voltage: 500 volts rms. The switch will break the circuit at 500 volts if turned rapidly to the new setting, but voltages above 150 may cause destructive arcing if the switch is set between detent positions.
Maximum Current: 70 times the pertinent I_1 value.
Terminals: Soldering lugs are provided. Circuit insulated from chassis.
Mounting: Each decade is complete with dial plate, knob, and mounting screws.
Dimensions: (Width) 7¼ x (height) 3½ x (depth behind panel) 3¼ inches, over-all.
Net Weight: 3½ pounds.

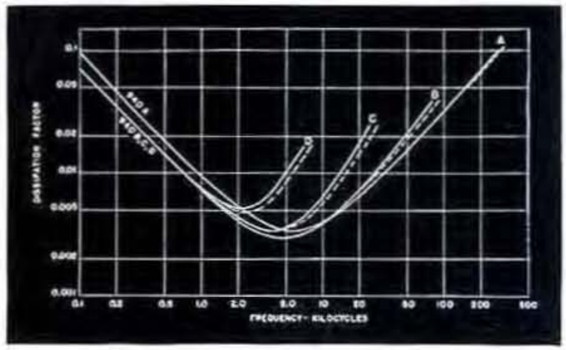
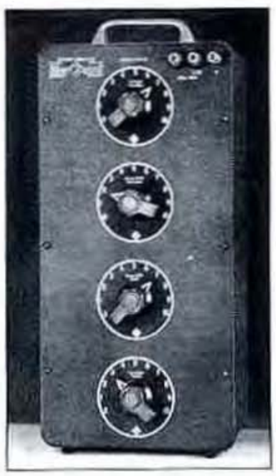


FIGURE 3. Variation of dissipation factor for the full value of each inductor. Dashed curves correspond to use with chassis floating.

Type	*Inductance*	*Code Word*	*Price*
940-A	**0.01 h in 0.001 h steps**	INDUCTOANT	**$64.00**
940-B	**0.1 h in 0.01 h steps**	INDUCTOBOY	**60.00**
940-C	**1 h in 0.1 h steps**	INDUCTOCAT	**64.00**
940-D	**10 h in 1 h steps**	INDUCTODOG	**72.00**

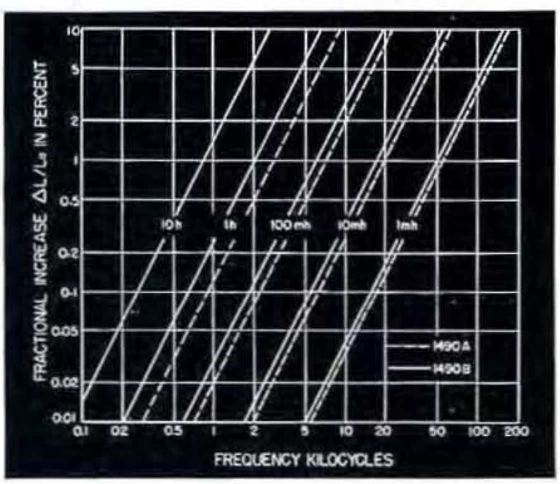
TYPE 1490 DECADE INDUCTOR



USES: Where an adjustable inductance covering several decades is required these boxes are particularly useful.

DESCRIPTION: The TYPE 1490 Decade Inductor is an assembly of three or four TYPE 940 Decade-Inductor Units in a single metal cabinet. The units have no electrical connection to the panel but a separate ground terminal is provided which may be connected to the "low" terminal of the smallest unit.

Percent increase in L_0 with frequency.



SPECIFICATIONS

Frequency Characteristics: By vertical interpolation in the accompanying plot the percentage increase in effective series inductance (above the geometric value when $f = 0$) may be obtained for any setting of the non-ground inductors.
Terminals: Jack-top binding posts.
Mounting: The decades are mounted on an aluminum panel in a metal cabinet.
Dimensions: 1490-A 12¾ x 7¾ x 5½ inches over-all height. 1490-B 16½ x 7¾ x 5½ inches over-all height.
Net Weight: TYPE 1490-A, 15½ pounds; TYPE 1490-B, 19¼ pounds.

Other specifications are identical with those for the TYPE 940 Decade-Inductor Units.

Type	*Inductance*	*Code Word*	*Price*
1490-A	**1.11 h, total, in steps of 0.001 h**	CLUMP	**$230.00**
1490-B	**11.11 h, total, in steps of 0.001 h**	COACH	**295.00**

IMPEDANCE-MEASURING INSTRUMENTS

METHODS

For the measurement of all types of impedance, resistive or reactive, inductive or capacitive, at frequencies well up into the u-h-f band, null methods have proved to be the most acceptable on grounds of both precision and convenience. Most of the null methods used from d-c to radio frequencies of the order of 100 megacycles are adaptations of the fundamental Wheatstone bridge circuit, although other types of networks which can be adjusted to give zero transmission for a particular configuration of circuit elements are sometimes used. Other systems, usually resonant circuits, using deflection-type instruments also have advantages for certain applications.

At very high frequencies where impedances can no longer be treated as lumped elements, coaxial-line techniques offer greater promise than bridge circuits made up of lumped elements, and null methods employing these techniques have been developed.

DIRECT-CURRENT BRIDGES

The so-called Wheatstone bridge, Figure 1, has been used for over a century for the measurement of direct-current resistance and is still considered the fundamental circuit for the purpose. It measures an unknown resistance in terms of calibrated standards of resistance from the relationship

$$\frac{R_A}{R_B} = \frac{R_N}{R_P} \qquad (1)$$

which is satisfied when the voltage across the detector terminals is zero. The ultimate accuracy of the measurement is thus determined by the accuracy of the standards, and is not limited by the readability of a deflecting instrument.

The General Radio Company manufactures three d-c bridges using the fundamental Wheatstone circuit of Figure 1: (1) the TYPE 650-A Impedance Bridge, which includes a d-c resistance measuring circuit with a d-c galvanometer as the detector; (2) the TYPE 544-B Megohm Bridge, designed for the measurement of very high resistances, in which the necessary sensitivity is obtained by using as a detector a vacuum-tube voltmeter with extremely high input resistance; and (3) the TYPE 1652-A Resistance Limit Bridge, designed primarily for production testing, but also capable of laboratory resistance measurements over a wide range. All three of these bridges are direct reading in resistance.

ALTERNATING-CURRENT BRIDGES

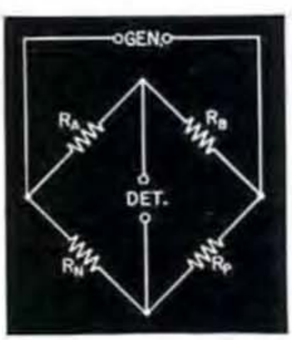
The basic circuit of Figure 1 is also applicable to a-c measurements. With impedances substituted for resistances, two conditions of balance must be satisfied simultaneously, one for the resistive component and one for the reactive component. The fundamental equations of balance can be written in either of the following forms:

$$R_N + jX_N = Z_A Z_P Y_B \qquad (2)$$

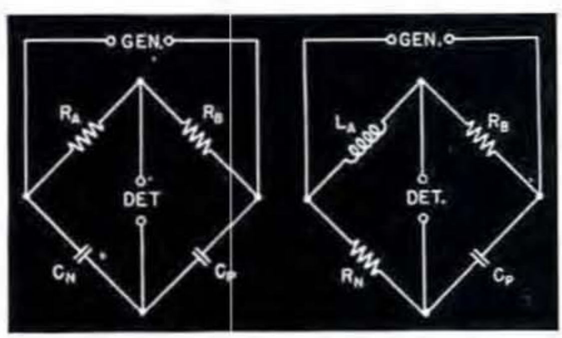
$$G_N + jB_N = Y_A Y_P Z_B \qquad (3)$$

Equation (2) is most convenient when it is desired to express the unknown in terms of its *impedance* components, while Equation (3) is used when the unknown is considered in terms of its *admittance* components. In order to satisfy these equations, one of the three arms A, P, or B must be complex.

The reactance X_N can be measured in terms of a similar reactance in an adjacent arm. Of the bridges described on the following pages, TYPES 716, 740, 1611 and 650 use this method for the measurement of capacitance, while TYPE 667 uses it for the measurement of inductance. The reactance of the unknown can also be measured in terms of an unlike reactance in the opposite arm. The TYPE 650 measures inductance in this manner, using a capacitor in the opposite arm as the standard.



(*Left*) FIGURE 1. The general Wheatstone bridge circuit. (*Right*) FIGURE 2. Circuits for capacitance bridges in which like reactances, C_N and C_P, or unlike reactances, L_A and C_P, are compared.



Resistive Balance

Four basic methods are in common use. These are (1) resistance in series with the standard reactance, (2) resistance in parallel with the standard reactance, (3) capacitance in parallel with a resistive arm and (4) capacitance in series with a resistive arm.

The series resistance method (1) is used in the TYPES 740-B, 1611-A, 667-A, and 650-A. The parallel resistance method (2) is used for some of the circuits in the TYPE 650-A. The parallel capacitance method (3) is used in the TYPES 716-C, 1601-A, 916-A, and 916-AL. As used in the TYPE 716-C the circuit is commonly referred to as the Schering bridge, with the controls calibrated in capacitance and dissipation factor. The circuit used in the 1601 and 916, although similar in configuration, is used in a different manner, with the controls calibrated in terms of resistance and reactance.

Dissipation Factor and Storage Factor

An important characteristic of an inductor or a capacitor is the ratio of resistance to reactance or of conductance to susceptance. This ratio is termed dissipation factor, D, and its reciprocal is storage factor, Q. These ratios are defined as follows:

$$D = \frac{1}{Q} = \frac{R}{X} = \frac{G}{B} \qquad Q = \frac{1}{D} = \frac{X}{R} = \frac{B}{G} \qquad (4)$$

where R and X are the series resistance and reactance, and G and B are the parallel conductance and susceptance of the impedance or admittance involved. Dissipation factor is directly proportional to the energy dissipated, and storage factor to the energy stored, per cycle. The relation of these factors to phase angle and loss angle is shown in Figure 4.

$$D = \frac{1}{Q} = \cot\theta = \tan\delta \qquad (5)$$

Power factor is defined as

$$\text{P.F.} = \cos\theta = \sin\delta \qquad (6)$$

and differs from dissipation factor by less than 1% when their values are less than 0.15.

Dissipation factor is commonly used for

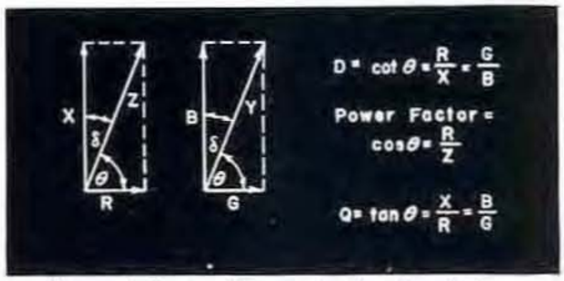


FIGURE 4. Vector diagram showing the relations between factors D and Q, and angles θ and δ.

capacitors and, to a lesser extent, for inductors because it varies directly with the loss. Storage factor Q is often used for inductors because it measures the voltage step-up in a tuned circuit.

The bridge control for the resistive balance can be calibrated in dissipation factor, or in storage factor, for a given frequency. The TYPES 740 and 1611 have dials calibrated in dissipation factor at 60 cycles, and the TYPE 716 is direct reading at 100 cycles, 1, 10 and 100 kilocycles. The TYPE 650 reads directly the dissipation factor of capacitors and the storage factor of inductors, at 1000 cycles.

OTHER NULL TRANSMISSION NETWORKS

The Twin-T

In addition to the bridge circuits described above there are a number of other networks which can be adjusted to give zero transmission. One of these, the Twin-T or Parallel-T

FIGURE 5. Parallel-T circuit for measuring impedance at radio frequencies.

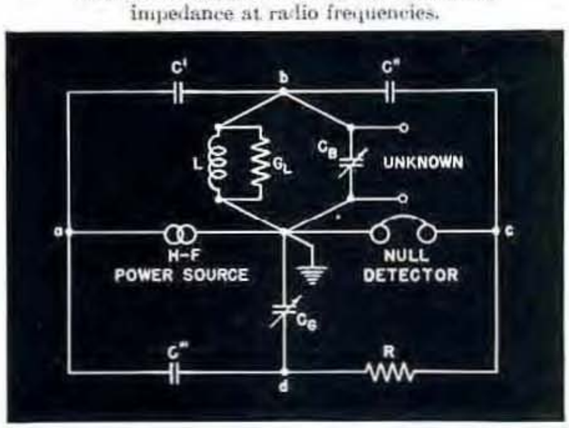
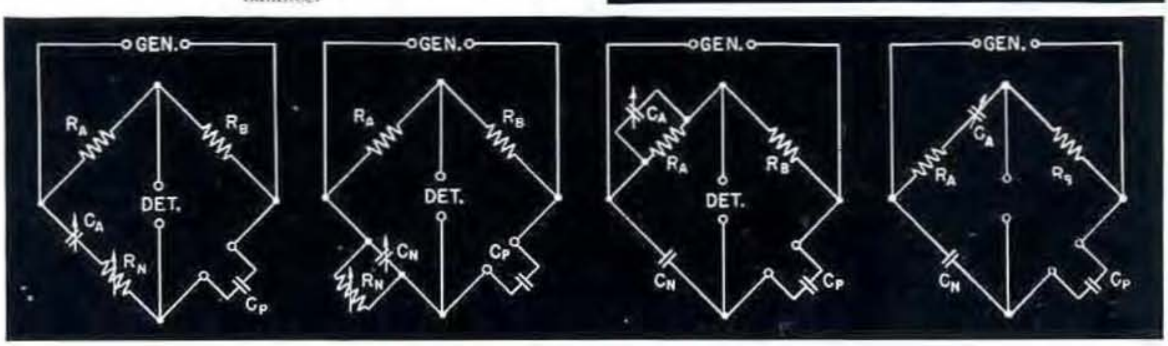


FIGURE 3. Four basic methods of obtaining resistance balance.



illustrated in Figure 5, has proved to be of great value for admittance measurements at high radio frequencies. This circuit is used in the Type 821 for impedance measurements from 0.5 to 40 megacycles.

In this circuit the conductive component of the unknown is measured in terms of a fixed resistance and a variable capacitance, thus avoiding the errors inherent in variable resistors at high frequencies.

The Admittance Meter

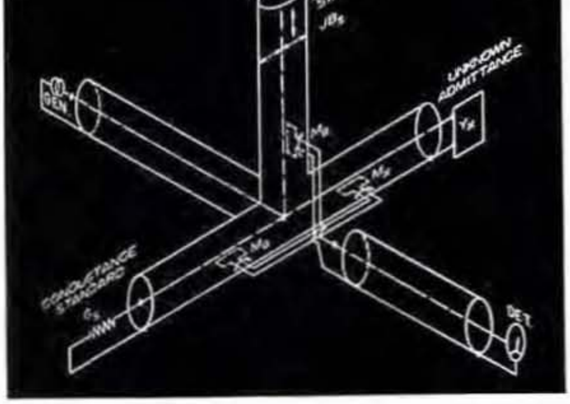
The upper-frequency limit of conventional bridge circuits using lumped-parameter elements is determined by the magnitude of the residual impedances (see below) of the elements and leads, and, in general, the corrections for these become unmanageable at frequencies higher than about 150 megacycles, and circuits based on coaxial-line techniques are more satisfactory.

The Type 1602-A U-H-F Admittance Meter, shown in Figure 6, is a null device based on these techniques. Through adjustable loops, it samples the currents flowing in three coaxial lines fed from a common source at a common junction point. The outputs of the loops are combined, and when the loops are properly oriented, the combined output becomes zero, so that a null balance is produced.

Figure 6 shows the functional arrangement of the admittance meter with standards connected. The standard conductance, G_s, is a resistor having a value equal to the characteristic impedance, Z_0, of the line, and the standard susceptance, jB_s, is an adjustable stub which is set to one-eighth or three-eighths wavelength at the operating frequency.

Since the voltage from the generator is common to all three lines, the sending-end

Figure 6. Schematic diagram of admittance meter circuit, with standards, generator, and null detector connected for admittance measurements.



current in each line is proportional to the sending-end admittance. This admittance is Y_x for the line terminated in the unknown, $G_s = \frac{1}{Z_0}$ for the line terminated in the standard conductance, and $jB_s = -j\frac{1}{Z_0}$ for the line terminated in the eighth-wave stub.

The induced voltage in each loop is proportional to the mutual inductance (M_X, M_G, or M_B), and to the current in the corresponding line. Thus, the induced voltage in the loop associated with the unknown admittance is proportional to the product,

$$M_X Y_X = M_X G_X + jM_X B_X; \qquad (7)$$

the induced voltage in the loop associated with the standard conductance is proportional to the product, $M_G G_S$; and the induced voltage in the loop associated with the standard susceptance is proportional to the product, $jM_B B_S$. It follows that these three induced voltages add up to zero when the couplings of the three loops have been adjusted to have the following relations: $G_X = -\frac{M_G}{M_X} G_S$, and $B_X = -\frac{M_B}{M_X} B_S$. G_S and B_S are constants, so the M_G scale can be calibrated in terms of G_X, the M_B scale in terms of B_X, and the M_X scale in terms of a multiplying factor to be applied to the other two scale readings. Since each coupling can be varied through zero, the two balance equations show that the theoretically measurable ranges of conductance and susceptance extend from zero to infinity. However, the percentage accuracy of reading the scales naturally decreases as the position of zero coupling is approached, and the 1 millimho to 400 millimhos range is found practical for reading and setting.

The loops associated with the unknown admittance and the standard conductance can each be rotated through an angle of 90°, but the loop associated with the standard susceptance is arranged to be rotatable through an angle of 180°, thus allowing the measurement of positive as well as negative values of unknown susceptance with a single susceptance standard.

A unique feature of the U-H-F Admittance Meter, which distinguishes it from bridges and other null devices, is that the susceptance scale, as well as the conductance scale, is independent of frequency. This comes about because the stub that forms the susceptance standard is always adjusted to one-eighth or three-eighths wavelengths at the operating frequency and therefore presents the same susceptance at all frequencies.

Slotted Line

One of the important basic measuring instruments used at ultra-high frequencies is the slotted line, which can be used to determine the characteristics of an unknown impedance from the change in the standing-wave pattern of the electric field in the line produced by connecting the unknown to the load end of the line. The TYPE 874-LB Slotted Line, a precise, inexpensive instrument, with an operating range of 300 to 4500 megacycles is described in the section on U-H-F Coaxial Elements, page 112 et seq.

SPECIAL-PURPOSE BRIDGES

Magnetic Test Set

The TYPE 1670-A Magnetic Test Set uses a Maxwell bridge to determine the permeability and core loss of small samples of laminar ferro-magnetic material from a measurement of the inductance and loss components obtained with a sample clamped in a test yoke of known constants. Measurement is made with sinusoidal magnetizing current, rather than with the sinusoidal voltage employed in the conventional Epstein method. Comparative measurements show no appreciable difference in results for the two methods.

Vacuum-Tube Bridge

Using a null transmission circuit, the TYPE 561 Vacuum-Tube Bridge measures three fundamental vacuum-tube parameters: amplification factor, transconductance, and plate resistance. Each of the three coefficients is obtained in terms of the ratio of two 1000-cycle test voltages. A third voltage is used in a capacitance balancing circuit.

RESONANT-CIRCUIT INSTRUMENTS

R-F Capacitance Meter

For the measurement of capacitance at one megacycle the TYPE 1612 R-F Capacitance Meter has the advantages of speed and simplicity. It is essentially a resonant-circuit instrument, consisting of a one-megacycle oscillator, loosely coupled to a measuring circuit that consists of a calibrated capacitor, an inductor, a crystal rectifier and a microammeter. Measurements are made by a substitution method in which the calibrated capacitance is reduced to re-establish resonance after an unknown capacitance is connected.

ERRORS

A bridge circuit provides a comparison of two impedances, an unknown and a standard. It does not provide an absolute measurement. The possible error in the measurement is always greater than the error in the standard itself by the errors in the other bridge arms entering into the comparison. If, for instance, the error in the standard and in each of the two ratio arms is ±0.1%, there can then occur in the most unfavorable case an error of ±0.3% in the measurement. This accuracy limitation is common to all direct-reading bridges in which a result is obtained from a single balance of the bridge.

Substitution Method

The errors in three of the bridge arms can be eliminated from the measurement through the use of a substitution method in which the unknown impedance is connected in the standard arm. Two readings of the standard

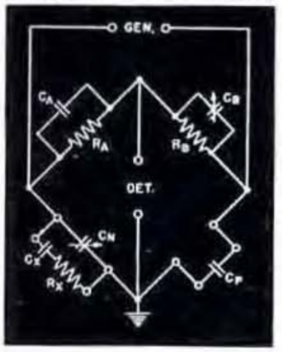
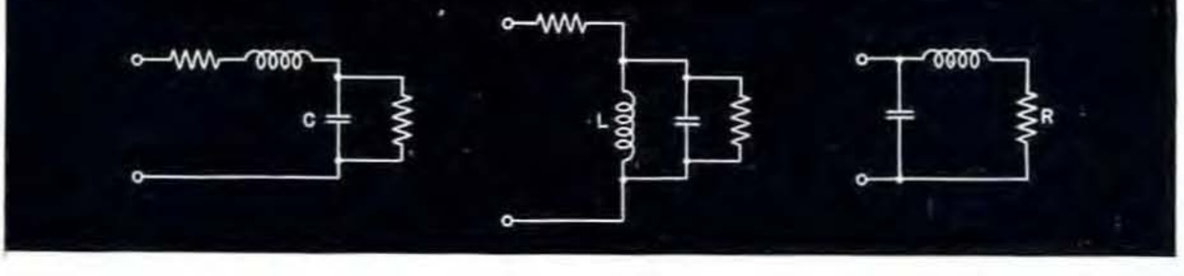


FIGURE 7. The substitution method (shown for a capacitance measurement with a Schering bridge) reduces the error to essentially the accuracy with which the capacitance *difference* between two settings of the standard capacitor is known.

FIGURE 8. Schematic representation of capacitance, inductance, and resistance standards, showing the most important residual impedances. The ohmic resistance and inductance of the stacks and leads of the capacitor (*left*) are represented by series resistance and inductance, while the dielectric losses are represented by a shunt conductance. For an inductor (*center*), the copper losses consisting of both ohmic resistance and eddy currents, and the distributed capacitance with dielectric losses are the important residuals. A resistor (*right*), to a first approximation, is represented by an inductance in series, and a capacitance in shunt.



are required, one with the unknown disconnected and another with it connected. With an error in the standard of ±0.1%, the maximum error of measurement is ±0.2%.

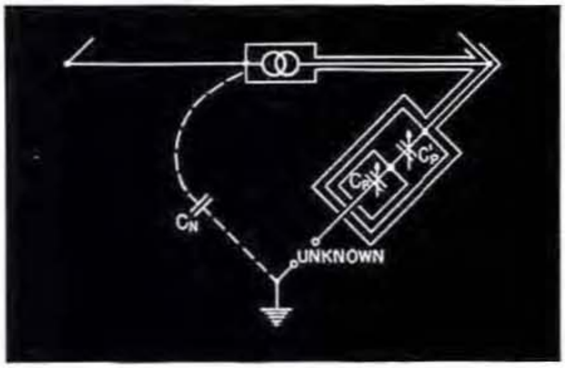
Residual Impedances

The bridge equations derived from Equation (1) presuppose an accurate knowledge of the behavior of the impedances in each arm. No impedance element, however carefully constructed, is entirely free from residual impedances. Resistors have series inductance and shunt capacitance. Inductors have relatively large series resistance and shunt capacitance. Even air capacitors, while more nearly perfect than other impedance standards, have resistive and inductive residual impedances. All of these extra impedances must be included in the values used for calculation in order to avoid error. The over-all residuals are greatly increased by the various connections forming the bridge circuit.

Shunt capacitance across the various arms is an important source of error even at audio frequencies. When capacitance occurs across a resistive arm, its effect on the resistive component of balance varies directly as the magnitude of the capacitance and directly as the operating frequency. Errors arising from this source account for the large differences between the listed errors in dissipation factor given for TYPE 650 and TYPES 740 and 1611

FIGURE 9. Showing the shielding of the unknown arm in the TYPE 916-A Radio-Frequency Bridge. In this assembly the innermost shield localizes the variable stray capacitance of the rotor of C_p and prevents it from falling across C''_p, where it would cause interlocking of the settings of the two capacitors. The middle shield throws the stray capacitances of the two capacitors to the right-hand corner of the bridge, while the outermost shield places the capacitance of the right-hand corner across the generator, where it is harmless.

This puts the capacitance from the outer shield to ground across the N arm of the bridge. Actually, the physical arrangement of the bridge is such that this capacitance constitutes the bridge arm, with only a trimmer capacitor connected across it to correct for small variations between instruments.



Bridges. TYPE 650 not only operates at a higher frequency but has unavoidable switching capacitances because it is designed for such a great variety of measurements.

Shunt capacitance across a reactive arm is also serious. In the TYPE 667-A Inductance Bridge, for instance, the capacitance across the unknown terminals increases the error in the measured inductance from ±0.2% to ±0.4% on the highest multiplier. Typical capacitances across the UNKNOWN terminals of General Radio bridges are:

TYPE 716-C	1 μμf
TYPE 740-B	3 μμf
TYPE 650-A	10 μμf
TYPE 1611-A	0 μμf

In the TYPE 1611-A this capacitance is effectively made zero, and its dissipation factor is eliminated by introducing across the detector terminals a voltage whose magnitude and phase is equal to the bridge unbalance voltage caused by this zero capacitance. Thus the bridge is made direct reading in capacitance and dissipation factor down to zero.

In the TYPE 916-A Radio-Frequency Bridge and the TYPE 1601-A V-H-F Bridge, the equivalent shunt capacitance across the resistance arm has been reduced to less than 0.4 μμf. This residual capacitance does not affect the resistive balance, and affects the reactance balance only slightly at 60 Mc; all other stray capacitances are either incorporated into the bridge arms or, by means of shielding, placed across the generator or detector terminals where they become harmless.

At high radio frequencies the limiting residual impedance has been found to be the residual inductance of variable air capacitors. Thus, in the TYPE 916-A Radio-Frequency Bridge, the residual inductance of the resistance balancing capacitor is the limiting factor on the upper frequency range of the bridge, in so far as the bridge elements themselves are concerned. In the TYPE 821, on the other hand, the residual inductance of the susceptance balancing capacitor is the factor which determines the upper frequency limit at which accurate measurements can be made.

Residual series inductance in bridge arms is ordinarily negligible at audio frequencies, except in measurements of very small inductors. The TYPE 667-A Inductance Bridge uses TYPE 668 Compensated Decade Resistors in order to avoid change in residual inductance as the resistance is varied. At radio frequencies the effect of inductance is much more serious, and variable resistors are not generally used above a few megacycles.

SHIELDING AND GROUNDING

The readings of any bridge should be sensibly independent of its surroundings and the position of the operator. To satisfy these conditions, bridges are completely surrounded by a grounded shield, and care is taken to use either grounded or insulated shafts on all controls. It is also common practice to ground the junction of the unknown and standard arms to this shield. Residual capacitances of the bridge arms to the shield are placed across the two arms thus grounded. Although a relatively large error may be introduced by these capacitances, it can often be eliminated by an initial zero reading or by making the residual capacitance part of the capacitance standard. A bridge with one unknown terminal grounded in this manner will measure the "total impedance" of the unknown, which includes the impedance to ground of one of its terminals. The TYPES 716, 1611, 916, and 667 are of this type, placing one terminal of the unknown at ground potential. If, on the other hand, neither of the unknown terminals is grounded, the bridge will measure the direct impedance connected across these terminals, provided that the terminal impedances to ground are large compared to the bridge arms. TYPES 650 and 740-B have neither unknown terminal grounded and hence measure direct impedance. Under certain conditions, however, the TYPE 650 can be adapted for measuring grounded impedances, and the TYPE 1611 for measuring direct impedance. The TYPE 544-B Megohm Bridge can be connected either way and can, therefore, measure either total or direct resistance.

Shielded Transformer

The bridge balance should be independent of the type of generator and detector used. This condition can be met by the use of a shielded transformer, such as the TYPE 578. One transformer winding is connected between two opposite corners of the bridge, neither of which is grounded. For bridge balances, the small, constant, and known terminal capacitances of the transformer are then substituted for the large, variable, and unknown capacitances of the generator or detector.

DETECTORS

To obtain the maximum precision of balance with any bridge or null-balance circuit it is necessary to obtain a virtually complete null balance. With modern vacuum-tube circuits, however, sufficient sensitivity

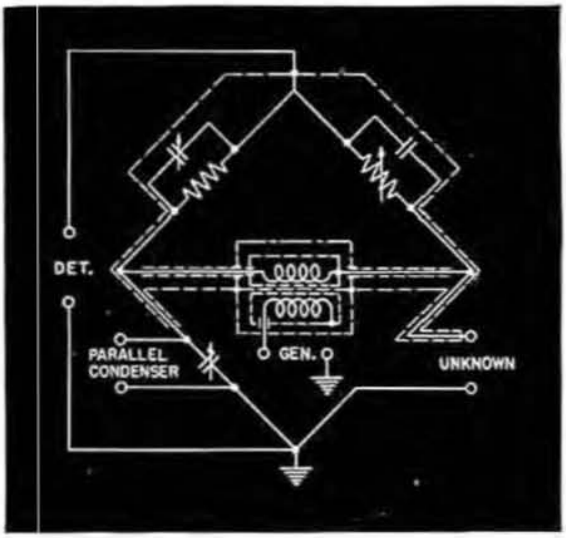


FIGURE 10. Illustrating the shielding arrangement of the TYPE 716-C Capacitance Bridge. The ratio arms with their compensating capacitor, the dissipation factor capacitor, and the input transformer are all mounted on insulated subpanels and completely shielded. The shield is connected to the junction of the ratio arms, thereby placing its capacitance to ground across the detector terminals.

The shield around each transformer winding is connected to the winding, eliminating the terminal capacitances. A third shield, between the winding shields, is connected to the junction of the ratio arms. The capacitance between the third shield and the secondary winding shield is thus placed across the right-hand ratio arm, and its effect can be eliminated in the initial balance. Similarly, the capacitance between the primary shield and the interwinding shield goes across the detector terminals and does not affect the balance.

No capacitances are placed across the standard and unknown arms other than that of the leads and of the panel binding posts. The small amount placed across the standard capacitor is taken into account in the calibration, while that across the unknown terminals is less than one micromicrofarad.

can be obtained to utilize all the potential precision of any null-balance network.

In some bridge circuits the balance is dependent upon frequency, and the value of the unknown impedance usually varies with frequency. Consequently, the presence of harmonics in the input to the bridge or their production in a non-linear impedance within the bridge may obscure the fundamental balance. A null balance may also be masked by the residual noise level of the oscillator and amplifier used. For these reasons it is usually advisable to employ a selective detector, tuned to the frequency at which it is desired to balance the bridge.

Audio and Sub-Audio Frequencies

At audio frequencies, the conventional detector is a vacuum-tube amplifier such as the TYPE 1231-B Amplifier and Null Detector and a pair of head telephones. Where a visual indication of balance is desired, as is necessary at frequencies below about 300 cycles, a rectifier-type voltmeter or a vacuum-tube voltmeter can be substituted for the head telephones.

The TYPE 1231-B Amplifier and Null Detector has a panel meter which can be used as a self-contained null indicator. This instrument can also be made selective by the addition of the TYPE 1231-P2, -P3, and -P5 Tuned-Circuit Filters.

The TYPE 736-A Wave Analyzer and the TYPE 760-A Sound Analyzer, in conjunction with an amplifier, are also very satisfactory selective bridge detectors. The wave analyzer is particularly useful when extreme selectivity at the higher audio frequencies is required, while the sound analyzer provides good selectivity at low audio frequencies. For measurements over a wide range of frequencies, these instruments have the advantage of being continuously variable in frequency.

Radio Frequencies

At radio frequencies, any well-designed commercial radio receiver can be used. Head telephones, a loudspeaker, or a meter can be used as the actual balance indicator. Since tuned radio-frequency devices are inherently selective, the problem of radio-frequency harmonics is not significant. The receiver should preferably have an r-f sensitivity control and provision for disconnecting the a-v-c circuit, in order to facilitate the approach to balance.

Ultra-High Frequencies

The ordinary communications receiver can be adapted for use at ultra-high frequencies by using a TYPE 874-MR Mixer Rectifier and a local oscillator (such as the TYPE 1208 or the TYPE 1209 Unit Oscillator) to convert the signal to a lower frequency within the range of the receiver.

SENSITIVITY

The precision to which a bridge can be balanced depends primarily upon the voltage applied to the bridge and the sensitivity of the detector. It also depends upon the ratio of impedances of the two arms across which the generator is placed and the ratio of the impedance of the detector to the bridge impedance.

If the generator is connected across two similar bridge arms, the ratio of output voltage to input voltage is

$$\frac{E_0}{E_i} = \frac{\left|\frac{Z_A}{Z_B}\right|}{\left(1 + \left|\frac{Z_A}{Z_B}\right|\right)^2} d \tag{8}$$

where $|Z_A|$ and $|Z_B|$ are the absolute magnitudes of impedance of the arms across which the generator is connected, and d is the fractional precision desired in balancing the reactive component, or the minimum value of dissipation factor to be detected.

If the two bridge arms across which the generator is connected are not alike, but one is resistive and one reactive, the equation becomes

$$\frac{E_0}{E_i} = \frac{\left|\frac{Z_A}{Z_B}\right|}{1 + \left(\left|\frac{Z_A}{Z_B}\right|\right)^2} d \tag{9}$$

Both expressions are developed on the assumption that the impedance of the detector is high compared to that of the bridge arms. When the input impedance of the detector is not high compared to that of the bridge, the sensitivity can be easily determined by applying Thevenin's theorem.

From the above equations and the known input voltage, the output voltage corresponding to a given value of d can be calculated. The ratio of this voltage to the minimum voltage which will actuate the detector is the amplification required.

As an example, consider the TYPE 716 Capacitance Bridge. For equal ratio arms at 1 kc, about 100 volts can be applied to the bridge from a 0.5 watt generator. To make a capacitance balance to ±0.1% demands the detection of 25 mv. To make a dissipation factor balance to ±0.00001 requires a sensitivity of 250 μv. The first voltage is easily within the range of head telephones without an amplifier, while the second is not. The TYPE 1231-B Amplifier and Null Detector has a gain of 77 db or 7000 when working with head telephones, which is more than sufficient. With the built-in vacuum-tube voltmeter (minimum deflection = 0.02 volt), the gain is also sufficient, since even for the dissipation factor balance a gain of only 80 is needed. Now suppose these same measurements to be made on a 1 μf capacitor for which the ratio arms must be 1000 to 1. Using the full gain of the amplifier, the meter can only balance for dissipation factor to about ±0.00003, so that telephones must be used to obtain the required sensitivity.

POWER SOURCE

The main considerations in the selection of a power source for a-c bridge measurements are frequency stability, power output, and harmonic content.

The TYPES 740-B and 1611-A are designed for 60-cycle measurements and operate directly from the power line. The TYPE 650-A has a self-contained 1000-cycle microphone hummer, or the TYPE 650-P1 Amplifier-Oscillator, and no external oscillator is required unless it is desired to make measurements at frequencies other than 1000 cycles. All the other bridges described in this section require some type of external oscillator.

For single-frequency measurements at 1000 cycles, the TYPE 572-B Microphone Hummer, the TYPE 813-A Audio Oscillator, and the TYPE 723-C Vacuum-Tube Fork are satisfactory provided the power requirements are low.

When a highly precise balance is desired, more power is required than can be furnished by oscillators of the type mentioned above. For measurements at 1000 cycles and 400 cycles, the TYPE 1214-A Unit Oscillator is recommended. When a continuously variable frequency is needed the TYPE 1304-A Beat-Frequency Oscillator or the TYPE 1302-A Oscillator is recommended.

For measurements at radio frequencies with the TYPE 916-A and TYPE 916-AL Radio-Frequency Bridges, or the TYPE 821-A Twin-T Impedance-Measuring Circuit, the TYPE 1330-A Bridge Oscillator should be used. For driving the TYPE 1601-A V-H-F Bridge and the TYPE 1602-A U-H-F Admittance Meter, the TYPE 1208-A and TYPE 1209-A Unit Oscillators are convenient power sources.

Modulation

For radio-frequency measurements, it is preferable that the power source be unmodulated. Distortion in the modulating system, frequency modulation, and assymetrical sideband cutting in the receiver can produce appreciable errors in the balance point. In addition, maximum sensitivity is obtained with an unmodulated signal and an oscillating detector.

CONNECTIONS

To achieve maximum freedom from electrostatic pickup, it is desirable to use shielded leads between generator and bridge and between bridge and detector. At audio and low radio frequencies the reactance of the leads and terminals is unimportant, and electrostatic shielding is all that is necessary to prevent the introduction of extraneous voltages into the detector or the unknown impedance. At frequencies above a few megacycles, the reactance of the interconnecting leads also becomes a potential source of error. This is illustrated by the block diagram of Figure 11.

The small series inductance in the ground side of the generator cable is designated as L_G, similar inductances in the receiver cable and the common ground lead as L_R and L_M. The voltage drop in L_G produces a flow of current around the loop consisting of the cable sheath, the ground lead, L_M, and the ground capacitance of the oscillator. Similarly, current flows in the right-hand loop that includes L_R.

The voltage applied to the receiver has, therefore, two components, one from the bridge, the other from the drop across L_R. When a null point is reached, therefore, the bridge is out of balance by an amount necessary to cancel the effect of the extraneous voltage from L_R, that is, to make the vector sum of the bridge output voltage and the extraneous voltage equal to zero.

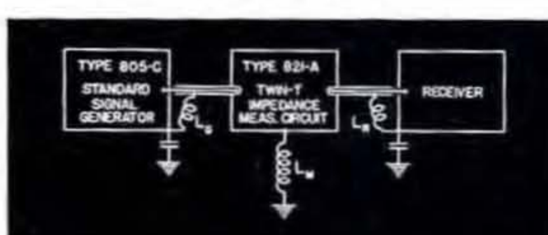
The error in measurement caused by this series inductance is one of the most serious encountered in null measurements at radio frequencies, but it can be avoided if coaxial terminals are used on both generator and receiver.

The TYPES 916-A, 821-A, 916-AL, 1601-A, and 1602-A are equipped with TYPE 874 Coaxial Terminals, and coaxial leads are supplied with these instruments to plug into the oscillator and detector.

CLASSIFICATION

The table on the next page briefly summarizes the operating ranges, accuracy, and other pertinent data regarding the bridges listed in this section. From this table the most suitable instrument for any given measurement can be determined at a glance, while detailed specifications for each bridge are given on the following pages.

FIGURE 11. Showing how series inductance in the generator and detector leads can cause errors in measurement at radio frequencies.



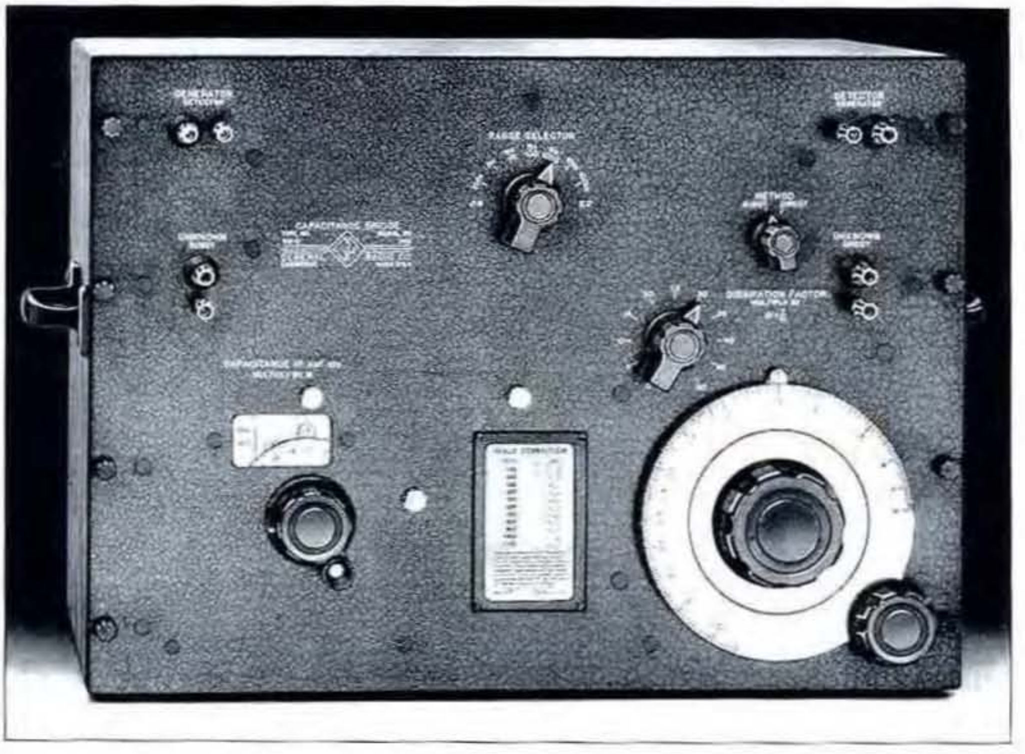
BRIDGES

Type	*Measures*	*Range of Measurement*	*Accuracy**	*Measurement Frequency*	*Remarks*	*See Page*
			D-C BRIDGES			
1652-A	*R*	1 to 1,111,111 Ω	0.5%	dc	As limit bridge	94
		1 to 1,111,111 Ω	0.2%	dc	By null method	
544-B	*R*	0.1 to 10,000 MΩ	±5%	dc	Has guard terminal	92
			60-CYCLE BRIDGES			
740-B	*C*	5 μμf to 1100 μf	±1%	60 cycles	Measures ungrounded capacitors	75
	D	0 to 50%	±1.5% of full scale	60 cycles		
1611-A	*C*	0 to 11,000 μf	±1%	60 cycles	Measures grounded capacitors	74
	D	0 to 60%	±2%	60 cycles		
			UNIVERSAL TYPE			
650-A	*R*	.001 Ω to 1 MΩ	±1%	dc	Completely self-contained	71
	L	1 μh to 100 h	±2%	1 kc		
	C	1 μμf to 100 μf	±1%	1 kc		
	D	.002 to 1	±20%	1 kc		
	Q	.02 to 1000	±20%	1 kc		
			AUDIO-FREQUENCY BRIDGES			
716-C	*C*	100 μμf to 1 μf at 1 kc§	±0.2%	100 c, 1 kc, 10 kc, 100 kc	Can also measure large inductances	69
	D	.00002 to .56	±2%	100 c, 1 kc, 10 kc, 100 kc		
667-A	*L*	0.1 μh to 1 h	±0.2%	1 kc		77
			RADIO-FREQUENCY INSTRUMENTS			
916-AL	*X*	±11,000 Ω	±2%	50 kc to 5 Mc	This model is preferable in standard broadcast band	80
	R	0 to 1000 Ω	±1%	50 kc to 5 Mc		
916-A	*X*	±5000 Ω†	±2%	400 kc to 60 Mc	Particularly useful for antenna measurements	80
	R	0 to 1000 Ω	±1%	400 kc to 60 Mc		
821-A	*C*	0 to 1000 μμf	±0.2%	460 kc to 40 Mc	For measurements on components and high impedances	82
	B	±6000 μmho‡		460 kc to 40 Mc		
	G	0 to 100 μmho‡	±2%	460 kc to 40 Mc		
1612-A	*C*	0 to 1000 μμf	±4%	1 Mc	Resonant-Circuit Instrument	78
1612-AL	*C*	0 to 100 μμf	±4%	1 Mc	Adaptors available for measuring socket capacitance	78
			V-H-F AND U-H-F INSTRUMENTS			
1601-A	*X*	±230 Ω	±5%	10 to 165 Mc		84
	R	0 to 200 Ω	±2%	10 to 165 Mc		
1602-A	*B*	±.2 to ±1000 millimhos	±5%	70 to 1000 Mc	Coaxial-line device	86
	G	±.2 to ±1000 millimhos	±5%	70 to 1000 Mc		
			SPECIAL-PURPOSE BRIDGES			
561-D	*μ*	.001 to 10,000	±2%	1 kc	Adaptors for standard tube bases are furnished	88
	r_p	50 Ω to 20 MΩ	±2%	1 kc		
	S_m	.02 to 20,000 μmho	±2%	1 kc		
1670-A	Permeability and core loss		±2%	60 cycles	Measures small strip samples	90

* Approximate. For detailed accuracy statement, see specifications for each bridge.

† At 1 Mc; Range varies inversely as the frequency. ‡ At 1 Mc; Range varies directly as the frequency.

§ 100 μμf to 1000 μμf at other frequencies.



TYPE 716-C CAPACITANCE BRIDGE

USES: This direct-reading capacitance bridge can be used for a wide variety of capacitance and dissipation-factor measurements. Within its scope are the determination of dielectric constant, dissipation factor, loss factor, phase angle, and other dielectric properties of insulating materials, as well as their change with such factors as frequency, temperature, and humidity.

In addition to direct-reading capacitance measurements, the bridge is capable of measuring other impedances by substitution methods. Among these are the inductance and storage factor of large inductors, up to several thousand henrys; the resistance and parallel capacitance of high-valued resistors, up to several thousand megohms; and capacitances up to several thousand microfarads.

By adding an external decade resistor, the bridge can be converted to a series- or parallel-resistance bridge, which latter is especially useful in measuring the resistance of electrolytes.

In the General Radio laboratories the Type 716 Capacitance Bridge is used for all capacitance standardization measurements. In production it is used for the testing and adjustment of all precision fixed capacitors.

DESCRIPTION: The Type 716-C Capacitance Bridge is a modified Schering bridge, direct reading in capacitance at any frequency, and in dissipation factor at 100 cycles, and 1, 10, and 100 kilocycles.

A wide capacitance range at 1 kilocycle is obtained by four sets of ratio arms giving multiplying factors from 1 to 1000 in decade steps. The standard capacitor is a Type 722 Precision Condenser, calibrated to read directly in total capacitance. The zero capacitance across the unknown terminals is not greater than 1 $\mu\mu f$. All capacitances to ground of the input transformer and ratio arms are removed from the capacitance arms by placing them in a shielded compartment insulated from the grounded panel and connected to the junction of the ratio arms.

Dissipation factor is read directly from the dial setting of an air capacitor and from a decade-step capacitor connected across the fixed ratio arm. The 12-inch scale of the air capacitor is approximately logarithmic, so that, while having a maximum reading of 0.06, its smallest division near zero is 0.0001, thus allowing the estimation of 0.00002. The accuracy of the dissipation factor reading over the wide capacitance range is made possible by adding capacitance across the lower-valued ratio arms, so that the product RC of all the ratio arms is the same.

FEATURES: → Wide capacitance and frequency ranges, high accuracy, and direct-reading dials are three very desirable features found in this bridge.

→ Operation is simple, and both terminals and controls are arranged for convenience and flexibility of operation.

→ The DISSIPATION FACTOR dial is direct reading for either direct or substitution measurements, because the setting of the METHOD switch determines the ratio arm across which the dissipation-factor capacitor is connected.

→ Operation up to 300 kilocycles is made possible by careful design of the shielded transformer to minimize leakage impedances and dielectric losses.

SPECIFICATIONS

Ranges: Direct reading — capacitance, 100 μμf to 1 μf at 1 kc; 100 μμf to 1000 μμf at 100 c, 10 kc, and 100 kc; dissipation factor, 0.00002 to 0.56.

Substitution Method — capacitance, 0.1 μμf to 1000 μμf with internal standard; to 1 μf with external standards; dissipation factor, $0.56 \times \frac{C''}{C_x}$ where C'' is the capacitance of the standard capacitor and C_x that of the unknown.

Accuracy: Direct Reading — capacitance, ±2 μμf × capacitance multiplier reading (±0.2% of full scale for each range) when the dissipation factor of the unknown is less than 0.01; dissipation factor, ±0.0005 or ±2% of dial reading, whichever is the larger, for values of D below 0.1.

Substitution Method — capacitance, ±0.2% or ±2 μμf, whichever is the larger; dissipation factor, ±0.00005 or ±2% for change in dissipation factor observed, when the change is less than 0.06.

A correction chart for the precision capacitor is supplied, giving scale corrections to 0.1 μμf at multiples of 100 μμf. By using these data substitution measurements can be made to ±0.1% or ±0.5 μμf, whichever is the larger. It is also possible to obtain, at an extra charge, a worm-correction calibration with which substitution measurements can be made to an accuracy of ±0.1% or ±0.2 μμf, whichever is the larger.

When the dissipation factor of the unknown exceeds the limits given above, additional errors occur in both capacitance and dissipation-factor readings. Corrections are supplied, by means of which the accuracy given above can be maintained over all ranges of the bridge.

Ratio Arms: The arm across which the dissipation factor capacitor is normally connected at 1 kc has a resistance of 20,000 ohms. The other arm has four values, 20,000 ohms, 2000 ohms, 200 ohms, 20 ohms, providing the four multiplying factors 1, 10, 100, 1000. Suitable capacitors are placed across these arms so that the product RC is constant. At 100 c, 10 kc, and 100 kc the ratio arms are equal and have resistances of 200,000 ohms, 2000 ohms, and 200 ohms, respectively.

Shielding: Ratio arms, dissipation-factor capacitors, and shielded transformer are enclosed in an insulated shield. The unknown terminals are shielded so that the zero capacitance across them is not greater than 1 μμf. A metal dust cover and the aluminum panel form a complete external shield.

Frequency Range: The accuracies given above hold for operating frequencies from 30 c to 300 kc, provided the operating frequency does not differ from the range selector frequency by more than a factor of three. Dissipation-factor readings must be corrected by multiplying the dial reading by the ratio of operating frequency to the range selector frequency.

Voltage: Voltage applied at the GENERATOR terminals is fed to the bridge through a 1-to-1 shielded transformer. A maximum of 1 watt can be applied, allowing a maximum of 200 volts at 1 kc, but only 50 volts at 60 cycles.

Temperature and Humidity: Variations of temperature over normal ranges (65° F to 95° F) have no significant effect on the accuracy of the bridge, but precise measurements of *dissipation factor* should not be attempted when the bridge has been exposed to conditions of abnormally high relative humidity.

Mounting: The bridge is supplied either for mounting on a 19-inch relay rack or in a walnut cabinet.

Accessories Required: Oscillator and detector. For the power source the TYPE 1302-A Oscillator (page 148) is recommended. TYPE 1231-B Amplifier and Null Detector (page 98) with TYPE 1231-P Filters (page 100) is recommended for use as the detector at audio frequencies. At low radio frequencies a radio receiver is satisfactory for aural null indications.

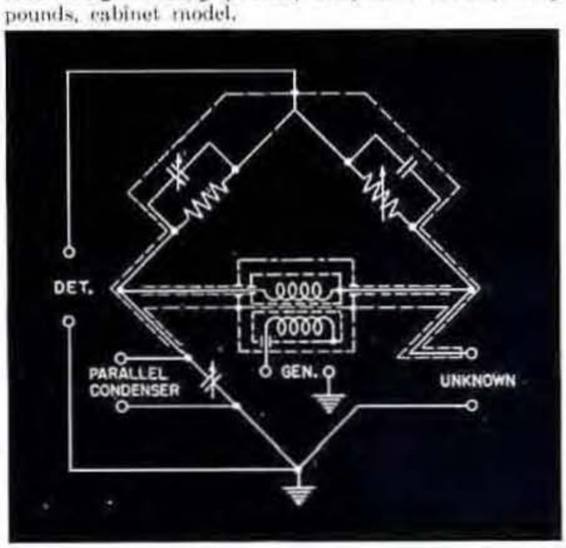
For substitution measurements, a balancing capacitor is needed. This may be a TYPE 772-D Precision Condenser, page 46, or a fixed mica capacitor, TYPE 505, page 49.

Accessories Supplied: Two TYPE 274-NE Shielded Connectors.

Other Accessories Available: For measurements on unguarded dielectric specimens, the TYPE 1690-A Dielectric Sample Holder (page 96) is recommended.

Dimensions: (Length) 19 x (height) 14 x (depth) 9 inches, over-all.

Net Weight: 44½ pounds, relay-rack model; 54½ pounds, cabinet model.



Type		*Code Word*	*Price*
716-CR	For Relay-Rack Mounting	BONUS	$500.00
716-CM	Mounted in Walnut Cabinet	BOSOM	545.00
	Worm-Correction Calibration for Internal Precision Capacitor	WORMY	50.00

TYPE 650-A IMPEDANCE BRIDGE

USES: The Type 650-A Impedance Bridge will measure the inductance and storage factor, Q, of coils, the capacitance and dissipation factor, D, of capacitors, and the a-c and d-c resistance of all types of resistors.

In the laboratory it is extremely useful for measuring the circuit constants in experimental equipment, testing preliminary samples, and identifying unlabeled parts. In the shop and on the test bench it has many applications in routine testing and fault location. Thousands of these bridges are in use all over the world, in government and industrial laboratories, educational institutions, electric generating stations, and radio broadcasting stations.

DESCRIPTION: Type 650-A Impedance Bridge is a conventional 4-arm impedance bridge. It is entirely self-contained, including standards, batteries, and tone source, and is direct reading over wide ranges of d-c resistance, a-c resistance at 1000 cycles, capacitance and dissipation factor $\left(D = \frac{R}{X}\right)$ at 1000 cycles, and inductance and storage factor $\left(Q = \frac{X}{R}\right)$ at 1000 cycles.

Results are read directly from dials having approximately logarithmic scales. The position of the decimal point and the electrical unit in terms of which the measurement is made are indicated by the positions of two selector switches.

Resistance is measured in terms of a standard resistance arm; inductance and capacitance are measured in terms of mica capacitance standards, similar in construction to the Type 505 Capacitors.

A built-in galvanometer is used as the detector for d-c work, and head telephones, usually preceded by an amplifier, are used for 1000-cycle measurements.

FEATURES: ➔ Complete availability, because of the self-contained standards and power supply, is an outstanding feature of this bridge. The only accessory needed is a pair of high impedance head telephones.

➔ Wide ranges of all kinds of impedances can be measured simply and with rapidity.

➔ Convenience, combined with sufficient accuracy for all but very precise work, makes the TYPE 650-A invaluable in every electrical laboratory.

➔ Direct-reading dials eliminate additional time and trouble with calculations. The panel photograph shows the simplicity of the controls.

SPECIFICATIONS

Range: The ranges of the instrument are given in the following table. The numerical values are the readings of the calibrated dials multiplied by the settings of the decade selector switches.

	Minimum	*Maximum*
Resistance	1 milliohm	1 megohm
Capacitance	1 micromicrofarad	100 microfarads
Inductance	1 microhenry	100 henrys
Dissipation Factor $\left(\frac{R}{X}\right)$	.002	1
Storage Factor $\left(\frac{X}{R} \text{ or } Q\right)$	.02	1000

Accuracy: The large direct-reading dial covers two decades, the main decade being spread out over 12 inches (three-quarters of the dial). It may be set to 0.2%.

Accuracy of readings for capacitance and d-c resistance is 1% for the intermediate multiplier decades; for inductance, 2%. The accuracy falls off in the lower ranges because of the extremely small values to be measured. The error increases to 2% for very large values of capacitance and d-c resistance, and to 10% for large values of inductance.

Accuracy of reading for dissipation factor or for storage factor in terms of its reciprocal is either 20% or 0.005, whichever is the larger. For dissipation factors larger than 0.05 and for corresponding storage factors, the accuracy is 10%. For capacitances of less than 500 $\mu\mu$f when measured on the lowest capacitance multiplier the error in dissipation factor increases as capacitance decreases, reaching about 100% for 100 $\mu\mu$f.

The frequency of the microphone hummer is 1000 cycles within ±5%.

Power Supply: Four No. 6 dry cells for the d-c measurements and for driving the microphone hummer are supplied with the TYPE 650-A Impedance Bridge and space for them is provided at the top of the cabinet.

The TYPE 650-P1 Oscillator-Amplifier described on the next page is also designed to fit into the battery compartment and provide increased a-c and d-c output for the bridge. In addition it has an amplifier for use in the detector circuit and a number of other operating features.

The bridge, with TYPE 650-P1 Oscillator-Amplifier installed, is available as the TYPE 650-AP. See price list below.

External Generator: Provision has been made for using an external generator, although its capacitance to ground may introduce some error. Subject to this limitation, the frequency may be varied over a wide range from a few cycles to 10 kc. The effect of generator ground capacitance can be reduced by using a TYPE 578 Transformer between generator and bridge. (See page 97). The reading of the main dial is independent of frequency, while the reading of the loss dials must be corrected for frequency. Provision is made for adding external resistance if it is necessary to increase the ranges of these dials.

Accessories Required: Head telephones; Brush, Model A, are recommended. To increase the sensitivity, an amplifier is recommended. (See TYPE 650-P1 Oscillator-Amplifier, next page.)

Mounting: Black crackle-finish aluminum panel mounted in a shielded walnut cabinet.

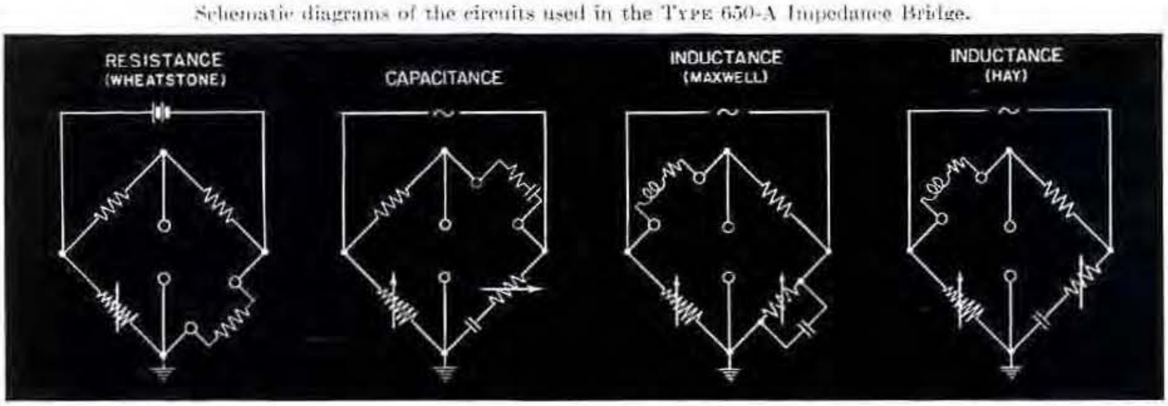
Dimensions: (Width) 12 x (depth) 20 x (height) 8½ inches, over-all.

Net Weight: 31½ pounds including batteries.

Type		*Code Word*	*Price*
650-A	**Impedance Bridge, with batteries**	BEAST	**$260.00***
650-AP	**Impedance Bridge, with Type 650-P1 Oscillator-Amplifier, A-C Operated**	FILLY	**410.00**
Brush, Model A, Head Telephones		TELLO	**12.00**

*Without telephones, but including batteries.
PATENT NOTICE. For TYPE 650-AP, see Notes 9 and 20, page vi.

Schematic diagrams of the circuits used in the TYPE 650-A Impedance Bridge.



TYPE 650-P1 OSCILLATOR-AMPLIFIER

USES: The TYPE 650-P1 Oscillator-Amplifier is a useful combination unit designed to fit into the battery compartment of the TYPE 650-A Impedance Bridge. The TYPE 650-P1 operates from the a-c power line and provides a vacuum-tube oscillator operating at one kilocycle, a source of dc for resistance measurements, and an amplifier to be used with headphones or an external a-c galvanometer as the bridge detector.

The TYPE 650-P1 is not limited to operation with the TYPE 650-A Bridge and can be used as a compact oscillator-amplifier combination with other bridge systems.

DESCRIPTION: The vacuum-tube oscillator, amplifier, and rectifier for providing the dc are all mounted in a compact metal cabinet with a top control panel which replaces the wooden cover normally used on the battery compartment of the TYPE 650-A. The control panel has a switch for selecting either the d-c or the one-kilocycle output, and a switch to select a flat amplifier characteristic or a response tuned to one kilocycle. Both the oscillator output and the amplifier gain can be varied by panel controls.

FEATURES: ➔ A-C operation of TYPE 650-P1 completely dispenses with need for batteries for all laboratory measurements on TYPE 650-A Bridge.

➔ D-C output is considerably higher than the 6 volts normally provided from batteries. Thus, when the self-contained galvanometer is used, the sensitivity of the bridge for higher resistance values is greatly increased.

➔ Oscillator frequency is within 1% of nominal frequency after warm-up periods, thus minimizing errors in *D* and *Q* measurements caused by dependence of dial calibrations on frequency.

➔ Output of oscillator is greater and distinctly purer than the output of the bridge hummer which it replaces.

➔ Oscillator output is adjustable. This feature is especially valuable when measuring iron-cored inductors at low flux densities approaching initial permeability.

➔ Shielded transformer between oscillator and bridge reduces stray capacitance errors normally encountered with external oscillators to values comparable with those from the internal hummer.

➔ TYPE 650-P1 can be used separately as oscillator and amplifier or source of dc for other applications.

SPECIFICATIONS

Oscillator:
Frequency — 1 kc ±1%.
Harmonics — less than 4% at full output.
Open-circuit Voltage — continuously adjustable up to maximum of 10 to 15 volts.
Internal Impedance — 2000 ohms.
Hum Level — 15 mv.

Amplifier:
Voltage Gain — continuously adjustable up to about 45 db (with average headphones).
Selectivity — approximately 15 db attenuation to second harmonic when tuned to 1 kc.
Hum Level — inaudible.

D-C Output:
Open-circuit Voltage — 180 volts, approximately.
Internal Resistance — 23,000 ohms.
Maximum Current — 8 ma, no adjustment provided. Can be short-circuited without damage.
Hum Level — less than 100 mv no load.

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles.

Power Input: 10 watts.

Vacuum Tubes: (all supplied).
1 — 6H6 2 — 6SL7-GT

Accessories Supplied: Connector for use between oscillator-amplifier and bridge, and line cord.

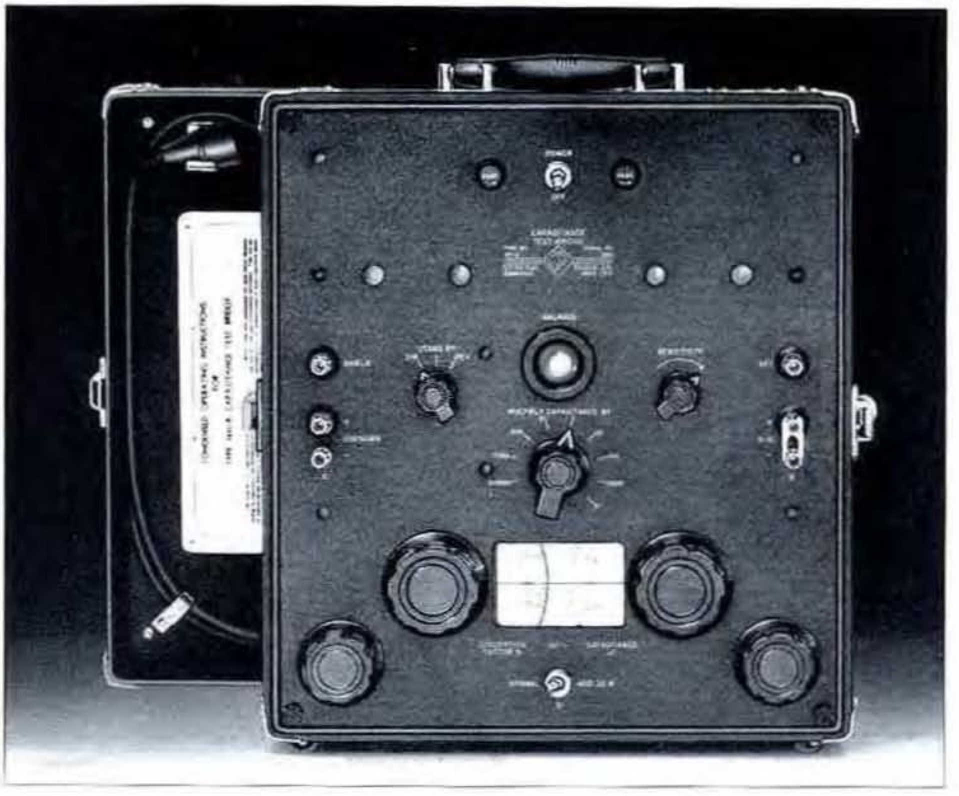
Accessories Recommended: Head telephones or a-c output meter for use with amplifier on a-c measurements.

Dimensions: Cabinet — $10\frac{1}{2}$ x $2\frac{1}{2}$ x $6\frac{3}{4}$ inches. Panel — 12 x $3\frac{3}{8}$ inches.

Net Weight: 9 pounds.

Type		*Code Word*	*Price*
650-P1	**Oscillator-Amplifier**	BOGUS	**$150.00**
Brush, Model A, Head Telephones		TELLO	**12.00**

PATENT NOTICE. See Notes 9 and 20, page vi.



TYPE 1611-A CAPACITANCE TEST BRIDGE

USES: The TYPE 1611-A Capacitance Test Bridge is designed for 60-cycle capacitance and dissipation factor measurements over very wide ranges. It is suitable for laboratory or shop testing of all kinds of paper and mica capacitors, as well as polarized electrolytic capacitors. It also meets the requirements of the electric power industry for shop testing of insulators, particularly for measurement of dissipation factor of bushings, insulators, the insulation of transformers, rotating machinery and cables. It can be used in such measurements even where there are adjacent bus potentials of several thousand volts.

For the wire and cable manufacturer, this bridge offers a convenient and rapid means for locating breaks in cable, and for laboratory and production tests of dissipation factor and capacitance on all kinds of cable.

The communications industry will find it useful not only for routine capacitance and dissipation factor tests on component capacitors but also for checking capacitance to ground of transformer windings, shields, and circuit elements.

DESCRIPTION: The circuit used is the series-resistance capacitance bridge. One ratio arm is continuously variable and calibrated to read directly in capacitance. The other ratio arm is variable in decade steps and serves as a multiplier for the direct-reading dial. The variable resistors in series with the standard capacitors are calibrated directly in dissipation factor.

Provision is made for conveniently applying an external d-c polarizing voltage to the capacitor under test.

A visual null indicator is used, consisting of a tuned amplifier and an electron-ray tube. The circuit is so designed that maximum sensitivity is obtained at balance, with reduced sensitivity off balance. This arrangement greatly facilitates the determination of the balance point. The detector system can be made linear and more suitable for limit testing by changing one tube.

A portable luggage-type carrying case houses the complete instrument.

FEATURES: ➔ Will measure any capacitor up to 11,000 microfarads. There is no fixed lower limit. The range extends down to zero.

➔ Requires no accessories — ready for operation when connected to power line.

➔ Visual null indicator is an advantage in noisy locations.

→ Detector sensitivity increases as balance point is approached, which greatly simplifies process of locating balance.

→ Use of low test voltage results in considerable saving in cost over equipment operating at several kilovolts. Tests have proved that capacitance and dissipation factor do not depend upon voltage if no corona occurs.

→ Moderate external electrostatic fields do not affect results, since connection to generator can be reversed and the observed results averaged.

→ A d-c polarizing voltage can be introduced from an external d-c source.

SPECIFICATIONS

Capacitance Range: 0 to 11,000 μf, covered by eight multiplier steps and an approximately logarithmic, direct-reading dial.

Dissipation-Factor Range: 0 to 60% (at 60 cycles). A dial having a scale characteristic approximately logarithmic covers the range 0 to 30%. An additional range of 30% can be added by a panel switch.

Capacitance Accuracy: $\pm(1\% + 1\ \mu\mu f)$ over the entire range of the bridge.

Dissipation Factor Accuracy: $\pm(2\%$ of dial reading $+ 0.05\%$ dissipation factor). Power Factor $= \frac{D}{\sqrt{1 + D^2}}$, where $D =$ dissipation factor. Below 100 $\mu\mu f$, the accuracy is limited by the decreasing sensitivity of balance.

Sensitivity: The sensitivity is such that any capacitance in the range 100 $\mu\mu f$ to 10,000 μf can be balanced to a *precision* of at least 0.1%.

Temperature and Humidity Effects: The readings of the bridge are unaffected by temperature and humidity variations over the range of room conditions normally encountered (65° F to 95° F, 0 to 90% RH).

A-C Voltage Applied to Capacitance under Test: The voltage impressed on the unknown capacitance varies from a maximum of approximately 125 volts at 100 $\mu\mu f$ to less than 3 volts at 10,000 μf. The circuit is so arranged that a maximum of one volt-ampere of reactive power is delivered to the sample.

External Fields: For bushing testing, the fields usually encountered in shop and laboratory, even up to several thousand volts, will not affect the accuracy. For measurements in locations where the overhead voltages are very high, the unknown should be shielded.

Polarizing Voltage: Terminals are provided for connecting an external d-c polarizing voltage. The maximum voltage that should be impressed is 500 volts.

One of the terminals is grounded so that any a-c operated power supply with grounded output can be used. The terminal capacitances of the power supply do not affect the bridge circuit.

Power Supply Voltage: 105 to 125 (or 210 to 250) volts, 60 cycles.

Power Input: 15 watts.

Accessories Supplied: Line connector cord.

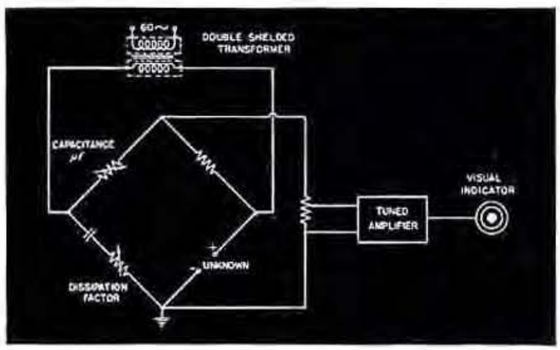
Mounting: Portable carrying case of luggage-type construction. Case is completely shielded to insure freedom from electrostatic pickup.

Vacuum Tubes: One each 6X5-GT, 6SJ7, and 6U5. All are supplied.

Net Weight: 30½ pounds.

Dimensions: (Width) 14½ x (depth) 16 x (height) 10 inches, over-all, including cover and handles.

Schematic diagram of the TYPE 1611-A Capacitance Test Bridge. Generator and detector connections are interchanged by the switching when the bridge is used to measure capacitances greater than 1 μf.



Type		*Code Word*	*Price*
1611-A	**Capacitance Test Bridge**	FORUM	**$440.00**

TYPE 740-B CAPACITANCE TEST BRIDGE

USES: The TYPE 740-B Capacitance Test Bridge is a 60-cycle capacitance and dissipation factor bridge for use in both laboratory and production testing of paper, mica, and electrolytic capacitors. The capacitor manufacturer can use it for production tests, the capacitor user for acceptance tests. It is particularly useful in testing polarized electrolytic capacitors because the test conditions approximate the normal operating conditions of use.

DESCRIPTION: The circuit used in this instrument is that of a series-resistance capacitance bridge. It is similar to the capacitance portion of the TYPE 650-A Impedance Bridge, but adapted for 60-cycle use. One ratio arm is variable in decade steps, and the other is continuously variable and calibrated directly in capacitance.

The TYPE 740-B Capacitance Test Bridge is a simpler instrument than the TYPE 1611-A, described above, with a smaller capacitance range, and lacking some of the features of the latter instrument.

FEATURES: ➔ Measures the direct capacitance of *ungrounded* capacitors.

➔ Visual null indicator makes the bridge useful for production testing in noisy locations.

➔ Simple to operate.

➔ Normal operating conditions can be reproduced when testing polarized electrolytic capacitors by using a d-c polarizing voltage. The a-c voltage impressed by the bridge itself is small and simulates the ripple usually encountered in power-supply filters.

➔ Adequate protection is afforded by the covered case, and small size and light weight make it possible to move the instrument easily and set it up wherever necessary.

SPECIFICATIONS

Capacitance Range: 5 $\mu\mu$f to 1100 μf in seven ranges. Capacitance values are read directly from a logarithmic dial and multiplier switch.

Capacitance Accuracy: Within ±1% over the main decade (1 to 11) of the CAPACITANCE dial for all multiplier settings except .0001. Within ±1.5% or ±3 $\mu\mu$f, whichever is the larger, on the .0001 multiplier on the main decade of the CAPACITANCE dial. Below 100 $\mu\mu$f the error gradually increases to ±5 $\mu\mu$f as zero is approached.

Dissipation Factor Range: 0 to 50% in two ranges. Dissipation factor values are read directly from an engraved scale and multiplier switch.

Dissipation Factor Accuracy: Within ±1.5% of full-scale reading for all capacitance multipliers except .0001.

On the .0001 capacitance multiplier a correction of 0.3% should be subtracted from the dissipation factor dial reading. When this correction is made the accuracy is within ±2 divisions on the x1 multiplier and within ±1 division on the x10 multiplier.

Voltage Applied to Unknown: The voltage impressed across the unknown terminals varies continuously with the bridge setting. For very small capacitances in the lowest range, this voltage is approximately 35 volts, and it decreases with increasing capacitance, so that at 100 μf it is approximately one volt.

Polarizing Voltage: Terminals for connecting a d-c polarizing voltage are provided on the panel.

Power Supply: 105 to 125 (or 210 to 250) volts, 60 cycles. The power input is 15 watts.

Controls: Capacitance dial and multiplier, dissipation factor control and multiplier, sensitivity control.

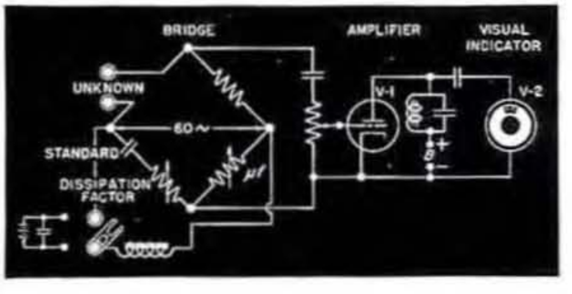
Accessories Supplied: A line connector cord and spare fuses.

Vacuum Tubes: One each 6X5GT/G, 6J7, 6E5; all are supplied with the bridge.

Mounting: Portable carrying case, of airplane-luggage construction.

Dimensions: (Length) 14½ x (width) 15 x (height) 9¼ inches, over-all, including cover and handles.

Net Weight: 19 pounds.



Type		*Code Word*	*Price*
740-B	**Capacitance Test Bridge**	BABEL	**$230.00**

TYPE 667-A INDUCTANCE BRIDGE

USES: This bridge is designed for accurately measuring the audio-frequency inductance of small coils, which have a low value of storage factor, Q, at audio-frequencies. It is used by many coil and receiver manufacturers for all audio-frequency measurements on the tuning coils for radio receivers. It is also capable of measuring higher values of inductance (up to 1 henry) and hence can be used as a general-purpose inductance bridge. When connected as a Campbell mutual inductance bridge, it can be used to measure mutual inductance in terms of the internal standard. Terminals are provided so that the bridge can be connected as a resonance bridge for such measurements as the ratio of a-c to d-c resistance. The d-c resistance can be determined by using a battery and galvanometer in place of the usual a-c generator and detector.

DESCRIPTION: The TYPE 667-A Inductance Bridge is a conventional impedance bridge specifically designed for inductance measurements. The necessary design features to eliminate residual sources of error and to make the bridge direct reading have been incorporated. The variable resistors in both the standard and the unknown arms are inductance compensated, identical in construction with TYPE 668 Compensated Decade-Resistance Units.

The variable inductor, L_p, in series with the unknown makes it possible to obtain a final inductance balance independent of the resistive balance of the bridge. The standard inductor is wound on a ceramic toroidal form in order to minimize magnetic coupling with the variable inductor. The switch, K, is used when the bridge is connected as a resonance bridge.

FEATURES: ➔ High accuracy (within 0.1 μh) for the measurement of small inductances is one of the outstanding features of this bridge.

➔ Errors introduced by a sliding-zero balance and the variation of inductance with setting of the decade resistors have been eliminated. Thus, inductances of a few microhenrys can be measured easily and accurately.

➔ An internal standard is provided for convenience, but terminals are available for external standards when necessary to extend the range of the bridge.

SPECIFICATIONS

Range: Inductance, 0.1 microhenry to 1 henry. The range can be extended by using TYPE 106 Standard Inductors as external standards. When the internal standard is used, the bridge will balance for storage factors between 0.06 and infinity at 1 kc.

Accuracy: Inductance, $\pm(0.2\% + 0.1\ \mu h)$. The capacitance across the UNKNOWN terminals is about 90 $\mu\mu f$. This capacitance will increase the measured value of large inductors fractionally by the amount $\omega^2 LC$. At 1 kc and 1 h the increase is 0.36%.

Frequency Range: All calibration adjustments are made at a frequency of 1 kc. The bridge can be used at any frequency between 60 cycles and 10 kilocycles, but errors resulting from stray capacitance increase with frequency. When large values of inductance are measured with external standards, the frequency should be lowered to avoid resonance effects.

Standards: The standard inductor is a 1-millihenry toroid wound on a ceramic form. Resistance balance of the bridge is made by means of inductance-compensated resistors.

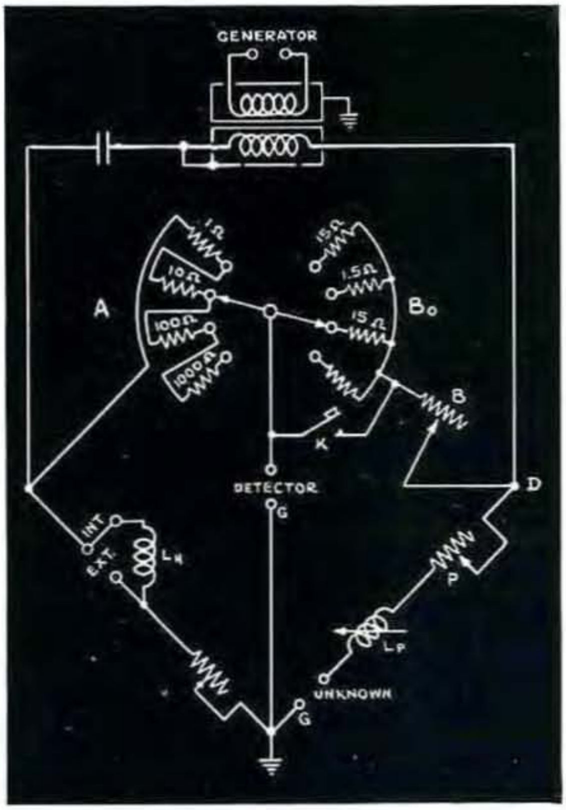
Mounting: The bridge is supplied in a shielded cabinet.

Accessories Required: Oscillator, amplifier, and head telephones. TYPE 1214-A Oscillator (see page 111) and TYPE 1231-B Amplifier and Null Detector (see page 98) are recommended.

Accessories Supplied: Two TYPE 274-NC Shielded Connectors.

Dimensions: (Length) $17\frac{1}{2}$ x (width) 16 x (height) $9\frac{1}{2}$ inches, over-all.

Net Weight: 33 pounds.



Type		Code Word	Price
667-A	Inductance Bridge	AERIE	$450.00

TYPE 1612 R-F CAPACITANCE METER

Low-Range Model Measures Tube Socket Capacitance in accordance with RTMA Specification TR-111.

USES: The TYPE 1612-A R-F Capacitance Meter is a device for conveniently measuring capacitances up to 1200 $\mu\mu f$ at 1 megacycle. It can also be used for comparing the losses in dielectric samples.

With the addition of a simple test jig, the Capacitance Meter is easily adapted for the rapid measurement of capacitors in production. With test cells, it has been used in chemical processes to compare the concentrations of ingredients in a process with a standard mixture.

The low-range model, TYPE 1612-AL, is particularly useful in measuring the capacitance between terminals of a vacuum-tube socket (RTMA Specification TR-111). Adaptors for the measurement are available and are listed below.

DESCRIPTION: The principle of operation is illustrated by the functional circuit diagram below. The main elements are a one-megacycle oscillator and a measuring circuit.

The oscillator is loosely coupled to the measuring circuit, which incorporates a calibrated capacitor, an inductor, and a crystal rectifier and microammeter. Manual control of the oscillator output is provided.

Measurement is made by a substitution method in which the capacitance of the calibrated capacitor is reduced to re-establish resonance after the unknown capacitance is connected to the *X* terminals.

The relative loss for capacitors similar in structure is indicated by the maximum deflection of the meter at resonance.

The instrument operates directly from a 115-volt, a-c or d-c line.

View showing socket adaptor attached to the *X* terminals of the capacitance meter.

FEATURES: ➔ Ease and speed of measurement are outstanding characteristics.

➔ The range of the instrument covers capacitors commonly used in r-f circuits.

➔ Comparative indications of dielectric losses are readily obtained.

➔ The meter is simple and accurate and has no complicated circuits.

➔ A-C or d-c can be used to furnish the necessary power.

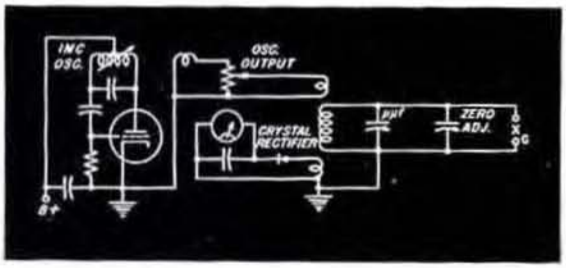
➔ Capacitances as low as 0.05 μμf can be measured on the Type 1612-AL model.

SPECIFICATIONS

Capacitance Range: Type 1612-A, 0 to 1200 μμf in two bands — 0 to 80 μμf and 0 to 1200 μμf; Type 1612-AL, 0 to 100 μμf in two bands — 0 to 10 μμf and 0 to 100 μμf. Ranges are switched automatically as capacitance dial is rotated.

Capacitance Accuracy:

Type	*Low Range*	*High Range*
1612-A	±0.4 μμf below 10 μμf ±4% above 10 μμf	±4 μμf below 100 μμf ±4% above 100 μμf
1612-AL	±0.04 μμf below 1 μμf ±4% above 1 μμf	±0.4 μμf below 10 μμf ±4% above 10 μμf



Capacitance Scale: Scale is spread out at low end of dial and nearly linear at high end. For Type 1612-A, smallest division is 1 μμf for the low range and 20 μμf for the high range. For Type 1612-AL, smallest scale divisions are 0.1 and 1.0 μμf, respectively. Minimum measurable capacitance is influenced by sharpness of resonance as well as scale distribution, and is about one-half the smallest division.

Dielectric Losses: Relative meter indications with different dielectric samples give a comparative measure of dielectric loss.

Oscillator Frequency: 1 megacycle ±1% adjusted at factory. Frequency can be readjusted if necessary by means of a movable dust core.

Resonance Indicator: A 1N34 crystal rectifier is used with a microammeter to indicate resonance.

Tube: A 117N7-GT tube is used in the oscillator circuit, and is supplied.

Accessories Supplied: Line connector cord and spare fuses.

Power Supply: 115 volts, 50 to 60 cycles ac, or dc.

Power Input: 12 watts at 115 volts, ac. 11 watts at 115 volts, dc.

Dimensions: (Length) 12 x (height) 6⅝ x (depth) 7½ inches, over-all.

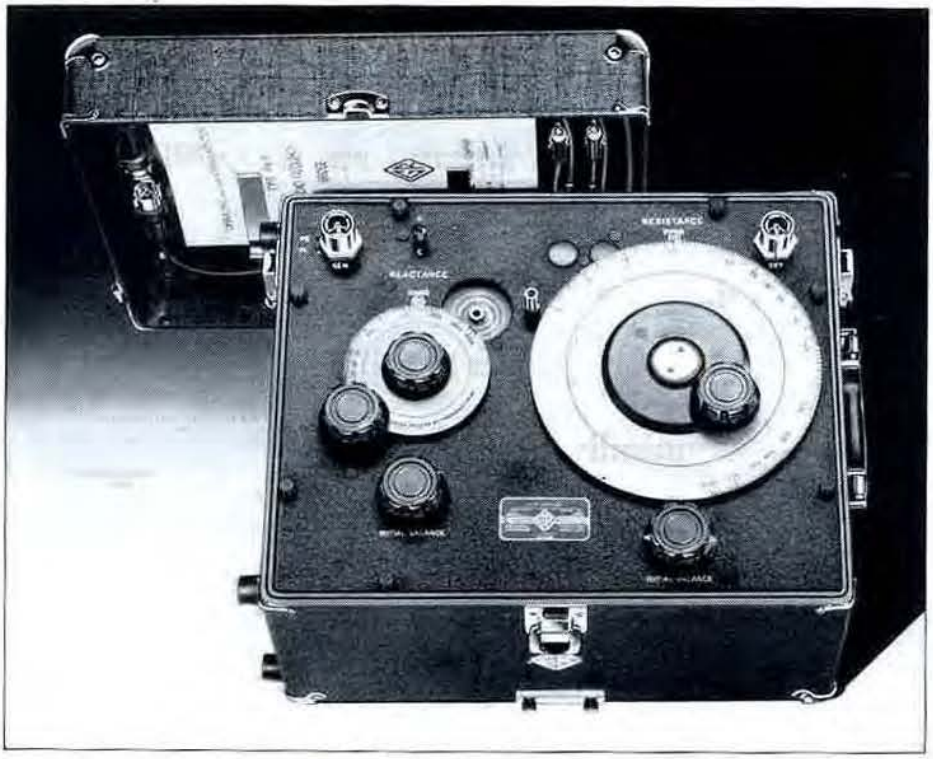
Net Weight: 12 pounds, 4 ounces.

Type		*Code Word*	*Price*
1612-A	**R-F Capacitance Meter**	AFTER	**$170.00**
1612-AL	**R-F Capacitance Meter**	AGAIN	**170.00**

PATENT NOTICE. See Note 2, page vi.

SOCKET ADAPTORS FOR USE WITH TYPE 1612-AL
(For RTMA Specification TR-111)

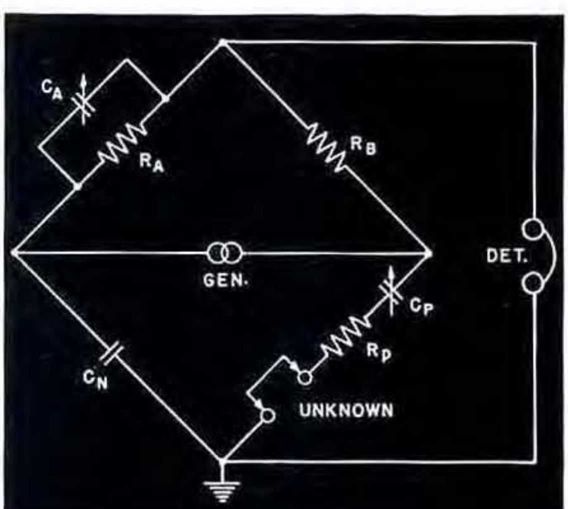
Type		*Code Word*	*Price*
1612-P1	**Adaptor for 7-pin miniature**	HEPTA	**$9.00**
1612-P2	**Adaptor for octal**	OCTAL	**9.00**
1612-P3	**Adaptor for 9-pin miniature noval**	NOVAL	**9.00**



TYPE 916 RADIO-FREQUENCY BRIDGE

USES: The TYPE 916 Radio Frequency Bridge is designed for impedance measurements at radio frequencies. It can be used to measure directly the reactance and resistance of antennas, transmission lines, and circuit elements. The use of an external parallel capacitor makes it possible to measure parallel tuned circuits, high resistances, and other high impedances.

The bridge is intended for measuring low impedances and complements the TYPE 821-A Twin-T, which is best suited for measuring high impedances. Two models are available: TYPE 916-A, for frequencies between 400 kc and 60 Mc; and TYPE 916-AL for frequencies between 50 kc and 5 Mc. For measurements in the standard broadcast band, the TYPE 916-AL is recommended, because of its higher sensitivity in that frequency range.



DESCRIPTION: The bridge circuit used is shown schematically in the diagram below. Measurements are made by a series-substitution method. The components of the unknown impedance are determined from the change in settings of capacitors C_A and C_P. The unknown reactance at 1 Mc is read directly in ohms from the dial of C_P, and the unknown resistance in ohms from the dial of C_A.

In making measurements the bridge is first balanced by means of capacitors C_P and C_A with a short-circuit across the unknown terminals. The short is then removed, the unknown impedance connected, and the bridge rebalanced. The resistance is then given by

$$R_x = R_B \frac{(C_{A_2} - C_{A_1})}{C_N}$$

and the reactance by

$$X_x = \frac{1}{\omega}\left(\frac{1}{C_{P_2}} - \frac{1}{C_{P_1}}\right)$$

where the subscripts 1 and 2 denote the dial readings for the initial and final balances, respectively.

The resistive component is measured in terms of a *fixed* resistor (R_B), a fixed capacitor (C_N), and a variable capacitor (C_A). This feature is an important factor in the high-frequency performance of the bridge because residual parameters can be made much smaller in a fixed resistor and a variable capacitor than in a variable resistor.

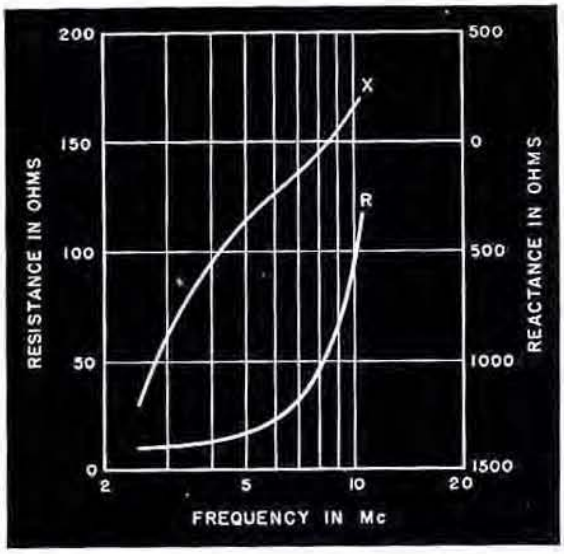
FEATURES: ➔ Direct-reading in resistance, independent of frequency.

➔ Direct-reading in reactance at a single frequency; reactance at other frequencies is determined by dividing dial reading by operating frequency.

➔ Rapid, convenient, and accurate for antenna impedance measurements.

➔ Wide frequency range.

➔ Easily portable — carrying case is rugged, and cover provides storage space for cables.



Reactance and resistance of an antenna system measured with the TYPE 916-A Radio-Frequency Bridge.

SPECIFICATIONS FOR TYPE 916-A

Frequency Range: 400 kc to 60 Mc.

Reactance Range: 5000 Ω at 1 Mc. This range varies inversely as the frequency, and at other frequencies the dial reading must be divided by the frequency in megacycles.

Resistance Range: 0 to 1000 Ω.

Accuracy: For reactance, at frequencies up to 50 Mc, $\pm(2\% + 1\ \Omega + 0.0008 \times R \times f)$, where R is the measured resistance in ohms and f is the frequency in Mc.

For resistance, at frequencies up to 50 Mc, $\pm(1\% + 0.1\ \Omega)$, subject to correction for residual parameters. At high frequencies the correction depends upon the frequency and upon the magnitude of the unknown resistance component. At low frequencies the correction depends upon the frequency and upon the magnitude of the unknown reactance component. Plots of both these corrections are given in the instruction book that is supplied with the bridge.

Satisfactory operation can be obtained at frequencies up to 60 Mc with somewhat poorer accuracy above 50 Mc than at lower frequencies.

Accessories Supplied: Two input transformers, one covering the lower portion of the frequency range, the other the higher portion; two leads of different lengths (for connecting the unknown impedance); two cables for connecting generator and detector; one TYPE 874-P Panel Connector.

Other Accessories Required: Radio-frequency generator and detector. The TYPE 1330-A Bridge Oscillator (page 150) is recommended as the generator, and a well-shielded radio receiver covering the desired frequency range makes a satisfactory detector. It is recommended that the receiver be fitted with the TYPE 874-P Panel Connector supplied to avoid leakage at the input connection.

Mounting: Airplane-luggage type case with carrying handle. Both input transformers are stored inside the case. Coaxial cables, leads, and instruction book are stored in the cover of the instrument when not in use.

Dimensions: 17 x 13½ x 11⅛ inches, over-all.

Net Weight: 34½ pounds.

SPECIFICATIONS FOR TYPE 916-AL

Frequency Range: 50 kc to 5 Mc. Satisfactory operation for many measurements can be obtained at frequencies as low as 15 kc.

Reactance Range: 11,000 Ω at 100 kc. This range varies inversely as the frequency, and at other frequencies the dial readings must be divided by the frequency in hundreds of kilocycles. To facilitate the measurement of small reactances, the instrument is provided with an incremental reactance dial which has a range of 100 ohms at 100 kc.

Resistance Range: 0 to 1000 Ω.

Accuracy: For reactance at frequencies up to 3 Mc, $\pm(2\% + 0.2 \times \frac{100}{f_{kc}}\ \Omega + 3.5 f_{kc}^2 R \times 10^{-10}\ \Omega)$ where R is the measured resistance in ohms and f_{kc} is the frequency in kilocycles. The errors in reactance increase relatively rapidly at frequencies above 3 Mc; and at 5 Mc the accuracy is $\pm(2\% + 0.01\ \Omega + 2.3\ R^{1.5} \times 10^{-3}\ \Omega)$. For resistance, at frequencies up to 5 Mc, $\pm(1\% + 0.1\ \Omega)$, subject to correction for residual parameters at low frequencies. The correction depends upon the frequency and upon the magnitude of the unknown reactance component. A plot of this correction is given in the instruction book supplied with the bridge.

Other specifications are identical with those for TYPE 916-A, above.

Type		*Code Word*	*Price*
916-A	**Radio-Frequency Bridge (400 kc to 60 Mc)** . .	CIVIC	**$475.00**
916-AL	**Radio-Frequency Bridge (50 kc to 5 Mc)**	CLUCK	**495.00**

PATENT NOTICE. See Notes 3, 4, and 13, page vi.

TYPE 821-A TWIN-T IMPEDANCE MEASURING CIRCUIT

USES: This instrument is used for impedance measurements at radio frequencies between 0.46 Mc and 40 Mc. It is calibrated in capacitance and conductance and can be used to measure the capacitance and dissipation factor of capacitors, the inductance and Q of coils, the resonant impedance of parallel tuned circuits, and the magnitudes and phase angles of high resistances. Through the use of an external fixed capacitor, low resistances, grounded antennas, coaxial transmission lines, and impedance-matching networks can be measured. It is particularly useful for measuring impedances having small phase differences from zero or 90°, such as dielectric samples, low-loss capacitors, high-Q coils, and r-f resistors.

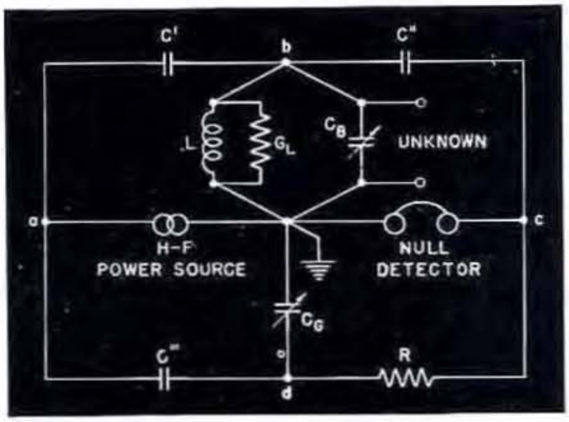
DESCRIPTION: The instrument uses a Parallel-T null circuit, as shown in simplified form in the schematic diagram. Measurements are made by a parallel-substitution method. An initial balance of the circuit is obtained with the unknown disconnected; the unknown impedance is then connected and the circuit rebalanced for a null. The components of the unknown impedance are determined from the changes in setting of capacitors C_B and C_G. The measurement is made in terms of the admittance components of the unknown.

The value of conductance is given by:

$$G_x = \omega^2 C' C'' R \frac{\Delta C_G}{C'''} = k\omega^2 \Delta C_G,$$

and the dial of C_G is calibrated to be direct reading at 1, 3, 10, and 30 Mc. For other frequencies, the dial reading is multiplied by the ratio of the squares of the working and direct-reading frequencies. For the initial balance, the conductance dial is set at zero.

The setting of the capacitor C_B determines the susceptive balance. The calibrated capacitor dial is direct reading in micromicrofarads. Capacitance can therefore be measured

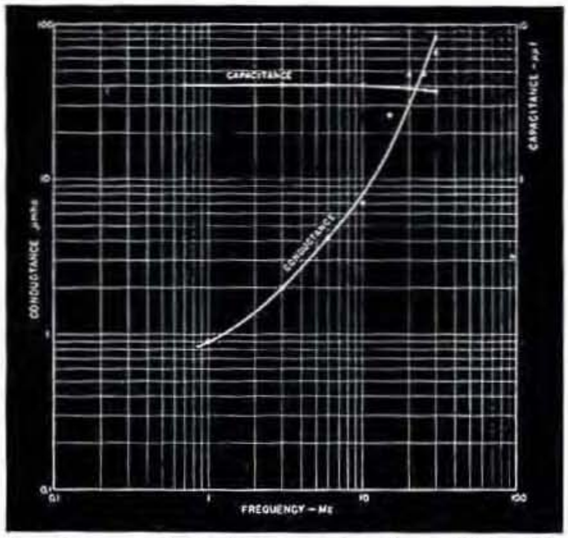


directly. For other types of unknown, it is generally more convenient to use the susceptance,

$$B_x = \omega \Delta C_B.$$

Impedance components, reactance and resistance, can, of course, be calculated from the admittance components.

The Twin-T is mounted in a shielded, airplane-luggage type case and is completely portable. TYPE 874 Coaxial Connectors are used for the generator and detector terminals. The unknown connects directly to terminals on the panel.



Capacitance and Conductance of a TYPE 119-A R-F Choke as measured on the Twin-T.

FEATURES: → The accuracy of measurement at high frequencies is achieved by eliminating the effects of some of the residual capacitances which normally limit the performance of bridge circuits.

→ Highly precise balances are made possible by the type of null method used with the Twin-T.

→ No transformer is needed because the generator, the detector, the unknown, and the two standard capacitors are brought to a common ground point.

→ The mechanical arrangement keeps leads short and direct, thus minimizing lead impedances.

→ The circuit elements themselves are designed to have low residual impedances.

→ Errors inherent in variable resistors at high frequencies are avoided by measuring susceptance in terms of an especially designed variable air capacitor, and conductance in terms of a variable air capacitor and a fixed resistor of the 663 type.

SPECIFICATIONS

Frequency Range: 460 kc to 40 Mc.

Capacitance Range: The dial of the standard capacitor is calibrated from 100 to 1100 µµf, and the range of capacitance measurement by the parallel-substitution method is therefore 0 to 1000 µµf.

Susceptance Range: −6000 µmho to +6000 µmho at 1 Mc. The range varies directly as the frequency, and at other frequencies the dial reading must be multiplied by the frequency in megacycles.

Conductance Range: Direct Reading:

0 — 100 µmho at 1 Mc   0 — 1000 µmho at 10 Mc
0 — 300 µmho at 3 Mc   0 — 3000 µmho at 30 Mc

Between these direct-reading ranges the range of the conductance dial varies as the square of the frequency.

Accuracy: ±(0.1% + 2 µµf) for capacitance. For conductance, ±(2% of actual dial reading + 0.1% of full scale). At the higher frequencies, corrections for residual parameters must be applied, and the correction data are included in the instruction book.

A correction chart for the precision capacitor is supplied, giving scale corrections to 0.1 µµf at multiples of 100 µµf. By using these data, capacitance measurements can be made to ±0.1% or ±0.5 µµf, whichever is the larger.

Accessories Supplied: Two TYPE 874-R21 coaxial cables for connections to generator and detector; TYPE 874-P Panel Connector.

Other Accessories Required: A suitable radio-frequency generator and a detector are required. The TYPE 1330-A Bridge Oscillator (page 150) is recommended as a generator, and a well-shielded radio receiver covering the desired frequency range is a satisfactory detector. It is recommended that the receiver be fitted with the TYPE 874-P Panel Connector supplied to avoid leakage at the input connection.

Other Accessories Available: For measurements on unguarded dielectric specimens, the TYPE 1690-A Dielectric Sample Holder (page 96) is recommended.

Mounting: The instrument is mounted in a shielded, airplane-luggage type of case with carrying handle.

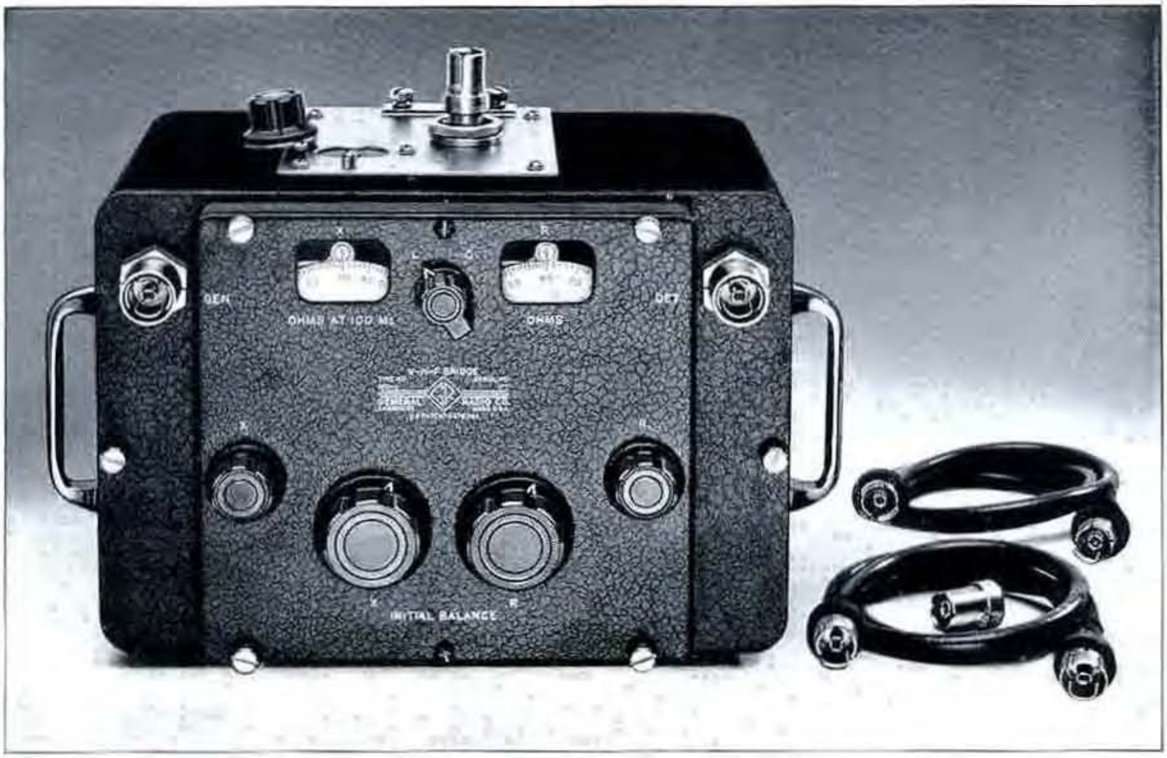
Dimensions: 17¾ x 12 x 9½ inches, over-all.

Net Weight: 29 pounds.

Interior view of the Twin-T.

Type		Code Word	Price
821-A	**Twin-T**	LAGER	**$520.00**

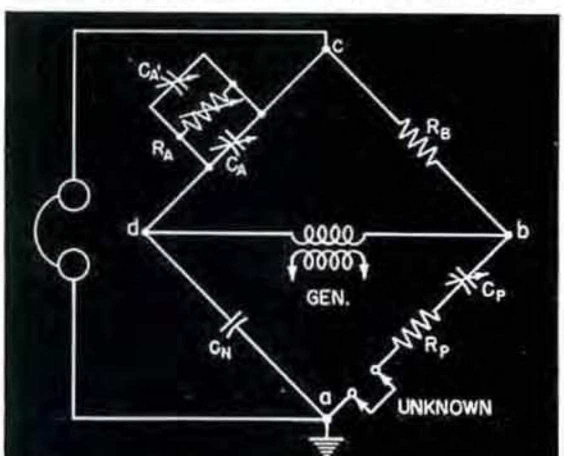
PATENT NOTICE. See Notes 3, 4, and 7, page vi.



TYPE 1601-A V-H-F BRIDGE

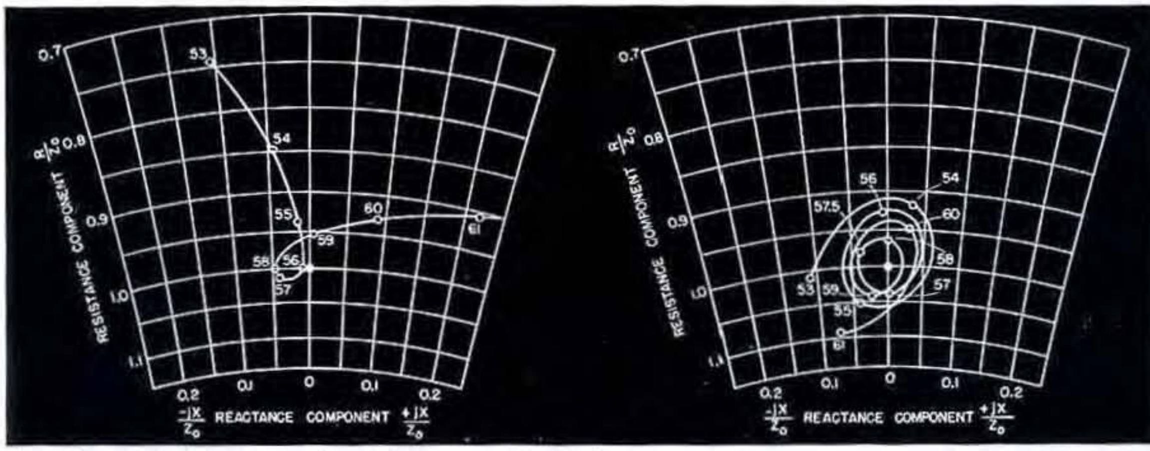
USES: The TYPE 1601-A V-H-F Bridge is designed for the direct measurement of relatively low impedances at frequencies between 10 and 165 megacycles. It will measure high impedances indirectly. Among its applications are measurements on antennas, lines, networks, and components. It is particularly well adapted for the accurate measurement of 50-ohm coaxial systems, and is supplied with a coaxial adaptor to fit the bridge unknown terminal. For measurements on components and other lumped impedances, a pair of terminals (one grounded) or a single terminal with ground plane are provided.

Basic bridge circuit for the TYPE 1601-A V-H-F Bridge.



DESCRIPTION: The measurement is made by a series substitution method using the same basic bridge circuit as the TYPE 916-A and TYPE 916-AL Radio-Frequency Bridges. The resistive and reactive components of the unknown impedance are measured in terms of incremental capacitances, and the magnitude of each is indicated on a separate dial. Calibrations are in ohms resistance and in ohms reactance at 100 megacycles. The resistance dial calibration is independent of frequency. Reactance at any other frequency is obtained by dividing the dial reading by the operating frequency in hundreds of megacycles.

Particular attention has been paid to the design of the bridge transformer and of the terminal structure to which the unknown impedance is connected, in order that the bridge be direct-reading, with a minimum of corrections. Although residual parameters have been minimized in the bridge design, corrections are necessary, as in all bridges, for those residuals which cannot be eliminated or compensated for. These corrections have been



(*Left*) Plot of the impedance of a single element of a 16-element antenna array as measured on the TYPE 1601-A V-H-F Bridge. Numbers on curve indicate frequency in megacycles. (*Right*) Plot of the impedance of the entire 16-element array, as seen from the transmitter.

plotted in the form of convenient charts, which are supplied in the instruction book.

Generator and detector terminals are the General Radio TYPE 874 Coaxial Connectors. This type of terminal is also used on the coaxial adaptor for the bridge unknown terminal.

FEATURES: ➔ This bridge is as convenient to use as those operating at much lower frequencies.

➔ Terminal arrangement permits both coaxial and lumped circuits to be measured.

➔ Bridge is small enough and light enough to permit its use in locations such as antenna towers which would be inaccessible to heavier equipment.

➔ Accuracy is better than that obtainable with other methods at these frequencies.

➔ Dials are direct-reading in both resistance and reactance.

SPECIFICATIONS

Frequency Range: 10 Mc to 165 Mc. Satisfactory operation can, for some measurements, be obtained at frequencies as low as 2 Mc and as high as 175 Mc, but the bridge sensitivity decreases markedly at frequencies beyond the nominal range of 10 to 165 Mc. In addition, the accuracy of measurement of small reactances decreases as the frequency decreases, owing to lack of precision in reading the reactance dial, whose range is inversely proportional to frequency, and at frequencies above the nominal range the corrections become larger.

Reactance Range: ±200 ohms at 100 Mc. Dial range varies inversely with frequency and is calibrated at 100 Mc.

Resistance Range: 0 to 200 ohms, independent of frequency.

Accuracy: For resistance, ±(2% + 1 Ω) subject to correction for inductance in the capacitor used to measure resistance. The correction increases with frequency and with the magnitude of the resistive component. A correction chart is supplied with the instrument. The ohmic uncertainty indicated in the accuracy statement, namely 1 ohm, is roughly proportional to the magnitude of the reactive component of the unknown impedance. The indicated value is the maximum obtainable, and the minimum is 0.1 ohm.

For reactance, ±(5% + 2 Ω). The ohmic uncertainty is roughly proportional to frequency and to the magnitude of the resistive component. The maximum value is indicated and the minimum value is 0.1 ohm at 100 Mc.

Accessories Supplied: Two TYPE 874-R20 Cables; one TYPE 1601-204 Coaxial Extension Assembly; one TYPE 874-WN Short-Circuit Termination; one Short-Circuiting Cap; one TYPE 874-P Panel Connector; Smith Charts.

Other Accessories Required: R-F generator and receiver covering the desired frequency range; TYPE 1208-A Oscillator (page 109) is recommended for frequencies above 65 Mc, and, for lower frequencies, the TYPE 1330-A Bridge Oscillator (page 150). Both oscillator and receiver should be reasonably well shielded. It is recommended that the receiver be fitted with the TYPE 874-P Panel Connector supplied to avoid leakage at the input connection.

Additional Accessories Recommended: A TYPE 874-WM 50-ohm Termination is useful in checking the bridge. The bridge generator and detector terminals are TYPE 874 Coaxial Connectors, and if connection is to be made to equipment using TYPE N Connectors, TYPE 874-Q1 Adaptors will be needed. An additional TYPE 874-Q1 Adaptor will be needed when coaxial systems to be measured are fitted with TYPE N Connectors. See page 124.

Dimensions: (Length) 13½ x (height) 9 x (depth) 10½ inches, over-all.

Net Weight: 18 pounds.

Type		*Code Word*	*Price*
1601-A	**V-H-F Bridge***†	FLORA	**$395.00**
874-WM	**50-Ohm Termination***	COAXNUTTER	**10.50**
874-Q1	**Adaptor to Type N Connectors***	COAXMEETER	**4.50**

PATENT NOTICE. *See Notes 3 and 4, page vi. †See Note 13, page vi.

TYPE 1602-A U-H-F ADMITTANCE METER

USES: The admittance meter is a null-type instrument for determining the components of an unknown admittance in the VHF-UHF range. It is designed primarily for measurements on coaxial systems: antennas, lines, coaxial components, etc. It can be used as an indicator for adjusting a network to a predetermined admittance or in matching one network to another and is particularly useful in matching antennas and other networks to 50-ohm circuits; the proper match is obtained quickly by setting the conductance scale to 20 millimhos (50 ohms), and varying the matching transformer or network until a null is reached.

As a comparator, the admittance meter can be used to determine impedance magnitude, reflection-coefficient magnitude, and voltage standing-wave ratio. The usefulness of the admittance meter is not limited to measurements on coaxial systems. Networks of other types, lumped or distributed, can be measured by equipping them with Type 874 Coaxial Connectors, or by using coaxial adaptors, to permit them to be plugged into the admittance meter. Adaptors for this purpose have been designed and will be available in the near future.

DESCRIPTION: The Type 1602-A Admittance Meter comprises a coaxial line to which the unknown is connected and containing a shielded pickup loop to sample the current, a second line, and loop, terminated in a pure resistance, and a third line, and loop, terminated in a pure reactance. All are fed from the same voltage source, so that their input voltages are in phase, and the current in each line is proportional to the admittance. The voltage induced in each loop is proportional to the current in the corresponding line and is dependent upon the orientation of the loop, which is adjustable.

The three loops are connected in parallel, and the voltage from the loop in the unknown line is matched by adjusting the loops coupled to the standard lines until a null is reached. The conductance and susceptance of the unknown are read directly from the scales of the standard loops, while the scale of the loop in the unknown line indicates multiplying factor.

FEATURES: ➔ Dial scales are direct-reading, independent of frequency.

➔ No sliding balance; conductance and susceptance adjustments are independent.

➔ No initial balance is necessary.

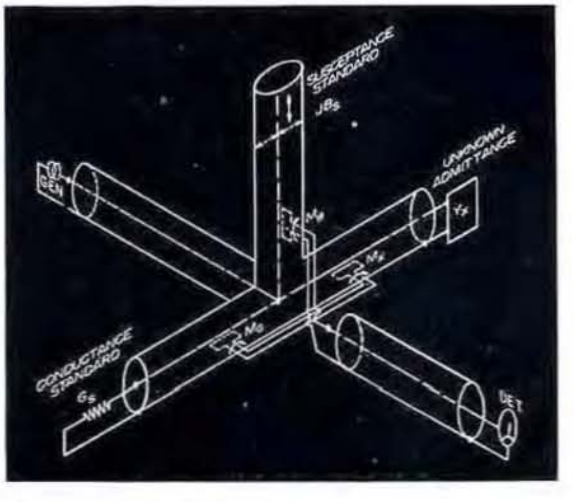
➔ Wide-frequency range—direct-reading from 66 to 1000 megacycles.

➔ Can be used at frequencies as low as 20 Mc and as high as 1500 Mc.

➔ Adaptable to many types of measurement.

➔ Line length corrections can be eliminated and the instrument made direct reading in impedance, if a coaxial line or other network of an effective length of one quarter wave is used between the unknown and the meter. The Type 874-LK Constant-Impedance Adjustable-Length Line can be used to adjust the over-all line length to the desired value.

Schematic diagram of admittance meter circuit, with standards, generator, and null detector connected for admittance measurements.



SPECIFICATIONS

Range: Theoretically, zero to infinity; practically, the lower limit is determined by the smallest readable increment on the scale which is 200 micromhos (0.2 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: 66 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:

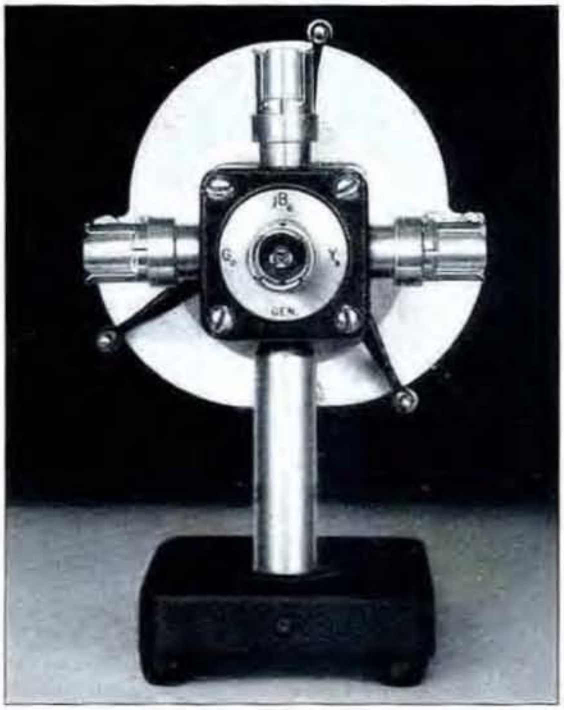
from 0 to 20 millimhos ±(5% + 0.2 millimho)

from 20 to ∞ millimhos $\pm 5\sqrt{M}$ %

where M is the scale multiplying factor.

Accessories Supplied: One Type 874-WM 50-Ω Termination, for use as conductance standard, and one each Type 1602-P1 and Type 1602-P2 Adjustable Stubs, for susceptance standards; two Type 874-R20 Patch Cords for connections to generator and detector; and one Type 874-P Panel Connector for installation on receiver. 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), and Type 1209-A (250 to 920 Mc) Unit Oscillators (see page 109), or Type 1021-A Standard-Signal Generator are recommended. Detector sensitivity should be better than 10 microvolts. Ordinary communications-type receivers can be used, in conjunction with a Type 1208-A or Type 1209-A Unit Oscillator and a Type 874-MR Mixer Rectifier (page 125). For best results the receiver should have a bandwidth of at least 20 kc. Certain military receivers are satisfactory, provided they are adequately shielded. Best results will be obtained by using the i-f amplifier and indicator circuit of these receivers with a Type 874-MR Mixer Rectifier and an appropriate oscillator.



Rear view of the admittance meter showing the four lines making up the generator junction assembly. The three arms for the sliding indicators can also be seen.

Terminals: All terminals are Type 874 Coaxial Connectors. Type 874-Q1 Adaptors are available for Type N Connectors.

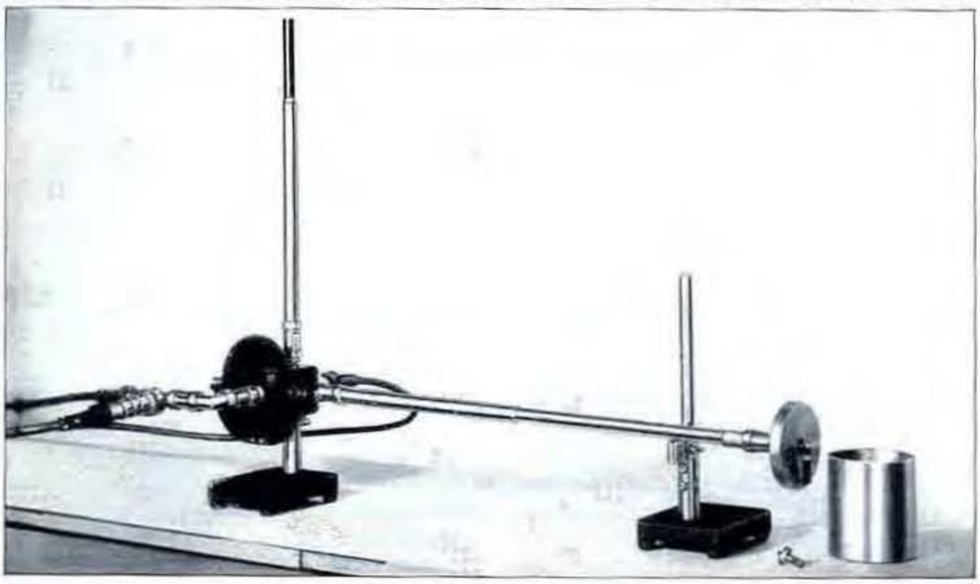
Dimensions: 7½ x 5½ x 5½ inches, without standards and unknown connected.

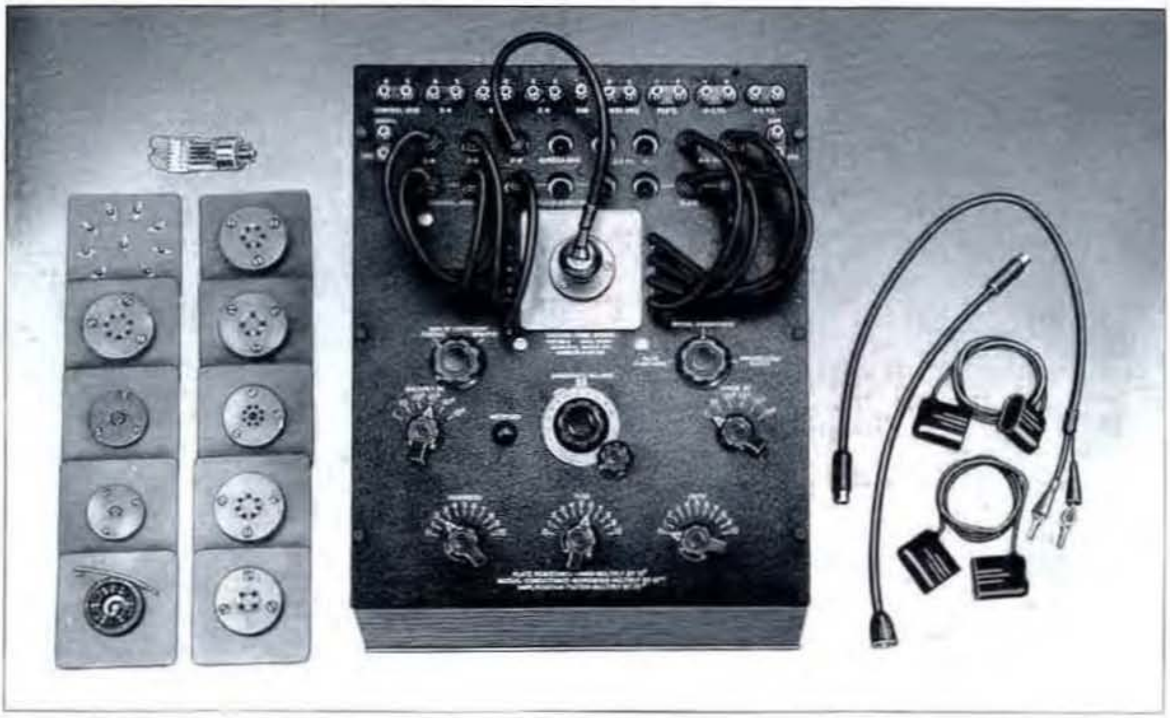
Net Weight: 8¼ pounds.

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

PATENT NOTICE. See Notes 3 and 4, page vi.

The Type 1602-A U-H-F Admittance Meter set up for measuring the effective impedance of a resistor. A coaxial adaptor is used to mount the resistor, and a Type 874-LK Constant-Impedance Adjustable Line is used to make the effective length from meter to resistor equal to a quarter wave.





TYPE 561-D VACUUM-TUBE BRIDGE

USES: This instrument makes possible accurate measurements of the three fundamental vacuum-tube parameters: amplification factor, transconductance, and plate resistance, over wide ranges of values. The accuracy is sufficient so that the bridge has found acceptance among tube manufacturers as a standard of reference for tube measurements, particularly where extreme values of the parameters are encountered and where ordinary measuring circuits become untrustworthy.

In the field of development and research the instrument, in addition to providing accurate measurements of the usual tube parameters, affords a means of studying the behavior of tubes used in unconventional and special circuits, when any one of the electrodes may be used as the operating electrode and where the parameters may have negative values.

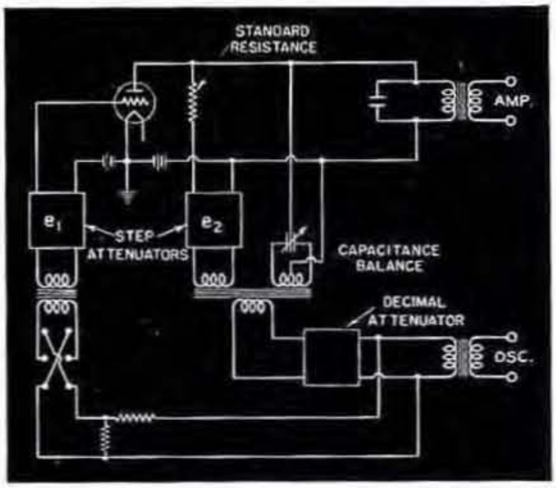
The tube circuits have large enough current-carrying capacity and sufficient insulation so that low-power transmitting tubes may be tested in addition to receiving tubes.

DESCRIPTION: The bridge makes use of alternating-current null methods of measurement, in which phase shift and capacitance errors have been given special consideration in order that the operating range of the bridge may be as wide as possible. Each of the three coefficients is obtained in terms of the ratio of two alternating test voltages. A third voltage is employed in the capacitance balancing circuit, but its value does not enter into the results.

An extremely flexible arrangement of the tube control circuits makes it possible to measure the tube parameters referred to any pair of electrodes. Connections from the tube under test to the measuring circuit are made by means of concentric cables and jacks, connected to a nine-terminal jack plate, mounted on the panel. Sixteen concentric plugs are mounted on the panel, permitting a wide variety of interconnections between the jack plate, the measuring circuit, and external batteries.

Twelve adaptors are provided. Eleven of these carry different standard tube sockets, and one is a "universal" adaptor furnished with soldering lugs.

FEATURES: ➔ A simple and straightforward measurement procedure is used and is exactly the same for all three coefficients. A three-position switch is turned to the desired quantity, multiplier switches are set at the appropriate value for the tube being tested, and a null balance is obtained by adjusting a three-decade attenuator and a variable capacitor. At balance, the decades read the quantity being measured directly to three significant figures.



Simplified diagram of the circuit employed for the measurement of transconductance with the TYPE 561-D Vacuum-Tube Bridge. The a-c plate current resulting from the application of e_1 to the grid is balanced by an equal and opposite current applied to the plate from the source e_2, through the standard resistance. The setting of the decimal attenuator at the bottom of the panel gives the significant figures in the result, and the settings of the step attenuators (e_1 and e_2) indicate multiplying factors (MULTIPLY BY and DIVIDE BY on the panel switches).

Any quadrature component through the output transformer resulting from the tube interelectrode capacitances can be balanced out by the voltage of the extra split secondary, acting through the double-stator capacitor. This balance does not affect the balance conditions for the in-phase components and consequently has no effect on the measurement.

The points of introduction of the test voltages e_1 and e_2 are changed by a switch when the other constants are measured. Another switch reverses the polarity of e_1 when negative values of the coefficients are to be measured.

➔ Independent measurements of the three main tube parameters are possible, i.e., none of the balances depends in any way on any other. Therefore independent cross checks can be obtained from the known relationship involving the three coefficients.

➔ Negative values of the tube coefficients can be measured as readily as positive values.

➔ Interelectrode capacitance effects are balanced out by a method which makes possible the independent measurement of all three parameters over very wide ranges. Errors have thus been reduced, and it is possible to measure the transconductance of a tube having a high value of grid to plate capacitance without any error from this capacitance.

SPECIFICATIONS

Range: Amplification factor (μ): 0.001 to 10,000.

Dynamic internal plate resistance (r_p): 50 ohms to 20 megohms.

Transconductance (s_m): 0.02 to 50,000 micromhos.

Under proper conditions, the above ranges can be exceeded. The various parameters can also be measured with respect to various elements, such as screen grids, etc. Negative, as well as positive, values can be measured.

Accuracy: Within ±2% for resistances (r_p switch position) from 1000 to 1,000,000 ohms. At lower and higher values the error increases slightly.

The expression $\mu = r_p s_m$ will check to ±2% when the quantities are all measured by the bridge, and when r_p is between 1000 and 1,000,000 ohms.

Tube Mounting: Adaptors are provided, as follows: 4-pin, 5-pin, 6-pin, small 7-pin, large 7-pin, octal, locking-in, miniature button 7-pin, miniature button 9-pin (noval), acorn (5- and 7-pin) and 5-wire sub-miniature. Thus all standard commercial receiving tubes can be measured. In addition, a "universal" adaptor, with nine soldering lugs, is provided so that unmounted tubes, or tubes with non-standard bases, can be measured conveniently. The panel jack plate and the adaptors are made of low-loss material, usually yellow phenolic, reducing to a minimum the shunting effect of dielectric losses on the dynamic resistance being measured.

Accessories Supplied: Two TYPE 274-NE Shielded Connectors for connecting bridge to oscillator and detector, two grid-lead connectors and one special connector.

Current and Voltage Ratings: The tube circuits have large enough current-carrying capacity and sufficient insulation so that low-power transmitting tubes may be tested in addition to receiving tubes. Maximum allowable plate current is 150 ma and maximum plate voltage is 1500 volts.

Electrode Voltage Supply: Batteries or suitable power supplies are necessary for providing the various voltages required by the tube under test.

Bridge Source: A source of 1000 cycles is required. The TYPE 1214-A Oscillator, TYPE 813-A Audio Oscillator or the TYPE 723-A Vacuum-Tube Fork is suitable for this purpose.

Null Indicator: The TYPE 1231-B Amplifier and Null Detector with TYPE 1231-P2 Filter (page 98) and a pair of sensitive head telephones are recommended.

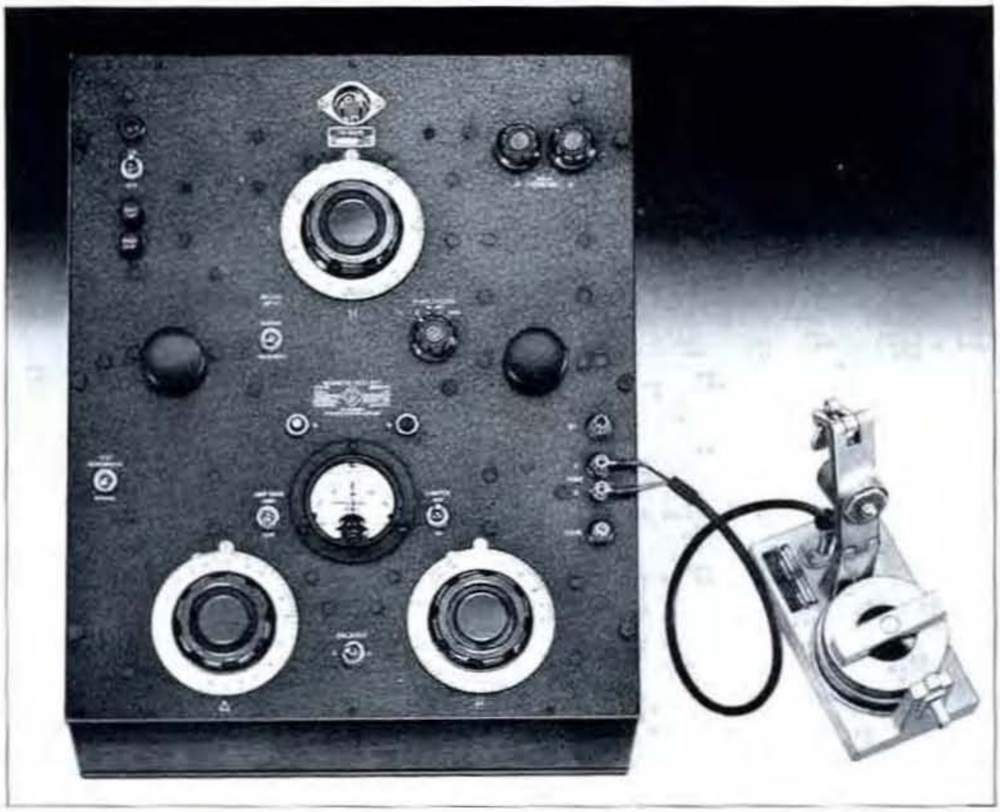
Mounting: The instrument is mounted in a walnut cabinet. A wooden storage case is provided for the plug plates and leads. Storage space is provided for a spare universal adaptor, on which any type of socket can be permanently mounted.

Dimensions: (Length) 18⅝ x (width) 15¾ x (height) 12 inches.

Net Weight: 60 pounds.

Type		*Code Word*	*Price*
561-D	**Vacuum-Tube Bridge**	BEIGE	**$650.00**

Tube socket capacitances are measured accurately and conveniently by means of adaptors available for use with the TYPE 1612-AL R-F Capacitance Meter, page 78.



TYPE 1670-A MAGNETIC TEST SET

USES: This equipment is designed to furnish convenient and rapid 60-cycle measurements of the permeability and core loss of small samples of laminated ferromagnetic material, such as might be cut from transformer laminations. Such samples may have a width up to 3/8 inch and any length in excess of 2 1/4 inches, and may be measured individually or in parallel combinations. They can be cut in any desired direction to the rolling.

DESCRIPTION: The instrument consists of a Maxwell bridge in conjunction with a phase-sensitive null detector. The measurement consists essentially of the determination of the inductance and the loss component of a solenoid built into the test yoke in which the sample is clamped. These parameters are interpreted as the permeability and core loss of the specimen material. Values of normal inductance, B, (flux density) are directly calculable from these data. The test yoke is designed to have sufficient permeability and cross section so that its reluctance, up to medium permeabilities, is negligible compared to that of the specimen. Corrections can be made when measuring high-permeability materials.

The measurement is made under known conditions of 60-cycle normal magnetizing force, H, with provision for adjusting this parameter over a wide range. The magnetizing *current* is sinusoidal. Comparative tests show no significant difference in the results from those obtained with sinusoidal voltage. Measurements close to initial permeability (H = one millioersted) can be made, and a steady biasing magnetizing force (dc) can be superimposed, if desired, for incremental measurements.

The detector system consists of (1) a degenerative selective amplifier, (2) a phase-shifting network, which permits either of two sensitizing phases to be selected, (3) a modulation bridge in which the zero-center galvanometer is connected, and (4) an amplitude-limiting network, which gives maximum sensitivity at balance, but prevents the galvanometer from going off scale.

A complete theoretical treatment of the method of measurement will be found in a paper by H. W. Lamson, entitled "A Method of Measuring the Magnetic Properties of Small Samples of Transformer Laminations," published in the *Proceedings of the Institute of Radio Engineers*, December 1940.

FEATURES: ➔ Small rectangular strip samples are used for measurements with the TYPE 1670-A Magnetic Test Set. Thus it is not necessary to prepare special ring-shaped samples or to use the amount of material required to construct the standard Epstein test core.

➔ Independent indications of balance for the two main bridge controls are provided by means of the phase-shifting network. This feature eliminates the inconvenience of the sliding balance that is characteristic of the bridge when a conventional null detector is used.

Direct comparison of the permeability and loss in various samples can generally be made from the bridge dial readings without the necessity of calculating absolute values.

The direction of off-balance is indicated on the zero-center galvanometer.

Measurements analogous to Epstein values for power purposes can be made on 72-grade silicon steel or higher-permeability materials at B_{max} equal to 10,000 gauss.

➔ The high gain necessary for measurements at low values of magnetizing force is furnished by the degenerative selective amplifier, which also eliminates the effect of harmonic response at high values of magnetizing force.

The limiting circuit prevents off-scale deflections of the meter, and eliminates the need of an adjustable gain control.

SPECIFICATIONS

Range of Magnetizing Force: The 60-cycle normal magnetizing force is adjustable from one millioersted to 6 oersteds (gilberts per centimeter) for a line voltage of 115 volts. A biasing magnetizing force (dc) up to 2 oersteds can also be applied. The necessary d-c power, up to 1.5 oersteds, can be obtained from the internal power supply of the test set.

High-Range Test Yoke: An auxiliary test yoke (not supplied) will extend the range of normal *H* up to 25 oersteds. The standard yoke, however, is preferable within its range.

Permeability and Core-Loss Range: The range for permeability and core-loss measurements varies with the cross-section area. For a sample cross section of 10 sq. mm. full scale on the μ dial is 25,000. The permeability and core loss of any ferromagnetic sample can be measured if a sample of proper cross section is chosen. It may sometimes be necessary to calculate corrections for high-permeability materials.

Accuracy of Measurement: The accuracy of data obtained with this instrument is chiefly determined by the precision with which the cross-section of the specimen is known. Similar samples of identical cross section can be compared, at any given *H*, with an accuracy of ±2%.

Power Supply: 115 volts, 60 cycles; by a change of connections on the power transformer primary, the instrument can be operated from a 230-volt line.

Power Input: 90 watts.

Tubes: 2 6C8-G, 1 6X5-G, and 1 0D3.

Accessories Supplied: Test yoke, line cord, and spare fuses.

Accessories Required: When a d-c magnetizing force is applied, a milliammeter and a rheostat for varying the dc are required. The TYPE 371-A 50,000 Ω Rheostat is suitable when the internal voltage source is used.

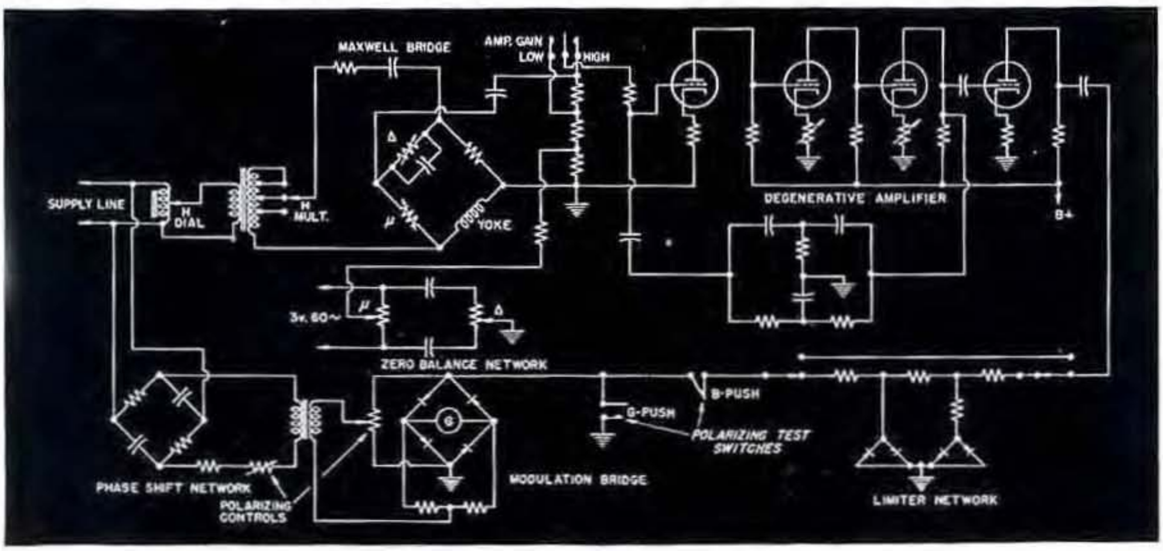
Mounting: The test set, exclusive of the test yoke, is housed in a walnut cabinet with sloping front panel.

Dimensions: Test set, (width) 16 x (depth) 18 x (height) 10 inches, over-all; test yoke, 8 x 4 x 5½ inches.

Net Weight: Test set, 45½ pounds; test yoke, 10 pounds.

Type		*Code Word*	*Price*
1670-A	Magnetic Test Set (with 6 Oersted Yoke)	AFIRE	$695.00
1670-P2	25-Oersted Yoke	YOKEL	115.00

PATENT NOTICE. See Notes 11, 20, and 28, page vi.



TYPE 544-B MEGOHM BRIDGE

USES: The megohm bridge is very useful for measuring all types of resistances in the megohm ranges. These uses include not only the resistance of cartridge-type resistors, but also the insulation resistance of electrical machinery such as generators, motors, and transformers; of electrical equipment such as rheostats and household appliances; of single conductors, cables, and capacitors; of sufficiently long sections of high-voltage cables; of paper capacitors; and of slabs of insulating materials. Volume resistivity and its change with temperature and humidity can be determined. Guard connections are provided for the measurement of three-terminal resistors such as multi-wire cables, three-terminal capacitors, networks, and guarded specimens of insulating materials.

This bridge has been widely used for measuring the dielectric absorption effects in the insulation of electrical machinery, transformers, and cables. Charging-current curves can be easily obtained over time intervals from one second to many hours.

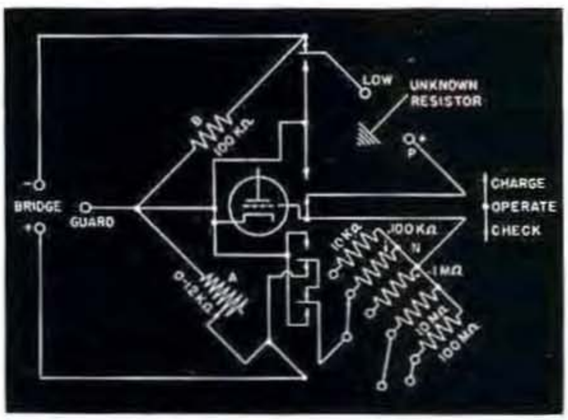
DESCRIPTION: The TYPE 544-B Megohm Bridge is a combination of Wheatstone bridge and vacuum-tube voltmeter.

The bridge is composed of the four arms, *A*, *B*, *N*, *P*, as shown for the OPERATE position in the diagram at the bottom of the next page, with the power applied across the arms, *A* and *B*, and the vacuum-tube voltmeter connected across the conjugate pairs, *A*-*N* and *B*-*P*. For checking the galvanometer zero, the tube is isolated from the bridge voltage as shown in the CHECK position, with the high resistors, *N* and *P*, connected to the grid exactly as in the OPERATE position. The effects of any voltages, alternating or direct, in the unknown resistor, *P*, and of any grid current of the tube will not appear in the bridge balance because they are balanced out in the zero adjustment. There is also a CHARGE position, in which the unknown resistor, *P*, is placed across the arm, *B*. This is valuable in measuring the resistance of large capacitors because full voltage is applied directly to the capacitor which can then charge at a maximum rate. The zero of the galvanometer can also be checked at any time without being affected by the residual charge in the capacitor.

FEATURES: → The direct measurement of resistances up to 1,000,000 megohms is made possible by the use of a vacuum-tube detector, which absorbs a negligible amount of power.

→ Constant fractional accuracy, regardless of setting, is obtained by using a resistance scale that is approximately logarithmic over one decade. The effective scale length for the range from 100,000 ohms to 10,000 megohms is 35 inches.

Schematic circuit diagram of the megohm bridge.



➔ The voltage applied to the unknown resistance is held approximately constant, regardless of the value of the unknown resistance. This condition is necessary to measure insulation resistance properly.

➔ Voltage stabilization is used in the a-c power supply to prevent surges in charging current when the leakage resistance of capacitors is measured.

The MEGOHMS dial of Type 544-B Megohm Bridge. The scale is approximately logarithmic over the main decade from 1 to 10.

SPECIFICATIONS

Range: 0.1 megohm to 1,000,000 megohms, covered by a dial and a 5-position multiplier switch. A resistance of 1,000,000 megohms can be distinguished from infinity.

Accuracy: ±3% on the 0.1, 1, and 10 multipliers; ±4% on the 100 and 1000 multipliers. Above 10,000 megohms, the accuracy is essentially that with which the scale on the MEGOHMS dial can be read.

Terminals: All high-voltage terminals are insulated as a protection to the operator. A maximum of 12 ma can be drawn on short circuit.

Power Supply: Two types of power supply are available: (1) an a-c unit delivering d-c test voltages of 500 volts and 100 volts to the bridge, and (2) a battery power supply of 90 volts. The a-c unit operates from a 105- to 125-volt (or 210- to 250-volt), 40- to 60-cycle line. The battery power supply consists of 2 No. 6 Dry Cells and 3 Burgess No. 5308 45-volt batteries. This supplies 45 volts for the tube anode and 90 volts for the test voltage.

Power Input: 60 watts at 115 volts, 60 cycles; with battery supply, approximate current requirements are 60 ma for cathode heaters and 7.5 ma for anode.

External Bridge Voltage: Terminals are provided so that the bridge voltage can be obtained from an external source if desired. Up to 500 volts can be applied.

Vacuum Tubes: With battery power supply, a 1D5-GP detector tube is used; the 500-volt power supply uses a 6K7-G detector, a 6X5-G rectifier, a 5U4-G rectifier, and, in the voltage regulators, a 6J5-G, a 6K6-G, a 4A1 Ballast Tube, and two Type 2LAG-949 neon lamps. All tubes are supplied.

Accessories Supplied: With a-c power supply, a seven-foot line-connector cord and spare fuses, test probe mounted in cover and spare neon ballast tube. Batteries are supplied with the battery-operated model.

Mounting: Shielded oak cabinet with cover.

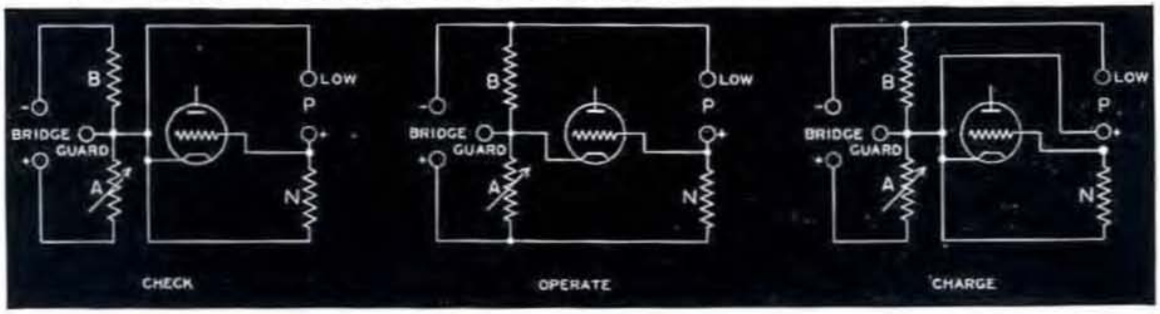
Dimensions: Cabinet with cover closed, (width) $8\frac{1}{2}$ x (length) $22\frac{1}{2}$ x (height) 8 inches, over-all.

Net Weight: With battery power supply, $29\frac{1}{2}$ pounds; with a-c power supply, $26\frac{3}{8}$ pounds; Type 544-P10, $14\frac{1}{4}$ pounds; Type 544-P3, $11\frac{1}{4}$ pounds.

Type		*Code Word*	*Price*
544-BA	Megohm Bridge, with A-C Power Supply	AGREE	$340.00
544-BB	Megohm Bridge, Battery Operated (Incl. Batteries)	ALOOF	250.00
544-P3	A-C Power Supply Unit Only	AGREEAPACK	130.00
544-P10	Battery Power Supply Unit Only	ALOOFAPACK	40.00

Type 1862-A Megohmmeter, a direct-reading instrument operating on the ohmmeter principle is described on page 178. A battery-operated, direct-reading megohmmeter, Type 729-A is described on page 177.

These diagrams show the bridge connections for the three positions of the CHECK-OPERATE-CHARGE switch.



TYPE 1652-A RESISTANCE LIMIT BRIDGE

USES: The Resistance Limit Bridge is intended primarily for the production testing of resistors. It can be used to indicate on a meter the percentage deviation from an internal standard, to match pairs of resistors, and to compare resistors to a standard sample. It is also a precision Wheatstone bridge for general resistance measurement by the null method.

For manufacturers and users of resistors, this bridge offers an accurate and rapid means of separating resistors into tolerance classifications, and for selecting resistors to close tolerances. The manufacturer of electronic equipment can use it to advantage in matching pairs of resistors for operation in balanced circuits. Its accuracy is adequate for all but the most exacting requirements in the laboratory, and its ability to measure resistors as large as one megohm without the inconvenience of adding booster batteries makes it much more convenient than the ordinary decade bridge.

The bridge can also be adapted for use as the control unit in automatic sorting or inspecting. A sensitive relay, substituted for the indicating meter, can be arranged to actuate various types of rejection mechanisms. By adjustment of the sensitivity of the relay, end points can be established to determine tolerances of ±5%, ±10%, and ±20%.

DESCRIPTION: The TYPE 1652-A Resistance Limit Bridge uses the conventional equal-arm Wheatstone bridge circuit. The bridge is supplied from a constant-voltage d-c source, and its indicating meter is calibrated in percentage difference between the unknown and the standard over a range of ±20%.

A built-in standard consisting of seven TYPE 510 Decade Resistors is adjustable from one ohm to 1,111,111 ohms in 0.1-ohm steps.

Measurements are made simply by setting the standard to the nominal value of the resistor under test and reading the percentage difference on the meter. This test procedure can be greatly facilitated by the use of a test fixture into which the resistors can be plugged, and which can be operated in conjunction with a switch that shorts the meter circuit prior to removing the resistor from the jig. Panel terminals for such a switch are provided.

For the matching of resistors, the resistor to be matched is connected to terminals provided and the internal standard is set to zero.

Used as a conventional Wheatstone bridge, the circuit is balanced by adjusting the internal standard to equality with the unknown resistor, using the calibrated meter as a null indicator.

FEATURES: ➔ Rapid and accurate for limit tests.

- Extreme simplicity of operation. Large meter colored gold for 5% limits and silver for 10% limits.
- Equally useful for general resistance measurement.
- Covers a wide resistance range — one ohm to one megohm.
- No batteries required. Operates from 115-volt or 230-volt, 60-cycle line.
- Rugged construction and enclosed in welded aluminum cabinet.
- Accuracy — can measure resistors to an accuracy of ±0.25%.
- Indicating meter can not be damaged by unbalance of bridge.

SPECIFICATIONS

Resistance Range: As a limit bridge, 1 ohm to 1,111,111 ohms, with internal standard; for null measurement, 1 ohm to 1,111,111 ohms with internal standard; 1 ohm to 2 megohms with external standard.

Limit Range: Meter reads from −20% to +20%, with the standard RTMA tolerance ranges of ±5% and ±10% clearly indicated by gold and silver coloring, respectively.

Accuracy: As a limit bridge, ±0.5% or better; for matching, ±0.2%; for null measurement, with internal standard, ±0.25% above 10 ohms and ±0.4% between 1 ohm and 10 ohms; with an external standard, from 1 ohm to 2 megohms ±(0.2% + accuracy of standard).

Voltage Applied to Unknown: The voltage across the unknown resistor is exactly one volt when the meter indication is zero. As the meter indication varies from −20% to +20% the voltage across the unknown will vary from 0.89 volt to 1.10 volts.

Relay: When a relay is used in place of the meter, the relay resistance should be not more than 850 ohms and its sensitivity 100 microamperes or better. A current of 100 microamperes corresponds approximately to a limit of 20%, 50 microamperes, to 10%, and 25 microamperes to 5%.

Power Supply: 105 to 125 volts or 210 to 250 volts, 60 cycles. The power input is approximately 30 watts.

Accessories Supplied: A line connector cord and spare fuses.

Vacuum Tubes: One Type 6X4 and two Type 6SU7-GTY's. All are supplied with the instrument.

Mounting: The bridge is supplied for either relay rack or cabinet mounting. Cabinet has black wrinkle finish.

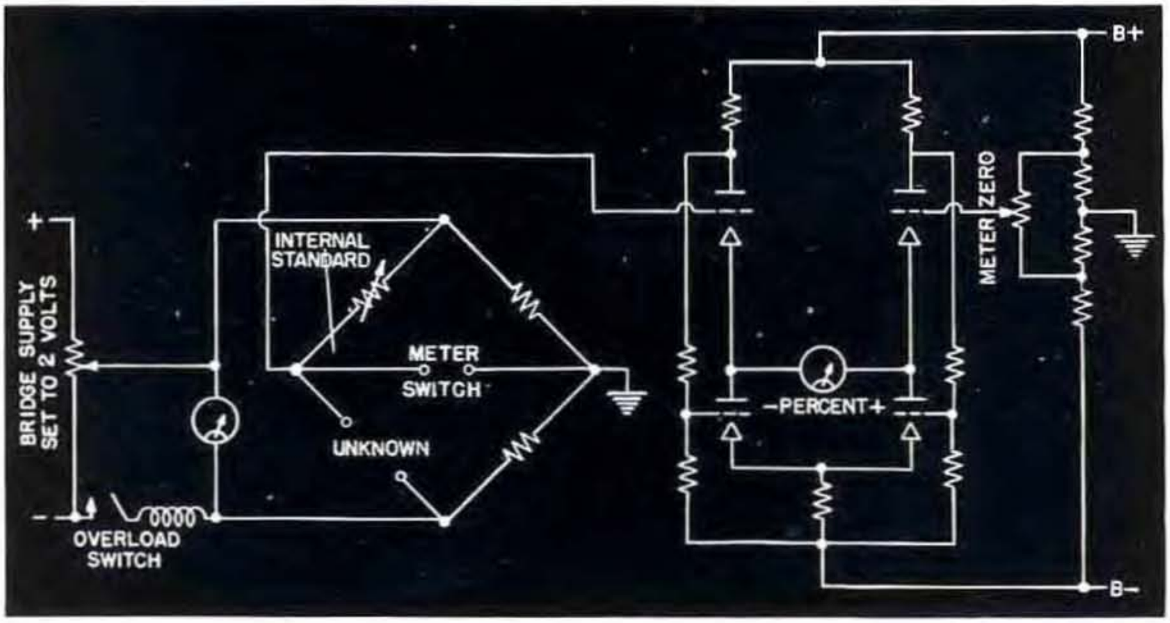
Dimensions: Over-all, (width) 19 inches x (height) 8¾ inches x (depth) 10½ inches.

Net Weight: 29 pounds.

Type		*Code Word*	*Price*
1652-AM	Resistance Limit Bridge (Cabinet Model) . . .	BUXOM	$365.00
1652-AR	Resistance Limit Bridge (Relay Rack Model)	BADGE	365.00

A Wheatstone bridge for the megohm range, capable of measurements from 0.1 megohm to 1,000,000 megohms, is described on page 92.

Schematic circuit diagram of the Type 1652-A Resistance Limit Bridge.



TYPE 1690-A DIELECTRIC SAMPLE HOLDER

USES: The Type 1690-A Dielectric Sample Holder is a micrometer-driven sample holder of the Hartshorn type,* intended primarily for measurement of dielectric constant and dissipation factors of specimens of dielectric materials in the form of standard ASTM 2" diameter discs. It can be used, for example, with resonant circuits for susceptance-variation or frequency-variation measurements, with the Type 716-C Capacitance Bridge or the Type 821-A Twin-T, with the Type 874-LB Slotted Line; or with the Type 1602-A Admittance Meter.

DESCRIPTION: A precision micrometer screw drives the movable grounded electrode with respect to a fixed insulated electrode. The screw adjustment is a large instrument knob, in contrast to the small thimble employed in the usual machinist's micrometer. Attached to the knob is an accurately divided drum which indicates the spacing between electrodes. The micrometer screw is electrically shunted by a metal bellows, assuring positive low-resistance connection at all times. A release mechanism is incorporated in the design of the movable electrode, so that when full positive contact is made between the two electrodes, the drive disengages, thus protecting the mechanism against mechanical stress. The same design feature also provides better contact between electrodes and specimens when the surfaces of the latter are not exactly parallel, since the movable electrode will adjust itself to the plane of the specimen surface.

A vernier capacitor with a capacitance range of 5 $\mu\mu$f is also provided, for use in determining capacitance increments in the susceptance-variation method. This capacitor is of the cylindrical type, the movable cylinder being a precision micrometer screw. Ten turns of the screw cover the range of 5 $\mu\mu$f, and the drum attached to the screw is accurately divided into 50 divisions, each corresponding to .01 $\mu\mu$f.

The assembly is mounted in a rugged aluminum casting, which shields the assembly on four sides. The shielding is completed by two removable cover plates, which permit access to the electrodes.

Connection to the electrodes may be made by Type 874 Coaxial Connectors or by Type 274 Pin Connectors. Adaptors are provided for mounting the Type 1690 Dielectric Sample Holder on the Type 716-C Bridge, and on the Type 821-A Twin-T. An additional adaptor for connection to the Type 874-LB Slotted Line and Type 1602 Admittance Meter is also available. The arrangement of the terminals is such that the holder can be mounted on a bridge with the panel in either the horizontal or vertical direction.

FEATURES: ➔ A dielectric specimen can be measured over a wide range of frequencies using the same holder but different measuring circuits.

➔ Corrections for edge fringing and stray capacitance are taken care of by the calibration.

➔ Rigid casting supports entire structure.

➔ Large easily read dials.

➔ Complete shielding.

➔ Flexibility — can be used with a number of different bridges or other measuring circuits.

➔ Precision calibration provided.

➔ "Floating" electrode protects precision drive against injury.

* L. Hartshorn and W. H. Ward, Proceedings of the Institution of Electrical Engineers, v. 79, pp. 597-609 (1936).

SPECIFICATIONS

Electrodes: Diameter, 2.000 inches ±0.0025. Surfaces are ground optically flat within a few wavelengths.

Electrode Spacing: Adjustable from zero to 0.3-inch maximum. The spacing is indicated directly by the micrometer reading.

Vernier: Incremental capacitance is 5 $\mu\mu$f nominal.

Calibration: For the main capacitor a chart is provided giving the calculated air capacitance as a function of spacing. A correction chart is also provided with each holder, giving the measured deviations from calculated values over the range from 300 mils to 10 mils spacing. In accordance with recommended ASTM practice, this calibration is referred to the calculated geometric value at a spacing of 100 mils.

For the vernier capacitor a correction chart is provided, from which capacitance differences can be determined to an accuracy of ±0.001 $\mu\mu$f.

Zero Capacitance: Approximately 11 $\mu\mu$f.

Frequency: This type of specimen holder introduces no significant error at frequencies below 100 Mc. At higher frequencies the technique of its use has not been firmly established, but satisfactory results can be obtained for many types of measurements.

Accessories Supplied: Type 1690-P1 Adaptor Assembly for mounting to the Types 716-C Capacitance Bridge and the Type 821-A Twin-T.

Accessories Available: Type 1690-P2 Adaptor Assembly for connecting for Type 874-LB Slotted Line or Type 1602-A Admittance Meter.

Mounting: Supplied with a wooden carrying case. A drawer in the case provides storage for hardware, and a spring clip holds the calibration charts, which are mounted in aluminum holders.

Dimensions: Over-all, mounted on adaptor, 6¼ x 5¾ x 4½ inches.

Net Weight: 3¾ pounds.

Type		*Code Word*	*Price*
1690-A	**Dielectric Sample Holder**	LOYAL	**$395.00**
1690-P2	**Adaptor Assembly (for Type 874-LB Slotted Line)**	LOYALMOUNT	**30.00**

PATENT NOTICE. See Notes 3 and 4, page vi.

TYPE 578 SHIELDED TRANSFORMER

USES: The Type 578 Shielded Transformer has been designed for use in direct-reading a-c bridges to isolate the bridge from changes of electrostatic potential in the external circuit and to reduce the effect of the capacitance of this external circuit to ground. It can also be used to isolate any measuring circuit from the generator or detector and to produce a balanced output from a grounded generator.

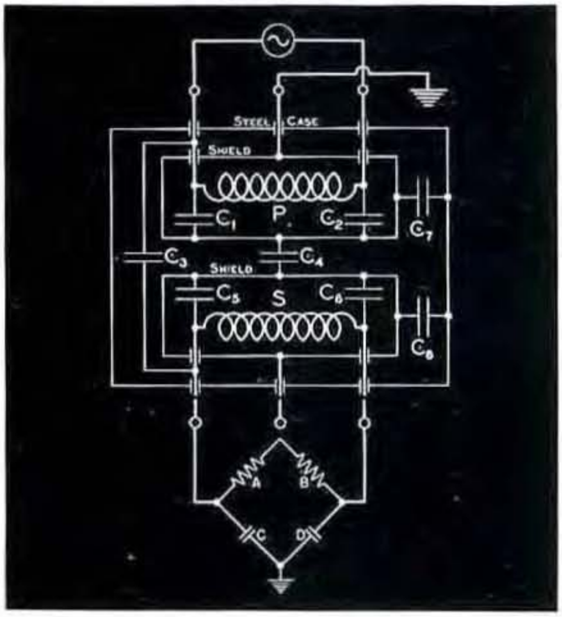
DESCRIPTION: The Type 578 Shielded Transformer is provided with two shields, one around each winding. A third shield effectively grounds the core laminations to the case.

FEATURES: ➔ The intershield capacitance is less than 30 $\mu\mu$f so the total added capacitance placed across the bridge arms is less than 80 $\mu\mu$f in place of the usually large and unknown generator-to-ground capacitance.

➔ Wide ranges of frequency and load impedance are covered by each model.

➔ All models can be used step up or step down from generator to bridge.

(*Below*) Grounded bridge supplied through a double-shielded transformer. When case is grounded, the capacitance placed across each capacitance arm is 40 $\mu\mu$f. Note that the winding shield on the bridge side is *not* grounded, but is floating.



SPECIFICATIONS

Turns Ratio: 4 to 1, or 1 to 4.

Frequency and Impedance Range: See table below.

Capacitance: The direct capacitance between primary and secondary windings is less than 0.3 $\mu\mu$f; that between the primary and secondary shields is less than 30 $\mu\mu$f. Average values for the capacitances in the diagram are:

C_1, C_2, C_5, C_6 .... each 200 $\mu\mu$f
C_3 .... 0.3 $\mu\mu$f
C_7, C_8 .... each 70 $\mu\mu$f
C_4 .... 30 $\mu\mu$f

Winding Inductance: Approximately equal to the square of the number of turns multiplied by 3.5×10^{-6} henrys. (See table below.)

D-C Resistance: (In ohms) approximately 30 times the inductance in henrys.

Applied Voltage: The high-impedance winding of Types 578-A or -B may be connected directly across a 115-volt 50- to 60-cycle line if the impedance connected to the other winding equals or exceeds the lowest value given under "low impedance" in the table below. The Type 578-B may be used at 25 cycles under the same conditions.

For Types 578-A or -B, the low-impedance winding may be connected directly to a 115-volt, 50- to 60-cycle line provided that the resistance across the high-impedance winding exceeds 10,000 ohms. The Type 578-B may be used at 25 cycles under the same conditions.

Insulation: The insulation from winding to winding and from windings to case will withstand 1000 volts, peak.

Mounting and Dimensions: These transformers are mounted in Model B cases (see page 165 for dimensions).

Net Weight: $2\frac{1}{2}$ pounds.

Type	*Turns*	*Frequency Range**	*Impedance Range**		*Code Word*	*Price*
			Low-Impedance Winding	*High-Impedance Winding*		
578-A	600 to 2400	50 cycles to 10 kc	50 Ω to 5 kΩ	1 kΩ to 100 kΩ	TABLE	$25.00
578-B	1000 to 4000	20 cycles to 5 kc	60 Ω to 6 kΩ	1.2 kΩ to 120 kΩ	TENOR	25.00
578-C	60 to 240	2 kc to 500 kc	20 Ω to 2 kΩ	0.1 kΩ to 40 kΩ	TEPID	25.00

*These ranges are for transmission within 6 db. At extremes of both impedance and frequency ranges, the transmission may be down by 12 db.

AMPLIFIERS

TYPE 1231-B AMPLIFIER AND NULL DETECTOR

(and Standing-Wave Indicator)

USES: The TYPE 1231-B Amplifier and Null Detector can be used as a high-gain amplifier for general laboratory use or as a sensitive visual null detector for bridge measurements.

For an aural indication of the null point the amplifier can be used with head telephones. It can also be used as a pre-amplifier for crystal microphones, vibration pickups and cathode-ray oscilloscopes.

With a suitable crystal detector it can be used as a sensitive indicator for amplitude-modulated high-frequency voltages and is recommended for use as a standing-wave indicator for measurements with the TYPE 874-LB Slotted Line.

DESCRIPTION: The instrument consists of a high-gain amplifier with an output stage that can be operated as a linear amplifier for general laboratory use or as a logarithmic amplifier for null-detector use. The panel meter indicates the amplifier output in two ranges, serves as a null indicator, and is also used to check the condition of the battery. The null-detector response is approximately logarithmic over a 40-db range. A 30-db input attenuator is provided for attenuation of high input voltages. Either a BA48 battery pack or the TYPE 1261-A Power Supply can be placed within the cabinet to operate the instrument, but over-all performance is somewhat better with the battery. Blocking capacitors at both input and output jacks isolate the instrument from direct current in the external circuits to which it may be connected. A filter jack on the panel of the instrument permits insertion of an antiresonant filter, such as the various TYPE 1231-P models, in the grid circuit of the last stage for modifying the frequency characteristic.

FEATURES: ➔ Plainly labelled push button controls make the operation of the amplifier simple and convenient.

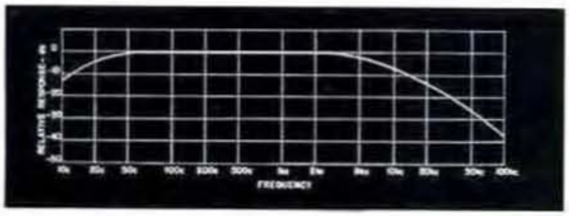
➔ Input and output terminals are arranged to take TYPE 274 Plugs.

➔ The self-contained meter makes the instrument a very convenient detector for bridge measurements.

➔ Harmonics or noise outside the operating frequency range are easily and effectively eliminated by the insertion of filter units.

➔ Meter ballistics have been chosen to give rapid response with minimum overshoot. This feature reduces to a minimum the time necessary to locate a null or to read the meter, with a consequent speeding-up of the measurement procedure.

SPECIFICATIONS



Input Impedance: 1 megohm in parallel with 20 $\mu\mu$f.

Maximum Gain: Greater than 83 db at 1 kc with 1 megohm load.

Meter Scales: NORM scale: This scale is the one normally used to monitor the amplifier output voltage. It is calibrated approximately in volts with an accuracy of reading of ±5% of full scale.

SENS scale: This scale is used for determining ratios of voltages successively applied to the input terminals, as in standing-wave measurements. It is calibrated approximately in decibels with an arbitrary zero. Thus a ratio expressed in decibels is obtained by subtracting one meter reading from another. Ratios so obtained are accurate within 30% of the correct value in decibels, provided at least one of the readings is above half scale.

No separate scale is provided for NULL DET operation, since actual readings are not needed.

Null Detector Sensitivity: Less than 100 microvolts input is required to give 10% indication on the meter at 1 kc.

Amplifier Sensitivity: Less than 25 microvolts input at 1 kc for 10% indication on SENS range of the meter.

Output Impedance: Approximately 50,000 ohms.

Maximum Output Voltage: 5 volts into 20,000 ohms; 20 volts into 1 megohm.

Noise and Hum Level: The open circuit noise level is less than 0.5 volt at full gain. When the Type 1261-A Power Supply is used, the open circuit noise and hum level is less than 1 volt.

Frequency Response: See curve on preceding page.

Tubes: The instrument requires two Type 1L4 and one Type 1D8-GT Tubes, which are shipped installed.

Power Supply: Burgess 6TA60 (Signal Corps BA48) Battery Pack is supplied in place in the instrument. When a-c supply is desired, the Type 1261-A Power Supply (see page 101) can be used.

Battery Life: Between 200 and 250 hours at 8 hours per day.

Mounting: Available either for 19-inch relay rack or mounted in a walnut cabinet. Relay-rack model can be obtained in combination with Type 1231-P5 Filters and with Type 1261-A Power Supply. See price list below.

Accessories Available: Filters, for providing frequency discrimination; adjustable calibrated attenuator; as listed on next page. Where shielded input and output are desired, Type 274-NE Patch Cords should be used.

Dimensions: 12¼ x 8 x 10¾ inches, over-all.

Net Weight: 23¾ pounds, including batteries.

CABINET MODELS

Type		*Code Word*	*Price*
1231-BM	**Amplifier and Null Detector, battery operated**	VALID	**$250.00**
1231-BMA	**Amplifier and Null Detector, a-c operated....**	VENUS	**370.00**

Filters, as required, should be ordered as separate items.

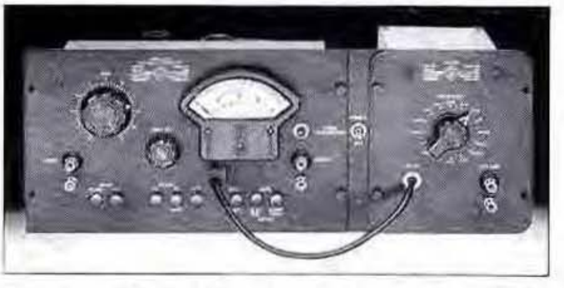
RELAY-RACK MODELS

Type		*Code Word*	*Price*
1231-BR	**Amplifier and Null Detector, battery operated**	VALOR	**$250.00**
1231-BRA	**Amplifier and Null Detector, a-c operated....**	VIGIL	**370.00**
1231-BRF	**Amplifier and Null Detector, battery operated, with Type 1231-P5 Filter...............**	VIGOR	**450.00**
1231-BRFA	**Amplifier and Null Detector, a-c operated, with Type 1231-P5 Filter...............**	VILLA	**570.00**

TYPE 1231-P5 ADJUSTABLE FILTER

USES: This filter is used with the Type 1231-B Amplifier and Null Detector to reduce harmonics and background noise in bridge measurements. It can be set to any one of eleven fixed frequencies, including those at which the Type 716-C Capacitance Bridge is direct reading.

DESCRIPTION: The filters are parallel-resonant circuits, consisting of toroidal inductors tuned with fixed capacitors to the eleven frequencies, any one of which can be selected by a switch. Terminals are provided for connecting an external capacitor to tune to any other frequency between 100 kc and 20 c.



Type 1231-P5R with Type 1231-BRA Amplifier and Null Detector. This combination is a Type 1231-BRFA as listed above.

FEATURES: ➔ Each of eleven tuned frequencies is quickly available.

➔ Any resonant frequency from 20 cycles to 100 kc can be obtained with external capacitors.

➔ Low insertion loss, in certain cases an actual gain.

➔ Sharp anti-resonant tuning, selectivity against second harmonic better than 30 db.

➔ Toroidal inductors used are highly astatic.

➔ Complete electrostatic shielding.

➔ Can be inserted in grid circuit of any conventional Class A amplifier.

SPECIFICATIONS

Nominal Operating Frequencies: 50, 100, 200, 500 cycles; 1, 2, 5, 10, 20, 50, 100 kc.

Frequency Calibration: Within ±2%.

Insertion Loss: Between 6-db loss and 6-db gain, de-

pending upon frequency.
Selectivity: Better than 30 db against the second harmonic.
Terminals: Shielded cord and plug for connection to TYPE 1231 Amplifier and Null Detector. Jack top terminals for connecting external capacitors.
Mounting: Aluminum cabinet for bench use. Also available for relay rack mounting in conjunction with TYPE 1231-B Amplifier and Null Detector. See price list below.
Dimensions: Front panel, (height) 7 x (width) 6¼ inches. Cabinet, (depth) 9¾ inches. Internal shield box, (height) 6¼ x (width) 4½ x (depth) 9 inches.
Net Weight: Complete, 9 pounds, 12 ounces.

Type		*Code Word*	*Price*
1231-P5M	Adjustable Filter (Cabinet Model).....	ALDER	$215.00
1231-P5R	Adjustable Filter (Relay-Rack Model)..	ADORE	215.00

TYPE 1231-P2 AND TYPE 1231-P3 TUNED CIRCUITS

These filters are parallel tuned circuits that plug into the TYPE 1231-B Amplifier and Null Detector, for suppressing harmonics, noise, and hum in single frequency measurements. The two-frequency model, TYPE 1231-P2, is provided with a switch for shifting from one frequency to the other.

SPECIFICATIONS

Tuning Accuracy: ±2% at low voltage levels, corresponding to normal usage. At higher voltage levels the inductance, and consequently the resonant frequency, changes.
Attenuation: At least 25 db to second harmonic.
Mounting: Standard drawn-steel case, Model C (see page 165 for dimensions). A plug and 24 inches of shielded cable are provided for connecting to the TYPE 1231-B Amplifier and Null Detector.
Net Weight: 3⅞ pounds, both models.

Type	*Frequency*	*Code Word*	*Price*
1231-P2	400 and 1000 cycles................	AMBLE	$25.00
1231-P3	60 cycles.........................	AMPLE	20.00

TYPE 1231-P4 ADJUSTABLE ATTENUATOR

USES: The Adjustable Attenuator is used with the TYPE 1231-B Amplifier and Null Detector and the TYPE 874-LB Slotted Line to measure standing-wave ratio. When so used, it increases both the range and accuracy of measurement over what can be obtained with the amplifier alone.

DESCRIPTION: The TYPE 1231-P4 Adjustable Attenuator is a high-impedance resistive voltage divider covering a range of 80 db, with three 20 db steps and a 20 db potentiometer.

SPECIFICATIONS

Source Impedance: 30 kΩ — approximately equal to output impedance of crystal detector in slotted line at low voltage levels.
Load Impedance: One megohm or greater.
Initial Insertion Loss: Approximately 3 db.
Attenuation Range: 80 db; dial can be read to nearest tenth db.
Accuracy of Attenuation Increments: ±0.3 db or better when operated between rated source and load impedances. Additional errors caused by source impedance between 15 kΩ and 60 kΩ are less than ±0.3 db.
Frequency Error: Negligible below 2 kc.
Maximum Input Power: ½ watt.
Terminals: Input, TYPE 938-W Binding Posts; Output, shielded cable with TYPE 274-D Shielded Plug to fit amplifier input terminals.
Circuit: Modified voltage divider.
Mounting: Metal cabinet.
Accessories Required: One TYPE 874-R32 Patch Cord for connections between slotted line and attenuator.
Dimensions: 5½ x 5½ x 4½ inches, over-all.
Net Weight: 2 pounds, 11 ounces.

Type		*Code Word*	*Price*
1231-P4	Adjustable Attenuator...............	ANNEX	$52.50
874-R32	Patch Cord..........................	COAXFITTER	5.75

TYPE 1261-A POWER SUPPLY

USES: The TYPE 1261-A Power Supply is an a-c power pack for use in place of batteries in battery-operated instruments where continuous operation, such as production testing, makes it desirable to operate the instrument from an a-c power line. The power pack is interchangeable electrically and mechanically with a BA48 (Burgess Type 6TA60) battery. It can be used in the following General Radio instruments:

TYPE 720-A Heterodyne Frequency Meter
TYPE 759-A* or -B* Sound-Level Meter
TYPE 1231-A* or -B Amplifier and Null Detector
TYPE 1550-A Octave-Band Noise Analyzer

DESCRIPTION: This power supply is a light compact unit that fits into the battery compartment of General Radio instruments which use the BA48 battery block.

A selenium rectifier and L-C filter with two flashlight cells floating across the output provide a low-impedance well-filtered and regulated d-c filament supply. A conventional vacuum-tube rectifier and R-C filter provide the plate supply. A four-terminal output socket fits the plug on the battery cable of instruments which use the BA48 battery.

Octal Selector Plugs inserted into a socket on the top of the power supply make it possible to select filament and plate voltages for various needs.

*Now obsolete.

FEATURES: ➔ Filtering action equivalent to that of a large capacitor and essentially constant filament voltage are obtained by floating two flashlight cells across the output filament supply.

➔ The life of the flashlight cells is practically equal to their shelf life. A small relay, built as part of one of the filter chokes, opens the circuit when the instrument is turned off, so that the cells will not run down.

➔ Quick interchangeability with the BA48 battery block is possible.

SPECIFICATIONS

OUTPUT:

Filament Supply: 1.5 volts or 3.0 volts; maximum current 350 ma. Normal current needed through filter choke to operate relay is 300 ma. A bleeder resistor is needed in the selector plug if the load current is less than this value.

Plate Supply: When the power supply is operated from a 115-volt 60-cycle line and the normal filament current of 300 ma is drawn, the plate supply has the following characteristics:

133 volts open circuit	107 volts at 3 ma
89 volts at 5 ma	72 volts at 7 ma

Maximum output current 8 ma

Selector Plugs: One of the following is furnished. Please specify type wanted.

Selector Plug 1261-P1 — Provides proper voltages for TYPE 759-A Sound-Level Meter. Battery Plate of Sound-Level Meter must be replaced by four-terminal plug to fit output socket of TYPE 1261-A Power Supply. Full sensitivity of instrument cannot be used. Attenuator settings below 50 db on B and C weighting networks and below 40 db on the A weighting network are not recommended.

Selector Plug 1261-P2 — Provides proper voltages for TYPE 759-B Sound-Level Meter.

Selector Plug 1261-P3 — Provides proper voltages for TYPE 720-A Heterodyne Frequency Meter.

Selector Plug 1261-P4 — Provides proper voltages for TYPE 1550-A Octave-Band Noise Analyzer and TYPE 1231-A or -B Amplifier and Null Detector.

Selector Plug 1261-P5 — To be wired by customer to meet his own requirements.

Hum and Noise Level: Sufficiently low to assure satisfactory operation of instruments listed under conditions specified.

Input Voltage: 105-125 (or 210-250) volts, 40 to 60 cycles.

Input Power: Approximately 10 watts.

Tube: One 6H6 is used, and is supplied with the instrument.

Batteries: Two Burgess No. 2 uni-cells which are floated across the output of the Filament Supply are furnished.

Accessories Supplied: Line connector cord with ON-OFF switch.

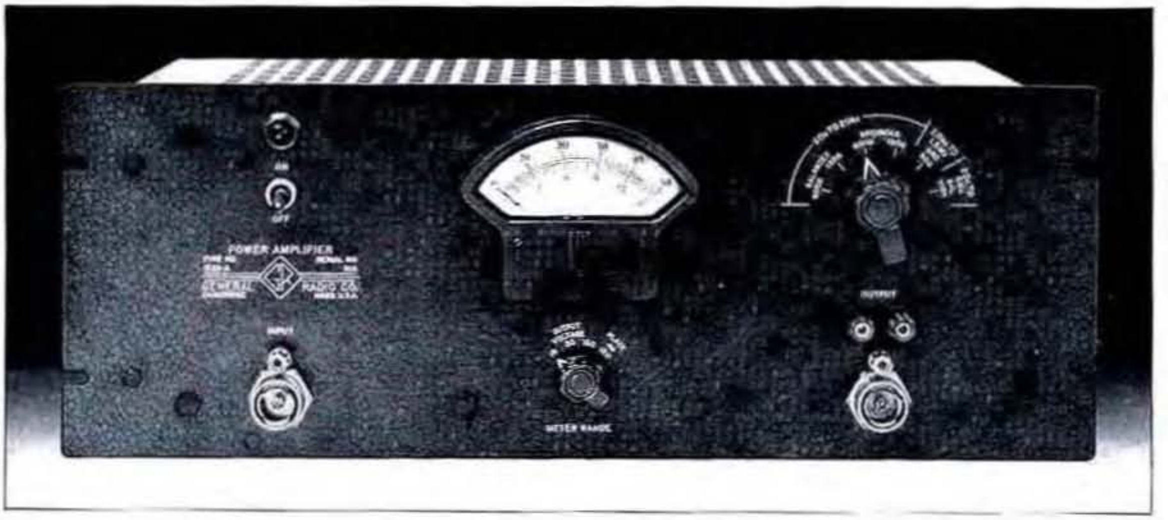
Terminals: A four-terminal output socket fits the plug on the battery cable of the TYPE 759-B, TYPE 720-A, TYPE 1550-A and TYPE 1231-A or -B.

Dimensions: (Length) 10 x (width) 2¼ x (depth) 5 inches.

Net Weight: 7¾ pounds.

Type		*Code Word*	*Price*
1261-A	**Power Supply**	NUTTY	**$120.00**

When ordering, specify type of selector plug desired and type number and serial number of instrument with which power supply is to be used. Extra selector plugs can be supplied at a price of $1.25 each.



TYPE 1233-A POWER AMPLIFIER

USES: The wide frequency range and high power output of the Type 1233-A Power Amplifier make it adaptable to many uses in the electronic and electro-acoustic laboratory. It can drive acoustic generators at levels up to 15 watts, and hence is particularly useful in the development and testing of audio-frequency and supersonic-frequency equipment.

At standard broadcast frequencies it can be used in conjunction with a low-power oscillator to excite antennas for measurements with deflection-type instruments. With its input connected to a tuned antenna, it can drive a Type 1931-A Modulation Monitor to monitor remote transmitters.

A voltage-output connection is provided for amplifying oscilloscope deflection signals over a range of 20 cycles to 3 megacycles.

DESCRIPTION: The amplifier consists of three push-pull broad-band stages and three possible output circuits, selectable by a range switch, as shown in the simplified schematic. The interstage couplings are of the series-peaked type, designed for constant gain up to 5 megacycles. The input stage functions as a phase inverter by virtue of a high common cathode resistor.

Separate output transformers are used for the 20c-to-20kc and the 20kc-to-1.5Mc ranges. Both transformers are of toroidal construction.

For the 20c-to-3Mc range, push-pull output is supplied through a series-peaked video network. A gradual roll-off above 3 megacycles yields excellent transient response. Pulses with rise times as short as 0.1 microsecond can be amplified with negligible overshoot.

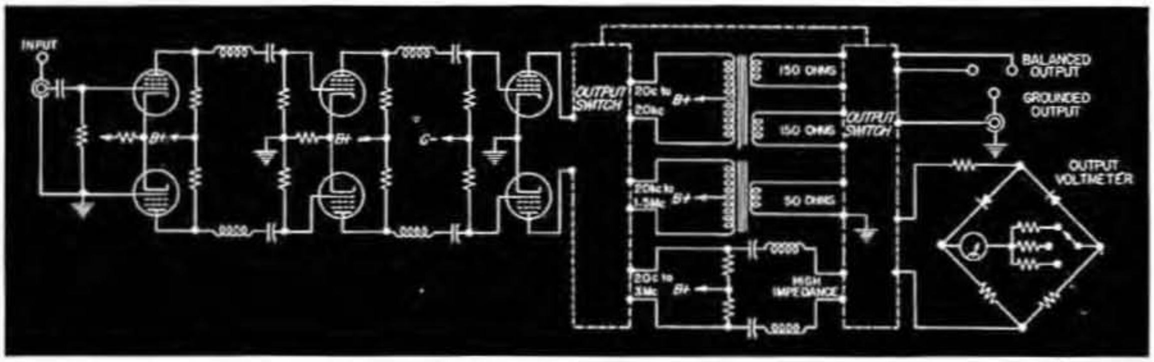
Type 874 Coaxial Connectors are provided at the input and output. Grounded binding posts spaced ¾-inch from the center conductor of these connectors permit connection to be made also by means of Type 274-MB Double Plugs if desired. Two insulated binding posts are provided at the output, which are used when balanced output is selected.

An output voltmeter is provided, which indicates the output terminal voltage on the 20 to 20,000-cycle range and the 20kc-to-1.5Mc range. On the 20c-to-3Mc range, the output voltmeter is connected to the grounded output terminals, which are not used for this range, making the voltmeter available for external use or permitting an external jumper to be used to connect it to either of the balanced output terminals. The meter can also be switched to indicate the plate current of the output amplifier tubes.

The voltmeter uses crystal diode rectifiers in a bridge circuit to give a full-wave-average indication.

The high-voltage power supply uses selenium rectifiers in a full-wave voltage-doubling circuit and a two-section LC filter. A bias supply, also using selenium rectifiers, provides fixed bias for the output stage.

FEATURES:
- ➔ Wide frequency range.
- ➔ High output.
- ➔ Astatic output transformers.
- ➔ Output voltmeter is provided.
- ➔ Excellent transient response.



Elementary schematic diagram of the TYPE 1233-A Power Amplifier.

SPECIFICATIONS

Frequency Range: Three ranges are provided:
For power, 20 cycles to 20 kilocycles.
For power, 20 kilocycles to 1.5 Mc.
For voltage, 20 cycles to 3 Mc.

Power Output:
20c-to-20kc range — 15 watts from 50 c to 15 kc; 8 watts at 20 c and 20 kc.
20kc-to-1.5Mc range — 15 watts from 20 kc to 0.5 Mc; 8 watts at 1.5 Mc.
Maximum available power output at low distortion depends upon power-line voltage. Rated output is obtainable at 105 line volts. At higher line voltages, output is greater.

Voltage Output: 20c-to-3Mc range — Peak-to-peak, 150 volts balanced, 50 volts grounded.

Tuned Output: The available power output drops rapidly above 1.5 megacycles on the 20kc-to-1.5Mc range. However, if desired, full output can be obtained, up to 5 megacycles, by disconnecting existing leads and connecting a suitable external tuned circuit from plate cap to plate cap on the output tubes and connecting the center tap of this circuit to the high voltage plate supply.

Load Impedance:
20c-to-20kc range — 600 or 150 ohms, balanced or grounded.
20kc-to-1.5Mc range 50 ohms, grounded.
20c-to-3Mc range deflection-plate terminals of cathode-ray oscilloscope, connected with 36-inch leads and with an *effective* input resistance of at least one megohm. Output may be balanced or grounded.

Transient Response: 20c-to-3Mc range — approximately 0.1 microsecond rise time, with negligible overshoot.

Input Voltage: Less than 0.2 volt for full output.

Input Impedance: 100,000 ohms in parallel with 37 $\mu\mu f$ (grounded).

Distortion: Less than 3% at rated output on all ranges.

Noise Level: 20c-to-20kc range, 60 db below 15 watts output.
20kc-to-1.5Mc range, 70 db below 15 watts output.
20c-to-3Mc range, less than 0.3 volt peak-to-peak balanced.

Frequency Response: See typical curves.

Power Supply: 105 to 125 (or 210 to 250) volts, 40 to 60 cycles ac.

Power Consumption: Approximately 140 watts at 15 watts output; approximately 120 watts at zero output.

Voltmeter:
Ranges, 150, 50, and 15 volts full scale.
Accuracy, ±5% of full scale.
Impedance, 15 kΩ compensated to 5 Mc.

Mounting: The panel is designed for mounting in a 19-inch relay rack, but removable end frames are supplied for table use.

Tubes: 2 — 6AC7, 2 — 6AG7, 2 — 807, 1 — 6J6

Terminals: TYPE 874 Coaxial Terminals at input and output. Adjacent ground posts for connecting by TYPE 274-MB Plugs are provided.
Two insulated binding posts for balanced output.

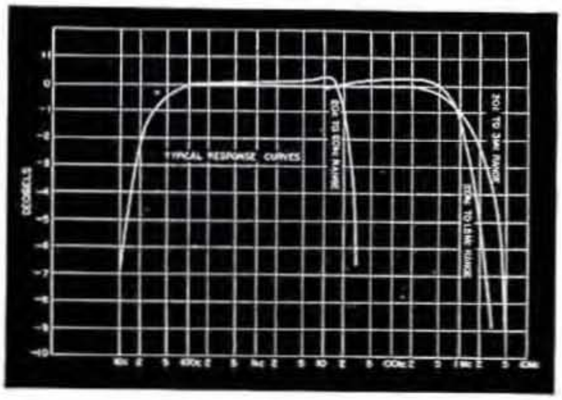
Accessories Supplied: Seven-foot power cord; two TYPE 274-MB Double Plugs; two spare line fuses; two TYPE 874-C Cable Connectors.

Other Accessories Available: TYPE 874-R21 Patch Cords; TYPE 874 Connectors and Adaptors.

Dimensions: (Width) 19⅜ x (depth) 14¼ x (height) 7½ inches, over-all.

Net Weight: 16½ pounds.

Typical response curves for the three amplifier ranges. The 20-cycle-to-3-megacycle range is given a smooth roll-off at the high end to assure good transient response.



Type		*Code Word*	*Price*
1233-A	Power Amplifier	ANGER	$525.00

PATENT NOTICE. See Notes 3 and 4, page vi.

The TYPE 715-AE Direct-Current Amplifier with a 5-milliampere Recorder manufactured by Esterline-Angus Co.

TYPE 715-A DIRECT-CURRENT AMPLIFIER

USES: The TYPE 715-A Direct-Current Amplifier is designed primarily for use with the Esterline-Angus 5-milliampere recorder. This combination of amplifier and recorder is capable of accurately recording small d-c voltages and currents. In addition to its obvious use as a recording d-c milliammeter or millivoltmeter, it has a number of applications in process control and in measurements in physical and chemical laboratories.

Since the introduction of this amplifier, it has found application to a wide variety of industrial and research problems. It has been used for the recording of frequency and for recording the modulation level of broadcast transmitters. Other applications include the recording of the insulation resistance of electrical machinery during dehydration, the measurement of the emf of electro-chemical cells, the recording of life tests on vacuum tubes, and the recording of sound and vibration intensities. The instrument may equally well be used to operate from photoelectric cells, resistance strain gauges, resistance thermometers, and similar devices.

DESCRIPTION: The amplifier is a highly stable a-c operated instrument and gives full-scale output over a range of input voltages from 0.1 volt to 1.0 volt. Means are provided for selecting input resistances between 100 ohms and 10 megohms.

The circuit employs three pentode tubes for the amplifiers in a degenerative circuit arrangement giving high stability of calibration. A bridge-type balancing network using a voltage regulator tube provides for balancing out the steady plate current in the meter, so that the meter indicates current change. Both fine and coarse zero adjustments are provided for setting the meter for normal zero. The circuit is unaffected by changes in plate voltage caused by normal variations in a-c supply voltage.

FEATURES: ➔ High gain and simplicity of operation have been combined with stability of calibration.

➔ A wide range of input voltages and resistance combinations can be accommodated.

➔ Variations in the temperature of the cathode of the first amplifier tube, a critical point, have been overcome very effectively by using a regulating transformer and a filament ballast lamp. This system maintains the heater voltage constant for line voltage changes from 105 to 125 volts.

➔ A-C operation and small size make this amplifier a convenient adjunct to the graphic recorder.

SPECIFICATIONS

Range: The instrument is provided with four calibrated ranges, selected by means of a switch, giving 5 milliamperes linear output in the recorder circuit of 1000 ohms, for input voltages of 0.1, 0.2, 0.5, and 1.0 volt applied at the input terminals with either polarity. The gain is best expressed as a transconductance; the maximum value is 50,000 micromhos.

Accuracy: As a calibrated voltmeter, the accuracy of calibration is approximately 1% of full scale, this accuracy being maintained over a considerable period of time.

Input Circuit: Means are provided for selecting any one of a number of input resistances, so that the instrument not only has an adjustable input resistance, but can serve as a calibrated millivoltmeter or microammeter. The input resistances range in powers of 10 from 100 ohms to 10 megohms. Short-circuit and open-circuit positions are also supplied on the selector switch.

For those applications where relative values only are of interest and where the voltage available exceeds 1 volt, one of the switch positions connects the input to a variable gain control, so that the voltage applied to the first grid can be adjusted to any desired value. The input resistance for this position is approximately 150,000 ohms.

Grid Current: The grid current in the input circuit is less than 0.002 microampere.

Output Circuit: The output circuit is designed to operate a 5-milliampere meter mounted on the panel and an external meter or device such as the Esterline-Angus 5-milliampere recorder, and is provided with a manually adjusted compensating resistance. The compensating resistance is adjusted to allow for the resistance of the external device, so that the instrument always works into a normal resistance of 1000 ohms. Although the instrument functions perfectly when operating into resistances from 0 to 2000 ohms, its calibration is affected slightly if the total impedance deviates materially from the 1000-ohm value.

Temperature and Humidity Effects: Over the range of room conditions normally encountered (65° Fahrenheit to 95° Fahrenheit; 0 to 95% relative humidity), the operation and stability are independent of ambient conditions.

Power Supply: The instrument is intended for operation directly from 105 to 125 (or 210 to 250) volts, 60 cycles. Other voltages or other frequencies can be supplied on special order only.

Power Input: The power drawn from the 60-cycle line is approximately 35 watts. No batteries of any kind are employed.

Vacuum Tubes: The tubes used are: two 6J7-G, one 6F6-G, one 6X5-G, one 105-30, one 4A1. All are furnished with the instrument.

Mounting: The amplifier is mounted in a cast metal case identical with that used on the Esterline-Angus recorder, or in walnut cabinet, as desired.

Accessories Supplied: Seven-foot line connector cord; spare fuses.

Dimensions: Type 715-AM, (height) 15¼ x (width) 9 x (length) 8½ inches, over-all; Type 715-AE, (height) 15 x (width) 8½ x (length) 8¾ inches, over-all.

Net Weight: With cast metal case to match Esterline-Angus recorder, 25¾ pounds; with walnut cabinet, 22¼ pounds.

Type 715-AM Direct-Current Amplifier.

Type		*Code Word*	*Price*
715-AE	In Cast Metal Case	ASIDE	$365.00
715-AM	In Walnut Cabinet	ALOFT	320.00

PATENT NOTICE. See Notes 1 and 2, page vi.

UNIT INSTRUMENTS

POWER SUPPLIES — OSCILLATORS — AMPLIFIER

General Radio Unit Instruments are small, compact, laboratory-type instruments, designed for high-quality performance at minimum price. The basic unit is a power supply, which plugs into the instruments as needed, thus eliminating the expense of providing a power supply in each individual instrument. Mechanically, the Unit Instruments are designed to make maximum use of interchangeable parts, and accessories are available for some of them, by means of which more specialized assemblies can be built up from the standard units. They are designed for compact side-by-side assembly with plug-type interconnections.

These Unit Instruments are useful, economical accessories for any laboratory, which will save both time and money for many of the everyday jobs of electronic engineering.

They find particular application in educational laboratories, where they provide experimental facilities for student exercises at a cost far below that of highly-specialized instruments. Thus more facilities for more students can be provided within a given budget.

For production testing, simple and compact single-purpose assemblies can be made up from these instruments at a considerable saving in cost, and in this field the various Unit Oscillators and Power Supplies will be found especially useful.

TYPE 1203-A UNIT POWER SUPPLY

USES: This power pack is designed primarily to supply a-c heater and d-c plate power for various General Radio Unit Instruments. It can also be used as a general-purpose source of heater and plate power for other electronic equipment.

DESCRIPTION: The elements of the power supply are a power transformer, a rectifier tube, and an R-C-type filter. Connections to other General Radio Unit Instruments are made through a multipoint connector. A mating plug is furnished to facilitate connection to any other circuits.

FEATURES: ➔ Low-priced and small in size.

➔ Can be permanently attached to some General Radio Unit Instruments. Combination of units is very compact, occupying a minimum of bench space.

➔ Both the a-c heater supply and the d-c plate supply are isolated from ground and from each other.

SPECIFICATIONS

Output Voltages: 6.3 volts ac, nominal; 3 amperes maximum; 300 volts dc, 50 milliamperes maximum. No-load voltage is about 410 volts.

Hum Level: About 250 millivolts at 300 volts and 50 milliamperes d-c output.

Input: 115 volts, 50 to 60 cycles; 50 watts full load. A line-connector cord is permanently attached to the instrument.

Rectifier: One 6X4-type, supplied with instrument.

Output Terminals: A standard multipoint connector is mounted on the side of the unit.

Accessories Supplied: A mating multipoint connector for connecting the power supply to other equipment; a 10-32 screw with wing nut for permanently attaching the power supply to other Unit Instruments. Also spare fuses.

Mounting: Black-crackle-finish aluminum panel and sides. Aluminum cover finished in clear lacquer.

Dimensions: (Width) 5 x (height) 5¾ x (depth) 6¼ inches, over-all, not including power-line connector cord.

Net Weight: 5¼ pounds.

Type		*Code Word*	*Price*
1203-A	Unit Power Supply	ALIVE	$47.50

TYPE 1204-B UNIT VARIABLE POWER SUPPLY

USES: This instrument supplies fixed a-c heater voltage and adjustable d-c plate voltage for general laboratory use. General Radio Unit Instruments can be plugged directly into its multipoint connector.

DESCRIPTION: The d-c plate supply is obtained from a pair of selenium rectifiers in a voltage-doubler circuit and is adjustable down to zero by a VARIAC® control. An R-C filter reduces hum to a low level. Both the d-c output voltage and the d-c load current are measured by a single switch-controlled panel meter.

The output voltages are available at binding posts on the panel and also at a multipoint connector.

FEATURES: ➔ D-C output voltage is continuously adjustable from zero to full value, with low output impedance over the entire range.

➔ Both the a-c heater supply and the adjustable d-c plate supply are isolated from ground and from each other.

➔ Metered d-c output voltage and current.

SPECIFICATIONS

Output Voltages: 6.3 volts a-c, nominal; 3 amperes maximum. The d-c output voltage is adjustable from zero to 300 volts with a maximum load of 100 milliamperes. Maximum no-load voltage, 400 volts.

Meter: A panel meter indicates the d-c output voltage and current.

Hum Level: About 250 millivolts at 300 volts, 100 milliamperes d-c load; about 150 millivolts at 350 volts, 50 milliamperes d-c load.

Input: 115 volts at 60 cycles; 75 watts at full output load. A line-connector cord is permanently attached to the instrument.

Rectifier: Two selenium rectifiers used in a voltage doubling circuit.

Output Terminals: The outputs are available at four insulated binding posts on the panel and also at a standard multipoint connector on the side of the instrument.

Accessories Supplied: Spare fuses; a mating multipoint connector.

Mounting: Black-crackle-finish aluminum panel and sides. Aluminum cover finished in clear lacquer.

Dimensions: (Width) 9⅞ x (height) 5¾ x (depth) 6¼ inches, over-all, not including power line connector cord.

Net Weight: 11½ pounds.

Type		*Code Word*	*Price*
1204-B	Unit Variable Power Supply..........	AGATE	$85.00

PATENT NOTICE. See Note 11, page vi.

TYPE 1206-A UNIT AMPLIFIER

USES: This amplifier is designed for general utility in the laboratory. Its maximum gain is sufficient for use in the detector circuits of impedance bridges, while its output power is adequate for driving many low-power laboratory devices. The normal operating range covers both audio and supersonic frequencies.

DESCRIPTION: The amplifier circuit contains two triode, RC-coupled, voltage-amplifier stages and an impedance-coupled output stage. Cathode degeneration is employed on the input stage, and additional degeneration is included between the second amplifier and the output tube. Power supply connections plug directly into the TYPE 1203-A Unit Power Supply.

FEATURES: ➔ A voltage gain of 45 db combined with a maximum output of 3 watts.

➔ Wide frequency range — flat from 100 cycles to 100 kc.

➔ Excellent gain stability, low distortion, and good phase-shift characteristic, resulting from the use of inverse feedback.

➔ Wire-wound volume control insures low noise level as gain is changed.

SPECIFICATIONS

Voltage Gain: Continuously adjustable from 0 to 45 decibels. Gain control scale is arbitrary.
Load Impedance: 7500 ohms optimum. Blocking capacitor is 1 μf.
Maximum Output: 3 watts into 7500 ohms can be obtained with less than 5% distortion.
Input Impedance: The input resistance is 200,000 ohms. Blocking capacitor is 0.05 μf.
Frequency Response: Essentially constant from 100 cycles to 100 kc. Response is down 2 db at 200 kc and drops 6 db per octave above 200 kc. Response at 20 c is down 6 db.
Distortion: The distortion when delivering 1 watt into a load of 7500 ohms is less than 2% at frequencies above 100 cycles. At lower frequencies the distortion increases, but is less than 3% at 50 cycles. At an output of 3 watts, total distortion is under 5% above 100 cycles.
A-C Hum: The maximum 60-cycle hum level in the output is about 125 millivolts.
Power Supply: The amplifier plugs directly into the TYPE 1203-A or TYPE 1204-A Unit Power Supply.
Accessories Supplied: Multipoint connector.
Tubes: One 6SN7-GT and one 6V6-GT are supplied.
Terminals: Jack-top binding posts on ¾-inch spacing.
Mounting: Black-crackle-finish aluminum panel.
Dimensions: (Width) 10¾ x (height) 5⅞ x (depth) 6½ inches, over-all.
Net Weight: 8¾ pounds.

Type		*Code Word*	*Price*
1206-A	Unit Amplifier*	ARBOR	$85.00
1203-A	Unit Power Supply	ALIVE	47.50

*PATENT NOTICE. See Note 1, page vi.

Type 1208-A

Type 1209-A

TYPE 1209-A U-H-F UNIT OSCILLATOR
TYPE 1208-A V-H-F UNIT OSCILLATOR

USES: The Type 1208-A and 1209-A Unit Oscillators are compact, moderately priced, general-purpose power sources for the electronics laboratory. They cover the frequency ranges of 65 to 500 Mc and 250 to 920 Mc, respectively, and can deliver 100 to 500 milliwatts of power. Output terminals are Type 874 Coaxial Connectors, for connection to General Radio measuring equipment as well as to the wide variety of Type 874 Coaxial Elements. Adaptors are available (see page 124) permitting the output to be connected to other coaxial systems.

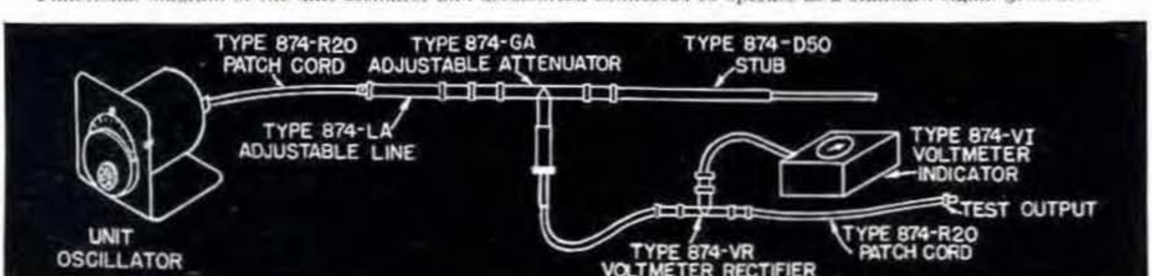
These oscillators are recommended as power sources for the Type 874-LB Slotted Line, the Type 1601-A V-H-F Bridge and the Type 1602-A U-H-F Admittance Meter. In conjunction with Type 874 Coaxial Elements such as attenuators, rectifiers, filters, terminations, modulators, and coupling devices, they can be adapted for a wide variety of uses in the laboratory, which would otherwise require specialized and expensive equipment.

Connected to a Type 874-MR Mixer Rectifier, the unit oscillators can provide the local signal in a heterodyne converter, to adapt a low-frequency communications receiver for use as a sensitive detector for v-h-f and u-h-f signals. This combination makes an excellent null detector for the Type 1601-A V-H-F Bridge and the Type 1602-A U-H-F Admittance Meter.

The Unit Oscillators can be used as signal generators if means are provided to measure and to attenuate the output. The Type 874-VR Voltmeter Rectifier, the Type 874-VI Voltmeter Indicator and the Type 874-GA Adjustable Attenuator are suitable for this purpose. At frequencies above 300 Mc, a Type 874-D50 Adjustable Stub is required as well, and, at lower frequencies, a Type 874-WM Matched Termination. The Type 874-LA Adjustable Line should be added to increase the output. It should be kept in mind however that the shielding of this system is not sufficient for accurate measurements in the microvolt region.

In combination with a Type 1000-P6 Crystal Diode Modulator and a Type 874-GA 20-db Fixed Attenuator the unit oscillator is a convenient source of television signals over its entire carrier-frequency range if video modulating voltage is available. The video modulating voltage required can be obtained

Functional diagram of the unit oscillator and accessories, connected to operate as a standard-signal generator.



from a standard television receiver tuned to the local station. Since the modulator is separated from the oscillator by an attenuator pad, amplitude modulation free from incidental frequency modulation is obtained.

The two unit oscillators cover very wide ranges in that part of the frequency spectrum that is beyond the region of conventional lumped circuit techniques and below the region of lines and cavities. Oscillators in this range cannot be put together readily from standard components, and much time and effort will be saved by using the small, convenient and reliable Unit Oscillators.

TYPE 1209-A U-H-F UNIT OSCILLATOR

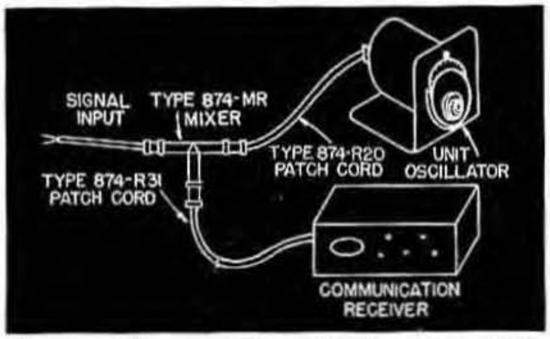
250-920 Mc

DESCRIPTION: The tuning element in this oscillator is a Butterfly Circuit, which has no moving contacts and in which inductance and capacitance are varied simultaneously. The oscillator tube is a TYPE TUE-1 Disc-Seal Triode (modified TYPE 5861).

The output system is a short coaxial line with a coupling loop and a TYPE 874 Coaxial Connector on the output end. Coupling to the oscillator can be adjusted over a wide range.

Plate and heater power can be furnished conveniently by the small TYPE 1203-A Unit Power Supply, although for some applications a well-regulated power supply with lower hum voltage may be desirable. (See specifications.) A multipoint connector attached to the oscillator plugs directly into the Unit Power Supply.

Amplitude modulation over the audio range can be obtained by superimposing a-f voltage in the plate supply. Convenient terminals have been provided for this purpose, and the TYPE 1214-A Unit Oscillator is recommended as a modulator. Incidental fm inherent in this system is of the order of 0.01% for 30% am in the lower part of the tuning range and increases rapidly at the high-frequency end. For applications where incidental fm must be negligible, the TYPE 1000-P6 Crystal Diode Modulator is recommended.



Functional diagram of the unit oscillator and mixer rectifier used as a frequency converter.

The oscillator is supported by an L-shaped bracket which requires a minimum of bench space. All components are mounted on a flat base casting which carries the supply line filters on one side and the tuned circuit on the other. The tuned circuit is enclosed in a cylindrical shield which carries the output circuit.

FEATURES: The TYPE 1209-A Unit Oscillator gives moderately high output over a wide frequency range. With simple accessories it is adaptable for a great variety of laboratory uses. Frequency stability is good, and warm-up drift, small.

SPECIFICATIONS

Frequency Range: 250-920 Mc.
Tuned Circuit: Butterfly, with no sliding contacts.
Frequency Control: 4-inch dial with calibration over 270°. Slow-motion drive, 4½ turns.
Frequency Calibration Accuracy: ±1%.
Warm-Up Frequency Drift: 0.2%.
Output System: Short coaxial line with an adjustable coupling loop on one end and a TYPE 874 Coaxial Connector on the other. Maximum power can be delivered to load impedances normally encountered in coaxial systems.
Output Power: Into 50 Ω, 200 mw at any frequency.
Modulation: Amplitude modulation of 30% at audio frequencies can be produced by an external source of 40 volts. Input impedance is about 8000 ohms. TYPE 1000-P6 Crystal Diode Modulator can be used for modulation at video frequencies.
Power Supply Required: 300 v; 40 ma, dc
6.3 v; 0.4 a, ac
TYPE 1203-A Power Supply is recommended.
Tube: General Radio TUE-1 Disc-Seal Triode.
Mounting: Oscillator is mounted in an aluminum casting surrounded by a spun aluminum container. Assembly is then mounted on an L-shaped panel and chassis piece.
Accessories Supplied: TYPE 874-R20 Patch Cord multipoint connector, TYPE 874-P Panel Connector, and TYPE 874-C Cable Connector.
Accessories Available: TYPE 1000-P6 Crystal Diode Modulator (page 133), TYPE 1214-A Unit Oscillator (page 111), TYPE 874 Coaxial Elements such as attenuators, filters, coupling devices, stubs, voltmeter, and mixer. See pages 112 to 125.
Dimensions: 7 x 6¼ x 9¼ inches, over-all.
Net Weight: 6¼ pounds.

Type		*Code Word*	*Price*
1209-A	U-H-F Unit Oscillator,* 250-920 Mc	AMISS	$235.00
1203-A	Unit Power Supply	ALIVE	47.50

*PATENT NOTICE. See Notes 3, 4, and 10, page vi.

TYPE 1208-A V-H-F UNIT OSCILLATOR

65-500 Mc

The TYPE 1208-A Unit Oscillator is similar to the TYPE 1209-A in construction and operation. The tuned circuit is a sliding contact type, with which a wider frequency range is obtained at some sacrifice in frequency settability.

Functional diagram of the unit oscillator with video modulator to form a television signal generator.

SPECIFICATIONS

Specifications for TYPE 1208-A are the same as those for the TYPE 1209-A, with the exceptions noted below.

Frequency Range: 65-500 Mc.
Tuned Circuit: Sliding contact type.
Frequency Calibration Accuracy: ±2%.
Warm-Up Frequency Drift: 0.5%.
Output Power: Into 50 Ω, 100 mw at any frequency; 500 mw in center of range.
Power Supply Required: 300 v; 40 ma, dc
6.3 v; 0.9 a, ac
TYPE 1203-A Power Supply is recommended.
Tube: 2C43 Lighthouse triode.
Dimensions: $6\frac{1}{4}$ x $6\frac{1}{4}$ x $8\frac{1}{4}$ inches, over-all.
Net Weight: $5\frac{1}{2}$ pounds.

Type		*Code Word*	*Price*
1208-A	**Unit Oscillator,* 65-500 Mc**	AMEND	**$190.00**
1203-A	**Unit Power Supply**	ALIVE	**47.50**

*PATENT NOTICE. See Notes 3 and 4, page vi.

TYPE 1214-A UNIT OSCILLATOR

USES: The TYPE 1214-A Unit Oscillator is a convenient modulator for the TYPE 1208-A and TYPE 1209-A Unit Oscillators. It is also useful as a power source for bridge measurements at 400 and 1000 cycles. Unlike other Unit Instruments, this instrument includes its own power supply.

DESCRIPTION: The design centers about the TYPE 117N7-GT Tube which contains both the power rectifier section and the oscillator section. There is no power transformer, isolation from the a-c line being obtained at the output through the use of a separate output winding coupled to the oscillator coil. The 400-cycle oscillator uses the Hartley circuit. At 1000 cycles, the single tuning capacitor is switched to a tap on the tuning coil. The output circuit is isolated from the power line and ground. The output control is rugged enough to carry large external d-c currents for modulator applications.

FEATURES: → Small, compact, and inexpensive.

→ Good output and good waveform.

→ Output circuit can be operated above ground level.

→ Output circuit can carry large external d-c currents for modulator service.

SPECIFICATIONS

Frequency: 400 and 1000 cycles accurate to ±2%.
Output: The maximum output power is over 200 milliwatts; the output impedance is about 8000 ohms with the (10 kΩ) output control at maximum. Open-circuit output voltage is about 80 volts.
Distortion: Less than 3% into matching load.
Output Circuit: The output can be isolated from ground for using the oscillator as a modulator in the plate circuit of a high-frequency oscillator, such as the TYPE 1208-A or the TYPE 1209-A. The output control is adequate for external d-c currents as great as 36 ma in the output circuit.
Controls: A toggle switch to select frequency, an output control and a power switch.
Terminals: The output terminals are jack-top binding posts with standard $\frac{3}{4}$-inch spacing; a ground terminal is provided, adjacent to one of the output terminals.
Power Supply: Unlike most instruments of the Unit line, the power supply is built into the instrument; 115 volts, 40-60 cycles; power consumption is about 16 watts.
Accessories Supplied: Spare fuses; the power cord is integral with the unit.
Tube: One 117N7-GT, which is supplied with the instrument.
Mounting: Aluminum panel and sides finished in black-crackle lacquer. Aluminum dust cover finished in clear lacquer.
Dimensions: (Height) $5\frac{3}{4}$ x (width) 5 x (depth) $6\frac{1}{4}$ inches, over-all, not including power-line connector cord.
Net Weight: $4\frac{1}{2}$ pounds.

Type		*Code Word*	*Price*
1214-A	**Unit Oscillator (including power supply)...**	ALLAY	**$60.00**

PATENT NOTICE. See Note 2, page vi.

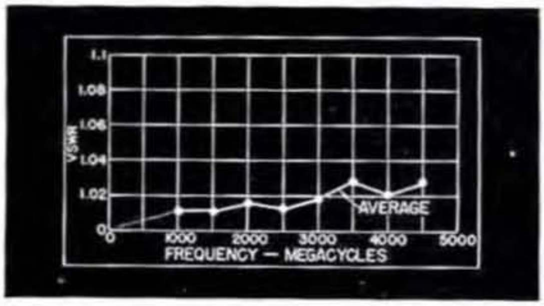
COAXIAL ELEMENTS

The TYPE 874 Coaxial Elements are a group of inexpensive, but precision-built, coaxial parts that can be plugged together quickly and easily to assemble different measuring systems in the frequency range from 300 to above 5000 megacycles.

The fundamental measuring tools are a slotted line for impedance and standing-wave ratio measurements, bolometer elements and a bolometer bridge for power measurements, and a crystal rectifier and indicator for voltage measurements. These devices are supplemented by all the necessary accessory parts, such as tuning stubs, a "line-stretcher," a tee, an ell, line sections of various lengths, a matching resistance termination, fixed and adjustable attenuators, low-pass filters, and other specialized devices.

The keystone of this group of coaxial elements is the TYPE 874 Coaxial Connector.[1] This unique connector, any two of which, though identical, can be plugged together, is ideally suited for use on coaxial measuring equipment and was specifically designed for this purpose. Its quick-connect-and-disconnect feature simplifies the assembly of coaxial elements into complete measurement setups, and its low reflections at ultra-high frequencies can be neglected except in very accurate work.

The use of the TYPE 874 Coaxial Connector makes it possible to assemble a given measuring setup with a minimum of parts. Since all connectors are identical, the necessity of stocking similar items with both male and female connectors is eliminated. This complete interchangeability of the elements, as



TYPE 874 Connector standing-wave ratio as a function of frequency.

well as the excellent electrical performance of the connectors are essential characteristics for measurement work.

The basic elements of the TYPE 874 Coaxial Connector are an inner conductor, an outer conductor and a supporting polystyrene bead. Figure 1 shows one of these connectors assembled at the end of a rigid, 50-ohm, air-dielectric, coaxial line. The inner and outer conductors are similar in principle; each is essentially a tube with four longitudinal slots in the end and with two opposite quadrants displaced inward. To make a joint, two connectors are plugged together so that the undisplaced quadrants of one connector overlap the displaced quadrants of the other. Figure 2 is a cross-section sketch of a joint in which the elements of one connector are shaded dark and those of the other light. The mutual overlapping referred to can be seen, as well as the resultant circularity of the joined conductors.

[1] W. R. Thurston, "A Radically New Coaxial Connector for the Laboratory," *General Radio Experimenter*, Vol. XXIII, No. 5, October 1948.

PATENT NOTICE. See Notes 3 and 4, page vi.

FIGURE 1. TYPE 874 Coaxial Connector (approximately $1\frac{1}{2}$ times normal size).

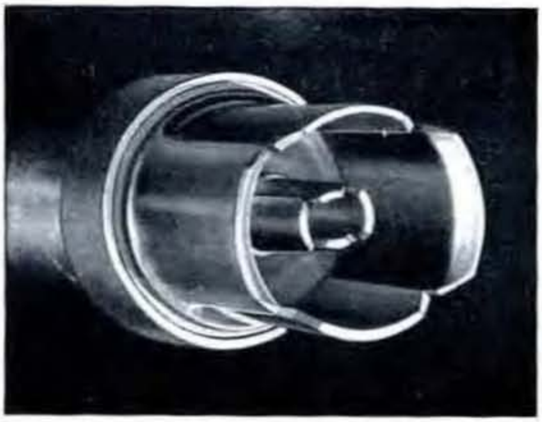
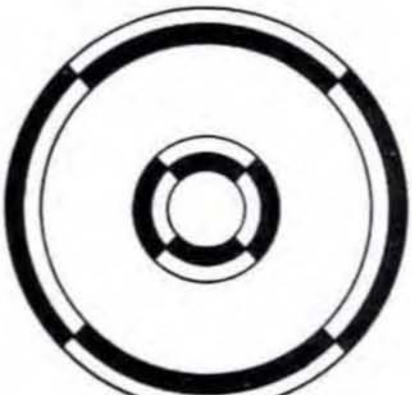


FIGURE 2. Cross-section sketch (enlarged about $2\frac{1}{2}$ times) of overlapping joints.



EQUIPMENT FOR STANDING-WAVE MEASUREMENTS
TYPE 874-LB SLOTTED LINE

USES: One of the important basic measuring instruments used at ultra-high frequencies is the slotted line. With it the standing-wave pattern of the electric field in a coaxial transmission line, having a known characteristic impedance, can be accurately determined. From a knowledge of the standing-wave pattern several characteristics of the circuit connected to the load end of the slotted line can be obtained. For instance, the degree of mismatch between the load and the transmission line can be calculated from the ratio of the amplitude of the maximum of the wave to the amplitude of the minimum of the wave, which is called the voltage standing-wave ratio, VSWR. The load impedance can be calculated from the standing-wave ratio and the position of a minimum point on the line with respect to the load. The wavelength of the exciting wave can be measured by obtaining the distance between minima. These properties make the slotted line valuable for many different types of measurements on antennas, components, coaxial elements, and networks.

DESCRIPTION: The TYPE 874-LB Slotted Line is a 50-ohm, air-dielectric, coaxial transmission line with a longitudinal slot in the outer conductor. The inner conductor is supported at its ends only by two TYPE 874 Connectors, thus minimizing reflections and discontinuities caused by dielectric supports.

An electrostatic pickup probe, mounted on a sliding carriage, projects through the slot and samples the electric field within the line. Coupling between line and probe is adjustable by changing the probe penetration. The maximum longitudinal travel of the probe is 50 centimeters, which is one-half wavelength at 300 Mc. The position of the probe is indicated on an adjustable centimeter scale mounted on the line.

The carriage can be moved along the line by grasping the knob or the base of the carriage and sliding it, or by lightly pressing down and turning the knob. The knob is attached to a pair of tapered discs which span one of the reinforcement rods. When the knob is pushed down, the tapered discs grip the rod and roll along it when turned, thus driving the carriage.

For the measurement of high standing-wave ratios by the width-of-minimum method, the TYPE 874-LV Micrometer Vernier is available.

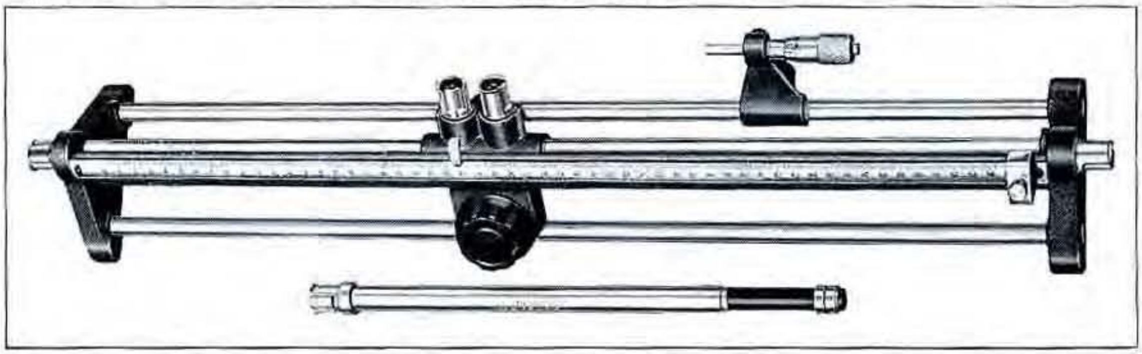
To operate the slotted line, a source of r-f power is required. For most measurements one milliwatt is adequate and in many cases much less can be used. In general, the higher the VSWR, the greater the amount of power required. Some detectors require modulation of the r-f power.

Either a crystal rectifier or a receiver can be used as a detector of the r-f voltage induced in the probe. A built-in crystal mount is incorporated in the carriage, and a TYPE 874 Connector is provided for the receiver. When the crystal is used, it is tuned to the operating frequency by an adjustable stub, which plugs into a connector on the probe carriage.

The crystal output can be measured with a d-c microammeter, but the sensitivity is poor. Much greater sensitivity can be obtained if an amplitude-modulated signal is used and the crystal output, which then is an audio frequency voltage, is fed through a calibrated attenuator into an amplifier supplied with an indicating meter, such as the TYPE 1231-P4 Adjustable Attenuator and the TYPE 1231-B Amplifier and Null Detector. The crystal output is very closely proportional to the square of the r-f input voltage over a wide range of input voltage.

Another detector, which is both sensitive and selective, consists of a TYPE 874-MR Mixer Rectifier and a local oscillator, used in conjunction with a communications-type receiver or a wide-band r-f amplifier. A wide

Top view of TYPE 874-LB Slotted Line with TYPE 874-LV Micrometer Vernier and TYPE 874-D20 Adjustable Stub.



frequency range can be covered, since harmonics of the local oscillator can be used.

FEATURES: ➔ This slotted line is a well-designed, rugged, and precisely constructed instrument, capable of accurate measurements.

➔ Its sturdiness and light weight make it convenient for field use.

➔ A wide variety of accessory coaxial units are available, all of which are fitted with TYPE 874 Coaxial Connectors.

➔ Usable up to 5000 megacycles.

SPECIFICATIONS

Characteristic Impedance: 50 ohms ±1%.
Probe Travel: 50 centimeters; scale is calibrated in millimeters.
Frequency Range: 300 to 5000 megacycles. Operation at frequencies below 300 Mc is possible, if lengths of TYPE 874-L30 Air Line are added.
Dielectric: Air.
Accuracy: Constancy of Probe Penetration — ±2½% or better.
VSWR of Terminal Connectors:
Less than 1.02 at 1000 Mc.
Less than 1.07 at 4000 Mc.
Crystal Rectifier: 1N21B-type silicon crystal.
Accessories Required: (TYPE 874-D20) Adjustable Stub for tuning the crystal rectifier; suitable detector and generator (see discussion on next page); one each TYPE 874-R20 and TYPE 874-R32 Patch Cords for generator and detector connections.
Other Useful Accessories: TYPE 874-WM 50-Ohm Termination, TYPE 874-WN Short-Circuit Termination, and TYPE 874-WO Open-Circuit Termination; TYPE 874-Q1 Adaptor to TYPE N. A complete kit of TYPE 874 Coaxial Elements, including the Slotted Line, is listed below. For the measurement of high standing-wave ratios (greater than 10), a TYPE 874-LV Micrometer Vernier is recommended.
Dimensions: 26 x 4½ x 3½ inches, over-all.
Net Weight: 8½ pounds.

Type		*Code Word*	*Price*
874-LB	**Slotted Line**	COAXRUNNER	**$220.00**

TYPE 874-LV MICROMETER VERNIER ATTACHMENT FOR SLOTTED LINE

For measurement of high standing-wave ratios by the width-of-minimum method. Consists of a micrometer caliper head, calibrated in centimeters, mounted on an arm that can be attached to the rear base rod of the slotted line. One turn of the micrometer barrel advances the head by one millimeter. Maximum range is 2 cms. Can be read to ±0.002 cm.

Net Weight: 9 ounces.

Type		*Code Word*	*Price*
874-LV	**Micrometer Vernier Attachment**	COAXREADER	**$20.00**

For other v-h-f and u-h-f impedance-measuring equipment, see TYPE 1602-A U-H-F Admittance Meter and TYPE 1601-A V-H-F Bridge, pages 84 and 86.

BASIC SLOTTED LINE KIT

For impedance and standing-wave measurements with the slotted line, a group of coaxial elements has been selected and is available as the TYPE 874-EK Basic Coaxial Kit. The following items are included.

Type	*Name*	*Quantity*	*Unit Price*	*Price*
874-A2	Coaxial Cable	25 feet	$27.00/100 feet	$ 6.75
874-B	Basic Connector	2	1.25	2.50
874-C	Cable Connector	2	2.00	4.00
874-C8	Cable Connector	2	2.00	4.00
874-D20	Adjustable Stub	1	10.50	10.50
874-D50	Adjustable Stub	1	12.00	12.00
874-LA	Adjustable Line	1	15.00	15.00
874-LB	Slotted Line	1	220.00	220.00
874-P	Panel Connector	2	2.50	5.00
874-Q1	Adaptor to Type N	1	4.50	4.50
874-R20	Patch Cord	2	6.00	12.00
274-NF	Patch Cord	1	2.50	2.50
874-Q6	Adaptor	1	2.00	2.00
274-NE	Shielded Connector	1	5.50	5.50
874-T	Tee	1	7.50	7.50
874-WM	Matched (50 Ω) Termination	1	10.50	10.50
874-WN	Short-Circuit Termination	1	3.50	3.50
874-WO	Open-Circuit Termination	1	2.00	2.00
874-Z	Stand	1	12.50	12.50
TOTAL	Type 874-EK Basic Coaxial Kit			$342.25

ACCESSORIES

If very high standing-wave ratios (greater than 10) are to be measured, a TYPE 874-LV Micrometer Vernier Attachment should also be purchased as well as a harmonic filter.

Type		*Price*
874-LV	Micrometer Vernier Attachment	$20.00
874-F1000	Low-Pass Filter (page 122)	22.50
874-F500	Low-Pass Filter (page 122)	22.50

See below for a listing of suitable generators and detectors.

GENERATORS AND DETECTORS FOR THE SLOTTED LINE

GENERATORS

The following generators are recommended:

Type 1208-A Unit Oscillator, 65-500 Mc (page 111) **$190.00**
OR
Type 1209-A Unit Oscillator, 250-920 Mc (page 110) **235.00**

The above Unit Oscillators do not include power supply; the TYPE 1203-A Unit Power Supply is recommended.
Type 1203-A Unit Power Supply (page 106) .... **$ 47.50**

A patch cord is required for connections between generator and Slotted Line.
Type 874-R20 Patch Cord (page 124) .... **$ 6.00**

If a modulated signal is desired, the TYPE 1214-A Unit Oscillator is recommended, to modulate either the TYPE 1208-A or the TYPE 1209-A Unit Oscillators.
Type 1214-A Unit Oscillator (page 111) .... **$ 60.00**

The TYPE 1021-AU Standard Signal Generator (page 134) is also a satisfactory source.

DETECTORS

A number of satisfactory detector combinations are listed below.

1. *Using audio-frequency output of crystal rectifier in slotted line.* Requires a modulated generator (see above). Necessary equipment consists of the following items:

Type 1231-B Amplifier and Null Detector (page 98)	**$250.00**
Type 1231-P2 Tuned-Circuit Filter (page 100)	**25.00**
Type 1231-P4 Adjustable Attenuator (page 100)	**52.50**
Type 874-D20 Adjustable Stub, 275-5000 Mc (page 120)	**10.50**
Type 874-R32 Patch Cord (page 124)	**5.75**
TOTAL	**$343.75**

2. *Using d-c output of crystal rectifier.* This method does not require a modulated generator.
For the measurement of relatively low standing ratios it is quite satisfactory, and its simplicity makes it attractive for many field measurements. It is relatively insensitive and is not capable of as great accuracy as other methods.

Type 874-R31 Patch Cord (page 124)	**$ 4.50**
Type 874-D20 Adjustable Stub (page 120)	**10.50**

Microammeter with sensitivity of 50 μa or better.

3. *Heterodyne system.* The signal from the generator and that of an auxiliary oscillator are combined in a mixer to produce a difference frequency within the range of a lower-frequency receiver, usually a communications type, or a wide band i-f amplifier. The receiver i-f band should be at least 20 kc.

A 30-megacycle i-f amplifier of the type used in AN/APR-4 receivers is particularly well suited to this application. Shielding is much better than when the receiver is used directly at the operating frequency. Selectivity is better with the heterodyne detector than with other methods of detection. Good selectivity is needed for measurement of high standing-wave ratios.

The S-meter readings, the i-f output, or the audio output of a receiver or i-f amplifier can be used as the measure of the relative amplitude of the standing wave on the line. For maximum accuracy, the S-meter on a receiver should be calibrated against a standard-signal generator.

The use of a single Unit Oscillator permits coverage of a far wider frequency range than the fundamental range of the oscillator, because oscillator harmonics can be used with only a slight increase in conversion loss.

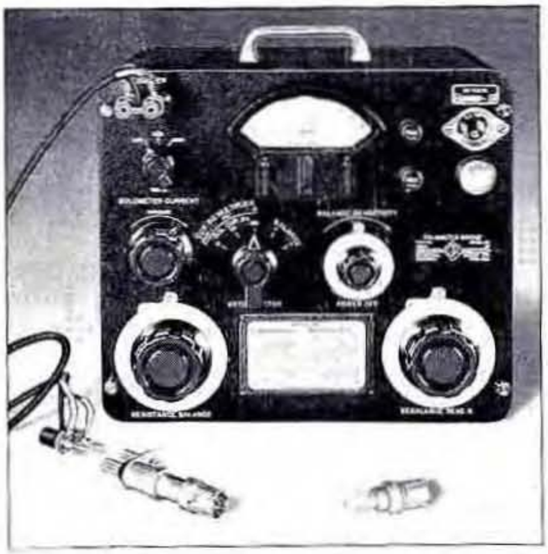
Equipment required:

Type 874-MR Mixer Rectifier (page 125)	**$ 35.00**
Type 874-R20 Patch Cord (page 124)	**6.00**
Type 874-R31 Patch Cord (page 124)	**4.50**
Type 1208-A Unit Oscillator (page 111) (Type 1209-A can also be used)	**190.00**

Communications Receiver or Wide-Band R-F Amplifier.

EQUIPMENT FOR POWER MEASUREMENTS

TYPE 1651-A BOLOMETER BRIDGE



TYPE 1651-A Bolometer Bridge with TYPE 874-H25 Thermistor Unit in left foreground.

USES: The Bolometer Bridge is a general-purpose instrument for measuring r-f power, in the milliwatt range, by either a d-c substitution or a direct-reading method.

It is intended for use with General Radio TYPE 874-H25 and TYPE 874-H100 Thermistor Units and with TYPE 874-HF Fuse Bolometer, but is equally usable with bolometers of other makes, since it can be set to accommodate any bolometer resistance between 25 and 400 ohms and currents up to 100 ma.

In conjunction with a General Radio TYPE 874-LB Slotted Line, the bridge can be used for calibrating r-f voltmeters and checking the output of standard-signal generators.

DESCRIPTION: The circuit is a d-c Wheatstone bridge, with the bolometer element in one arm. The bridge is supplied by a transformer and rectifier system, fed from the 60-cycle line, through a VARIAC.

In the d-c substitution method of measurement, the bridge is first balanced with r-f current in the bolometer, the r-f power is removed, and the bridge rebalanced by increasing the d-c bolometer current. R-F power is then determined by multiplying dial and meter readings.

In this bridge all quantities are noted after the final balance has been made and after the r-f power has been removed, which eliminates errors due to changes in the r-f power level while readings are being taken and, by permitting dial and meter indications to be read slowly and carefully, tends to improve the accuracy.

In the direct-reading method, the meter scale is standardized in terms of a substitution measurement, after which it reads r-f power directly.

Condensed operating instructions are mounted on the panel.

FEATURES: ➔ The TYPE 1651-A Bolometer Bridge is flexible in application and can be adapted to a variety of r-f power-measurement problems.

➔ Bolometers or power sensitive elements having a wide range of resistance can be used.

➔ Measurements can be made by either a direct-reading or a substitution method.

➔ Resistance vs. current characteristic of bolometer elements can be measured.

SPECIFICATIONS

Range and Accuracy — Substitution Method

With TYPE 874-H25 Thermistor Unit		
Thermistor resistance set for max. sensitivity	0 to 6 mw	±(10% + 0.05 mw)
Thermistor resistance set at 50 ohms	0 to 18 mw	±(10% + 0.12 mw)
With TYPE 874-H100 Thermistor Unit		
Thermistor resistance set for max. sensitivity	0 to 20 mw	±(10% + 0.15 mw)
Thermistor resistance set at 50 ohms	0 to 70 mw	±(10% + 0.5 mw)
With TYPE 874-HF Fuse Bolometer Holder, MJB $\frac{1}{32}$-ampere fuse		
Fuse resistance set for max. sensitivity	0 to 8 mw	±(10% + 0.1 mw)
Fuse resistance set at 50 ohms	0 to 14 mw	±(10% + 0.15 mw)
Fuse resistance set for max. power range	0 to 50 mw	±(10% + 0.3 mw)
With TYPE 874-HF Fuse Bolometer Holder, MJB $\frac{1}{12}$-ampere fuse		
Fuse resistance set for max. sensitivity	0 to 20 mw	±(10% + 0.5 mw)
Fuse resistance set at 50 ohms	0 to 100 mw	±(10% + 0.75 mw)
Fuse resistance set for max. power range	0 to 500 mw	±(10% + 3 mw)

Bolometer Resistance Range: 25 to 400 ohms.

Current Range: 0 to 100 milliamperes.

Power Supply: 105–125 volts, 60 cycles.

Frequency Range: Determination of power is independent of frequency. Practical range:

5 — 4000 Mc with thermistor units.

5 — 1000 Mc with fuse units.

Accessories Supplied: One CAP-35 Power Cord; one TYPE 274-NE Patch Cord; spare fuses.

Accessories Required: Bolometer element. TYPES 874-H25 and 874-H100 Thermistor Units, and TYPE 874-HF Fuse Bolometer Holder are recommended.

Dimensions: (Height) 12 x (width) 12 x (depth) 8¾ inches, over-all.

Net Weight: 22¼ pounds.

Type		*Code Word*	*Price*
1651-A	Bolometer Bridge	BEGIN	$325.00

PATENT NOTICE. See Note 11, page vi.

BOLOMETERS

Type 874-H25 Thermistor Unit (25 mw)

Consists of a thermistor mounted in a coaxial holder with a disc-type by-pass capacitor. Binding posts are provided for connections to bolometer bridge. Can be used for power measurements over the frequency range from 5 Mc to about 4000 megacycles. A d-c path is required in the r-f source. Complete with thermistor.

By-Pass Capacitance: Approximately 2000 μμf.
Physical Length Over-all: 3⅞ inches.
Maximum Total Power: 25 mw.

Type 874-H100 Thermistor Unit (100 mw)

Similar to Type 874-H25, with maximum power rating of 100 mw. Complete with thermistor.

Physical Length Over-all: 3¾ inches.

Type 874-HF Fuse Bolometer Holder

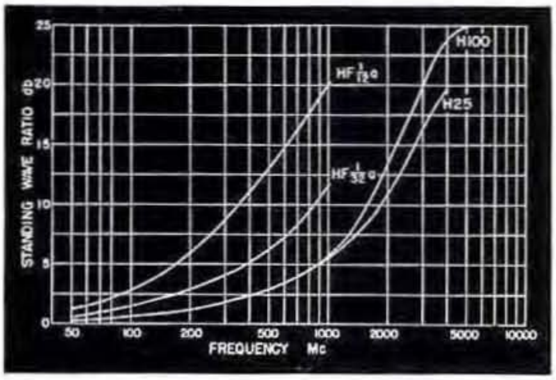
A coaxial holder for fuse bolometers 1 inch long by ¼ inch diameter (SAG size). Otherwise similar to the thermistor units described above. Supplied with one Type 874-HF-P1 Fuse Assortment.

Maximum Frequency Limit: Approximately 1000 Mc.
By-Pass Capacitance: Approximately 2000 μμf.
Physical Length Over-all: 4 inches.

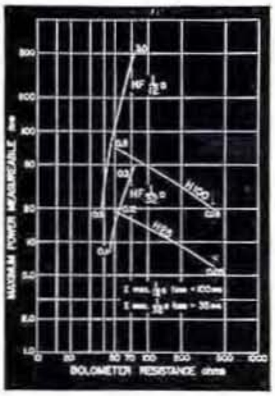
Type 874-HF-P1 Fuse Assortment

Replacement fuses for Type 874-HF. Includes five 1/12-amp fuses and five 1/32-amp fuses.

Connections between the bolometer bridge and the bolometer units can be made by the Type 274-NE Shielded Connector.



Standing-wave ratio *in db* of the Fuse Bolometer and Thermistor Units as a function of frequency.



Power-measurement ranges of Fuse and Thermistor Bolometers and the Bolometer Bridge, by substitution method, as a function of bolometer resistance. Minimum detectable power in milliwatts is indicated by the numbers at the ends of each curve.

Type 874-WL Lamp Termination

For rough indications of power in the 50 mw to 100 mw range. Useful for making preliminary tests on experimental oscillators. Consists of a flashlight bulb in a screw-type, miniature socket on the rear of a connector. Bulb has a straight-wire filament and is rated at 80 mw. Can be used with a photoelectric cell and meter (such as a photographic exposure meter) in a d-c substitution method for more accurate measurements.

Type		*Code Word*	*Price*
874-H25	Thermistor Unit	COAXWARMER	$25.00
874-HP25	Replacement Thermistor for Type 874-H25	THERM	9.00
874-H100	Thermistor Unit	COAXHEATER	27.50
874-HP100	Replacement Thermistor for Type 874-H100	CALDO	9.00
874-HF	Fuse Bolometer Holder	COAXHOLDER	18.00
874-HF-P1	Fuse Assortment	FUSOR	2.50
874-WL	Lamp Termination	COAXLAMPER	5.00
274-NC	Patch Cord	STANPARZOO	3.80

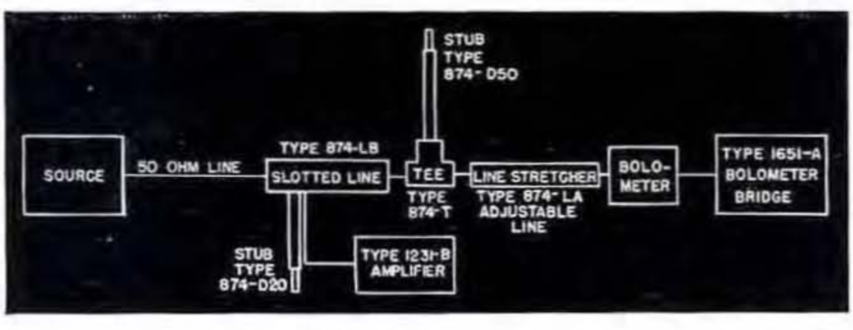


Diagram of a transformer made up of standard Type 874 Coaxial Elements for matching a bolometer element to a 50-ohm line. Source should be modulated.

EQUIPMENT FOR VOLTAGE MEASUREMENTS

TYPE 874-VR VOLTMETER RECTIFIER

Type 874-VR Voltmeter Rectifier, Type 874-VI Voltmeter Indicator, and Type 874-R31 Patch Cord.

The Voltmeter Rectifier is used in conjunction with the Voltmeter Indicator to measure or to monitor the voltage in coaxial systems. It consists of a short coaxial line with a crystal rectifier mounted between inner and outer conductors and with a 50-ohm cylindrical resistor in series with the line inner conductor at one end. A by-pass capacitor is included.

When a generator is connected to the input end (see diagram) of the unit, it provides at the output end the equivalent of a 50-ohm generator whose open-circuit voltage equals the voltage at the crystal, less attenuation in the output line, and hence this system can be used to convert any shielded oscillator into a signal generator.

If no termination is desired, the resistor can be replaced by a metal rod.

The rectifier is also useful as a general-purpose detector in conjunction with a microammeter for unmodulated signals or with a high-gain amplifier, such as the Type 1231-B, for modulated signals.

Maximum Voltage: 2 volts.

Resonant Frequency: Approximately 3600 megacycles.

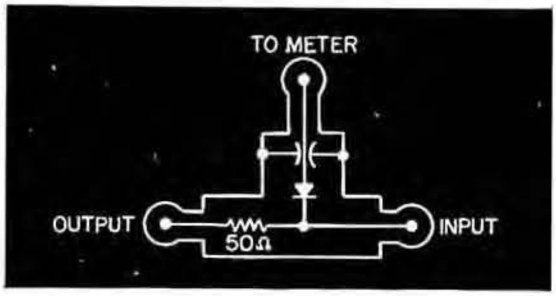
By-Pass Capacitance: Approximately 300 $\mu\mu f$; shunt capacitance of crystal, approximately 1 $\mu\mu f$.

Frequency Range for Voltage Measurements: 15 Mc to 2500 Mc, subject to resonance correction above 1000 Mc. Voltage *indications* and *correct voltage ratios* can be obtained at both lower and higher frequencies.

Dimensions: (Length) 3¾ x (height) 2½ inches.

Net Weight: 5 ounces.

Schematic of Type 874-VR Voltmeter Rectifier.



Type		*Code Word*	*Price*
874-VR	Voltmeter Rectifier	COAXRECTOR	$35.00
874-R31	Patch Cord	COAXELEXOR	4.50

TYPE 874-VI VOLTMETER INDICATOR

The Voltmeter Indicator indicates the rectified d-c output of the Type 874-VR Voltmeter Rectifier and provides means for measuring the voltage by a substitution method. It includes a microammeter, a sensitivity control, and a 60-cycle circuit for calibrating the crystal at any desired level between 0.1 volt and 2 volts, so that the accuracy of the voltage measurement is independent of the crystal characteristic. The calibrating circuit is regulated against line voltage fluctuations.

Range and Accuracy of Calibrating Voltage: 0.1–2 volts ±0.05 volt.

Crystal Current for Full-Scale Indication: 200 μa.

Power Supply: 105 to 125 volts, 50 to 60 cycles.

Input Resistance: 600 ohms, minimum; 10,000 ohms, maximum.

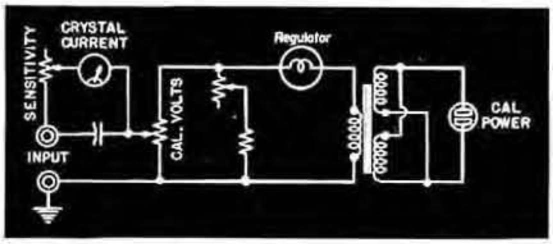
Accessories Supplied: Line connector cord.

Other Accessories Required: For connections between the Voltmeter Rectifier and Voltmeter Indicator, a Type 874-R31 Patch Cord is recommended.

Dimensions: 5½ x 5½ x 4½ inches, over-all.

Net Weight: 3 pounds, 1 ounce.

Schematic of Type 874-VI Voltmeter Indicator.



Type		*Code Word*	*Price*
874-VI	Voltmeter Indicator	COAXVOLTER	$70.00

LINE ELEMENTS

50-Ohm Air Lines

For spacing stubs or other elements of a coaxial system. Each air line consists of a length of 50-ohm, air-dielectric, coaxial line with a connector at each end. The electrical lengths are 10 cm, 20 cm, and 30 cm, respectively.

Type		*Code Word*	*Price*
874-L10	50-Ω Air Line (10 cm)	COAXDECKER	$6.50
874-L20	50-Ω Air Line (20 cm)	COAXVENTER	6.50
874-L30	50-Ω Air Line (30 cm)	COAXTRIPLY	7.50

NOTE: ALL CROSS-SECTION BACKGROUNDS SHOWN IN PHOTOS ARE 1/8-INCH SQUARES.

Type 874-T Tee

Used for connecting stubs and other elements in shunt with a coaxial line.

Type		*Code Word*	*Price*
874-T	Tee	COAXTOGGER	$7.50

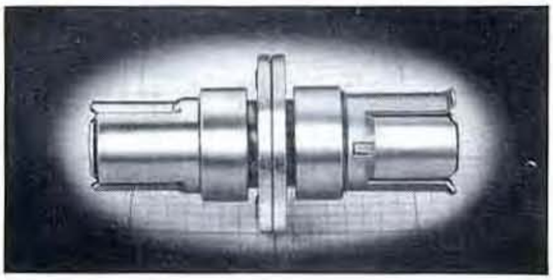
Type 874-EL 90° Ell

For making a right-angle bend in a coaxial system.

Characteristic Impedance: 50 ohms.
Electrical Length: Approximately 7 cm.
VSWR: Less than 1.06 at 2000 Mc; less than 1.15 at 4000 Mc.

Type		*Code Word*	*Price*
874-EL	90° Ell	COAXANGLER	$6.50

Type 874-JR Rotary Joint



Used when one part of a system must be rotated with respect to another part, as when measuring antenna patterns or when changing the coupling of a loop.

VSWR: Less than 1.05 at 1000 Mc; less than 1.3 at 4000 Mc.

Type		*Code Word*	*Price*
874-JR	Rotary Joint	COAXJOINER	$8.50

Type 874-LA Adjustable Line (Line-Stretcher)

An air-dielectric, coaxial line that can be telescoped to change its length. Used in matching networks. Contacts are made by multiple spring fingers.

Length Change: 25 cm.
Characteristic Impedance: Not constant — approximately 50 ohms when fully collapsed. Approximately 57 ohms when fully extended.

Type		*Code Word*	*Price*
874-LA	Adjustable Line	COAXLAPPER	$15.00

A constant-impedance line stretcher, Type 874-LK, will soon be available. Write for details.

Adjustable Stubs

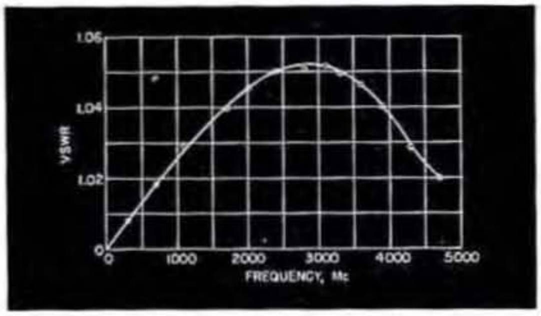
For matching or tuning, and use as reactive elements. Can be used with indicator and scale as reaction-type wavemeters. Stubs consist of a coaxial line with a sliding short circuit of the multiple-spring-finger type. The short circuit is moved by a bakelite tube having a sliding reference marker to facilitate use as a wavemeter.

Characteristic Impedance: 50 ohms.

Maximum Travel of Short Circuit:
20 cm for 874-D20.
50 cm for 874-D50.

Type		*Code Word*	*Price*
874-D20	**Adjustable Stub (20 cm)**	COAXTUBBER	**$10.50**
874-D50	**Adjustable Stub (50 cm)**	COAXBEGGER	**12.00**

TERMINATIONS

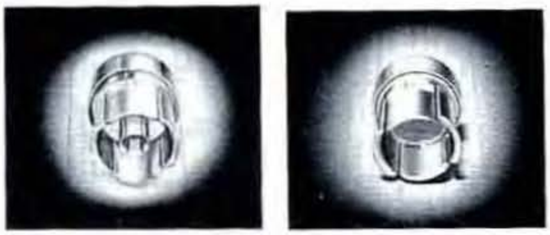


Plot of standing-wave ratio of Type 874-WM 50-Ohm Termination as a function of frequency.

Type 874-WM 50-Ohm Termination

Provides a good impedance match for 50-ohm coaxial systems from dc to several thousand megacycles. Useful for establishing reference conditions, for terminating filters and attenuators, and for many other purposes. Consists of a 50-ohm cylindrical resistor mounted in a tapered coaxial holder.

D-C Resistance: 50 ohms ±1%.
Maximum Power: ½ watt.
VSWR: Less than 1.08 up to 2000 Mc; less than 1.13 up to 4000 Mc.



(*Left*) Type 874-WN Short-Circuit Termination and, (*Right*) Type 874-WO Open-Circuit Termination.

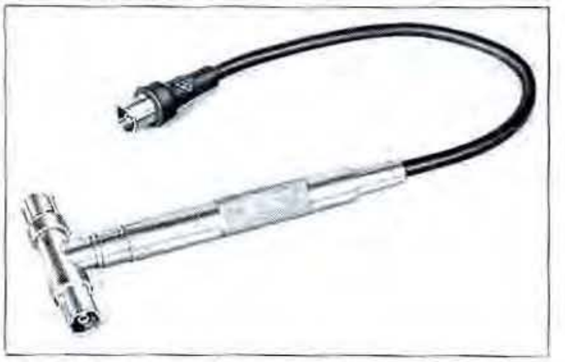
Type 874-WN Short-Circuit Termination
Type 874-WO Open-Circuit Termination

Useful for establishing reference conditions on coaxial lines. Can be used in substitution measurements when the unknown is to be replaced by a short circuit or an open circuit. The short-circuit termination consists of a fixed shorting strap mounted in a connector. The effective position of the electrical short-circuit is fixed. The open-circuit termination is a shielding cap for open-circuited lines. Because of unavoidable end capacitance, the effective position of the electrical open-circuit varies with frequency over a distance range of 2 mm. On the average, it is 2 mm from the effective position of the electrical short-circuit produced by the short-circuit termination.

Type		*Code Word*	*Price*
874-WM	**50-Ohm Termination**	COAXMEETER	**$10.50**
874-WN	**Short-Circuit Termination**	COAXSCULLER	**3.50**
874-WO	**Open-Circuit Termination**	COAXOPENER	**2.00**

ATTENUATORS

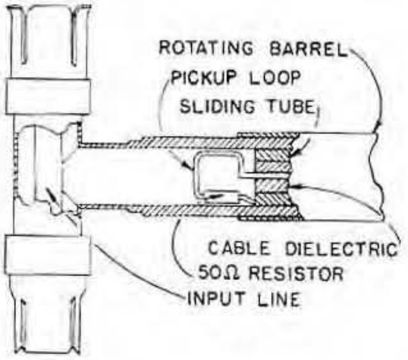
Type 874-GA Adjustable Attenuator



A mutual-inductance (waveguide-below-cutoff) type attenuator useful for producing known voltage ratios, for measuring attenuation, and for adjusting voltage magnitude. Consists of a loop that can be positioned longitudinally within a hollow tube by rotating an outside sleeve. One turn of the sleeve produces a 20 db change in attenuation. The sleeve advances when it is turned, so that complete turns are indicated by engraved lines on the tube. Sleeve and tube are calibrated directly in decibels, and unit is read like micrometer calipers. The input system is a short coaxial line with a connector at each end, one end for connection to the power source and the other for connection to a 50-ohm termination, an adjustable stub, or any desired load. The hollow tube of the attenuator joins the input line at right angles and is excited through a hole in the outer conductor by the inner-conductor current.

Can be used in conjunction with TYPE 874-VR and TYPE 874-VI to convert a TYPE 1208-A or TYPE 1209-A Unit Oscillator into a signal generator.

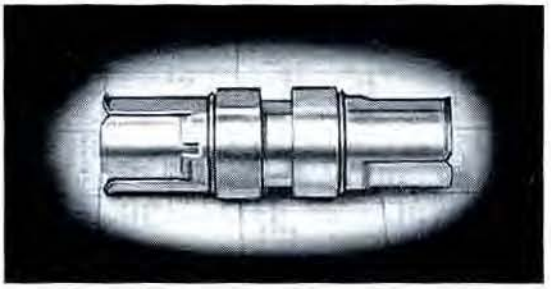
The output of the loop is brought out through three feet of double-shielded flexible cable, which is approximately matched at the loop end by a 50-ohm resistor between the low side of the loop and ground.



Cross-section of the coupling system used in the TYPE 874-GA Adjustable Attenuator.

Calibrated Range: 120 db — usable range depends upon shielding between input and output.
Insertion Loss at Beginning of Calibrated Range: Approximately inversely proportional to frequency up to 1000 Mc; approximately 20 db at 1000 Mc with tuned input; approximately 33 db with input line terminated in 50 ohms.
Minimum Insertion Loss (Outside of Calibrated Range): Approximately inversely proportional to frequency; approximately 18 db at 1000 Mc.
Waveguide Mode: $TE_{1,1}$; cutoff frequency: 12,300 Mc.
VSWR Introduced into Line: Less than 1.03 at 1000 Mc; less than 1.2 between 1000 and 4000 Mc.
VSWR of Output: Less than 4 at 1000 Mc.
Less than 5 up to 4000 Mc.
Frequency Range: 100 Mc to 4000 Mc.
Accuracy of Attenuation: Tuned Input, ±(1% of difference in attenuation readings +0.2) db, direct reading. Terminated Input, ±(1½% of difference in attenuation readings +0.2) db when corrected, correction chart supplied.
Net Weight: 1¼ pounds.

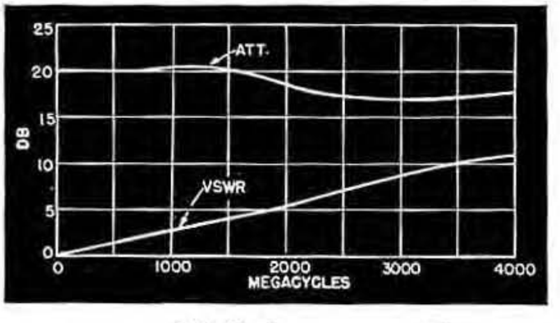
Type 874-GF, GG Fixed Attenuators



A single-section, π-type resistance attenuator useful over the frequency range from dc to several thousand megacycles. Consists of two disc resistors and one cylindrical resistor as the shunt and series elements respectively.

Impedance: 50 ohms.
Maximum Power Input: ½ watt.
Physical Length Over-all: 2½ inches.
Low-Frequency Accuracy: ±0.5 db.

Attenuation and standing-wave ratio of the TYPE 874-GF Fixed Attenuator as a function of frequency.



Type		Code Word	Price
874-GA	Adjustable Attenuator	COAXLOSSER	$55.00
874-GF	Fixed Attenuator (20 db)	COAXNEPPER	18.00
874-GG	Fixed Attenuator (10 db)	COAXBELLER	18.00

FILTERS

Type 874-F500, F1000 Low-Pass Filters

Reduction of harmonics from an u-h-f generator by filters such as these is usually necessary for best measurement results, particularly if a system contains peak-reading voltmeters or sections that might resonate at a harmonic frequency, or if high standing-wave ratios are to be measured using a slotted line. These filters are of the Tschebyscheff type, in which very sharp cutoff is obtained at some sacrifice of uniformity in the pass band. The alternately large and small diameter sections of the inner conductor form the equivalent of shunt capacitances and series inductances respectively. Unequal section lengths reduce the likelihood of spurious pass bands above cutoff.

Insertion Loss: In pass band, varies as a function of frequency between 0 and 4 db; beyond cutoff, 20 db at 10% above cutoff, 40 db at 30% above cutoff.

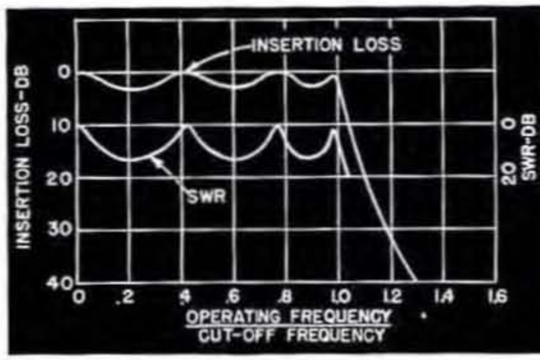
Cutoff Frequencies:

Type 874-F500, 500 Mc $\left\{\begin{matrix}-0\\+10\end{matrix}\right\}$ %;

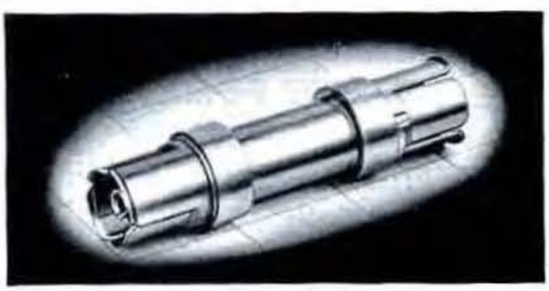
Type 874-F1000, 1000 Mc $\left\{\begin{matrix}-0\\+10\end{matrix}\right\}$ %.

Physical Length Over-all:
Type 874-F500, 10 3/16 inches;
Type 874-F1000, 7⅛ inches.

Insertion loss and standing-wave ratio in db of the Type 874-F500 and the Type 874-F1000 Low-Pass Filters.



Type 874-K Coupling Capacitor



Consists of a short length of coaxial line having a cylindrical capacitor in series with the inner conductor. High frequencies are transmitted with small reflections, but dc and low audio frequencies are blocked. This unit is often necessary for separating d-c paths in systems including two or more crystal rectifiers, as in measurements of insertion loss.

Coupling Capacitance: Approximately 5000 $\mu\mu f$.

VSWR: Less than 1.06 at 1000 Mc.
Less than 1.2 at 2000 Mc.

Type		*Code Word*	*Price*
874-F500	500-Mc Low-Pass Filter........................	COAXDIPPER	$22.50
874-F1000	1000-Mc Low-Pass Filter........................	COAXMEGGER	22.50
874-K	Coupling Capacitor........................	COAXKICKER	14.00

EXTERNAL COUPLING ELEMENTS

(*Left*) Type 874-MA Adjustable Coupling Loop and, (*Right*) Type 874-MB Coupling Probe.

Type 874-MA Adjustable Coupling Loop

A general-purpose coupling loop. Consists of short coaxial line with a one-turn loop at one end and a connector at the other. A collet is supplied for panel mounting. The loop can be adjusted for desired degree of coupling and clamped in that position by the collet.

Physical Length Over-all: 3 inches.

Maximum Diameter: 1⅝ inches.

Type 874-MB Coupling Probe

A general-purpose electrostatic probe consisting of a binding post, mounted on a connector.

Physical Length Over-all: 2⅛ inches.

COAXIAL ELEMENTS

Type 874-LR Radiating Line

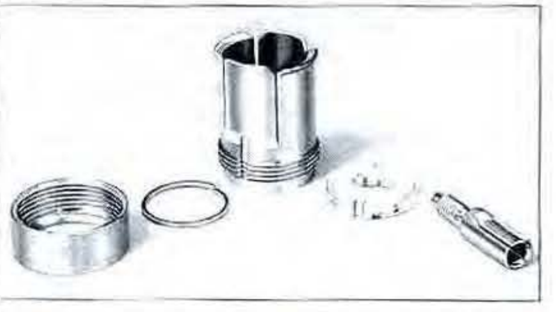
Allows coupling an external wavemeter or heterodyne frequency meter to the fields within a coaxial system. Consists of short coaxial line with opening in outer conductor that can be partially or completely covered by a rotatable sleeve.

VSWR: Closed, less than 1.05 at 1000 Mc, less than 1.4 at 3000 Mc, and less than 1.2 at 4000 Mc; open, less than 1.12 at 1000 Mc, less than 1.6 at 3000 Mc, and less than 1.35 at 4000 Mc.

Type		*Code Word*	*Price*
874-LR	Radiating Line	COAXMITTER	$10.00
874-MA	Adjustable Coupling Loop	COAXLOOPER	7.50
874-MB	Coupling Probe	COAXPROBER	5.00

FOUNDATION ELEMENTS

Connectors



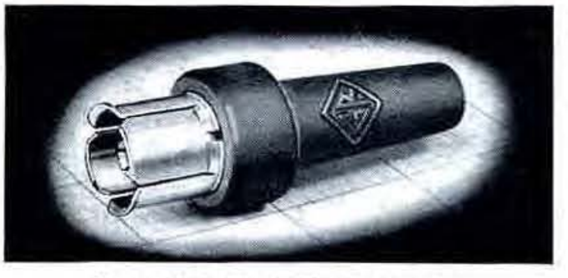
All Type 874 Connectors are supplied unassembled with complete assembly instructions. No special tools are needed.

Type 874-B Basic Connector

For use on rigid, 50-ohm, air-dielectric, coaxial lines. Consists of inner and outer conductors, insulating bead, coupling nut, and retaining ring. Fits lines made from 5/8" O.D., 9/16" I.D. tubing, and 0.244" D rod. The inner conductor is to be screwed into an 8-32 tapped hole in the end of the rod, and the retaining ring for the coupling nut is to be snapped into a 1/64" deep, 0.035"-wide groove cut in the 5/8" tubing.

Type 874-C Cable Connector

For use on Type 874-A2 Polyethylene Cable. Consists of the basic connector parts plus inner and outer transition pieces, a soft copper ferrule, and a rubber guard. The transition pieces are tapered so as to maintain the 50-ohm characteristic impedance of the connector and cable throughout the change in diameters. The cable inner conductor is to be soldered to the inner transition piece, and the cable braid is attached to the outer transition piece by crimping the ferrule. The rubber guard provides strain relief and a protective handle.



Type 874-C8 Cable Connector

For use on Army-Navy Type RG-8/U Cable. Same as Type 874-C, except outer transition piece fits R-8/U Cable.

Type		*Code Word*	*Price*
874-B	Basic Connector	COAXBRIDGE	$1.25
874-C	Cable Connector	COAXCABLER	2.00
874-C8	Cable Connector	COAXCORDER	2.00

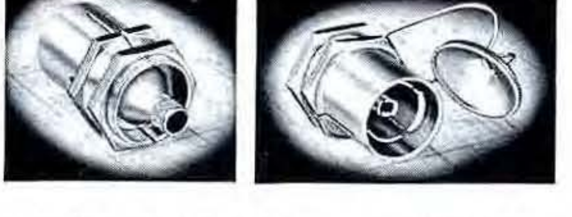
PANEL CONNECTORS

Type 874-P Panel Connector

For use on panels. Rear ends fits Type 874-A2 Cable. Is similar to the cable connector, except a panel adaptor and nut are supplied in place of rubber guard. The panel adaptor fits into a 15/16" D hole in panels from 1/16" to 1/4" thick and is designed to clamp the connector in any desired orientation.

Type 874-PC Panel Connector with Cap

For use on panels. Same as Type 874-P, with addition of a spring-hinged cap to shield the connector when not in use. Rear end fits Type 874-A2 Cable.



(Left) Type 874-P Panel Connector and, *(Right)* Type 874-PC Panel Connector with Cap.

Type 874-P8 Panel Connector

Same as Type 874-P, except rear end fits Army-Navy Type RG-8/U Cable.

Type 874-PC8 Panel Connector with Cap

Same as Type 874-PC, except rear end fits Army-Navy Type RG-8/U Cable.

Type		*Code Word*	*Price*
874-P	Panel Connector................................	COAXPEGGER	$2.50
874-P8	Panel Connector................................	COAXPUTTER	2.50
874-PC	Panel Connector with Cap......................	COAXCAPPER	3.00
874-PC8	Panel Connector with Cap......................	COAXTOPPER	3.00

ADAPTORS

Type 874-Q1

Type 874-Q6

Type 874-Q2

Type 874-Q7

Type 874-Q1 Adaptor to Type N

Plugs into Army-Navy Type UG-22/U and similar jack-type connectors.

Type 874-Q6 Adaptor

Fits Type 274-NF Shielded Cable.

Type 874-Q2 Adaptor to Type 274

Makes output of a coaxial system available at a pair of ¾-inch-spaced binding posts or banana plugs.

Type 874-Q7 Adaptor to Type 774

Plugs into any General Radio Type 774 Connector.

Type		*Code Word*	*Price*
874-Q1	Adaptor to Type N............................	COAXNUTTER	$4.50
874-Q2	Adaptor to General Radio Type 274............	COAXTIPPER	5.00
874-Q6	Adaptor to General Radio Type 274-NF.........	COAXCLOSER	2.00
874-Q7	Adaptor to General Radio Type 774	COAXPASSER	5.00

PATCH CORDS

Type 874-R20

Type 874-R21

Type 874-R31

Type 874-R32

Type 874-R20 Patch Cord

For making shielded connections. Consists of three feet of Type 874-A2 Polyethylene Cable (double shielded) with a Type 874-C Connector on each end.

Type 874-R21 Patch Cord

Similar to Type 874-R20, but with single-shielded cable.

Type 874-R31 Patch Cord

Consists of a Type 274-NF Cable (see page 228), with one Type 874-Q6 Adaptor. For connections between coaxial system and pin-jack system.

Type 874-R32 Patch Cord

Consists of a Type 274-NF Cable, with a Type 874-Q6 Adaptor on one end and a Type 274-ND Shielded Plug on the other. For shielded connections between a coaxial system and a pair of jack-top binding posts.

Type		*Code Word*	*Price*
874-R20	Patch Cord.........	COAXHATTER	$6.00
874-R21	Patch Cord.........	COAXHUNTER	5.50
874-R31	Patch Cord.........	COAXFLEXOR	4.50
874-R32	Patch Cord.........	COAXFITTER	5.75

TYPE 874-A2 POLYETHYLENE CABLE

Bulk cable for permanent or semipermanent installations and for making long patch cords. Characteristic impedance is 50 ohms ±5%. Cable is double-shielded and has good mechanical flexibility. Nominal capacitance is 32 μμf per foot. Attenuation at 100 Mc is about 2.6 db per 100 feet, and at 1000 Mc about 10.5 db per 100 feet. Consists of a No. 14 stranded inner conductor, separated from the two, braided, tinned-copper shields by 0.214" OD Polyethylene insulation, and an outer gray Plastex jacket 0.365" OD.

Type		*Code Word*	*Price*
874-A2	Polyethylene Cable............................	COAXCUTTER	$ .50 foot 27.00 100 feet*

*In lengths of 25 feet or over.

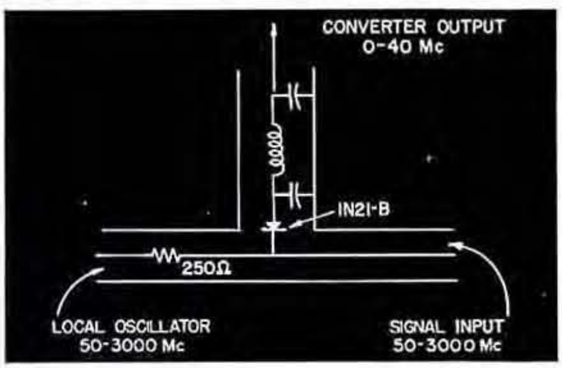
TYPE 874-MR MIXER RECTIFIER

USES: The Mixer Rectifier is used as the first detector in a heterodyne frequency converter and permits a standard communications-type receiver or a 30-Mc wide-band i-f amplifier to be employed as a detector for u-h-f measurements. The high-frequency signal which may have a frequency between 50 and 5000 Mc is mixed with a signal from a local oscillator to produce a difference frequency below 40 megacycles, which is then fed to the receiver or i-f amplifier. The heterodyning signal of the local oscillator may be one of its harmonics.

DESCRIPTION: The TYPE 874-MR Mixer Rectifier consists of a short coaxial line with a 250-ohm series resistor and a crystal rectifier terminated in a low-pass filter having a cut-off frequency of 40 Mc.

FEATURES: This mixer, in combination with a local oscillator, makes it possible to use a low-frequency receiver for v-h-f and u-h-f measurements over a range of 50 to 5000 megacycles. See diagram on page 110.

Schematic diagram of TYPE 874-MR Mixer Rectifier.



SPECIFICATIONS

Operating Frequency Range: 50 to 5000 Mc.
Maximum Crystal Current: 5 ma.
Maximum Input from Local Oscillator: 2 volts.
Cut-Off Frequency of Output Filter: 40 Mc.
Conversion Loss at 30-Mc Output: Depends upon load impedance and is about 12 db with typical communications receivers when local oscillator fundamental is used.
Accessories Required: Local oscillator for heterodyning. TYPE 1208-A and TYPE 1209-A Unit Oscillators are recommended. For signal frequencies above the fundamental oscillator ranges, harmonics can be used. Patch cords as indicated in the diagram on page 110 are needed for connections. Bandwidth of receiver or i-f amplifier should be at least 20 kc.
Terminals: TYPE 874 Coaxial Connectors.
Net Weight: 6¼ ounces.

Type		*Code Word*	*Price*
874-MR	Mixer Rectifier	COAXVERTER	$35.00

TYPE 874-Z STAND

Provides firm support for the parts of a wide variety of coaxial systems. Consists of a heavy bronze base with rubber feet, 22-inch and 8-inch brass rods, and three universal clamps. Will not rust or corrode. The vertical rod can be used to hold long tuning stubs. The horizontal rod can be moved longitudinally or interchanged with the vertical rod to provide support where needed. Two bases can be used with one 22-inch rod between them to support a long horizontal run of coaxial parts. Clamps will fit a range of diameters and will hold between two rods of different diameters. Any desired arrangement can be set up quickly. Base can be screwed down to table top for permanent setups.

Net Weight: 5½ pounds.

Type		*Code Word*	*Price*
874-Z	Stand	COAXHELPER	$12.50

STANDARD-SIGNAL GENERATORS

A standard-signal generator is an oscillator calibrated in both frequency and output voltage, so that it furnishes an output signal of known frequency and known amplitude. Such generators are used for testing radio receivers, as standards of comparison for radio field-intensity measurements, and generally, in the laboratory for measuring gain, bandwidth, noise level, frequency response, and other properties of electronic circuits.

The elements of a standard-signal generator are shown in Figure 1. A buffer amplifier is sometimes added to reduce incidental frequency modulation. The requirements for the oscillator are that it be stable, that it have reasonably constant output over any one frequency range, that the waveform be good, and that hum and noise modulation be negligible.

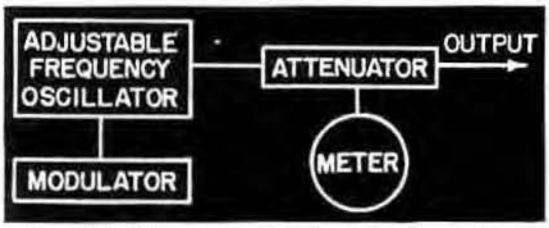


FIGURE 1. Elements of a standard-signal generator.

OUTPUT SYSTEMS

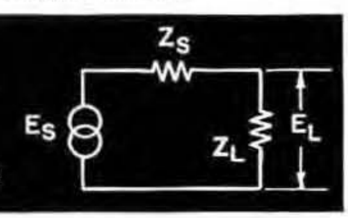
The output system must be designed to produce a known voltage at the output terminals. At frequencies below 50 Mc, resistive attenuators are commonly used. A voltmeter indicates the voltage at the attenuator input, which is held to a constant "calibration" value by manual adjustment of oscillator-output level. The output voltage is then indicated by the voltmeter indication and the attenuator setting. According to Thévenin's theorem, the generator can be represented as a voltage source behind — i.e., in series with — an impedance. This equivalent voltage is the open-circuit voltage of the signal generator, and the equivalent impedance is that seen looking into the system with the terminals at which the voltage is measured short circuited. For low-frequency generators, the equivalent source impedance is usually made as low as possible, 10 ohms or less.

At low and medium frequencies, with a 10-ohm output impedance, it is frequently possible to neglect the effect of the load on the output voltage and to assume that the terminal voltage is the open-circuit voltage. In any case, the correction for the load can be determined by calculation as indicated in Figure 2.

The effect upon the output voltage and output impedance of the cable used to connect the generator to the load depends upon the frequency and upon the relative impedances of generator, cable, and load.

FIGURE 2. Load voltage E_L is easily determined for a load Z_L with a generator of internal voltage E_s and internal impedance Z_s.

$$E_L = \frac{Z_L}{Z_L + Z_S} E_S = \left(1 - \frac{Z_S}{Z_S + Z_L}\right) E_S$$



Four typical cases are shown in Figure 3, and their characteristics are tabulated in Figure 4.

Case I corresponds to the TYPE 805-C Standard-Signal Generator when the termination unit is used, and to the TYPE 1001-A Standard-Signal Generator when the TYPE 1000-P1 Termination Unit and the TYPE 1000-P2 40-Ohm Series Unit are used.

Case II corresponds to the TYPE 805-C without the termination unit and to the TYPE 1001-A with the series unit but without the termination unit.

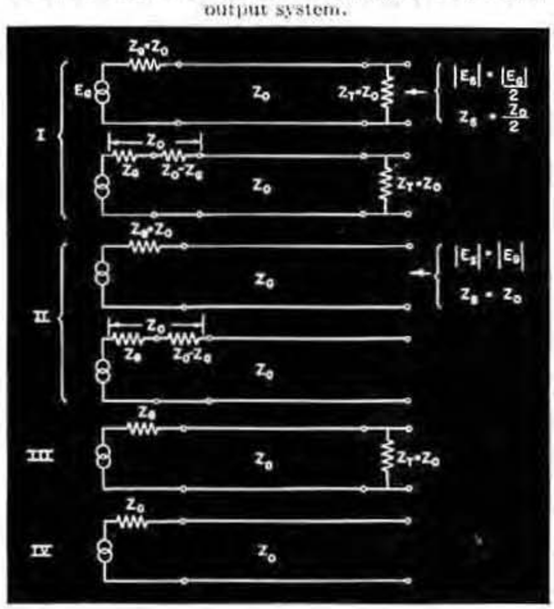
Case III illustrates the TYPE 1001-A with termination unit, but without series unit, while Case IV is the TYPE 1001-A without either unit.

When an external load is connected, the load voltage will differ from the open-circuit voltage at the end of the cable by an amount depending upon the magnitude and phase of the load impedance.

At high frequencies the residual reactance in a resistive attenuator becomes great enough to impair its accuracy and the mutual-inductance (waveguide-below-cutoff) type is more satisfactory. The system used in the TYPE 1021-A Standard-Signal Generator, and which is illustrated in Figure 5, has the voltmeter connected across the output of the attenuator rather than across the input. This system has the advantage that the accuracy of the output voltage at the reference point is determined by the voltmeter alone, and is unaffected by the length of the cable from the attenuator pick-up loop to the point at which the voltage is measured, or by the perfection of the termination at this point. The accuracy of the effective output impedance is determined by the resistor R_1 alone because it is immediately preceded by the voltmeter, which can be considered a zero-impedance source. This makes the output system equivalent to that shown in Case II, Figure 3. Resistor R_2 at the attenuator pick-up loop is a matching resistance to prevent high-amplitude standing waves in the cable when the load is removed.

Voltages between 0.5 volt and 2 volts are indicated directly by the output meter. For voltages below 0.5 volt, the output is first set to 0.5 volt as indicated by the meter; and the attenuator index, which is ad-

FIGURE 3. Schematic diagrams of four types of generator output system.



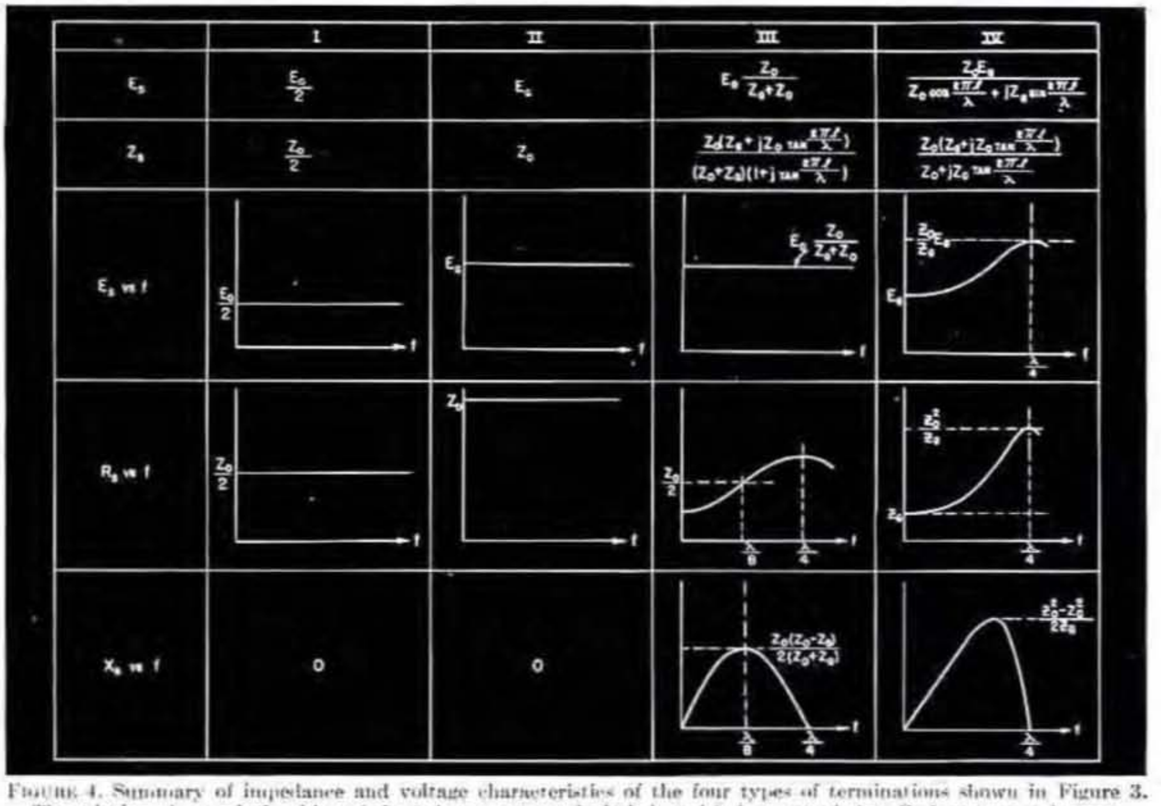


FIGURE 4. Summary of impedance and voltage characteristics of the four types of terminations shown in Figure 3. The relative phase relationships of the voltages are not included, and it is assumed that Z_0 is a pure resistance.

justable, is set at the 0.5-volt point on the attenuator dial. Lower voltages are then indicated directly on the attenuator dial, so long as the load is not changed. When the load is changed, the attenuator must be standardized again at 0.5 volt for the new load.

For ultra-high frequencies, this system gives more accurate output indications than the more common arrangement with the voltmeter at the attenuator input.

MODULATION

For receiver testing, in particular, a range of modulation frequency is desirable. For general testing, a single modulating frequency is usually sufficient.

Internal amplitude modulation at one or more fixed frequencies is provided in General Radio signal generators. Terminals are provided to permit connection to an external continuously variable source, for modulation over a band of frequencies.

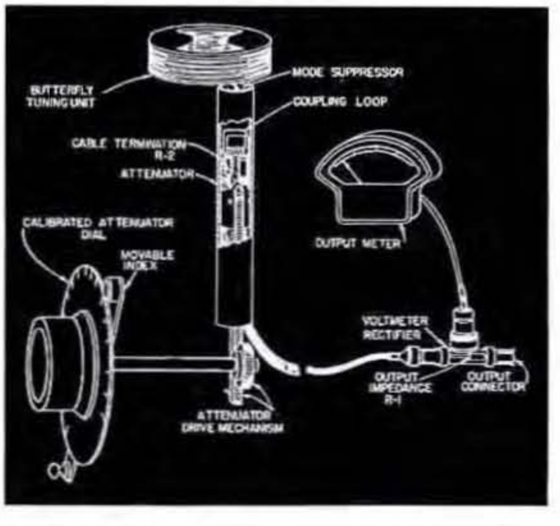
The TYPE 1001-A Standard-Signal Generator is capable of being modulated up to 80%, the TYPE 805-C up to 100%, and the TYPE 1021-A up to 50%. When a tuned-circuit oscillator is amplitude-modulated directly, some degree of frequency modulation is inevitably present.

If the signal is modulated in a buffer amplifier instead of directly in the oscillator circuit, the incidental fm is reduced. For many receiver measurements, incidental fm is of no consequence, but for others it cannot be tolerated. Where it must be eliminated, an external modulator provides an excellent solution. Two such modulators are available: the TYPE 1023-A Amplitude Modulator, capable of accurately calibrated, high-quality, audio-frequency modulation up to 80%, from 20 cycles to 15 kilocycles over an r-f range of 5 Mc to 220 Mc; and the TYPE 1000-P6 Crystal Diode Modulator, which produces 30% modulation from 0 to 5 Mc at carrier frequencies between 20 and 1000 Mc.

These modulators connect to the output terminal of the standard-signal generator, that is, between the attenuator and the load. With TYPE 1000-P6, the isolation that the attenuator provides between oscillator and modulator effectively eliminates incidental-frequency modulation. Because the signal is modulated at a low level, comparatively little modulating power is required.

The TYPE 1023-A includes a buffer amplifier and is therefore capable of modulating higher-level signals. With this modulator, the full output of the signal generator can be modulated.

FIGURE 5. Functional diagram of the TYPE 1021-A output system.



TYPE 1001-A STANDARD-SIGNAL GENERATOR

USES: The TYPE 1001-A Standard-Signal Generator is a laboratory instrument for use in determining the performance of receivers and other equipment at radio and supersonic frequencies. Its sturdy construction and simplicity of operation make it suitable for production testing. Because of its small size, low weight, and low power consumption, it can be adapted for use in field strength measurements.

When used with the TYPE 1000-P6 Crystal Diode Modulator, the generator can be modulated at video frequencies for testing television i-f circuits. The TYPE 1023-A Amplitude Modulator can be used with this generator to provide accurately known values of amplitude modulation, free from incidental fm.

DESCRIPTION: The welded aluminum cabinet of the TYPE 1001-A Standard-Signal Generator houses three separate groups of circuits. The power supply is at the top, the completely shielded radio-frequency portion in the middle, and the modulation and control circuits at the bottom.

The Hartley-type carrier-frequency oscillator covers in eight ranges the frequency spectrum from 5 kc to 50 Mc. The plates of the main tuning capacitor are shaped to give a logarithmic variation of frequency with angular rotation. The precision of frequency setting, therefore, is constant, and the vernier dial is calibrated directly in percentage frequency increments.

A buffer amplifier is used between the oscillator and the low-impedance output circuits. The amplifier is grid modulated to provide amplitude modulation from 0 to 80 percent. Loose coupling between the oscillator and the amplifier minimizes incidental frequency modulation. The attenuator system and the output meter are coupled to the amplifier through a high-pass filter, which reduces voltages of the modulation frequency in the output.

The output voltage is determined by establishing a fixed carrier level at the attenuator input and by setting two attenuator controls.

The carrier level is set by adjusting the plate supply voltage of the oscillator and is indicated by a vacuum-tube voltmeter at the attenuator input. The attenuator system consists of a continuously adjustable L-network controlled by the output dial and a decade ladder-network attenuator.

The modulation circuits include a 400-cycle R-C oscillator for internal modulation and a germanium crystal rectifier to determine modulation percentage. Percentage modulation is read on the same panel meter that indicates the carrier output level.

FEATURES: ➜ Output cable termination can be removed for matching into a 50-ohm system.

➜ Very low residual output and stray field.

➜ Aperiodic output amplifier avoids sideband cutting and minimizes reaction of attenuator setting or load on carrier frequency.

➜ High stability and low drift are assured by high-quality components, low power consumption, and stabilized power supply.

➜ Simplicity of design and construction has resulted in an unusually sturdy instrument of small size, low weight, and long life.

SPECIFICATIONS

Carrier-Frequency Range: 5 kilocycles to 50 megacycles covered in eight direct-reading ranges as follows: 5 to 15 kc, 15 to 50 kc, 50 to 150 kc, 150 to 500 kc, 0.5 to 1.5 Mc, 1.5 to 5 Mc, 5 to 15 Mc, and 15 to 50 Mc.

Frequency Calibration: Logarithmic up to 15 Mc, departing slightly from the logarithmic scale at higher frequencies. Accuracy, ±1%.

Incremental-Frequency Dial: Frequency increment is 0.1% per dial division, at frequencies up to 15 Mc.

Frequency Stability: Warm-up drift is of the order of 0.25%. Half the maximum drift is reached in 1½ hours.

Output Voltage Range: Open-circuit output voltage at the attenuator jack is continuously adjustable from 0.1 microvolt to 200 millivolts. With output cable terminated at both ends, output voltage is continuously adjustable from 0.05 microvolt to 100 millivolts. Open-circuit output voltage at the 2 VOLTS panel jack is measured directly by the output meter and is 2 volts if the meter is set to the reference mark. This voltage is available up to at least 15 Mc.

Output Impedance: Output impedance at the attenuator jack is 10 ohms (50 ohms when the series unit is used) except for the highest output position of the attenuator, where it is 50 ohms.

Output impedance at the end of the terminated cable is 25 ohms. Output impedance at the 2 VOLTS panel jack is about 300 ohms.

An output impedance of one ohm (with output voltage reduced 100:1) can be obtained with the Type 1000-P3 Voltage Divider, a standard (IRE) test impedance with the Type 1000-P4 Dummy Antenna, and a known induction field for testing loop receivers with the Type 1000-P10 Test Loop.

Accuracy of Output Voltages: At frequencies below 10 Mc, when the output dial is set at about full scale or at about one-tenth full scale, the output voltage is correctly indicated to ±(6% + 0.1 μv). With the output dial set in the mid-scale region, the error may be greater or smaller by 4%. At frequencies above 10 Mc, when the output dial is set at about full scale, the output voltage is correctly indicated to an accuracy of ±(10% + 0.3 μv) and the error may be as much as 10% larger or smaller at other output dial settings.

The accuracy of the open-circuit output voltage at the 2 VOLTS panel jack is ±3%, up to 15 megacycles.

Amplitude Modulation: Adjustable from zero to 80%. Modulation percentage is indicated on the panel meter and is accurate within ±10% of the indicated value, with a possible additional error of 2% in modulation level.

The internal modulation frequency is 400 cycles ±5%. The external modulation characteristic is flat within ±1 decibel from 20 cycles to 15 kilocycles. To provide 80% modulation, the external audio oscillator must supply 12 volts into a 4000-ohm load (36 milliwatts).

Incidental Frequency Modulation: At 80% amplitude modulation, the incidental frequency modulation varies from about 10 to 100 parts per million over each carrier-frequency range except for the highest frequency range (15 to 50 Mc) where it may be three times as great. At lower modulation percentages, frequency modulation is approximately proportional to modulation percentage.

For applications where incidental frequency modulation must be very low, the use of the Type 1023-A Amplitude Modulator (page 136) or the Type 1000-P6 Crystal Diode Modulator (page 133) is recommended.

Carrier Distortion: Of the order of 5% on all except the lowest range, where it may increase to 12% at 5 kc.

Envelope Distortion: About 6% at 80% amplitude modulation.

Noise Level: Carrier noise level corresponds to about 0.1% modulation.

Leakage: Stray fields at 1 Mc are substantially less than one microvolt per meter two feet from the generator.

Terminals: Type 874 Coaxial Terminals are provided for the attenuator output and for the constant 2-volt output.

Power Supply: 105 to 125 (or 210 to 250) volts, 40 to 60 cycles. Power input is approximately 65 watts at 115 volts.

Tubes: Supplied with the instrument.

1 — 6C4	1 — 5Y3-GT
1 — 6L6	2 — 0C3/VR105
1 — 6AL5	1 — 6SN7-GT

Accessories Supplied: Type 874-R21 3-foot Coaxial Cable, Type 1000-P1 50-Ohm Termination Unit, Type 1000-P2 40-Ohm Series Unit, Type 874-Q2 Adaptor, Type TO-44 Adjustment Tool (stored in cabinet), Type 274-MB Plug, spare fuses, and a power cord.

Other Accessories Available: Not supplied but available on order are the Type 1000-P3 Voltage Divider, the Type 1000-P4 Standard Dummy Antenna, the Type 1000-P10 Test Loop, the Type 1023-A Amplitude Modulator, and the Type 1000-P6 Crystal Diode Modulator.

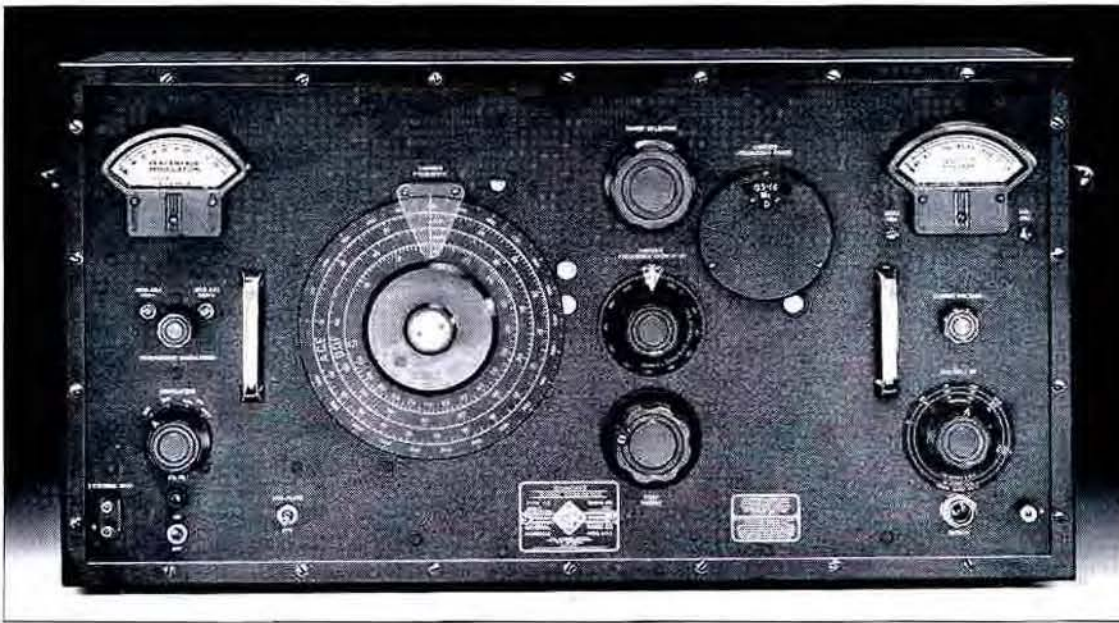
Mounting: The instrument is assembled on an aluminum panel finished in black crackle lacquer and mounted in an aluminum cabinet with a black wrinkle finish. The cabinet is provided with carrying handles. A recessed compartment is built into the top of the cabinet for storing accessories.

Dimensions: (Height) 14⅜ x (width) 20¼ x (depth) 10$\frac{9}{16}$ inches, over-all.

Net Weight: 54 pounds.

Type		*Code Word*	*Price*
1001-A	**Standard-Signal Generator**	ARGUS	**$675.00**

PATENT NOTICE. See Notes 2, 3, 4, and 9, page vi.



TYPE 805-C STANDARD-SIGNAL GENERATOR

USES: The TYPE 805-C Standard-Signal Generator is designed primarily as a precision laboratory instrument for rapid and accurate testing of radio receivers. Because of its accuracy, wide frequency range, and high voltage output, it is a valuable instrument for laboratories engaged in research and design on radio receivers and allied apparatus, while its speed and simplicity of operation make it well adapted to production testing.

It can be adapted for testing television i-f circuits by the use of a TYPE 1000-P6 Crystal Diode Modulator.

For measurements of the highest precision, it can be used with the TYPE 1023-A Amplitude Modulator to provide accurately known values of amplitude modulation with practically undetectable incidental frequency modulation.

DESCRIPTION: Functionally this instrument consists of (1) a carrier-frequency oscillator, (2) a tuned radio-frequency amplifier, (3) a resistive output attenuator and a voltmeter to read the output level, (4) a modulating oscillator (400 cycles and 1000 cycles) with a voltmeter for reading percentage modulation, and (5) a well-regulated power supply.

The oscillator and amplifier assemblies are virtually identical in construction, and the coil switching assemblies, as well as the tuning capacitors, are ganged and driven from common panel controls. Seven coils covering the frequency range from 16 kc to 50 Mc are carried on a selector disc in each assembly. An eighth coil position is also provided, so that an extra set of coils may be installed if desired. The discs are driven from a panel knob through a gear mechanism, which also brings into panel view a frequency range identification dial. As each coil is rotated into position, it is connected into circuit through silver-overlaid contact blades, which firmly engage silver alloy brushes, mounted on the tuning capacitor. The contacts are mounted on polystyrene strips, insuring both low capacitance and low dielectric losses.

The main tuning capacitors are exceptionally rugged, utilizing the cast frame type of construction, with ball-bearing supports for the rotor. The plates are shaped to give a logarithmic variation of frequency with angular rotation. The two capacitors are driven through a set of gears, which also drive the direct-reading frequency dial.

The output system consists of a vacuum-tube voltmeter, a resistive attenuator network, a 3-foot, 75-ohm output cable, and a terminating unit. This unit terminates the cable in its characteristic impedance. It provides, in addition to the normal output at 37.5 ohms, outputs reduced by factors of 10 and 100, with corresponding output impedances of 7.1 and 0.75 ohms. A standard broadcast band dummy antenna output is also provided.

FEATURES: → Output voltmeter indicates voltage at end of properly terminated cable.

→ Radio-frequency leakage and stray fields are low.

→ Tuned amplifier minimizes reaction of output circuit on carrier frequency.

→ Tuned circuit is heavily damped to prevent side-band clipping.

→ Take-up springs minimize backlash in gear trains.

→ Regulated power supply eliminates the effects of line-voltage fluctuations over a range of 105 to 125 (or 210 to 250) volts.

SPECIFICATIONS

Carrier Frequency Range: 16 kilocycles to 50 megacycles, covered in seven direct-reading ranges, as follows: 16 to 50 kc, 50 to 160 kc, 160 to 500 kc, 0.5 to 1.6 Mc, 1.6 to 5.0 Mc, 5.0 to 16 Mc, 16 to 50 Mc. A spare range position is provided so that a special set of coils can be installed if desired.

Frequency Calibration: Each range is direct reading to an accuracy of ±1% of the indicated frequency.

Frequency Drift: Not greater than ±0.1% on any frequency range for a period of 5 hours' continuous operation.

Incremental Frequency Dial: A slow-motion vernier drive dial is provided, by means of which frequency increments as small as 0.01% may be obtained.

Output Voltage Range: Continuously adjustable from 0.1 microvolt to 2 volts. The output voltage (at the termination of the 75-ohm output cable) is indicated by a panel meter and seven-point multiplier.

Output System: The output impedance at the panel jack is 75 ohms, resistive. A 75-ohm output cable is provided, together with a termination unit that furnishes constant output impedances of 37.5, 7.1, and 0.75 ohms. The calibration of the panel voltmeter-multiplier combination is in terms of the actual voltage across the 37.5-ohm output. When the 7.1- and 0.75-ohm positions are used, the indicated output voltage must be divided by 10 and 100, respectively. A standard dummy-antenna output is also available at the termination unit.

Output Voltage Accuracy: For multiplier settings below 1 volt the maximum error in output voltage is the sum of the attenuator and voltmeter errors listed below.

Maximum Voltmeter Error: ±5% of indicated reading up to 25 megacycles. Above 25 megacycles, an additional frequency error occurs, amounting to ±7% at 50 megacycles. At 1/10 full scale and 50 Mc, there is also a transit-time error of −5% in the voltmeter tube.

Maximum Attenuator Error:

Below 3 Mc, ±(3% +0.1 microvolt)
3 to 10 Mc, ±(5% +0.2 microvolt)
10 to 30 Mc, ±(10% +0.4 microvolt)
30 to 50 Mc, ±(15% +0.8 microvolt)

There is no attenuator error for the 1-volt multiplier setting.

Modulation: Continuously variable from 0 to 100%. The percentage of modulation is indicated by a panel meter to an accuracy of ±10% of the meter reading up to 80%, for carrier frequencies below 16 Mc; ±15% for higher carrier frequencies.

Internal modulation is available at 400 cycles and 1000 cycles, accurate in frequency within ±5%.

The generator can be modulated by an external oscillator. Approximately 10 volts across 500,000 ohms are required for 80% modulation. The over-all modulation characteristic is as follows:

Carrier Frequency	*Audio Range*	*Level*
0.5—50 Mc	50~ —15,000~	±1 db
0.1—0.5 Mc	50~ —10,000~	±1.5 db
16—100 kc	50~ —10% of Carrier Frequency	±1.5 db

Frequency Modulation: On the highest carrier frequency range the frequency modulation is about 0.05% for 100% modulation, and 0.02% for 30% modulation. At lower carrier frequencies the frequency modulation is less than these percentages.

For applications where incidental fm must be negligible, the TYPE 1023-A Amplitude Modulator should be used, or, for wide-band (video) modulation, the TYPE 1000-P6 Crystal Diode Modulator.

Distortion and Noise Level: The envelope distortion at a modulation level of 80% is less than 4% at 1 Mc carrier frequency. Carrier noise level is at least 40 db below 80% modulation.

Leakage: The magnetic induction leakage is less than 5 microvolts per meter at a distance of 2 feet from the generator. The 3-foot output cable permits the receiver under test to be kept beyond this limit. Radiation fields are negligible.

Power Supply: The instrument operates from any 40 to 60 cycle, 115-volt (or 230-volt) line. An electronic voltage regulator compensates for line voltage fluctuations from 105 to 125 volts (or from 210 to 250 volts). A maximum input power of 150 watts is required.

Tubes: Supplied with instrument.

1 — 6C8-G	1 — 0D3
3 — 6L6	1 — 6AL5
1 — 5U4-G	1 — 6H6
2 — 2A3	1 — Amperite 3-4
1 — 6SF5	

Accessories Supplied: Line connector cord, shielded output cable and termination unit, and spare fuses.

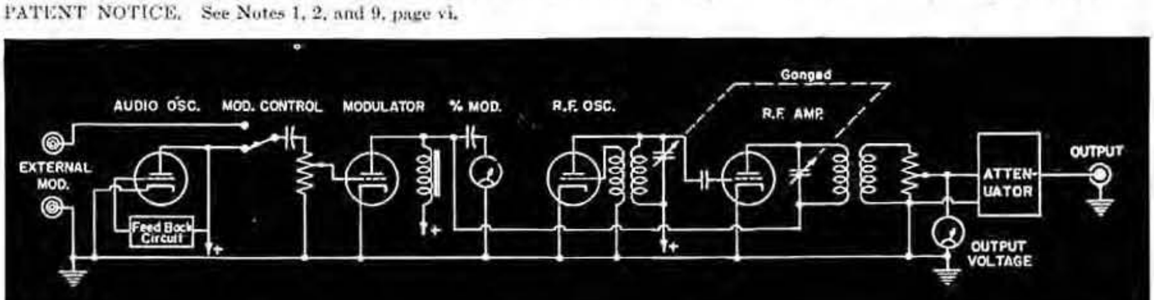
Mounting: The panel is finished in black crackle and the cabinet is black wrinkle finish.

Dimensions: (Height) 16 x (width) 33 x (depth) 12 inches, over-all.

Net Weight: 117½ pounds.

Type		*Code Word*	*Price*
805-C	**Standard-Signal Generator**	LEPER	**$1450.00**

PATENT NOTICE. See Notes 1, 2, and 9, page vi.



TYPE 1000-P SIGNAL-GENERATOR ACCESSORIES

View of the TYPE 1000-P10 Test Loop, the TYPE 1000-P3 Voltage Divider, and the TYPE 1000-P4 Standard Dummy Antenna.

TYPE 1000-P3 VOLTAGE DIVIDER

This voltage divider, used with the TYPE 1001-A Standard-Signal Generator, provides a known voltage across a one-ohm resistor, which can be inserted in series with a loop antenna for testing loop receivers.

It plugs into the output jack of the signal generator (TYPE 1001-A) and divides the indicated output voltage by a factor of 100.

Input Impedance: 50 ohms.
Output Impedance: 1 ohm.
Terminals: TYPE 874 Coaxial Connectors.
Net Weight: 3¼ ounces.

Type		*Code Word*	*Price*
1000-P3	100:1 Voltage Divider	ARMOR	$17.50

TYPE 1000-P4 DUMMY ANTENNA

Connected to the terminated output of a standard-signal generator of 50 Ω output impedance (25 Ω), this dummy antenna provides the output characteristics specified by the Institute of Radio Engineers in their 1948 "Standards on Radio Receivers, Methods of Testing Amplitude-Modulation Broadcast Receivers." Terminals are TYPE 874 Coaxial Connectors, which fit both the signal generator output jack and the output cable.

Net Weight: 3¼ ounces.

Type		*Code Word*	*Price*
1000-P4	Dummy Antenna	ARROW	$15.00

TYPE 1000-P10 TEST LOOP

With this shielded test loop, radio receivers with loop antennas can be tested by the preferred method of the 1948 "Standards on Radio Receivers, Methods of Testing Amplitude-Modulation Broadcast Receivers," published by the Institute of Radio Engineers. The 3-turn loop is inclosed in copper tubing for electrostatic shielding. Circuit constants are chosen to make the field strength in volts per meter, at a distance of 19 inches from the loop, equal to one-tenth the signal generator output in volts, with a 50 Ω generator.

Terminal: TYPE 874 Coaxial Connector.
Dimensions: (Height) 16½ x (width) 11¾ x (depth) 3½ inches.
Net Weight: 4½ pounds.

Type		*Code Word*	*Price*
1000-P10	Shielded Test Loop	ARRAY	$33.00

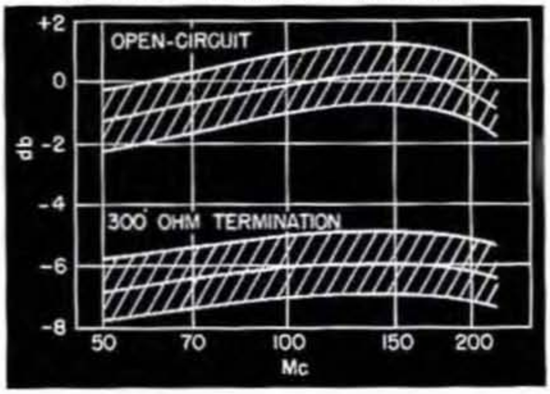
TYPE 1000-P5 V-H-F TRANSFORMER

50 Ohms, Grounded, to 300 Ohms, Balanced

The TYPE 1000-P5 V-H-F Transformer is designed to plug into a standard-signal generator having a 50-ohm unbalanced output and produce an equal balanced open-circuit voltage behind a 300-ohm balanced impedance for r-f measurements of f-m and t-v receivers.

The transformer is mounted in a cylindrical container terminated at one end in a TYPE 874 Coaxial Connector and at the other in a socket designed to receive the Alden TYPE HA902P Connector for standard 300-ohm open parallel-wire line.

Frequency Characteristics of TYPE 1000-P5 V-H-F Transformer. Shaded areas show tolerances.



Frequency Range: 50 Mc to 250 Mc.
Frequency Characteristic: See plot.
Input Impedance: Approximately 300 ohms. Designed to work out of 50-ohm source.
Terminals: Input — General Radio Type 874 Coaxial Connector.
Output — Fits Alden Type HA902P Connector; mating connector is furnished.
Dimensions: (Length) $1\frac{3}{8}$ x (diameter) $\frac{7}{8}$ inches.
Net Weight: $3\frac{1}{2}$ ounces.

Type		Code Word	Price
1000-P5	V-H-F Transformer	ARSON	$27.50

TYPE 1000-P6 CRYSTAL DIODE MODULATOR

USES: The crystal diode modulator is an absorption modulator for amplitude modulating the output of a radio-frequency generator over the carrier range from 20 to 1000 megacycles. It can be used to modulate the output of standard-signal generators and other oscillators over a modulating-frequency range of 0 to 5 megacycles. It is particularly useful where wide-band modulation, as for television receiver testing, is required, or for radio receiver tests where incidental fm must be negligible.

DESCRIPTION: The modulator consists of a crystal diode between input and output terminals, a simple output filter to prevent appreciable modulating voltage appearing in the output, and a means of isolating and applying modulating and bias voltages. Since the resistance of the crystal diode is a function of the voltage across it, this resistance can be modulated by applying a varying voltage. Inserted between a radio-frequency generator and its load, the unit produces amplitude modulation by variation of load impedance.

When the modulator is used with a standard-signal generator, the output attenuator of the generator provides sufficient isolation to prevent reaction of the modulator on the generator frequency. With an oscillator not equipped with an output attenuator, it is recommended that a Type 874-GF (20 db) or a Type 874-GG (10 db) Attenuator be used.

FEATURES: ➔ When used with a standard-signal generator, the crystal diode modulator works on the output side of the attenuator, so that reaction on the oscillator frequency, and hence frequency modulation, is practically negligible. The power required for modulation is very low.

➔ For testing television receivers, a video signal, conveniently obtained from a standard receiver tuned to a local station, can be applied to the modulator. The picture modulation can then be put on any desired channel by tuning the signal generator.

SPECIFICATIONS

Carrier Frequency Range: 20 to 1000 megacycles. The insertion loss increases approximately 10 db at a carrier frequency of 10 megacycles due to output filter.

Modulating Frequency Range: 0 to 5 megacycles. Response is approximately 2 db down at 5 megacycles with a gradual roll-off to prevent serious phase distortion of video signals.

Impedance: The impedance looking into either the input or output terminals is a function of the bias and modulating voltages. This unit was designed for use with a 50-ohm source and a 50-ohm load. The impedance at the modulation terminals is approximately 600 ohms.

Modulation: With no greater than 50 millivolts r-f input, 30% amplitude modulation can be obtained at carrier frequencies between 20 and 1000 Mc. For optimum sine-wave modulation, an average crystal requires 1.5 volts at the bias terminal. The insertion loss under these conditions is approximately 12 db, and approximately 0.2 volt r-m-s at the modulation terminals will produce 30% modulation. Maximum percentage modulation is an inverse function of carrier frequency, and at 1000 megacycles is limited to about 30%. Peak modulation voltage with respect to ground should not exceed 4 volts.

Terminals: The radio-frequency and modulating terminals are provided with Type 874 Coaxial Connectors. The modulation terminals will accept either a Type 874 Coaxial Connector or a Type 274-M Plug.

Crystal Diode: 1N21B.

Accessories Supplied: One Type 274-MB Plug.

Other Accessories Required: Terminal adaptors, unless generator and load are equipped with Type 874 Coaxial Connectors; 1.5-volt battery for fixed bias, or a 3-volt battery and a 10,000-ohm rheostat for adjustable bias.

Accessories Available:
Type 874-GF Fixed Attenuator, 20 db
Type 874-GG Fixed Attenuator, 10 db
Type 874-R20 Patch Cord
Type 1000-P5 V-H-F Transformer
(For descriptions and prices, see pages 112 to 125, and 129.)

Dimensions: (Width) 5 x (height) 4 x (depth) $1\frac{1}{16}$ inches, over-all.

Net Weight: 1 pound.

Type		Code Word	Price
1000-P6	Crystal Diode Modulator	APPLE	$40.00

PATENT NOTICE. See Notes 3, 4, page vi.

TYPE 1021-AU STANDARD-SIGNAL GENERATOR
(250–920 Mc)

TYPE 1021-AV STANDARD-SIGNAL GENERATOR
(50–250 Mc)

USES: The TYPE 1021-A Standard-Signal Generators are as reliable and as convenient at very high and ultra-high frequencies as conventional Standard-Signal Generators are at much lower frequencies. Their main use is the determination of radio-receiver and amplifier characteristics in the engineering laboratory and in production. In addition, they are convenient and well shielded sources of power for v-h-f and u-h-f bridges, slotted lines, and other measuring devices. In combination with the TYPE 1000-P6 Crystal-Diode Modulator and a source of video signals, they can be used to produce television picture modulation on all channels between 50 and 920 Mc. A convenient source of television video signals is a standard television receiver tuned to a local television station.

The TYPE 1023-A Amplitude Modulator can be used with the TYPE 1021-AV to produce accurately known values of amplitude modulation up to 80% with completely negligible fm.

DESCRIPTION: Each TYPE 1021-A Standard-Signal Generator is a compact and light-weight instrument of simple, yet rugged and durable design. For flexibility and economy, each signal generator is made up of two units. The power supply, modulator, and metering system make up one unit, the TYPE 1021-P1 Modulator Unit, which occupies the left-hand side of the welded aluminum cabinet. The right-hand side of the cabinet houses one of two readily interchangeable carrier oscillator units: The TYPE 1021-P2 U-H-F Unit for 250 to 920 Mc or the TYPE 1021-P3 V-H-F Unit for 50 to 250 Mc.

As noted in the price table, additional tuning units can be furnished to convert either generator into the other.

The internal modulation frequency is 1000 cycles. External modulation is possible over the audio-frequency range. Modulation is continuously adjustable from 0 to 50%. A single panel meter is used to indicate either carrier output voltage or modulation percentage. With the TYPE 1000-P6 Crystal Diode Modulator, the generator can be modulated externally over a range of 0 to 5 megacycles, with negligible incidental frequency modulation.

The carrier oscillator units for the two instruments differ only in the frequency range covered. Each uses a butterfly circuit as the tuning element and covers its range in a single band. A mutual-inductance-type attenuator is used, with a dial calibrated from 0.5 μv to 0.5 volt. Voltages over 0.5 volt are read directly on the panel meter. The meter is actuated by a standard silicon crystal connected across the output cable. The crystal is followed by a 50-ohm matching resistor and can be standardized against the regulated power supply.

FEATURES: ➔ Generator is as easy to operate and as reliable as low-frequency types.
➔ High output is available.
➔ Both output voltage and output impedance are accurately known.
➔ No sliding contacts are used in tuned circuit. Worm-driven tuning element covers frequency range smoothly in a single band, with 1100 dial divisions.
➔ Good stability and low drift are insured by ruggedly designed butterfly oscillators and regulated power supply.
➔ Clear beat tones are produced when output is heterodyned.
➔ Residual output and stray fields are below the sensitivity of most receivers. Oscillators are doubly shielded and all supply leads are well filtered.
➔ Output terminals are Type 874 Coaxial Connectors, and a wide variety of accessories is available (see pages 110 to 123).
➔ Unit design provides flexibility. V-H-F and U-H-F oscillator units are easily interchanged.

SPECIFICATIONS

Type 1021-AU U-H-F Standard-Signal Generator

Carrier Frequency Range: 250 Mc to 920 Mc in one band.
Frequency Calibration: Direct reading to ±1%.
Output Voltage: Continuously adjustable from 0.5 μv to 1.0 volt, open-circuit.
Output Impedance: 50 ohms ±10%.
Output Voltage Accuracy: Over-all accuracy of output voltage is better than ±20%. The accuracy of output voltmeter calibration between 0.5 volt and 1.0 volt is better than ±10%. The accuracy of the attenuator dial calibration for voltages between 1.0 μv and 0.1 volt is better than ±5%; from 0.1 volt to 0.5 volt, better than ±10%. At 920 Mc, the resonance error in the voltmeter is +6%.
Amplitude Modulation: Adjustable, 0 to 50%. Internal, 1000 c ±5%. External, flat within 3 db from 30 c to 15 kc. For 50% modulation, external audio oscillator must supply 18 volts across a 100 kilohm load.
Envelope Distortion: Less than 5% at 50% modulation.
Noise Level: Carrier noise level corresponds to about 0.2% modulation.
Incidental Frequency Modulation: For 50% amplitude modulation the incidental fm is approximately 100 parts per million for frequencies up to 400 Mc and is approximately 1000 parts per million at 920 Mc. When lower values of incidental fm are required, the Type 1000-P6 Crystal Modulator is recommended.
Leakage: Stray fields and residual output voltage cannot be detected with a receiver having 2 to 3 μv sensitivity.
Terminals: Type 874 Coaxial Terminals are provided for the output connection.
Power Supply: 115 or 230 volts, 50 to 60 cycles. Power input is approximately 50 watts.
Tubes: Supplied with the instrument:
1—G. R. Co. Type TUE-1 (modified 5861)
1—6X5-GT   1—Amperite 6-4
1—6K6-GT   2—0C3
Accessories Supplied:
1 Type 874-R20 3-foot Coaxial Cable (50 Ω)
1 Type 874-C Coaxial Cable Connector
1 Type CAP-35 Power Cord
Other Accessories Available: Not supplied, but available on order are Type 874-GF 20 db Attenuator Pad, Type 874-GG 10 db Attenuator Pad, Type 874-K Coupling Capacitor, and Type 1000-P6 Crystal Modulator.
Mounting: The aluminum cabinet has a black wrinkle finish. The left-hand side houses the Type 1021-P1 Power Supply; the right-hand side houses the Type 1021-P2 U-H-F Unit. Panels are black crackle-finished aluminum.
Dimensions: (Height) 14⅜ x (width) 20¼ x (depth) 10 9/16 inches, over-all.
Net Weight: 37½ pounds.

Type 1021-AV V-H-F Standard-Signal Generator

Same as Type 1021-AU (above) except as noted.
Carrier Frequency Range: 50 Mc to 250 Mc in one band.
Incidental Frequency Modulation: For 50% amplitude modulation the incidental fm is approximately 100 parts per million for frequencies up to 100 Mc, and is approximately 500 parts per million at 250 Mc. When lower values of incidental fm are required, the Type 1000-P6 Crystal Modulator or the Type 1023-A Amplitude Modulator is recommended.
Tubes: Supplied with the instrument:
1 GE 12AT7 (Oscillator instead of TUE-1).
Other tubes as listed above.
Mounting: Cabinet is same as for Type 1021-AU, above. Generator consists of the Type 1021-P1 Power Supply and Type 1021-P3 V-H-F Unit.

Type		*Code Word*	*Price*
1021-AU	U-H-F Standard-Signal Generator, 250-920 Mc	EVADE	$615.00
1021-AV	V-H-F Standard-Signal Generator, 50-250 Mc	EVENT	595.00

To cover the complete frequency range of 50 to 920 Mc, an additional tuning unit can be furnished with either generator. Tuning units are easily and quickly interchanged.

Type		*Code Word*	*Price*
1021-A	Standard-Signal Generator with both oscillator units, 50-920 Mc........................	EXERT	$1015.00
1021-P2	U-H-F Oscillator Unit only, 250-920 Mc......	ETHIC	420.00
1021-P3	V-H-F Oscillator Unit only, 50-250 Mc.......	EVOKE	400.00

PATENT NOTICE. See Notes 3, 4, 10, page vi.

TYPE 1023-A AMPLITUDE MODULATOR

USES: An accurately calibrated amplitude-modulated signal with no significant incidental fm is produced by the TYPE 1023-A Amplitude Modulator, used with a standard-signal generator or other oscillator at frequencies between 5 and 220 megacycles.

It is particularly useful with a frequency-modulated Standard-Signal Generator for performance tests on limiters, discriminators, and ratio detectors. Since no extraneous fm is produced by the a-m process, *accurate* simultaneous measurement of a-m rejection and f-m response are made possible.

With conventional a-m signal generators, such as the TYPE 1001-A, the TYPE 1021-AV, and the TYPE 805-C, as well as those of other manufacture, the Amplitude Modulator can be used to provide accurately known amplitude modulation, free from incidental fm, for those receiver tests where the inherent fm of a modulated oscillator is not tolerable. This is particularly important for receiver tests at frequencies where the incidental fm in the generator may exceed the receiver band width. For this purpose, the use of the modulator will greatly improve the accuracy of measurements on receivers and other equipment for such services as voice ground-to-air communication, air navigation, omnirange, ILS, telemetering, and remote control.

DESCRIPTION: This instrument consists of a grid-modulated aperiodic amplifier that is connected between the output of the standard-signal generator and the device under test. Two substantially flat pass-band ranges are provided, one from 10 to 150 Mc with a gain of 0.1, and the other from 10.1 to 11.3 Mc with a gain of 10.

FEATURES: ➔ When used with a standard-signal generator, the TYPE 1023-A Amplitude Modulator greatly improves the a-m performance by eliminating incidental fm, thus increasing the scope of measurements that can be made.

➔ Gain and output impedance are substantially constant over the calibrated ranges.

➔ Gain can be standardized in terms of the signal generator attenuator.

➔ Up to 80% modulation.

➔ Accurately calibrated in percentage modulation.

➔ Low envelope distortion.

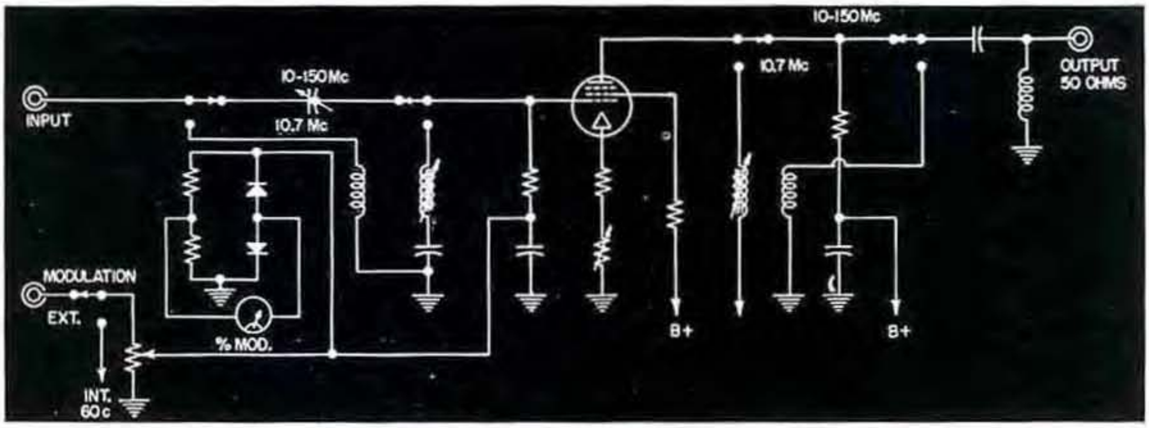
➔ High gain is provided in the 10.7-Mc RTMA standard f-m intermediate-frequency band for a-m tests.

SPECIFICATIONS

*Pass Band**	*Input Voltage Range** (From 50-ohm source)	*Output Impedance* *Nominal*	*Output Impedance* *VSWR*	*Output Volts*	*Gain*
10 to 150 Mc	0-1.5 v at 50 ohms	50 ohms	1.15	1/10 Input V	0.1
10.1 to 11.3 Mc	0-0.1 v at 50 ohms	50 ohms	1.4 (1.13 at 10.7 Mc)	10 Input V	10

*Instrument can be used over the range of 5 to 220 Mc, but gain will vary somewhat with frequency, and output impedance will not stay within above limits. Input voltages can be increased beyond above figures at some increase in envelope distortion and decrease in gain.

Loss is about 12 : 1 at 220 Mc, and VSWR is approximately 2. At 5 Mc, VSWR is approximately 1.2.



Elementary schematic of the TYPE 1023-A Amplitude Modulator.

Amplitude Modulation: 0 to above 80% continuously adjustable, accurate to (5% of meter reading +1% modulation).

Internal Modulation: At power line frequency.

External Modulation: Flat within ±1 db from 20 c to 15 kc; approx. 5 volts into 10,000 ohms will produce 80% modulation.

Envelope Distortion: Less than 5% at 80% modulation. Decreases with the modulation percentage.

Frequency Modulation: Direct incidental fm from reaction on a low-impedance standard-signal generator is negligible. Equivalent fm from variable phase shift is of the order of 10 cycles for 80% modulation at 60 cycles and is proportional to modulating frequency and modulation percentage.

Impedance: The modulator is designed for use between 50-ohm impedances. With other generator and load impedances, TYPE 874-GC or -GF Attenuator should be used between the modulator and the generator and or load.

Carrier Noise Level: Better than 45 db below 80% modulation.

Leakage: At least 45 db below output signal on 10 to 150 Mc range; at least 60 db on 10.7 Mc range.

Terminals: Input and output terminals are TYPE 874 Coaxial Connectors.

Power Supply: 105 to 125 (or 210 to 250) volts; 50 to 60 cycles. Demand is 15 watts.

Tubes: One 6AC7 and one 6X5GT; both are supplied.

Accessories Supplied: TYPE 874-R20 Patch Cord, TYPE 874-Q2 Adaptor, spare fuses, one TYPE 274-MB Double Plug and a power cord.

Other Accessories Available: TYPE 1000-P5 Transformer (50 ohms unbalanced to 300 ohms balanced); TYPE 1000-P1 Termination Unit, 50 ohms; TYPE 874-Q1 Adaptor (for Type N Connectors).

Mounting: Aluminum panel with black crackle finish; aluminum cabinet with black wrinkle finish.

Dimensions: (Height) $14\frac{5}{8}$ x (width) $9\frac{1}{8}$ x (depth) $8\frac{1}{4}$ inches, over-all.

Net Weight: $15\frac{1}{2}$ pounds.

Type		*Code Word*	*Price*
1023-A	**Amplitude Modulator**	EXULT	**$250.00**

PATENT NOTICE. See Notes 3 and 4, page vi.

The TYPE 1023-A Amplitude Modulator and the TYPE 1021-AV V-H-F Standard-Signal Generator arranged for tests on a communications-type receiver.

SIMPLE TEST-SIGNAL GENERATORS

Oscillators such as the TYPE 1208-A and the TYPE 1209-A Unit Oscillators, in conjunction with suitable TYPE 874 Coaxial Elements can be assembled into convenient test-signal generators. Although not so well shielded as standard-signal generators, such assemblies are adequate for many measurements and are useful auxiliary generators for production testing and for student laboratory measurements. The oscillators are described on pages 110 and 111, and the coaxial accessories on pages 112 to 125.

OSCILLATORS AND GENERATORS

A source of power or test voltage is a prerequisite to nearly all types of measurements — impedance, transmission, waveform, sensitivity, and many others. Since 1919 the General Radio Company has been supplying laboratory oscillators for this purpose and has always pioneered in new designs and new circuits.

Functionally, these oscillators can be grouped under the following classifications:

(1) Resonant-circuit (L-C) types — the frequency of oscillation is determined by a tuned circuit having inductive and capacitive elements.

(2) Beat-frequency types — the output frequency is the difference between the frequencies of two oscillators, one variable and one fixed. This type covers a wide frequency range with a single control.

(3) R-C degenerative types — the frequency is determined by a selective circuit composed of resistive and capacitive elements and the circuit is highly degenerated except at the pass frequency. This type of oscillator also covers a wide frequency range with a single control, and alternatively can be designed to produce a number of fixed frequencies, as selected by a switch. Excellent waveform can be obtained from the R-C degenerative oscillator at low power levels.

(4) Electro-mechanical types — the frequency is determined by a vibrating element.

Oscillators are often designed for specific applications, so that emphasis in the design must be given to a single characteristic, such as high output power, pure waveform, frequency stability, or wide frequency range. While any one of these characteristics, or in many cases, two, can be achieved, it is not, in general, economical to combine all four in a single instrument.

The General Radio Company manufactures all of the functional types listed above, and the characteristics of available models are tabulated in convenient form on the next page.

Tuned Circuit Types: The tuned-L-C oscillator is little used now for audio-frequency measurement and testing, because of the relatively expensive array of inductors and capacitors necessary if a wide range of frequency is to be covered. For audio-frequencies, it has been superseded by beat-frequency and R-C types. At radio-frequencies, however, where tuning can be accomplished by air capacitors, the L-C circuit remains the best and most economical frequency-determining system. The Type 1330-A Bridge Oscillator uses tuned-circuits to cover frequency ranges as large as 10,000 : 1. The Type 857-A U-H-F Oscillator is a tuned-circuit instrument using the butterfly circuit (a General Radio development) as the tuning element.

Other oscillators using the butterfly or similar circuits are listed in the section on Unit Instruments. This line of inexpensive oscillators also includes an audio-frequency model.

Beat-Frequency Types: The first commercial beat-frequency oscillator was produced by General Radio in the middle 1920's. As the development of tubes and circuits has progressed, increasingly better models have been developed, culminating in the present Type 1304-A.

The Type 700-A delivers output frequencies up to 5 megacycles and hence can be used in testing wide-band systems. The Type 1303-A produces two output frequencies simultaneously and is an excellent source for measurements of intermodulation distortion in audio systems.

R-C Types: The R-C degenerative type is a General Radio development, covered by a basic patent, under which other manufacturers have been licensed. Two models are offered, the Type 1301-A, whose primary characteristic is low distortion, and the Type 1302-A designed for a wide frequency range. The former finds its greatest use as a test tone source for distortion measurements, and the latter as a power source for bridge measurements up to 100 kc.

Electro-Mechanical Types: The General Radio Company manufactures a number of electromechanical oscillators. Quartz-crystal-controlled types, for use as frequency standards, are listed in the FREQUENCY section of this catalog. Listed in the following section are two audio-frequency tuning-fork models, the Type 813 and the Type 723. These are useful as low-power sources for continuous operation, as in modulating beacon transmitters. A microphone hummer, the Type 572-B, uses a tuned reed as the frequency stabilizing element, and is a convenient, low-priced device for building into other equipment.

Miscellaneous Types: The Random Noise Generator delivers a continuous noise spectrum, as generated by a gas-discharge tube.

The Pulse Generator, while nominally listed in the OSCILLATOR section of the catalog, is primarily a wave-shaping device, requiring excitation from an external audio oscillator.

OSCILLATORS

Type	*Name*	*Class*	*Frequency Range*	*Maximum Output*	*Open-Circuit Volts*	*Output Impedance*	*Harmonic Distortion*	*Power Supply*	*See Page No.*
1304-A	Beat-Frequency Oscillator	Beat-Frequency	20–20,000 cycles	Normal—0.3 watt High—1 watt	25 40	600 ohms, balanced or grounded	<0.25% <1%	A-C Line	138
1303-A	Two-Signal Audio Generator	Beat-Frequency	(1) 20–20,000 cycles (2) 20,000–40,000 cycles (3) Two signals separately adjustable (4) Two signals with a fixed difference	Normal—10 mw High—1 watt	5 50	600 ohms, grounded	<0.2% <1%	A-C Line	140
700-A	Wide-Range Beat-Frequency Oscillator	Beat-Frequency	50 cycles—40 kc 10 kc—5 Mc	0.1 watt	10–15	3500-ohm pot.	<3%	A-C Line	142
1301-A	Low-Distortion Oscillator	R-C Degenerative	20–15,000 cycles (27 fixed frequencies)	18 mw 100 mw	6.6 30	600 ohms, balanced or grounded 5000 ohms, grounded	<0.1%	A-C Line	144
1302-A	Oscillator	R-C Degenerative	10–100,000 cycles	40 mw 20 mw 80 mw	10 5 20	600 ohms, balanced 300 ohms, grounded 5000 ohms, grounded	<1%	A-C Line	146
1330-A	Bridge Oscillator	Tuned Circuit	400 cycles, 1000 cycles 5 kc—50 Mc	0.75 watt 1 watt	12 10	50 ohms 20–80 ohms	<3%	A-C Line	148
857-A	U-H-F Oscillator	Butterfly Tuned Circuit	100–500 Mc	0.5 watt	5–10	Coaxial Line		A-C Line	150
1390-A	Random Noise Generator	Gas Discharge	30 cycles—20 kc 30 cycles—500 kc 30 cycles—5 Mc		1	800 ohms, grounded	Noise Spectrum	A-C Line	152
869-A	Pulse Generator	Must be excited from external oscillator	20–4000 cycles		18–300		Flat-top Pulse 0.1 μsec rise time	A-C Line	154
723	Vacuum-Tube Fork	Electro-Mechanical	400 or 1000 cycles (2 models)	50 mw	31 max.	50, 500, 5000 ohms	<0.5%	A-C Line	156
813	Audio Oscillator	Electro-Mechanical	400 or 1000 cycles (2 models)	30 mw	24 max.	50, 500, 5000 ohms	<1%	Batteries	157
572-B	Microphone Hummer	Electro-Mechanical	100 cycles ±10%	15 mw	4.2 max.	10 and 300 ohms		Batteries	157

TYPE 1304-A BEAT-FREQUENCY OSCILLATOR

USES: This is a general-purpose beat-frequency oscillator that is particularly useful as a power source for tests on audio-frequency lines and associated networks. It is also useful as a voltage source for bridge measurements and for modulating signal generators and test oscillators. The oscillator can be used on either balanced or unbalanced systems.

DESCRIPTION: The TYPE 1304-A Beat Frequency Oscillator utilizes the conventional beat-frequency oscillator design, but has a number of unusual design features that contribute to improved performance and ease of operation. Two radio-frequency oscillators, one fixed and one variable, feed a pentagrid converter through buffer amplifiers. The resulting difference frequency, after passing through a low-pass filter, is amplified in a balanced, degenerative amplifier. The output level is controlled by a constant-impedance attenuator that is calibrated in decibels with respect to an output of one milliwatt into a 600-ohm line.

For permanent or relay-rack installation, duplicate output terminals are provided at the rear of the instrument, through standard multipoint connectors.

A neon lamp beat indicator is provided to assist in standardizing the frequency calibration of the oscillator by setting either to the power line frequency or to zero beat. The frequency dial carries a logarithmic scale, and is driven by a slow-motion gear-reduction drive, essentially free from backlash.

A cycles-increment dial provides a means of varying the frequency over a range of ±50 cycles at any setting of the main dial.

FEATURES: ➔ The output voltage of this oscillator is practically constant over the entire frequency range. Because of this fact and because the output control is calibrated directly in decibels, it is possible to take frequency characteristics directly without a dummy generator resistance and oscillator voltmeter.

➔ A high degree of stability, in output voltage as well as frequency, is obtained by the use of highly stable elements in the oscillator circuits and stabilization of the power supply.

➔ Power-supply hum is reduced to a very low level by careful design of the power-supply filter.

➔ Excellent waveform is achieved by means of careful oscillator circuit design in conjunction with degeneration in the audio amplifier.

➔ Small size and light weight make the oscillator conveniently portable and contribute greatly to its general utility.

SPECIFICATIONS

Frequency Range: 20 to 20,000 cycles.

Frequency Control: The main control is engraved from 20 to 20,000 cycles per second and has a true logarithmic frequency scale. The total scale length is approximately 12 inches. The effective angle of rotation is 240°, or 80° per decade of frequency. The frequency-increment dial is calibrated from +50 to −50 cycles.

Frequency Calibration: The calibration can be standardized within 1 cycle at any time by setting the instrument to the line frequency or to zero beat. The calibration of the frequency control dial can be relied upon within ±(1% + 0.5 cycle) after the oscillator has been correctly set to zero beat. The accuracy of calibration of the frequency-increment dial is ±1 cycle.

Zero Beat Indicator: A neon lamp is used to indicate zero beat at the line frequency or at zero scale.

Frequency Stability: The drift from a cold start is less than 7 cycles in the first hour and is essentially completed within two hours.

Output Impedance: The output impedance is 600 ohms, either grounded or balanced-to-ground, and is essentially constant regardless of the output control setting. With load impedances of 2000 ohms or less, the output is balanced for all settings of the output control. With higher load impedances, unbalance may occur at low settings of the output control.

Output Voltage: Approximately 25 volts open circuit. For a matched resistive load the output voltage varies by less than ±0.25 db between 20 and 20,000 cycles. The open-circuit output voltage is approximately 40 volts with the output switch in the HIGH position.

Output Control: The output control is calibrated from +25 to −20 db, referred to 1 milliwatt into 600 ohms.

Output Power and Waveform: NORMAL output 0.3 watt maximum when operated into a matched load, with total harmonic content approximately 0.25% between 100 and 7500 cycles. Below 100 cycles the harmonic content increases, and may reach 0.5% at 50 cycles. A panel switch allows an increase in the output power to a maximum of 1 watt. For this HIGH position of the OUTPUT switch the distortion is less than 1% between 100 and 7500 cycles and may reach 2% at 50 cycles. With the OUTPUT control turned fully on, the harmonic content is approximately doubled when the oscillator is operated into a very low impedance. With the OUTPUT control turned 3 db or more below maximum load impedance has very little effect upon the waveform.

A-C Hum: For NORMAL output the a-c hum is less than 0.1% of the output voltage.

Terminals: Jack-top binding posts with standard ¾-inch spacing and standard Western Electric double output jack are provided on the panel. A standard multipoint socket and plug provide duplicate output terminals on the back of the instrument for relay-rack installation.

Accessories Supplied: Power cord, multipoint connector, and spare fuses.

Mounting: 19-inch relay rack panel; removable ends are supplied so that it may be used equally well on a table.

Power Supply: 105 to 125 volts, 50 to 60 cycles ac. A simple change in the connections to the power transformer allows the instrument to be used on 210 to 250 volts. The total consumption is about 100 watts.

Tubes:

3—6SL7-GT	2—6V6-GT
1—6SA7	2—0D3
1—5V4-G	1—991

All are supplied with the instrument.

Dimensions: 19⅜ x 14¼ x 7½ inches, over-all.

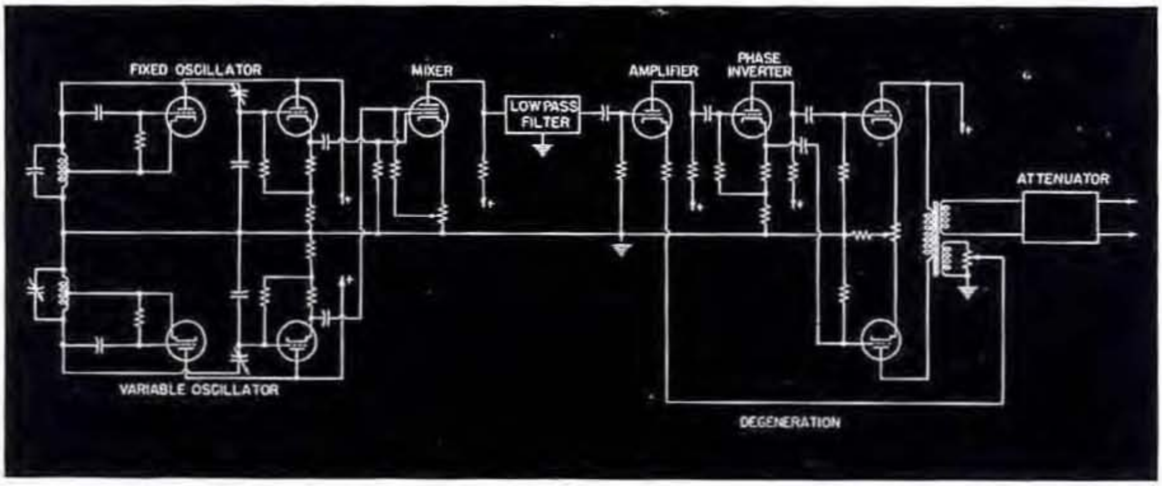
Net Weight: 41½ pounds.

Type		*Code Word*	*Price*
1304-A	**Beat-Frequency Oscillator**	CAROL	**$475.00**

PATENT NOTICE. See Notes 1, 2, 21, page vi.

OTHER BEAT-FREQUENCY OSCILLATORS

Other types of beat-frequency oscillators are described on pages 144 and 205. Type 700-A (page 144), with an upper frequency limit of 5 Mc, is designed for wide-band measurements. Type 1107-A (page 205) has a linear scale from 0 to 5000 cycles, and is used as an interpolation device in frequency measurements. Type 1303-A (page 142) is designed particularly for intermodulation distortion tests.



TYPE 1303-A TWO-SIGNAL AUDIO GENERATOR

USES: The TYPE 1303-A Two-Signal Audio Generator is designed primarily as a convenient test-signal source for intermodulation distortion measurements. It is suitable for use in measurements by all three of the usual non-linear distortion measurement methods. These are:

(1) The harmonic method.

(2) The intermodulation method using a strong low-frequency tone and a weaker high-frequency tone (standardized by the SMPTE).

(3) The intermodulation method, sometimes called a double-tone test, using two tones of equal intensity (recommended by the CCIF).

The TYPE 736-A Wave Analyzer is recommended as a detector for these distortion tests.

The Two-Signal Audio Generator is also useful as a general purpose audio-frequency source for tests on audio-frequency lines, networks, and amplifiers; for modulating signal generators and test oscillators; and as a voltage source for acoustic tests, recording tests, and bridge measurements.

DESCRIPTION: The TYPE 1303-A Two-Signal Audio Generator utilizes a beat-frequency system to provide the various signals available at the output. Three radio-frequency oscillators are included, one fixed and the other two adjustable. When a signal output of a single-frequency tone is desired, the fixed and one of the adjustable oscillators feed a pentagrid converter. The resulting difference frequency, after passing through a low-pass filter, is amplified in a degenerative amplifier. When a signal output of two tones is desired, the third oscillator and one of the other two oscillators feed an additional pentagrid converter. The resulting difference frequency, after filtering, is added to the output of the first pentagrid converter. This combined signal is amplified in a degenerative amplifier.

The output level is adjustable by an output-level control and an L-pad attenuator. This level is indicated by a voltmeter calibrated in voltage and in decibels with respect to an output of one milliwatt into a 600-ohm line. Following the voltmeter is a six-position 600-ohm attenuator also calibrated in decibels.

For bench use the signal generator is supplied with end supports that can be removed to permit permanent installation of the instrument in a standard 19-inch relay rack.

FEATURES: ➔ Can be used as a single-frequency beat-frequency oscillator from 20 to 40,000 cycles.

➔ Supplies combinations of two frequencies for intermodulation distortion tests.

→ The ratio of the voltages of the two frequencies is adjustable.
→ The constant-difference-frequency feature of the two-signal output is particularly convenient for the CCIF method of testing.
→ Harmonics and intermodulation products in the oscillator output are very low.
→ Output voltage is essentially constant with frequency.
→ Frequency and voltage stability are high.
→ Output Meter and attenuator are provided, so that the oscillator can be used as a standard-signal generator for such measurements as voltage, gain, and attenuation.

SPECIFICATIONS

Frequency Range: The four settings of the OUTPUT FREQUENCIES control, labelled A, B, C, and D, respectively, correspond to the following output combinations:

A: 20 to 20,000 cycles per second.

B: 20,000 to 40,000 cycles per second.

C: One frequency, f_1, of 20 to 20,000 cycles and a second frequency, f_2, higher than f_1 by a fixed amount, which may be between 0 and 10,000 cycles. As f_1 is varied the difference frequency remains constant.

D: One frequency, f_1, of 20 to 20,000 cycles and a second frequency, f_2, of 20 to 10,000 cycles.

Frequency Control: The main control is engraved from 20 to 20,000 cycles per second and has a true logarithmic frequency scale. The total scale length is approximately 12 inches. The effective angle of rotation is 240° or 80° per decade of frequency. The frequency-increment dial is calibrated from +50 to −50 cycles. 20 kc is switched in to give 20 kc to 40 kc. A 3¼ inch auxiliary frequency dial, f_2, is engraved from 0 to 10,000 cycles over approximately 180° of dial rotation. The scale distribution is approximately logarithmic above 500 cycles and approximately linear below 500 cycles.

Frequency Calibration: Main dial, 20 to 20,000 cycles: The calibration can be standardized within 1 cycle at any time by setting the instrument to zero beat. The calibration of the frequency control dial can be relied upon within ±(1% + 0.5 cycle) after the oscillator has been correctly set to zero beat.

The accuracy of calibration of the frequency-increment dial is ±1 cycle.

Auxiliary dial, 20 to 10,000 cycles: The frequency can be standardized within 1 cycle by setting to zero beat. The calibration of the dial can be relied upon within ±(3% + 10 cycles).

Zero Beat Indicator: The output voltmeter can be used to indicate zero beat.

Frequency Stability: The drift from a cold start is less than 7 cycles in the first hour and is essentially completed within two hours.

Output Attenuator: The output attenuator has six steps from −100 to 0 db with an accuracy of ±1% of the nominal attenuation.

Output Control: For each step of the attenuator the output voltage can be continuously varied from zero to maximum voltage. With two-frequency output, the ratio of the voltages at the two frequencies can be adjusted from less than 0.1 to greater than 10 by means of a control calibrated from 0.1 to 10.

Output Voltage: NORMAL output provides full-scale, open-circuit output voltages of 50 microvolts, 500 microvolts, 5 millivolts, 50 millivolts, 500 millivolts, and 5 volts. HIGH output provides full-scale, open-circuit output voltages from 500 microvolts to 50 volts. When the output voltage is of two frequencies, the indicated voltage is the sum of the voltages at the two frequencies.

For a matched resistive load, the variation of output voltage with frequency is as follows:

f, range *A*, and f_1, ranges *C* and *D*: Between 20 and 20,000 cycles the output voltage varies less than ±0.25 db.

f + 20 kc, range *B*: Between 20 and 35 kilocycles the output voltage varies less than ±0.3 db. It may drop 1 db at 40 kilocycles.

f_2, range *C*: Between 20 and 20,000 cycles the output voltage varies less than ±0.3 db. It may rise 0.75 db at 30 kilocycles.

f_2, range *D*: Between 20 and 10,000 cycles the output voltage varies less than ±0.25 db.

Output Voltmeter: Calibrated in volts output at open circuit and in dbm. Above 10% of full scale, the calibration is accurate within ±5% of the reading.

Output Impedance: 600 ohms, resistive, within ±2%. One side of the output circuit is grounded.

Output Power: HIGH output is 1 watt maximum into a matched load. NORMAL output is 10 milliwatts, maximum, into a matched load.

Harmonic and Intermodulation Distortion: Distortion is not affected by the load impedance or the settings of the output control and attenuator except on HIGH output with the 0 db attenuator position. On HIGH output with the 0 db attenuator position and with a load less than 600 ohms the distortion will be higher than the values quoted below, which apply to all other conditions of load and output settings.

Harmonic Distortion: For NORMAL output the total harmonic content is less than 0.25% from 100 to 8000 cycles. Below 100 cycles the harmonic content increases and may reach 0.5% at 50 cycles. For HIGH output the total harmonic content is less than 1% from 100 to 8000 cycles. Below 100 cycles the harmonic content increases and may reach 2% at 50 cycles.

Intermodulation Distortion: (1) CCIF: Quadratic and cubic distortion for frequencies above 1000 cycles and a difference frequency greater than 100 cycles are each less than 0.15% on NORMAL output and less than 0.5% on HIGH output.

(2) SMPTE: The square root of the sum of the squares of the quadratic and cubic distortion for f_1 between 40 and 300 cycles and f_2 between 1000 and 15,000 cycles is less than 0.5% on NORMAL output and less than 3% on HIGH output.

A-C Hum: Less than 0.1% of the output voltage.

Terminals: Type 938 Binding Posts on panel. 4-terminal socket in back.

Mounting: 19-inch relay rack panel with walnut end pieces.

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles. Power consumption 135 watts.

Tubes:

4—6SL7-GT	1—5R4GY
3—6SA7	1—6Y6-G
2—6V6-GT	1—6SJ7
2—6SN7-GT	1—0D3
1—6J5-GT	1—3-4
1—6H6	

Accessories Supplied: Power cord, multipoint plug, and spare fuses.

Other Accessories Required: For measurements of harmonic and intermodulation distortion the Type 736-A Wave Analyzer is recommended as a detector.

Dimensions: (Width) 19¼ x (height) 17⅞ x (depth) 17⅞ inches, over-all.

Net Weight: 81 pounds.

Type		*Code Word*	*Price*
1303-A	**Two-Signal Audio Generator**	BEGET	**$1050.00**

PATENT NOTICE. See Note 2, page vi.

TYPE 700-A WIDE-RANGE BEAT-FREQUENCY OSCILLATOR

USES: This oscillator is useful for taking selectivity curves on tuned circuits over a wide range of frequencies, for measuring the transmission characteristics of filters, and for testing wide-band systems such as television amplifiers and coaxial cables. The instrument is also an excellent general laboratory oscillator for use as a source for bridge measurements and as a modulator for standard-signal generators.

DESCRIPTION: Two high-frequency oscillators, one fixed and the other variable, feed a detector from which the difference frequency is obtained. The detector is followed by a low-pass filter and a two-stage wide-band amplifier.

Both oscillator circuits are mounted in a heavy, cast-aluminum, divided box to assure uniform heat distribution and good shielding. Two ranges are provided for by changing the frequencies of both the oscillators by a factor of one hundred. A single switch on the panel changes from one range to the other.

Degeneration is employed in the amplifier to minimize hum and distortion, and to equalize the frequency response. Low-pass filters are provided to maintain a high ratio of desired output voltage to beating voltage. A pentagrid mixer tube and a buffer amplifier are used to isolate the two oscillators electrically.

FEATURES: ➔ Covers a wide range of frequencies with single direct-reading control dial.

➔ The frequency variation with dial setting is approximately logarithmic.

➔ An incremental frequency control, also direct reading, can be used to make small variations in frequency at any point.

➔ A low-frequency range has been incorporated into the oscillator for convenience in working at audio frequencies.

➔ A high degree of output voltage stability is obtained by a delayed automatic volume control circuit, which also helps to eliminate variations caused by line voltage fluctuations.

SPECIFICATIONS

Frequency Range: Two ranges are provided: 50 cycles to 40 kilocycles, and 10 kilocycles to 5 megacycles.

Frequency Control: The main dial is direct reading in frequency and carries two approximately logarithmic frequency scales covering the ranges specified above. A frequency range switch is provided for rapidly changing from one range to the other. There is also an incremental frequency control which is calibrated between −100 and +100 cycles on the low range and −10 and +10 kilocycles on the high range. Any frequency change made with this control adds algebraically to the frequency of the main control.

Frequency Calibration: The calibration may be standardized at any time by setting the instrument to zero beat with the zero adjustment control. This adjustment can be made within 5 cycles on the low range or 2 kilocycles on the high range.

After the oscillator has been correctly set to zero beat, the calibration of the main frequency-control dial can be relied upon within $\pm(2\% + 5$ cycles) on the low range and $\pm(2\% + 2$ kilocycles) on the high range. The calibration of the incremental frequency dial is within ±5 cycles or ±500 cycles on the low and high ranges, respectively.

Frequency Stability: Through careful design adequate thermal distribution and ventilation are provided for minimizing frequency drifts. The oscillator can be accurately reset to zero beat at any time, thereby eliminating errors caused by any small remaining frequency drift.

Output Impedance: The output is taken from a 3500-ohm Ayrton-Perry-wound potentiometer. One output terminal is grounded.

Output Voltage: The maximum open-circuit output voltage of the oscillator is greater than 10 volts. Because of the automatic volume control circuit, this voltage remains constant within ±1.5 decibels over each entire frequency range.

Waveform: The total harmonic content of the open-circuit voltage is less than 4% for frequencies above 300 cycles on the low range.

A-C Hum: When the oscillator is operated at any supply frequency from 40 to 60 cycles, the power-supply ripple is less than 1% of the output voltage on either range.

Voltmeter: A vacuum-tube voltmeter circuit is used in the oscillator for measuring the output voltage. The indicating meter on the panel is calibrated directly in volts at the output terminals.

Controls: In addition to the main frequency-control dial and the incremental frequency dial, there is a frequency range switch, and a zero beat adjustment. The output voltage is varied by a potentiometer control provided near the output terminals.

Terminals: The output terminals are jack-top binding posts with standard ¾-inch spacing. The lower terminal is grounded to the panel and shields.

Mounting: The instrument is normally supplied for table mounting, but can be easily adapted for relay-rack mounting by removing two walnut frames at the ends of the panel.

Power Supply: A-C power supply, 105 to 125 volts, 40 to 60 cycles, is used. A simple change in the connections to the power transformer allows the instrument to be used on 210 to 250 volts.

The total power consumption is approximately 85 watts.

Tubes: The following tubes are used:

2—6J5-GT/G	2—25L6
1—6J7	1—6H6
1—6L7	1—5U4-G
1—Type 2LAG-949	

All tubes are supplied.

Accessories Supplied: Power cord, spare neon lamp, spare fuses, and one Type 274-ND Shielded Plug.

Dimensions: Panel, (width) 19 x (height) 10½ inches, depth behind panel, 11 inches.

Net Weight: 57½ pounds.

Type		*Code Word*	*Price*
700-A	**Wide-Range Beat-Frequency Oscillator**	ORGAN	**$700.00**

PATENT NOTICE. See Note 2, page vi.

TYPE 700-P1 VOLTAGE DIVIDER

The Type 700-P1 Voltage Divider extends the readable range of the output voltmeter-potentiometer combination of the Type 700 Oscillator down to 100 microvolts. It is also recommended for use with the Type 1390-A Random-Noise Generator to obtain low output levels. The voltage divider consists of a ladder-type resistive network, mounted in a metal container, which is connected to the oscillator output by means of a shielded plug and cable. Multiplying factors of 0.1, 0.01, 0.001, and 0.0001 can be selected.

Measurements on high-gain, wideband systems are possible because the frequency characteristic of the divider is flat within 10%, for all settings at frequencies up to 5 megacycles.

SPECIFICATIONS

Accuracy: The accuracy of attenuation at low frequencies is $\pm3\%$.

Impedance: The input impedance is 2000 ohms; the output impedance is 200 ohms.

Dimensions: (Height) 4½ x (diameter) 4½ inches.

Net Weight: 1½ pounds.

Type		*Code Word*	*Price*
700-P1	**Voltage Divider**....................	OTTER	**$50.00**

TYPE 1301-A LOW-DISTORTION OSCILLATOR

USES: The Type 1301-A Oscillator was designed particularly for use as a tone source for distortion measurements and as a power source for bridge measurements at audio frequencies. It is also satisfactory for use as a general-purpose laboratory oscillator.

The output frequencies include those recommended by the FCC for distortion measurements on broadcast transmitters. This oscillator is thus ideal for use with the Type 1932-A Distortion and Noise Meter for rapid distortion measurements.

The unusually pure waveform delivered by this oscillator at low frequencies makes distortion measurements possible at low frequencies.

DESCRIPTION: The oscillator is of the resistance-capacitance type and uses an inverse feedback circuit developed by the General Radio Company. Separate feedback networks control the frequency and amplitude independently, thus providing high stability and low distortion.

The degenerative feedback which controls the frequency is obtained by means of a parallel-T network including mica capacitors and wire-wound resistors. The regenerative network includes an automatic control system whereby a high degree of stability is obtained together with low harmonic distortion, without requiring any manual feedback adjustments.

The desired frequency is selected by push-button switches. Another push-button switch selects the output impedance. A control is provided for adjusting the output voltage.

FEATURES: ➔ Very low distortion.

➔ A high degree of frequency stability. The frequency stability makes this oscillator particularly adaptable for use with distortion meters employing R-C null networks.

➔ Instant selection of any one of 27 frequencies from 20 to 15,000 cycles by push-button control.

➔ Any other desired frequency within the normal range can be obtained by the use of plug-in resistors.

➔ An internal range-extension unit, the Type 1301-P1, is available which plugs into the oscillator and provides a multiplying factor of 0.1 for all frequencies. The frequency range is thus extended downward by a full decade to cover from 2 to 15 cycles.

SPECIFICATIONS

Frequency Range: 27 fixed frequencies between 20 and 15,000 cycles.

Frequency Control: The frequency is controlled by two push-button switches. The first provides frequencies of 20, 25, 30, 40, 50, 60, 75, 100, and 150 cycles, while the second multiplies these frequencies by 1, 10, and 100. The frequencies included cover practically the entire audible range in approximately logarithmic increments.

The Type 1301-P1 Range Extension Unit is available to provide a multiplying factor of 0.1 (see price list on next page). This range extension unit plugs directly into jacks provided inside the oscillator.

Frequency Calibration: Each instrument is adjusted within ±(1½% + 0.1 cycle).

Frequency Stability: The internal voltage regulator eliminates frequency changes resulting from changes in plate supply. Changes in load have no effect upon the frequency. The frequency drift is not greater than 0.02% per hour after the first 10 minutes of operation.

Output Impedance: Three output circuits are provided. Selection among them is obtained by means of a push-button switch on the panel. The output impedances are as follows:

1. 600-ohm balanced to ground.
2. 600-ohm unbalanced.
3. 5000-ohm unbalanced.

The volume control is a potentiometer in the 5000-ohm circuit. The actual output impedance of the 5000-ohm circuit will vary between 1000 and 6000 ohms, depending upon the setting of the volume control. Suitable resistance pads keep the impedance of the 600-ohm output circuit essentially constant, regardless of the volume control setting. The 600-ohm balanced output circuit is balanced at all frequencies when operating into a balanced load of any impedance.

Output Power: 18 milliwatts into 600-ohm load, or 6.6 volts open circuit; 100 milliwatts into 5000-ohm load, or 30 volts open circuit. The output voltage, for either impedance position, will remain constant within ±1 db throughout the frequency range.

Waveform Distortion:

5000-ohm output: — Not more than 0.1% between 40 and 7500 cycles.
Not more than 0.15% at other frequencies.

600-ohm output: — Not more than 0.1% between 50 and 7500 cycles.
Not more than 0.25% between 20 and 50 cycles.
Not more than 0.15% above 7500 cycles

When the range extension unit is used, distortion will be less than 1%.

Temperature and Humidity Effects: The operation of the instrument is substantially independent of climatic changes in temperature and humidity. Under extremely high temperature and humidity the two highest frequencies may be affected somewhat during the warm-up period of the instrument.

Power Supply: 105 to 125 (or 210 to 250) volts, 25 to 60 cycles ac. The total power consumption is approximately 45 watts. Specify line frequency when ordering.

Tubes:

1—6Y6-G
1—6SJ7
1—6SK7
1—6SQ7
1—2LAG-3
1—6X5
1—6B4-G
1—6SL7-GT
1—0D3

Terminals: Jack-top binding posts with standard ¾-inch spacing and standard Western Electric double output jack are provided on the panel. A ground terminal is also provided. A standard multipoint connector provides duplicate output terminals on the rear of the instrument for relay-rack installation. These terminals are disconnected when a plug is inserted in the Western Electric-type panel jack.

Accessories Supplied: Power cord, multipoint connector, and spare fuses.

Mounting: The instrument is relay-rack mounted. End frames are available to adapt the instrument for table mounting. (See price list below.)

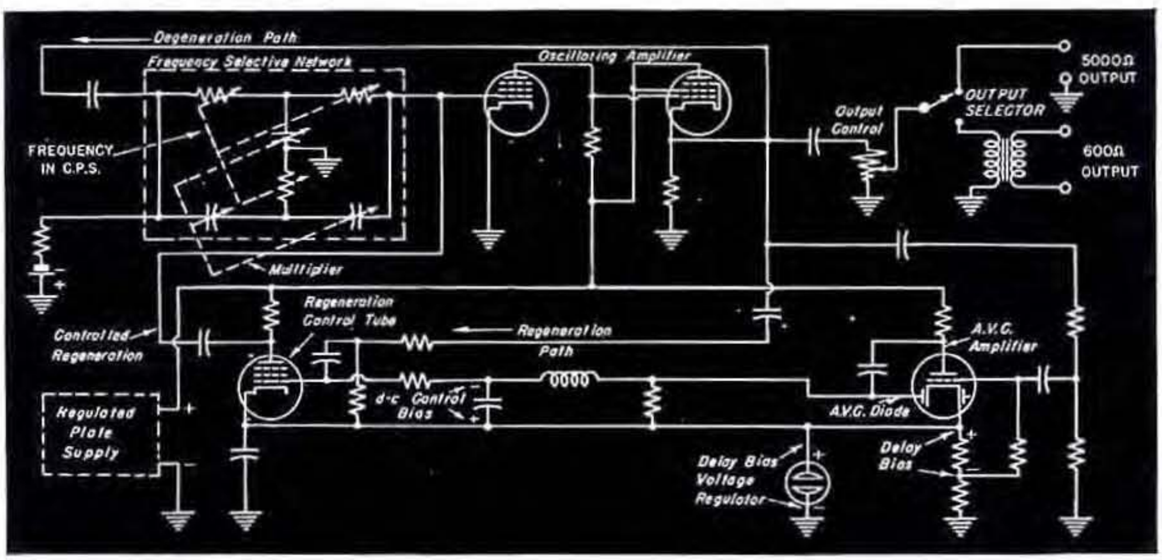
Panel Finishes: Standard General Radio black crackle. Certain standard grays which can be processed in quantity can be supplied at a price increase of $11.00.

Dimensions: Panel (length) 19 x (height) 7 inches; depth behind panel, 12 inches.

Net Weight: 31½ pounds.

Type		*Code Word*	*Price*
1301-A	Low-Distortion Oscillator	OZONE	$425.00
1301-P1	Range Extension Unit (2 to 15 c.p.s.)	OVATE	80.00
FRI-412	Aluminum End Frames	ENDFRAMDIG	10.00 Pair

PATENT NOTICE. See Notes 2, 9, page vi.



TYPE 1302-A OSCILLATOR

USES: The TYPE 1302-A Oscillator is a convenient source of power for bridges and other networks especially where the frequency range needed extends beyond the normal limit of audio oscillators into the supersonic range. It is particularly recommended for use with the TYPE 716-C Capacitance Bridge. The entire audio spectrum is covered down to 10 cycles and the upper frequency limit of 100,000 cycles extends far enough into the radio-frequency range to overlap the low end of r-f generators. The oscillator can be used on either balanced or unbalanced systems.

DESCRIPTION: This instrument is a resistance-tuned oscillator employing an inverse feedback circuit. The frequency-determining network is a Wien bridge, in which the capacitive elements are controlled by the main frequency dial, and two resistive elements are selected by a range switch.

The amplitude of oscillation is held constant by using a second bridge section, one arm of which is a non-linear resistance. A buffer amplifier is inserted ahead of the output level control to minimize reaction on the oscillator frequency.

The output amplifier is arranged to provide balanced-to-ground output for 600-ohm loads as well as unbalanced output for 300- or 5000-ohm loads. The circuit design is such that considerable variations in load values from these nominal outputs can be tolerated without appreciably increasing the distortion.

FEATURES: ➔ Wide frequency range, extending from 10 cycles to 100,000 cycles.

➔ Frequency multiplier is arranged in convenient decade steps.

➔ Excellent frequency stability is obtained by means of the bridge-type feedback circuits.

➔ Harmonic distortion has been kept low.

➔ A semi-logarithmic scale eliminates crowding at the low-frequency end and still allows the high frequencies to be set with the same precision as the low frequencies.

➔ Voltage regulation in the power supply removes effects of line-voltage transients and allows the instrument to operate from a wide range of supply voltages.

SPECIFICATIONS

Frequency Range: 10 to 100,000 cycles, in four ranges. Each range covers a decade (10-100 cycles, 100-1000 cycles, 1000-10,000 cycles, and 10,000-100,000 cycles) continuously variable.

Frequency Control: The main control dial is engraved from 10 to 100 cycles over a scale length of approximately 8¾ inches. Four multiplier switches multiply the scale frequencies by 1, 10, 100, or 1000.

Frequency Calibration: Each instrument is adjusted within ±(1½% + 0.2 cycle).

Frequency Stability: The warm-up drift is less than 1% in the first ten minutes and is less than 0.2% during the next hour.

Output Impedance: Two output circuits are provided, balanced 600 ohms and unbalanced 5000 ohms.

The internal impedance of the 600-ohm output is constant at 550 ohms unless the LOW output terminal is connected to ground by means of the strap provided on the panel. The output impedance is then halved and the output is unbalanced to ground.

The 5000-ohm output position is intended for 5000-ohm loads, unbalanced to ground, although the effective internal impedance of the oscillator averages about 400 ohms in this position.

Output Voltage: Approximately 20 volts open circuit on 5000-ohm output, and 10 volts open circuit on 600-ohm output. The output voltage is constant within ±1.0 db over the entire frequency range.

Output Power: A maximum power output of 80 milliwatts can be obtained into an unbalanced 5000-ohm load. A maximum of 40 milliwatts can be obtained into a balanced-to-ground 600-ohm load (20 milliwatts into an unbalanced 300-ohm load).

Waveform: Harmonic content is less than 1% for all output values and at all frequencies within its range.

A-C Hum: 5000 Ω output, 24 millivolts, maximum. 600 Ω output, 12 millivolts, maximum.

Terminals: Jack-top binding posts with standard ¾-inch spacing. The separate ground terminal has a strap which can be used to ground the LOW output terminal. Output is also available at a multi-point connector at the rear of the instrument. A mating connector is supplied.

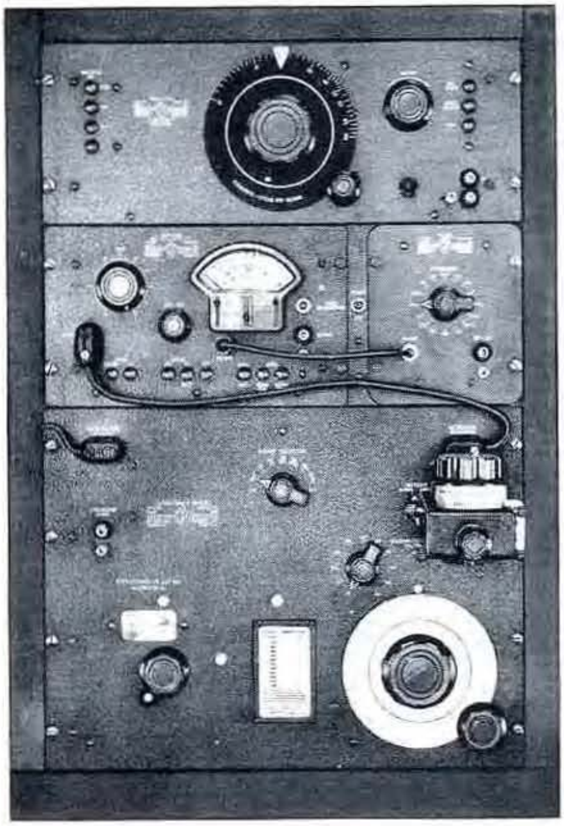
Mounting: The instrument is normally supplied for relay-rack mounting, but can be easily adapted for table mounting by the addition of two frames at the ends of the panel (see price list below).

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles.

Total power consumption is about 90 watts.

Tubes: The following tubes are used and are all supplied with the instrument.

2—6SL7-GT	1—6V6
2—6B4-G	1—6J5
1—6AK6	1—5V4-G
1—6F6	1—0D3



A dielectric measurement assembly using the TYPE 1302-A Oscillator as the generator. The other instruments in the assembly are the TYPE 1231-BRFA Amplifier and Null Detector, the TYPE 716-C Capacitance Bridge, and the TYPE 1690-A Dielectric Sample Holder.

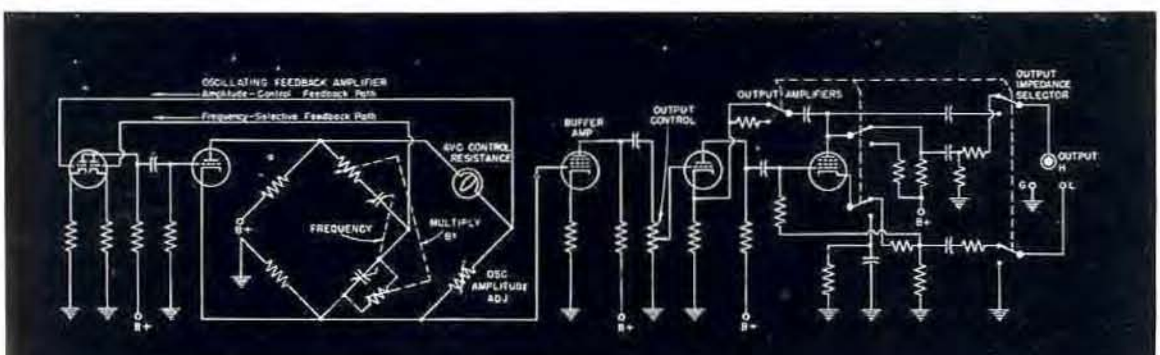
Accessories Supplied: A line connector cord, TYPE 274-ND Shielded Plug, spare fuses and multipoint connector.

Dimensions: (Length) 19⅜ x (height) 7½ x (depth) 14¼ inches, over-all.

Net Weight: 30 pounds.

Type		*Code Word*	*Price*
1302-A	Oscillator	FINAL	$375.00
FRI-412	Aluminum End Frames	ENDFRAMDIG	10.00 Pair

PATENT NOTICE. See Notes 1, 2, 9, 15, page vi.



TYPE 1330-A BRIDGE OSCILLATOR

USES: The Bridge Oscillator is a stable, variable-frequency source of power for bridge and other measurements at audio and radio frequencies. It supplies three fixed audio frequencies and a wide range of radio frequencies, continuously adjustable, with power output sufficiently high for most laboratory measurements. It covers the frequency range of the TYPE 916-A and TYPE 916-AL Radio-Frequency Bridges and the TYPE 821-A Twin-T. At audio frequencies it can be used with the TYPE 716-C Capacitance Bridge, the TYPE 667-A Inductance Bridge, and the TYPE 561-D Vacuum-Tube Bridge. Its maximum power output of one watt is adequate for most resonant circuit measurements. The TYPE 1330-A Bridge Oscillator is an economical general-purpose laboratory source of maximum utility and adaptability.

DESCRIPTION: Both the circuit and the mechanical construction of the Bridge Oscillator are similar to those used in the TYPE 1001-A Standard-Signal Generator (page 126), but a higher power oscillator tube is used, and the aperiodic output stage has been omitted. Tuning capacitor and inductors are ruggedly constructed to assure frequency stability; the oscillator circuits are doubly shielded to minimize stray fields; and a modulating circuit of unusual design provides excellent modulation characteristics over the radio-frequency range.

Modulation is available at two audio frequencies and at two levels, selected by a switch.

Output terminals are TYPE 874 Coaxial Connectors, and coaxial cables and adaptors are supplied to permit complete shielding from the oscillator to the measuring circuit.

FEATURES:
- ➔ Wide frequency range.
- ➔ One watt output over much of the radio-frequency range.
- ➔ Excellent shielding.
- ➔ Good frequency stability and low distortion.

The TYPE 1330-A Bridge Oscillator used as a source for the TYPE 821-A Twin-T Impedance-measuring circuit.

View of the oscillator unit removed from the cabinet. The servicing cable is shown coiled in its storage position. This cable makes possible the operation of the r-f section when it is removed from the cabinet for complete servicing.

SPECIFICATIONS

Frequency Range: Three fixed audio frequencies (power line frequency, 400 c, and 1000 c) and a continuous frequency spectrum from 5 kc to 50 Mc in eight direct-reading ranges as follows: 5 to 15 kc, 15 to 50 kc, 50 to 150 kc, 150 to 500 kc, 0.5 to 1.5 Mc, 1.5 to 5 Mc, 5 to 15 Mc, and 15 to 50 Mc.

Frequency Accuracy: ±5% for the 400- and 1000-cycle fixed frequencies, ±2% for the carrier frequencies above 150 kilocycles, and ±3% for the carrier frequencies below 150 kilocycles under no-load conditions. A 50-ohm resistive load may cause a frequency shift of as much as ±5% at some of the lower carrier frequencies; above 150 kilocycles, the frequency shift due to a 50-ohm load is usually less than +1%. From 5 kilocycles to 15 Mc, the dial calibration is logarithmic.

Incremental-Frequency Dial: The slow-motion dial indicates frequency increments of 0.1% per division from 5 kc to 15 Mc.

Output Voltage and Power: The AUDIO output jack provides a fixed voltage output of about 12 volts open circuit, or a power output of about ¾ watt into a matching 50-ohm load; the output at the R-F jack is controlled by the R-F control, and supplies adjustable output for the 5 kc to 50 Mc range; over the mid-frequency range, the open circuit output voltage is about ten volts and the output power into a 50-ohm load (output control at maximum) is about one watt. The output falls off at the upper and lower ends of the frequency spectrum.

Output Impedance: 50 ohms at the AUDIO jack; between 20 and 80 ohms, depending on frequency, at the R-F jack when the 300-ohm output control is at maximum.

Modulation: The R-F range (15 kc to 50 Mc) can be internally amplitude-modulated at either 400 c or 1000 c at the two modulation levels of approximately 30% and 60%. There is no provision for external modulation.

Envelope Distortion: Less than 6% at the 60% modulation level; less than 3% at 30% modulation.

R-F Distortion: 3% over most of the range; at the lower radio frequencies it is about 6%.

A-F Distortion: Approximately 5% at 400 and 1000 cycles.

Leakage: Stray fields at 1 Mc are about 50 μv per meter at two feet from the oscillator. With the instrument out of its cabinet, the stray field may be greater by a factor of ten.

Controls: A switch for selecting between AUDIO (LINE, 400 c, or 1000 c) and R-F output (CW or MODulated — 400 c, or 1000 c); a switch for selecting between HIGH and LOW modulation; a voltage divider for controlling the R-F output; a range switch; a calibrated dial and a vernier dial for setting the radio frequency; a power switch.

Accessories Supplied: Type 874-R21 3-foot Coaxial Cable, Type 874-Q2 Adaptor, Type 874-Q7 Adaptor, Type TO-44 Adjustment Tool (stored in cabinet), spare fuses, and a power cord.

Mounting: Aluminum panel finished in black-crackle lacquer. Aluminum cabinet is finished in black wrinkle and is provided with carrying handles. Cabinet can be removed for relay-rack mounting.

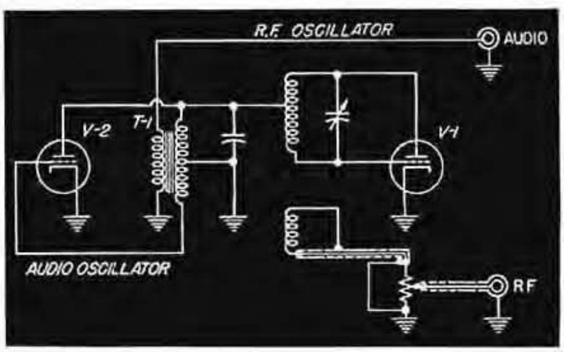
Power Supply: 115 (or 230) volts at 40 to 60 cycles. The power input is about 30 watts.

Tubes: Supplied with the instrument: Two 6AQ5-type tubes and one 6X4-type tube.

Terminals: Type 874 Coaxial Terminals are provided for both the AUDIO output and the R-F output.

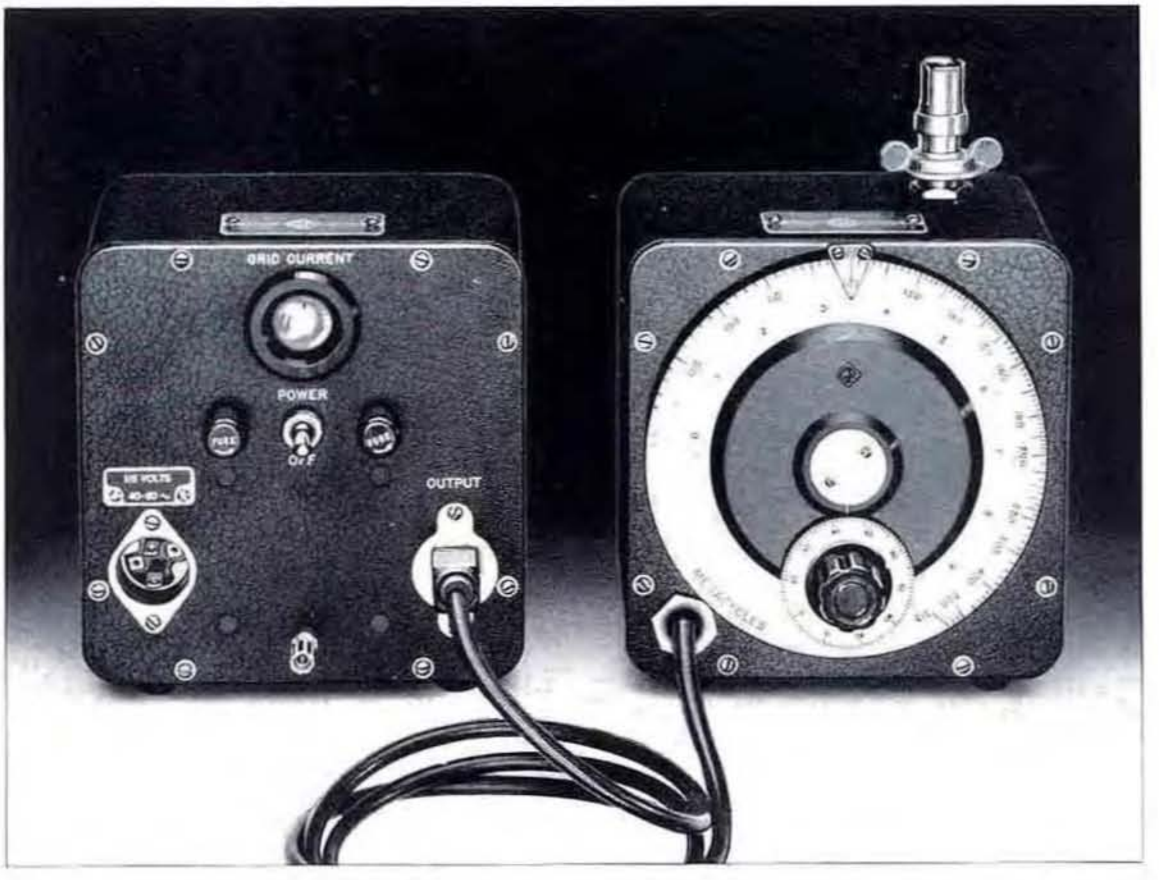
Dimensions: (Height) 7½ x (width) 21¾ x (depth) 11¼ inches, over-all.

Net Weight: 37½ pounds.



Type		*Code Word*	*Price*
1330-A	**Bridge Oscillator**	ACORN	**$525.00**

PATENT NOTICE. See Notes 2, 3, 4, page vi.



TYPE 857-A U-H-F OSCILLATOR

100 Mc to 500 Mc

USES: The TYPE 857-A U-H-F Oscillator is a power source for measurements and testing in the frequency range between 100 Mc and 500 Mc.

DESCRIPTION: The oscillator consists of a butterfly-type tuned circuit and a W. E. 316-A Vacuum Tube, enclosed in a metal housing that provides a moderate amount of shielding. The a-c power-supply unit is in a separate cabinet.

Output is obtained at a coaxial jack on the side of the cabinet. Output coupling is inductive and can be varied continuously from maximum to practically zero.

The main dial is calibrated directly in megacycles. The vernier dial carries 100 uniform divisions and covers the tuning range in about 10 revolutions. An auxiliary scale indicates revolutions of the slow-motion dial.

Filament and plate power are supplied by the TYPE 857-P1 Power Supply. A 3-conductor shielded cord of 6-foot length, permanently connected to the oscillator, plugs into the power supply unit.

FEATURES:
- ➔ Delivers at least 0.25 watt over a wide frequency range.
- ➔ Single-dial control.
- ➔ Direct-reading in frequency.
- ➔ Slow-motion drive facilitates precise settings.
- ➔ Negligible backlash — rotor shaft runs in ball bearings.
- ➔ Butterfly circuit eliminates sliding contacts.
- ➔ Small size — light weight.

SPECIFICATIONS

Frequency Range: 100 Mc to 500 Mc.

Frequency Calibration: The frequency dial reads directly in megacycles with an accuracy of ±1%. Replacement of the vacuum tube may cause a shift in the calibration. A trimmer capacitor is provided to compensate for variations in tube capacitance.

Output Power: Approximately 0.5 watt maximum.

Output Coupling: Adjustable from zero to maximum by rotating the output terminal or by moving it in or out. Wing nut locks jack in any desired position. Output terminal is a Type 874 Coaxial Connector.

Output Impedance: The output system, with its adjustable coupling, is adapted for use with coaxial lines. Maximum power can be delivered to load impedances in the range normally encountered in coaxial systems.

Power Supply: Filament and plate power is furnished by the Type 857-P1 Power Supply, which is mounted in a separate cabinet with connecting cord and plug. The plate voltage supplied by this unit is fixed at the maximum value for safe operation of the tube. It operates from a 105- to 125-volt (or 210- to 250-volt) a-c line, 40 to 60 cycles. The power input is about 60 watts.

Oscillation Indicator: An electron-ray tube is provided in the Type 857-P1 Power Supply to indicate grid current and thus furnish an indication of oscillation.

Tubes: 316-A (oscillator); 6E5, 5Y3-GT (power supply). All are supplied.

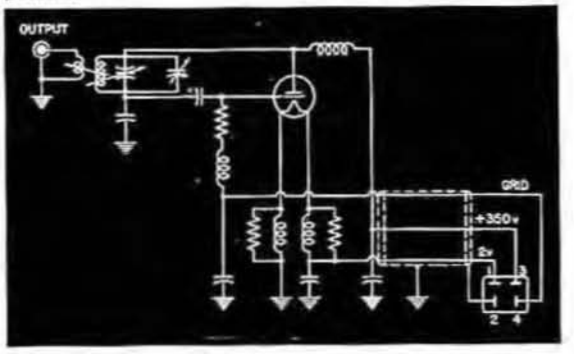
Accessories Supplied: Line connector cord, a Type 874-C Cable Connector and spare fuses.

Accessories Available: Type 1000-P6 Crystal Diode Modulator (page 133), Type 1214-A Unit Oscillator (page 111), Type 874 Coaxial Elements such as attenuators, filters, coupling devices, stubs, volmeter and mixer. See pages 112 to 125.

Mounting: Both oscillator and power supply unit are mounted in metal cabinets. Aluminum panels are finished in black crackle, cabinets in black wrinkle.

Dimensions: Oscillator, $6\frac{7}{8} \times 7\frac{5}{8} \times 7\frac{1}{4}$ inches, over-all; power supply, $5\frac{1}{2} \times 6\frac{3}{4} \times 6\frac{7}{8}$ inches, over-all.

Net Weight: Oscillator, 7 pounds; power supply, $9\frac{1}{2}$ pounds.



Type		*Code Word*	*Price*
857-A	**U-H-F Oscillator (with Power Supply)**	OFTEN	**$300.00**

PATENT NOTICE. See Notes 3, 4, and 10, page vi.

TYPE 1390-A RANDOM-NOISE GENERATOR

USES: The Random-Noise Generator is useful as a source for room acoustics measurements, loudspeaker and microphone tests, psycho-acoustic tests, filter tests, cross talk measurements for multichannel carrier systems, interference tests, noise figure measurements, meter testing, and modulating signal generators and test oscillators. A pair of these generators can also be used as sources for illustrating various degrees of correlation, the fluctuations of random sampling, and some other points in statistical theory.

DESCRIPTION: The Type 1390-A Random Noise Generator uses a gas-discharge tube as the noise source. A magnetic field is applied to the tube to eliminate the oscillations usually associated with a gas discharge. The noise output is amplified in a two stage amplifier. Between the first and second stage the noise spectrum is shaped in three different ways depending upon the setting of the range switch. The 20-kc setting puts in a low-pass filter which has a gradual roll-off above about 30 kc with the audio range to 20 kc uniform in spectrum level. The 500-kc setting puts in a low-pass filter that rolls off above 500 kc. The 5-Mc setting puts in a peaking network that approximately compensates for the drop in noise output from the gas tube at high frequencies so that a reasonably good spectrum is obtained out to 5 Mc.

FEATURES: ➜ A wide range of frequencies is covered.

➜ The over-all output level is relatively high.

➜ The spectrum level for audio frequencies is high and uniform over the audio range.

➜ A meter to indicate the over-all level is provided.

➜ A wide range of output levels can be obtained by using the Type 700-P1 Voltage Divider as an output control. (See page 145.)

SPECIFICATIONS

Frequency Ranges: Three bands of noise as selected by a switch are provided:

(a) 20 kc: The spectrum level is uniform from 30 c to 20 kc within ±1 db.

(b) 500 kc: The spectrum level is uniform from 30 c to 500 kc within ±3 db.

(c) 5 Mc: The spectrum level is uniform from 30 c to 500 kc within ±3 db and from 500 kc to 5 Mc within about ±8 db.

Output Voltage: The maximum open-circuit output voltage on any of the three bands is about 1 volt rms.

The average spectrum level with 1 volt output is approximately as follows:

(a) 20 kc band; 6 millivolts for one-cycle band.

(b) 500 kc band: 1 millivolt for one-cycle band.

(c) 5 Mc band: 0.5 millivolt for one-cycle band.

The Type 700-P1 Voltage Divider (page 145) can be used with this instrument to provide low output levels. It has

multiplying factors of 0.1, 0.01, 0.001, and 0.0001.

Output Impedance: The source impedance for maximum output is approximately 800 ohms. The output is taken from a 2000-ohm potentiometer. One output terminal is grounded.

Waveform: The noise source is a gas tube that has a very good normal, or Gaussian, distribution of amplitudes for limited ranges of the frequency spectrum. For the 20-kc range, this distribution is modified only slightly by the unavoidable amplitude limitations of a vacuum-tube amplifier. Moderate clipping occurs on the 500-kc range and on the 5-Mc range.

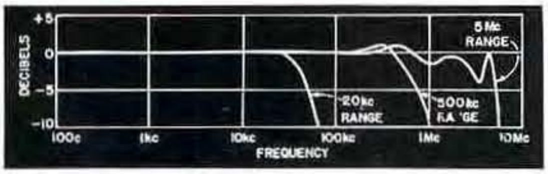
Voltmeter: A rectifier-type, average meter is used for measuring the output voltage. It is calibrated to read the r-m-s value of the noise at the output terminals.

Controls: Frequency range switch, power switch, output potentiometer, and a 10 : 1 level attenuator.

Terminals: Jack-top binding posts with standard ¾-inch spacing. The lower terminal is grounded to the panel.

Accessories Supplied: Power cord, spare fuses.

Other Accessories Recommended: Type 700-P1 Voltage Divider (page 145), for obtaining low output levels.



Typical Spectrum Level Characteristics for Type 1390-A Random-Noise Generator.

Mounting: Metal cabinet.

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles. Total power consumption is about 50 watts.

Tubes: The following tubes are used:

1—6D4 2—6AQ5 1—3-4

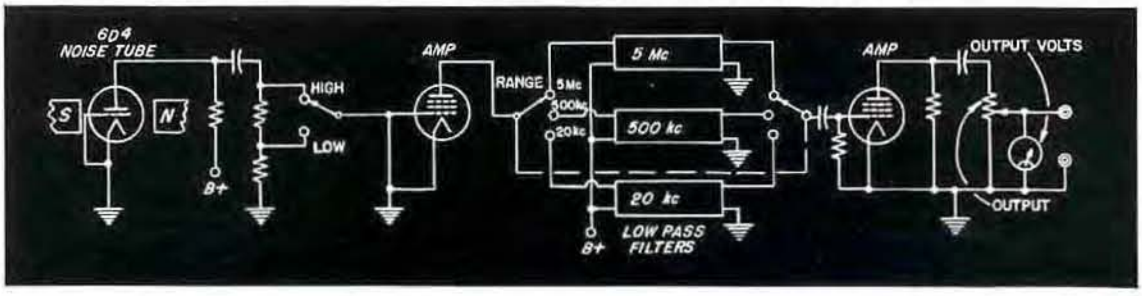
All tubes are supplied.

Dimensions: (Width) 12 x (height) 7½ x (depth) 9¼ inches, over-all.

Net Weight: 15 pounds.

Type		Code Word	Price
1390-A	Random-Noise Generator	BUGLE	$275.00

Elementary schematic circuit diagram of the Type 1390-A Random Noise Generator.



TYPE 869-A PULSE GENERATOR

USES: The pulse generator is intended for use in tests on circuits designed to pass short electrical pulses. It generates pulses of either positive or negative polarity, whose width can be set to any value between 0.3 and 70 microseconds and whose repetition rate can be controlled between 20 and 4000 cycles per second from an external a-c source. Complete shielding of the entire instrument makes it useful for pulsing standard-signal generators and similar apparatus, where extremely low voltage levels are encountered.

DESCRIPTION: The microsecond pulses are generated in an output amplifier stage by driving the control grid between the limits of plate-current cutoff and plate-current saturation. Either positive or negative output pulses are provided by switching the load resistance into the cathode or plate circuit. The amplitude of the pulse is continuously adjustable by means of a screen voltage control. A negative bias voltage applied to the grid of this tube maintains the tube in a cutoff condition between pulses. During the pulse period a high positive bias is applied to the grid.

The positive pulse, used to control the output amplifier, is derived from a circuit employing two gas-triodes. The output amplifier grid is coupled to the center point of these series-connected gas-triodes which are, in turn, placed across a capacitor. A positive d-c potential is developed across the capacitor terminals by charging it from the power supply through a suitable series resistance.

When the first gas-triode becomes conducting, the positive capacitor voltage appears across both the output amplifier grid and the other gas-triode. Conduction in the second gas-triode removes the positive voltage from the amplifier grid. Simultaneously, the two gas-triodes now present a low-impedance path across the capacitor and discharge it. When the capacitor terminal voltage falls below a critical value, both gas-triodes deionize and resume their normal non-conducting state. The capacitor then recharges through the series resistor and the circuit is ready for a second pulse operation.

FEATURES: → A continuous range of adjustment on pulse width is obtained by using variable circuit elements in the simple R-C circuit that controls the time delay between the conduction periods of the two gas-triodes.

→ An output voltage is provided for synchronizing a high-speed sweep circuit.

→ A limited phase adjustment is provided between the input and the synchronizing output. This permits adjustment of the timing of the pulse with respect to the high-speed sweep circuit of an external oscilloscope.

→ The timing of the pulse and the sweep circuit can be maintained within a fraction of a microsecond, even at the lowest repetition rates. This condition is necessary if microsecond pulses are to be visible clearly on synchroscopes.

SPECIFICATIONS

Repetition Rate: 20 to 4000 cycles. Pulses longer than 10 microseconds are limited to a maximum frequency of 1000 cycles.

Input Voltage: Between 5 and 10 volts are required for normal control. For improved stability at the lowest frequencies, this may be increased to a maximum of 30 volts.

Input Voltage Waveform: This is not critical, and may vary from a sine wave to a triangular wave. Care must be taken, however, to keep this signal reasonably free from power supply hum voltage.

Synchronizing Output: A clipped sine wave of approximately −160 and +50 peak volts appears across the synchronizing output terminals. This may be used to control the high-speed sweep circuit of a synchroscope that has been provided with suitable triggering amplifiers.

Pulse Amplitude Control: A panel control permits the pulse amplitude to be adjusted from zero to maximum, with a negligible effect upon the pulse waveform.

Pulse Waveform: The pulse is essentially flat-topped, and has an effective rise time of 0.1 microsecond for pulse widths less than 10 microseconds. For longer pulses, the rise time is less than 10% of the pulse width.

Output Selector: A panel switch permits any one of four resistances to be inserted in the output amplifier, and also provides either positive or negative pulses.

Pulse Widths: The output pulse is continuously adjustable over three ranges. These are 0.1–3.0, 3–10, and 10–70 microseconds, respectively. The calibration of these controls is approximately correct over the entire frequency range.

Output Amplitude: See table below.

Phasing Controls: Panel controls are provided to permit adjustable phasing of the output pulse over a limited range, with respect to the voltage obtained at the synchronizing output terminals.

Power Supply: 115 (or 230) volts, 50–60 cycles. A variation of ±10% in the supply voltage will cause a minor variation in the output pulse amplitude, and will generally tend to change the pulse width. For optimum performance, operation at the 115- or 230-volt value is recommended. Power input is 60 watts.

Accessories Required: To drive the generator an a-c source is needed. The General Radio Type 1304-A Beat-Frequency Oscillator is recommended.

Accessories Supplied: A line connector cord, spare fuses and one Type 874-R31 Patch Cord are supplied.

Tubes Supplied with Instrument:

2—6H6	2—884
1—6AC7	1—6SC7
1—6X5	1—6ZY5-G
1—0D3	1—0C3
1—6SN7-GT	1—6L6

Mounting: Metal cabinet.

Dimensions: (Length) 19 x (height) 9¾ x (depth) 12¼ inches, over-all.

Net Weight: 29 pounds.

PEAK OUTPUT VOLTS — OPEN CIRCUIT

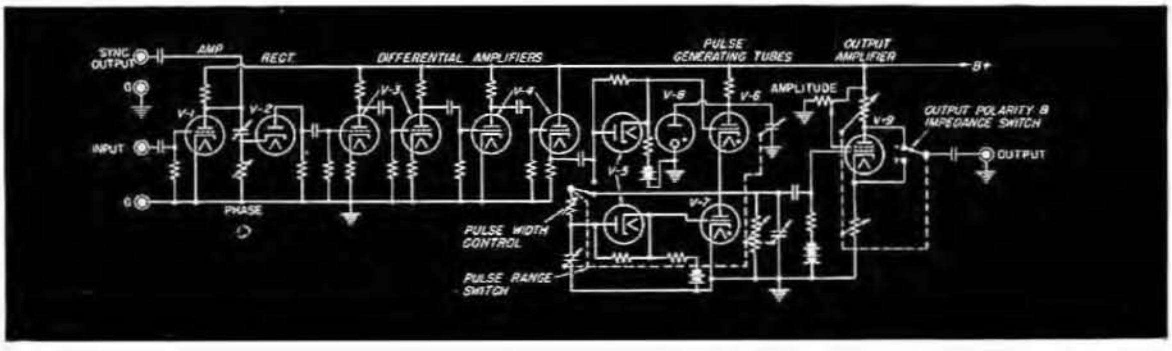
Pulse Polarity / *Output Setting*	*Positive*				*Negative*				*Operating Frequency**
	†20 KΩ	1000 Ω	500 Ω	100 Ω	100 Ω	500 Ω	1000 Ω	†20 KΩ	
Range A	90	80	70	20	18	80	150	300	500 ~
Range B	100	90	80	20	18	90	170	300	500 ~
Range C	100	80	80	20	18	90	180	300	500 ~

*For other operating frequencies, the voltages will be within approximately 20% of the values given above. In general, the open circuit output voltage will tend to decrease as the pulse width and operating frequency increase.

†This position is intended for use with low-impedance pulse transformers.

Type		*Code Word*	*Price*
869-A	**Pulse Generator**	OLIVE	**$350.00**

PATENT NOTICE. See Notes 3 and 4, page vi.



TYPE 723 VACUUM-TUBE FORK

USES: The TYPE 723 Vacuum-Tube Fork is a compact, stable, fixed-frequency oscillator. It is particularly useful as a modulating source for standard-signal generators and beacon transmitters, as a power source for impedance bridges and for transmission measurements on lines and cables, and as a test-tone generator for communication systems. Because of its excellent waveform, it is suitable for use as a test-signal source for many types of distortion measurements. Another important use is as a source of timing pulses for oscillograms.

DESCRIPTION: This instrument is an electromechanical oscillator whose frequency is determined by a vacuum-tube driven tuning fork. The driving and pickup coils are so arranged as to load the tines of the fork equally and to affect only slightly its free vibration.

An a-c power-supply unit is included. This can be removed and batteries installed in the same compartment, for field use in locations where a-c service is not available.

FEATURES: ➔ Excellent accuracy and stability of frequency.
➔ Low harmonic content.
➔ Three output impedances.
➔ A-C operation.
➔ Constant output.

SPECIFICATIONS

Frequencies: Two frequencies are available, 400 and 1000 cycles.

Frequency Stability: The temperature coefficient of frequency is approximately −0.008% per degree Fahrenheit. The frequency is entirely independent of load impedance. An initial downward drift of frequency occurs as the temperature of the fork is affected by heat generated in the power-supply unit. The total frequency drift is of the order of 0.15% to 0.2%. Most of this drift, however, occurs in the first 30 minutes of operation.

The voltage coefficient of frequency is negligible.

Accuracy: The stabilized frequency is adjusted to within ±0.05% of its specified value, at a room ambient of 77° Fahrenheit.

Output: Approximately 50 milliwatts to a matched load.

Internal Output Impedance: 50, 500, and 5000 ohms.

Waveform and Hum Level: The total harmonic content is less than 0.5%. The power supply hum is negligible.

Power Supply: 105- to 125-volt, 40- to 60-cycle line. Power pack can be removed and batteries substituted for field use. For battery operation one Burgess 4FH (1½-volt) and two Burgess Z30NX (45-volt), or equivalent, are required. The ON-OFF switch is arranged to control the a-c line or the battery current.

Vacuum Tubes: 1 — 1A5-GT/G
1 — 0C3

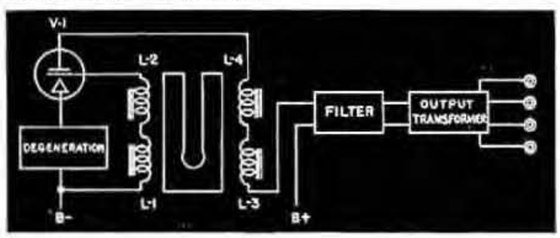
The necessary tubes are supplied.

Accessories Supplied: A line connector cord is supplied.

Mounting: The oscillator assembly is mounted on a phenolic panel and is enclosed in a walnut cabinet.

Dimensions: (Length) 10⅝ x (width) 6¼ x (height) 7¾ inches, over-all.

Net Weight: 9¼ pounds.



Type	*Frequency*	*Code Word*	*Price*
723-C	**1000 cycles**	SOLID	**$165.00**
723-D	**400 cycles**	SULKY	**165.00**

TYPE 813 AUDIO OSCILLATOR

USES: The TYPE 813-A Audio Oscillator is intended for the same general applications as the TYPE 723 Vacuum-Tube Fork, but where the requirements of waveform, stability, and output are not so severe.

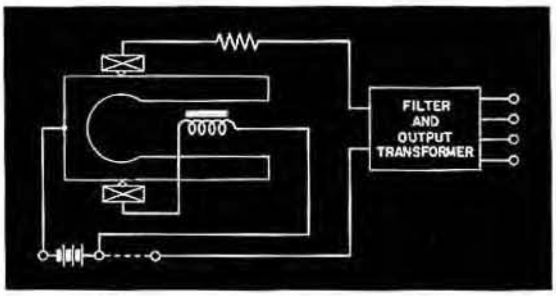
The 400-cycle model, TYPE 813-B is recommended as a power source for TYPE 1552-A Sound-Level Calibrator.

DESCRIPTION: This instrument is a battery-operated electro-mechanical oscillator in which the frequency is determined by a tuning fork. Two microphone buttons, one for the driving circuit and one for the output circuit, are mounted in such a way as to load the tines equally and to affect only slightly the free vibration of the fork.

A filter and output transformer are mounted inside the cabinet underneath the fork. A battery compartment is also provided although external batteries may be used, if desired.

SPECIFICATIONS

Frequency: 1000 cycles or 400 cycles.
Frequency Stability: The temperature coefficient of frequency is −0.008% per degree Fahrenheit. The voltage coefficient is less than 0.01% per volt. The frequency is entirely independent of load impedance.
Accuracy: The frequency is adjusted within 0.5% of its specified value. The actual frequency is measured, at a stated temperature between 70 and 80 degrees Fahrenheit, and recorded on the base of the cabinet to an accuracy of 0.1%.
Output: 20 to 30 milliwatts to a matched load with 6-volt drive and 10 to 15 milliwatts with 4½-volt drive. When the oscillator is operated continuously for several hours, the output may drop below these values.
Internal Output Impedance: 50, 500, and 5000 ohms.



Waveform: The total harmonic content is approximately 0.75% with 4½-volt drive and approximately 1% with 6-volt drive.
Power Supply: For intermittent operation with a moderate power output, an internal 4½-volt battery, Burgess No. 2370, can be used. For greater output or continuous operation, an external battery of 4½ to 6 volts should be used. Batteries are not supplied.
Terminals: Binding posts for external batteries, if used, and for the output circuit are provided on the panel.
Mounting: Phenolic panel and a walnut cabinet.
Dimensions: (Length) 9 x (width) 5 x (height) 6 inches, over-all.
Net Weight: 8½ pounds.

Type	*Frequency*	*Code Word*	*Price*
813-A	**1000 cycles**	ANGEL	**$85.00**
813-B	**400 cycles**	AMUSE	**85.00**

TYPE 572-B MICROPHONE HUMMER

USES: The hummer is intended for use as a low-power a-c source for bridge and other measurements where extreme purity of waveform and frequency stability are not essential.

DESCRIPTION: A tuned reed determines the frequency of oscillation. Feedback is provided through a microphone button mechanically coupled to the base of the reed.

FEATURES: The Type 572-B Microphone Hummer is extremely compact, convenient, simple to use, and inexpensive.

SPECIFICATIONS

Frequency: 1000 cycles ±10%.
Output Power: Approximately 15 milliwatts into a matching load with 4½-volt drive.
Internal Output Impedance: 10 and 300 ohms.
Waveform: Varies with mechanical adjustment, driving voltage, and other operating parameters. Consequently, no definite specifications can be given.
Power Supply: From 4½-volt or 6-volt battery.
Terminals: Soldering lugs are provided.
Mounting: A die-cast mounting base is used.
Dimensions: (Length) 3¼ x (width) 2⅛ x (height) 1⅝ inches, over-all.
Net Weight: 9 ounces.

Type		*Code Word*	*Price*
572-B	**Microphone Hummer**	APHIS	**$15.00**

TYPE 1932-A DISTORTION AND NOISE METER

USES: The TYPE 1932-A Distortion and Noise Meter measures distortion, noise, and hum level in audio-frequency circuits. In conjunction with the TYPE 1931-A Modulation Monitor or the TYPE 1170-A F-M Monitor, it can be used to measure these quantities directly in the output of radio broadcasting transmitters. It finds many uses in the communications laboratory and in the production testing of radio receivers as a wide-range, highly sensitive voltmeter for such measurements as signal-to-noise ratio, AVC characteristics and hum level.

DESCRIPTION: The principal elements of the distortion and noise meter are 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. Degeneration maintains a high degree of stability in amplifier gain and also a flat transmission characteristic except within an octave of the null frequency. The null frequency is continuously variable and is controlled by a dial on the panel. The function of the null network is to eliminate the fundamental of the audio-frequency signal, leaving only the distortion products, which are indicated directly on the panel meter.

The null network is switched out of the circuit for noise and hum measurements, and the instrument then operates as a highly sensitive voltmeter. Two input circuits are provided: (1) a transformer for bridging a 600-ohm line; and (2) a direct connection to the 100,000-ohm gain control.

FEATURES: ➔ Continuous adjustment of frequency over the entire audio range is provided.

➔ Any frequency can be selected quickly, since there is only one main tuning control, with an auxiliary trimmer.

➔ Frequencies up to 45,000 cycles are passed by the amplifier circuits, so that distortion measurements can be made on fundamental frequencies up to 15,000 cycles.

➔ Distortion values as low as 0.1% can be measured, since the lowest range is 0.3% full scale.

➔ An auxiliary dbm calibration is provided on the range switch.

➔ An oscilloscope connection is provided for visual observation of the noise or distortion components.

SPECIFICATIONS

Distortion Range: Distortion is read directly from a large meter. A multiplier allows full-scale deflections for 0.3%, 1%, 3%, 10% or 30% distortion.

Noise Measurement Range: The range for noise measurements extends to 80 db below reference calibration level, or 80 db below an audio-frequency signal of zero dbm level, at maximum sensitivity.

Audio-Frequency Range: 50 to 15,000 cycles (funda-

A relay-rack assembly of broadcast test equipment showing, from top to bottom, TYPE 1931-A Amplitude-Modulation Monitor, TYPE 1932-A Distortion and Noise Meter, and TYPE 1301-A Low-Distortion Oscillator.

mental), for distortion measurements; 30 to 45,000 cycles for noise and hum measurements.

Dbm Range: The power-level range is from +20 to −60 dbm. Full scale values of +20, +10, 0, −10, −20, −30, and −40 dbm are provided. The scale is calibrated in terms of a reference level of one milliwatt in 600 ohms.

Input Voltage Range: The input signal level should be between 1.2 and 30 volts for the 100-kilohm input, and between 0.8 and 30 volts for the 600-ohm bridging input.

Accuracy: For distortion measurements, ±5% of full scale for each range ± residual distortion as noted below; for noise and dbm measurements, ±5% of full scale.

Residual Distortion Level:

100-Kilohm Input: 0.05%, maximum, below 7,500 cycles
0.10%, maximum, above 7,500 cycles

Bridging Input: 0.10%, maximum, between 50 and 70 cycles
0.05%, maximum, between 70 and 7,500 cycles
0.10%, maximum, above 7,500 cycles

Residual Noise Level: Less than −80 db.

Input Impedance: Two input impedances are provided, 100,000 ohms unbalanced, and 600-ohm bridging input (10,000 ohms), balanced or unbalanced.

Meter: A large meter with an easily read, illuminated scale is provided. Percentage and decibel calibrations are included. The ballistic characteristic is similar to that of a VU meter.

Vacuum Tubes: The following tubes are used and are supplied with the instrument:

4—6J5	1—6H6
1—6SN7-GT	1—6X5GT
1—6K6-GT G	2—0D3

Accessories Supplied: Line connector cord and cable for connecting to the TYPE 1931-A Modulation Monitor, and spare fuses.

Other Accessories Required: For measuring the distortion in oscillators and other audio-frequency sources, no additional equipment is required. For measurements on amplifiers, lines, and other communications networks, a low-distortion oscillator is required to furnish the test tone. TYPE 1301-A Low-Distortion Oscillator (see page 144) is recommended. When the modulated output of a radio transmitter is to be measured, a linear demodulator to produce the audio envelope is necessary. The TYPE 1931-A Modulation Monitor (page 186) or TYPE 1170-A F-M Monitor (page 188) is recommended for this purpose. However, any detector system having minimum undistorted output of 1.5 volts rms can be used.

Terminals: Input terminals are provided at the rear of the instrument for direct connection to the modulation monitor. A Western Electric jack is provided at the panel also, as an auxiliary input circuit. Plugging into this jack automatically disconnects the rear connectors.

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles. The line input power is 65 watts. The power supply is voltage regulated. Line surges have no appreciable effect.

Mounting: The instrument is relay rack mounted. End frames are available to adapt the instrument for table mounting. (See price list below).

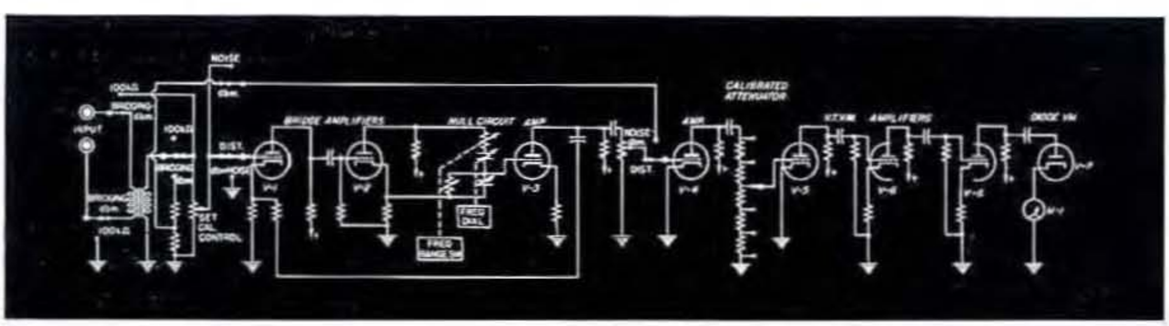
Panel Finishes: Standard General Radio black crackle. Certain standard grays which can be processed in quantity can be supplied at a price increase of $11.00.

Dimensions: Panel (length) 19 x (height) 7 inches; depth behind panel, 12 inches.

Net Weight: 37¾ pounds.

Type		*Code Word*	*Price*
1932-A	**Distortion and Noise Meter**	TABOO	**$595.00**
FRI-412	**Aluminum End Frames**	ENDFRAMDIG	**10.00 Pair**

PATENT NOTICE. See Notes 2, 15, 21, page vi.



TYPE 1932-P1 A-M DETECTOR UNIT

USES: The A-M noise level in F-M transmitters can be measured conveniently with this detector unit, which plugs into jacks on the panel of the TYPE 1932-A Distortion and Noise Meter.

DESCRIPTION: The TYPE 1932-P1 A-M Detector Unit consists of a linear rectifier and an r-f filter, with provision for introducing an audio-frequency calibrating voltage. The detector output, after filtering, is passed through a standard 75-microsecond de-emphasis circuit to the Distortion and Noise Meter. The de-emphasis circuit can be switched out to give a flat characteristic, if desired. A microammeter indicates the diode current.

In operation, any level of unmodulated r-f input within the operating range is applied and the diode current noted. The r-f voltage is then removed, an audio voltage is applied and adjusted to produce the same diode current. At this audio level, the Distortion and Noise Meter is set to full scale in the usual way, after which the audio voltage is removed, the r-f voltage introduced once more, and the a-m noise level read directly from the Distortion and Noise Meter.

FEATURES:
- Makes use of the TYPE 1932-A Distortion and Noise Meter, already available in most stations.
- Audio amplitude control is provided.
- Can be used with or without de-emphasis circuit.
- Plug-in construction for convenience.

SPECIFICATIONS

R-F Input:
50-220 Mc.
4 to 8 volts required, from low-impedance line.
TYPE 774-G Connector.

Audio Input:
400 cycles.
4 to 8 volts required; internal potentiometer is provided.
Input impedance = 1000 Ω.
Standard single-contact telephone-jack connector.

Audio Output:
30-30,000 cycles ±1 db; or 75 μsec de-emphasis characteristic.
1 to 1.5 volts, into 100 kΩ load.
Plugs to fit standard W.E. panel jacks, on TYPE 1932-A Distortion and Noise Meter are provided.

Diode: 1N34-A Crystal.

Terminals: Telephone jack for a-f voltage; coaxial jack for r-f voltage; standard W.E. plug for inserting into Distortion and Noise Meter.

Accessories Supplied: 1 TYPE 774-M Cable Jack.

Mounting: Black wrinkle-finish case.

Dimensions: $5\frac{1}{4}$ x 6 x $2\frac{1}{2}$ inches, over-all.

Net Weight: $1\frac{1}{2}$ pounds.

View of the TYPE 1932-P1 A-M Detector Unit plugged into the panel jacks of a TYPE 1932-A Distortion and Noise Meter. Below the Distortion and Noise Meter is a TYPE 1301-A Low-Distortion Oscillator.

Type		*Code Word*	*Price*
1932-P1	A-M Detector Unit	AMDET	$60.00

TYPE 736-A WAVE ANALYZER

USES: The wave analyzer is used to measure the amplitude and frequency of the components of a steady-state complex electrical waveform. These include not only the components of harmonic distortion, but also those of intermodulation distortion, noise, and hum.

Specific uses of the TYPE 736-A Wave Analyzer include the measurement of distortion components in audio-frequency equipment, broadcast receivers and transmitters, telephone systems, public address equipment, oscillators, amplifiers, and vacuum-tube circuits in general; harmonic studies on electric power systems and electrical machinery; hum measurement in a-c operated communication equipment; noise analysis; and induction studies on telephone lines. As a sharply tuned voltmeter, it is invaluable in the measurement of the transmission characteristics of electric wave filters and as a null detector for impedance bridges. It is an excellent detector for intermodulation distortion measurements using the TYPE 1303-A Two-Signal Audio Generator as a source.

DESCRIPTION: The TYPE 736-A Wave Analyzer is a heterodyne type of vacuum-tube voltmeter. The intermediate-frequency amplifier includes a highly selective filter using three quartz crystals. The use of a heterodyne method makes it possible to vary the response frequency while using a fixed-frequency filter.

The output of the local oscillator and the whole of the complex waveform to be examined are fed to a balanced modulator where their combination produces both the sum and difference frequencies, or side bands, in the output. The original of the complex waveform is not passed by the modulator intermediate-frequency output transformer, and the local oscillator carrier frequency is suppressed in the output because of the two-tube balanced modulator employed.

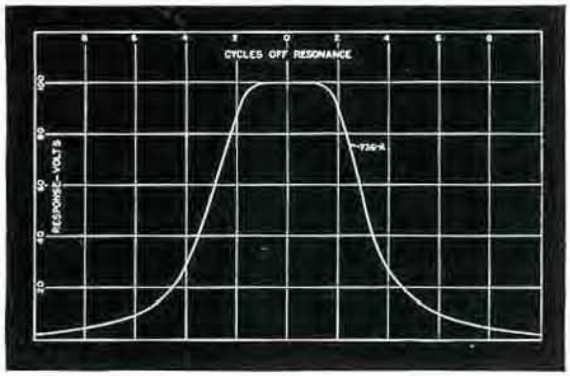
The 50-kilocycle component of the upper side band, proportional to the voltage of that frequency present in the original wave to which the main dial is set, is selected and amplified by the intermediate stages. The adjustable gain control of the amplifier makes it possible to measure a wide range of voltages.

FEATURES: ➔ A "flat top" characteristic as shown by the curve at the right is obtained by using the three-crystal filter. This feature makes tuning easier and increases the stability of the tuning adjustment.

➔ A very wide range of input voltages — 1,000,000 to 1, full scale — can be accommodated directly.

➔ Self-contained calibrating systems make it possible to standardize the voltage and frequency calibrations easily at any time.

➔ The input impedance is constant at 1 megohm, but a built-in 100,000-ohm potentiometer is provided as an alternate input system where absolute voltage levels need not be determined.



Transmission characteristic of the crystal filter in the Type 736-A Wave Analyzer.

➔ External magnetic fields cause no trouble because the balanced modulator is fed by a phase inverter tube, rather than by a transformer.

➔ Humidity effects are minimized by hermetically sealing all critical parts including the crystals.

SPECIFICATIONS

Frequency Range: 20 to 16,000 cycles.

Selectivity: Approximately as shown in plot, above. The response is down 15 db at 5 cycles, 30 db at 10 cycles, 60 db at 30 cycles from the peak. The selectivity is constant over the frequency range.

Voltage Range: 300 microvolts to 300 volts full scale. The lowest division on the meter corresponds to 10 μv. The over-all range is divided into four major ranges: 300 μv to 300 mv, 3 mv to 3 v, 30 mv to 30 v, 0.3 v to 300 v. Each of these ranges is divided into seven scale ranges: for example, the 0.3 v to 300 v range has the following full-scale ranges: 0.3 v, 1 v, 3 v, 10 v, 30 v, 100 v, 300 v.

A direct-reading decibel scale is also provided.

Voltage Accuracy: Within ±5% on all ranges. Spurious voltages from higher order modulation products introduced by the detector are suppressed by at least 70 db. Hum is suppressed by at least 75 db.

Input Impedance: One megohm when used for direct voltage measurements. When used with the input potentiometer it is approximately 100,000 ohms.

Accuracy of Frequency Calibration: ±(2% + 1 cycle).

Vacuum Tubes Required:

3—6C6	1—6C5
2—6K6-GT/G	1—6X5-GT/G
3—6J7	1—6F5-GT/G
1—6B8	3—Type 2LAG-949 neon lamps

These are supplied with the instrument.

Power Supply: A-C line, 105 to 125 volts, 40 to 60 cycles. A change in the power transformer connection permits the use of 210 to 250 volts, 40 to 60 cycles. A voltage-stabilizing circuit is included. Power input is about 65 watts.

Accessories Supplied: Spare neon lamps, spare fuses, one Type 274-NE Shielded Connector, and a line connector cord.

Mounting: Shielded oak cabinet.

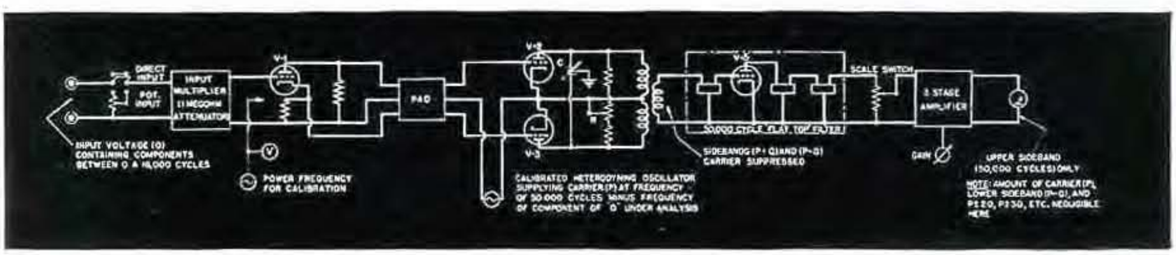
Dimensions: (Width) 19½ x (height) 25⅛ x (depth) 10⅞ inches, over-all.

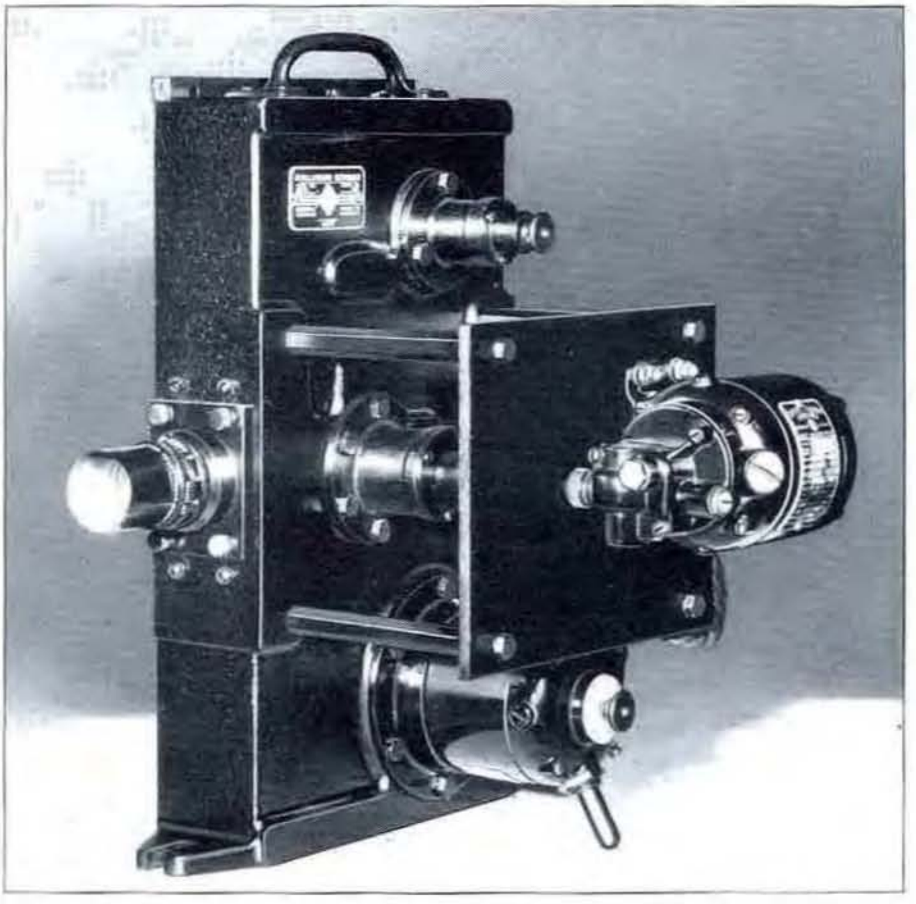
Net Weight: 86¼ pounds.

Type		*Code Word*	*Price*
736-A	**Wave Analyzer**	ASKEW	**$1075.00**

PATENT NOTICE. See Notes 2, 16, 23, page vi.

For other audio-frequency analyzers, see pages 15, 16, and 18.





TYPE 651-AE OSCILLOGRAPH RECORDER

USES: This device is suitable for recording the trace of a cathode-ray oscillograph to obtain an accurate record of transient phenomena. Typical applications are the study of the response of electrical networks to suddenly applied voltages, the recording of switching transients, and the study of the instantaneous variations of voltages and currents in electrical machinery under arbitrary load variations.

DESCRIPTION: In the TYPE 651-AE Oscillograph Recorder the film is driven continuously past the aperture, so that the trace of the horizontally deflected cathode-ray spot is recorded as a continuous line.

A large central driving sprocket and a bottom take-up reel are driven by separate motors. The torque characteristics of the motors are such that the proper film tension is maintained as the film passes from the loading reel to the take-up reel. Focusing is accomplished by viewing the image through the focusing eyepiece when two apertures in the driving sprocket are aligned horizontally. The image forms on a small piece of translucent film which can be located on the sprocket.

FEATURES: ➔ A wide range of film speeds, extending up to 35 feet per second, can be obtained by varying the voltage applied to the driving and take-up motors. With special motors very slow speeds can also be obtained.

➔ The lens mounting is arranged to permit focusing over a wide range of distances. A simple and direct focusing means is provided.

➔ Reels will hold a full 100 feet of film and are interchangeable.

SPECIFICATIONS

Film: Any 35-mm film or paper with standard perforations can be run. Daylight loading and unloading with negligible waste.

Film-Speed Range: When the motors are operated at the voltages mentioned below, film speeds between 5 and 35 feet per second are obtainable. At the highest recommended operating voltage, higher speeds will sometimes be obtained.

Motors geared for lower speed ranges can be supplied on special order.

Lens System: Lens must be purchased separately. A lens of aperture *f* 1.5 and 2-inch focal length in an adjustable mounting that permits focusing for distances between 8 and 100 inches is available, assembled with mounting plate to fit the recorder. (See price list.) The image for focusing is observed directly on the equivalent of a ground glass in the plane of the film. The lens is equipped with an iris diaphragm.

This lens is sufficiently "fast" to permit the recording of traces from a cathode-ray oscillograph on supersensitive panchromatic film at a speed of 35 feet per second, when the ratio of total length along the trace to length of film is less than 5 to 1.

Oscillograph Screen: A low-persistence actinic blue screen, such as one with a P5 or P11 phosphor, should be used for best results.

Reels: Specially made reels for loading and take-up are supplied. Capacity of reels, 100 feet.

Drive System: Both the film-drive sprocket and the take-up reel are driven by universal (a-c or d-c) motors. The film speed is varied by applying voltages between 65 and 200 volts to these motors.

Speed Control: When 115-volt or 230-volt, 50- to 60-cycle service is available, a Type V-5HMT or Type V-5H Variac may be used to vary the voltage applied to the motors. For d-c service, resistance methods of voltage control must be used.

Starting Characteristics: Full operating speed is reached in about approximately 25 feet of film travel at maximum speed. At lower speeds less film is consumed in reaching operating speeds.

Accessories Supplied: A line connector cord.

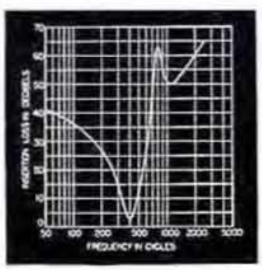
Dimensions: (Length) 11 7/8 x (width) 6 1/2 x (height) 16 1/2 inches, over-all.

Net Weight: 32 pounds.

Type		*Code Word*	*Price*
*651-AE	**Oscillograph Recorder**	DINER	**$600.00***
651-P5	**Lens Assembly, f 1.5 x 2.0"**	DIARY	**165.00**

*Without lens.
PATENT NOTICE. See Note 6, page vi.

TYPE 530-A BAND-PASS FILTER



This filter is designed for use with a 400-cycle oscillator to provide a very pure signal for distortion measurements, and for other applications where only an extremely small harmonic content can be tolerated. It may be used with fundamental frequencies from 375 to 425 cycles, providing an attenuation of at least 50 decibels to all harmonics. In addition considerable attenuation to power-line frequencies is provided.

SPECIFICATIONS

Attenuation Characteristic: (See accompanying curve.) A peak of maximum attenuation is set for rejection of the 800-cycle second harmonic.

Voltage Limit: Voltages up to approximately 3 volts at any frequency may be applied without significantly altering the response curve. At higher voltage levels slight shift in the location of the attenuation peak may be expected.

Mounting: Filters are mounted in standard drawn steel, wax-filled Model D cases.

Dimensions: See dimensioned drawing below.

Net Weight: 8 pounds.

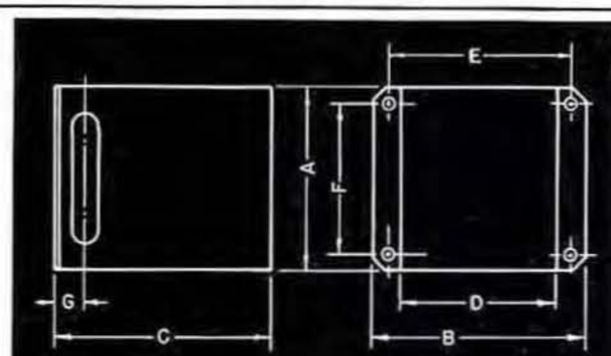
Type	*Impedance*	*Pass Band*	*Code Word*	*Price*
530-A	600 ohms	375 to 425 cycles	FOCAL	$40.00

OTHER FILTERS

Tuned-circuit filters for reducing harmonics in bridge measurements are described on pages 99 and 100. Coaxial-line filters for ultra-high frequencies are listed on page 122.

DIMENSIONS OF FILTER CASES

	MODEL B	*MODEL C*	*MODEL D*
A	2 13/16 inches	3 9/16 inches	5 3/4 inches
B	3 1/8 inches	4 inches	5 1/4 inches
C	4 1/8 inches	4 1/8 inches	5 3/16 inches
D	2 5/16 inches	3 1/16 inches	4 1/4 inches
E	2 3/4 inches	3 1/2 inches	4 3/4 inches
F	1 7/8 inches	2 7/8 inches	4 1/2 inches
G	5/8 inch	5/8 inch	5/8 inch



TYPE 830 WAVE FILTERS

USES: Electric wave filters are widely used for the elimination of harmonics from distorted waveforms, for the isolation of specific components of complex waveforms, and, in general, to remove voltages of undesired frequencies from measuring and communications circuits.

DESCRIPTION: TYPE 830 Wave Filters are compact, two-section filters having exceptionally good characteristics. The sections co-operate to give both a sharp cut-off and high discrimination against frequencies outside the pass band.

The band-pass model, TYPE 830-R, is sharply tuned to pass 1000 cycles with a maximum of attenuation for the second harmonic at 2000 cycles. The input and output coils of this unit are tapped so that the filter can be used with different terminating impedances.

FEATURES: ➔ Low attenuation at cut-off frequency.

➔ Sharp cut-off.

➔ At least 40 db at 3/2 times cut-off frequency and above for high-pass models, and at 2/3 cut-off and below for low-pass models.

➔ An excellent band-pass filter covering one octave may be obtained by using the 500-cycle high-pass and the 1000-cycle low-pass in tandem.

➔ The TYPE 830-R may be worked from either a 500-ohm line or a vacuum tube (plate resistance approximately 5000 ohms) into a circuit of almost any impedance with satisfactory results.

SPECIFICATIONS

Attenuation Characteristic: See accompanying curves.

Voltage Limit: Voltages up to approximately 3 volts at any frequency may be applied to the 500-ohm filter (10 volts for 5000-ohm filter) without significantly altering the response curves. At higher voltage levels, slight shift in the location of the attenuation peaks may be expected.

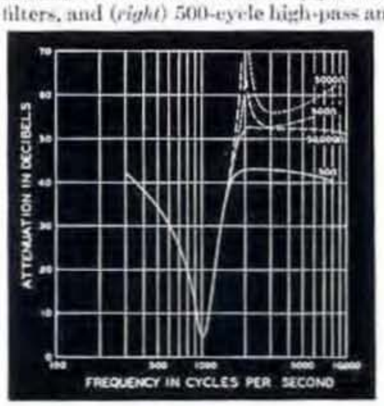
Terminals: TYPES 830-A to 830-H inclusive are provided with both soldering lugs and jack-top binding posts. TYPE 830-R has soldering lugs only.

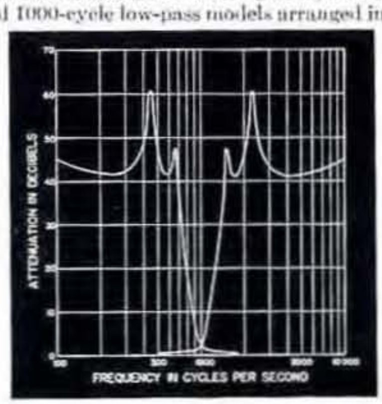
Mounting: TYPE 830-B is mounted in a Model D case. All other models in Model C cases. See dimensions on next page. An extra ¼ inch must be allowed in the depth for the projection of the terminals on all models except TYPE 830-R.

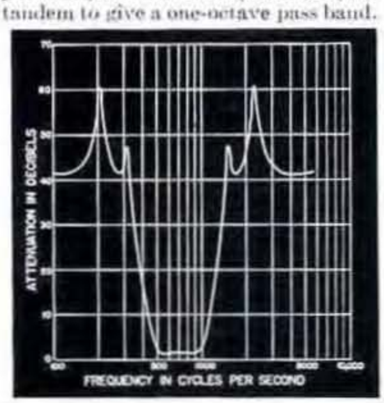
Net Weight: TYPE 830-B, 7½ pounds; all others, 3½ pounds.

Type	*Cut-Off Frequency*	*Impedance*		*Code Word*	*Price*
830-A	500 cycles	500 Ω	Low-Pass	FILTERGOAT	$35.00
830-B	500 cycles	500 Ω	High-Pass	FILTERGIRL	35.00
830-C	500 cycles	5000 Ω	Low-Pass	FILTERSHOE	35.00
830-D	500 cycles	5000 Ω	High-Pass	FILTERSEAT	35.00
830-E	1000 cycles	500 Ω	Low-Pass	FILTERTOAD	35.00
830-F	1000 cycles	500 Ω	High-Pass	FILTERMUSH	35.00
830-G	1000 cycles	5000 Ω	Low-Pass	FILTERSIGN	42.00
830-H	1000 cycles	5000 Ω	High Pass	FILTERPIPE	42.00
830-R	1000 cycles	5000 or 500 Ω to 50,000, 5000, 500 or 50 Ω	Band Pass	FILTERROTE	42.00

Attenuation characteristics of (*left*) TYPE 830-R Band-Pass Filter (*center*) 1000-cycle low-pass and 1000-cycle high-pass filters, and (*right*) 500-cycle high-pass and 1000-cycle low-pass models arranged in tandem to give a one-octave pass band.







METERS

In the following section of the catalog are described general-purpose meters of several types and two specialized instruments, the TYPE 1500-B Counting-Rate Meter and the TYPE 1501-A Light Meter. The general-purpose meters include vacuum-tube voltmeters for the measurement of alternating voltages over very wide ranges of frequencies, crystal-rectifier voltmeters used principally at the higher radio frequencies, oxide-rectifier meters for measuring input voltage and output power, principally in the audio range, vacuum-tube voltmeters for measuring direct voltage where negligible current can be taken from the source, and megohmmeters for the measurement of high resistances ranging up to two million megohms.

Meters of all these types represent pioneer work of the General Radio Company. The first instrument combining a diode peak rectifier with a degeneratively stabilized d-c amplifier to indicate the rectified voltage was introduced in 1937. Advantages of this arrangement are wide frequency range, high inherent stability, a convenient circuit for obtaining a multi-range meter, and a calibration substantially independent of tube characteristics. Voltmeters of this type are now used the world over in every conceivable type of application.

The first megohmmeter was introduced in 1936 and applied the degenerative vacuum-tube d-c meter to the conventional ohmmeter circuit. In this application the degenerative circuit not only gives stability and linearity, but permits a large voltage swing to take place in the grid circuit of the tube and greatly increases the effective input resistance resulting from grid current.

General Radio Company also pioneered in the application of oxide rectifier meters to communication problems. The first constant-resistance output power meter of this kind was introduced in 1929 and was followed by the TYPE 583-A Output Power Meter combining the oxide rectifier meter with a resistive load and a tapped transformer, providing a sensitive power meter for load resistances varying over a range of 8000 to 1. This last instrument is still a popular item in the GR line.

An important group of meters comprises the a-c voltmeters intended for use up through the radio frequency range. These are the TYPE 727-A Vacuum-Tube Voltmeter (battery operated), the TYPES 1800-A and 1803-A Vacuum-Tube Voltmeters (line operated), and the TYPE 1802-A Crystal Voltmeter (battery operated). In addition there is the combination of the TYPE 874-VR Voltmeter Rectifier and 874-VI Voltmeter Indicator described in the Coaxial Elements section of the catalog. It is useful to compare these instruments in regard to upper frequency limit, input resistance and capacitance, sensitivity and voltage range and finally the response to different types of waveforms.

Figure 1 gives the frequency at which resonance in the diode input circuit introduces an error of 10 per cent, and shows curves for the corresponding reduction in the input resistance. The curves are generally similar in shape, and it will be noted that the 10 per cent error point for the vacuum-tube voltmeters occurs at a frequency where the input parallel resistance has dropped to a value of the order of 10 kilohms. The TYPE 727-A instrument has the lowest frequency limit, 100 megacycles, as is to be expected since a separate probe is not employed for the diode. The crystal voltmeters have a higher frequency limit but lower input resistance. All the meters are useful for comparison measure-

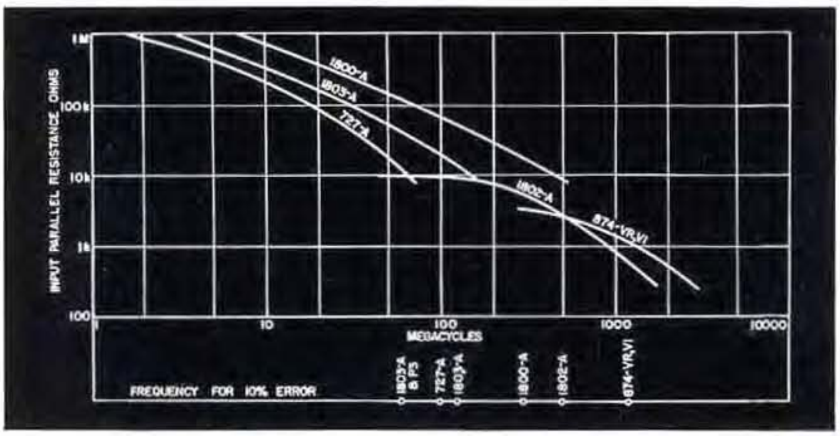


FIGURE 1.
Curves of input parallel resistance of different General Radio voltmeters. The frequency at which resonance in the input circuit introduces a 10% error is given at the bottom of the figure.

ments well beyond the frequency limits given in the plot, or for voltage measurements if a calibration is made.

In Table I are given the input capacitances of the meters and of the meters with external multipliers. It will be noted that the capacitive type multipliers used with the TYPE 1800-A Vacuum-Tube Voltmeter and the TYPE 1802-A Crystal Voltmeter considerably reduce the input capacitance (and the losses as well). The resistive multipliers for the TYPE 1800-A and the TYPE 1803-A Vacuum-Tube Voltmeters, on the other hand, increase the input capacitance and lower the frequency limit.

Figure 2 gives comparative data on voltage range and sensitivity. It will be seen that the TYPE 727-A Voltmeter gives the lowest useful reading, 0.05 volt, and the highest reading without a multiplier, 300 volts. The TYPE 1800-A and 1803-A cover from 0.1 to 150 volts. The TYPE 1802-A Crystal Voltmeter does not have a range-changing switch, but the base range from 0.1 to 1.0 volt can be extended to 10 volts or to 100 volts by using external multipliers which are supplied. The TYPE 874-VR, VI combination covers from 0.1 to 2 volts in a single range. 10 : 1 multipliers, TYPES 1800-P2 and P3, are available for the TYPE 1800-A and TYPE 1803-P3 for the TYPE 1803-A to extend the range of these instruments to 1500 volts.

All the voltmeters which have been compared are essentially peak reading instruments, except that the vacuum-tube voltmeters on the more sensitive ranges approach a square-law characteristic. Although a peak-reading instrument is less useful than some

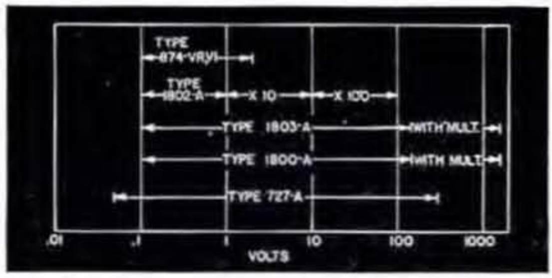


FIGURE 2. Voltage ranges of the different voltmeters.

other types for measuring the value of the fundamental component of a complex waveform in the presence of harmonics, the high stability of the peak instrument and its independence of tube characteristics makes it preferable for a large proportion of communication measurements. Except on very sharply peaked waveforms the lowest range of the TYPE 1800-A or the TYPE 727-A Vacuum-Tube Voltmeter can be used with an external multiplier to read the r-m-s value of complex waveforms.

TABLE I

Voltmeter Input Capacitance with and without External Multipliers

Meter	*Input Capacitance* ($\mu\mu f$)
TYPE 1803-A+P3 (resistive multiplier)	17
TYPE 727-A	16
TYPE 1803-A	10
TYPE 1800-A+P3 (resistive multiplier)	10
TYPE 1802-A	5
TYPE 1800-A with probe cap and plug	4.3
TYPE 1800-A without probe cap or plug	3.1
TYPE 1802-A, 10 : 1 multiplier	2.5
TYPE 1800-A+P2 (capacitive multiplier) with cap	2.0
TYPE 1802-A, 100 : 1 multiplier	1.6
TYPE 1800-A+P2 without cap	1.5

CLASSIFICATION OF METERS

Type	*Name*	*Quantity Measured*	*Range*	*Nominal Accuracy*	*Power Supply*	*See Page*
1800-A	Vacuum-Tube Voltmeter	Volts, A-C or D-C	0.1–150*	±2%	A-C Line	169
1803-A	Vacuum-Tube Voltmeter	A-C Volts	0.1–150*	±3%	A-C Line	172
1802-A	Crystal Voltmeter	A-C Volts	0.1–100	±5%	Batteries	173
727-A	Vacuum-Tube Voltmeter	A-C Volts	0.05–300	±3%	Batteries	175
728-A	Vacuum-Tube Voltmeter	D-C Volts	0.05–3000	±3%	Batteries	176
729-A	Megohmmeter	Megohms	0.002–50,000	±5%	Batteries	177
1862-A	Megohmmeter	Megohms	0.5–2,000,000	±3%	A-C Line	178
583-A	Output Power Meter	Power Impedance	0.1 mw–5 w 2.5–20,000 Ω	±0.6 db ±20%	None	180
783-A	Output Power Meter	Power Impedance	0.2 mw–100 w 2.5–20,000 Ω	±0.25 db ±2%	None	181
546-C	Microvolter	Voltage	0.1 μv–1 v	±3%	Audio Oscillator	182
1501-A	Light Meter	Light	50–12,800 lumen-seconds per square foot		Batteries	183
1500-B	Counting-Rate Meter	Radio-Activity	5–20,000 cpm	±3%	A-C Line	184

*Multipliers are available to extend range to 1500 volts.

TYPE 1800-A VACUUM-TUBE VOLTMETER
(A-C OPERATED)

DESCRIPTION: The high-frequency probe contains an acorn-type diode rectifier connected by very short leads to the input capacitor which is a small button-type unit mounted on a low-loss insulating disc. Except for the small area of this insulation at the front, the probe is completely shielded. A metal cap screws onto the end of the probe and is used to attach various fittings and terminations to the probe input. The cable, which also supplies heater power to the diode in the probe, carries the rectified voltage to a d-c amplifier and indicating meter in the cabinet of the instrument.

The d-c amplifier consists of a balanced twin triode operating in a highly degenerative circuit. The rectified alternating voltage is applied directly to the control grid of one triode, and a diode, which serves only to balance the effect of the initial-velocity current in the rectifying diode, is connected to the control grid of the second triode. Degeneration is obtained by connecting another twin triode in the cathode circuit of the amplifier. The indicating meter is connected in series with precision resistors between the cathodes of the amplifying twin triodes. The change from one voltage range to another is made by changing the value of this series resistance.

USES: The Type 1800-A Vacuum-Tube Voltmeter is a high-impedance wide-range voltmeter which can be used not only for measurements at audio and radio frequencies up to several hundred megacycles but also at dc.

In addition to its use as a voltmeter, the Type 1800-A can be used, with the special 50-ohm terminating resistor which is furnished, to measure current and power in the termination of lines or other locations.

Although calibrated in r-m-s values of approximately sinusoidal voltages, the voltmeter can be used, except on the lowest voltage ranges, to determine the peak value of a complex voltage wave.

FEATURES: ➔ High input impedance.

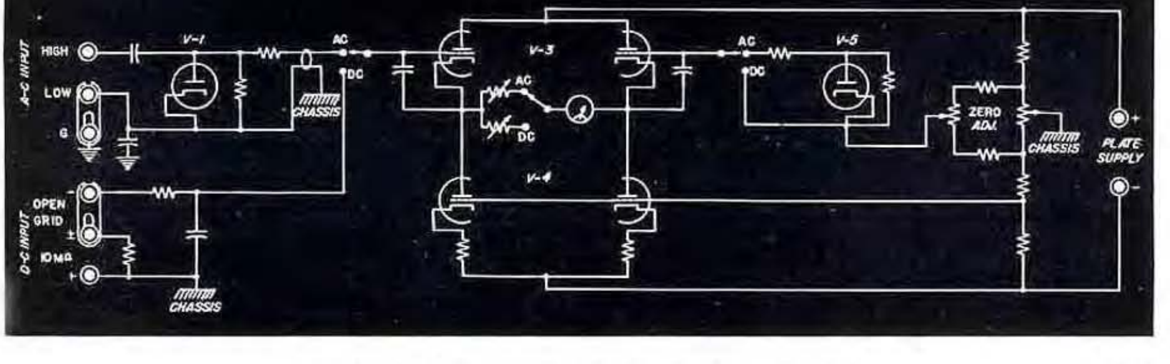
➔ Mirror-type scale.

➔ Accurate measurements at frequencies up to several hundred megacycles can be made, because the small probe makes possible very short leads. The plug terminals on the probe can be removed to shorten the leads still further, or other fittings or terminations can be used instead.

➔ Excellent low-frequency response.

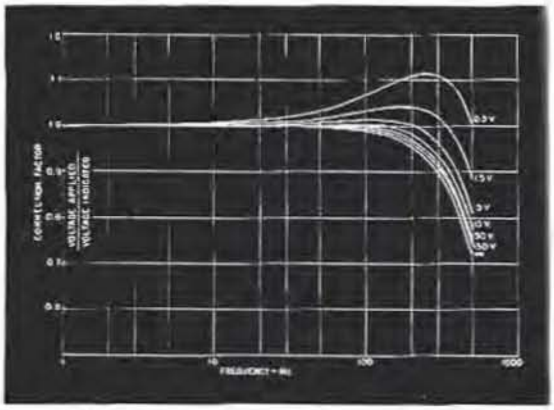
➔ Calibration is substantially independent of tube characteristics.

➔ The three highest a-c scales are practically linear, and there is sufficient overlapping of



the various ranges so that all readings can be made well up on the scale.

- One zero adjustment control serves for all ranges, and resetting is not required from range to range.
- A regulated power supply eliminates fluctuations in the zero setting or in the meter readings over a wide range of line-voltage variations.
- Probe cap can be screwed to ground plane to make inductance of ground connection negligible.
- A Type 874 Coaxial Connector is supplied for the probe.
- A 50-Ω coaxial resistance is supplied.
- Handle detents into position at right angles to panel to form support with panel at 30° to horizontal.



Plots showing ratio of applied voltage to indicated voltage as a function of frequency for various values of indicated voltage, taken with cap on but plug removed.

SPECIFICATIONS

Voltage Range: 0.1 to 150 volts, ac, in six ranges (0.5, 1.5, 5, 15, 50, and 150 volts, full scale); 0.01 to 150 volts, dc, in six ranges (0.5, 1.5, 5, 15, 50, and 150 volts, full scale).

Multipliers: Multipliers are available for increasing the range to 1500 volts. See next page.

Accuracy: DC, ±2%, of full scale on all six ranges; AC, ±2% of full scale on all six ranges for sinusoidal voltages, subject to frequency correction (see below).

Waveform Error: On the a-c voltage ranges, the instrument operates as a peak voltmeter, calibrated to read r-m-s values of a sine wave, or 0.707 of the peak value of a complex wave. On distorted waveforms the percentage deviation of the reading from the r-m-s value may be as large as the percentage of harmonics present.

Frequency Error: At high frequencies, resonance in the input circuit and transit-time effects in the diode rectifier introduce errors in the meter reading. The resonance effect causes the meter to read high and is independent of the applied voltage. The transit-time error is a function of the applied voltage and tends to cause the meter to read low. The accompanying curves give the frequency correction for several different voltage levels. It will be noted that at low voltages the transit-time and resonance effects tend to cancel, while at higher voltages the error is almost entirely due to resonance. The resonant frequency with cap on but plug removed is about 1050 Mc.

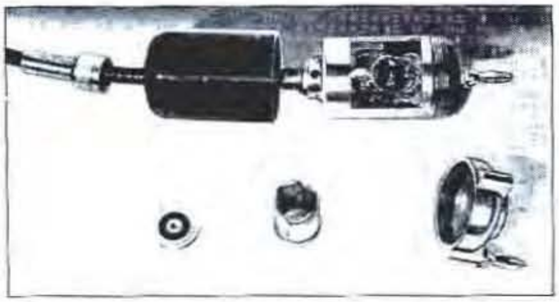
This voltmeter may be used at frequencies as low as 20 cycles with a frequency error of less than 2%.

Input Impedance: At low frequencies the equivalent parallel resistance of the a-c input circuit is 25 megohms. At higher frequencies this resistance is reduced by losses in the shunt capacitance. The equivalent parallel capacitance at radio frequencies is 3.1 μμf with the probe cap and plug removed. At audio frequencies this capacitance increases slightly. The probe cap and plug add approximately 1.2 μμf. The plot on page 167 gives the variation of R_p with frequency.

On the d-c ranges two values of input resistance are provided, 10 megohms and open grid.

Power Supply: 105 to 125 or (210 to 250) volts, ac, 50 to 60 cycles. The instrument incorporates a voltage regulator to compensate for supply variations over this voltage range. The power input is less than 25 watts.

View of probe for Type 1800-A Vacuum-Tube Voltmeter partly disassembled. In the foreground are shown accessories supplied with the instrument.



Tubes:

2—9005	1—6SL7-GT
1—6SU7-GTY	1—6AT6
1—6C4	1—6X5-GT
1—3-4	2—991

The tubes are supplied with the instrument.

Accessories Supplied: A line connector cord, spare fuses, Type 274 and Type 874 terminations, and 50-ohm coaxial terminating resistor for probe.

Mounting: Black crackle finish aluminum panel mounted in a shielded walnut cabinet. The cable and probe are stored in the cabinet. The carrying handle can be set as a convenient support for the instrument when placed on a bench with the panel tilted back.

Dimensions: (Width) 7 3/8 x (depth) 7 1/2 x (height) 11 1/4 inches, over-all.

Net Weight: 13 3/4 pounds.

Type		*Code Word*	*Price*
1800-A	**Vacuum-Tube Voltmeter............**	DUCAT	**$355.00**

PATENT NOTICE. See Notes 3, 4 and 6, page vi.

MULTIPLIERS FOR TYPE 1800-A AND TYPE 1803-A VACUUM-TUBE VOLTMETERS

TYPE 1800-P2 HIGH-FREQUENCY MULTIPLIER

This multiplier extends the a-c voltage range of the TYPE 1800-A Vacuum-Tube Voltmeter to 1500 volts. It consists of a capacitive voltage divider which provides a ten-to-one reduction between the voltage applied to the multiplier and the voltage appearing across the voltmeter terminals. The multiplier screws onto the end of the voltmeter probe, adding about two inches to its length.

Multiplication Ratio: 10 : 1 ±3%, as received. An adjustment is provided to permit the user to match the multiplier to his TYPE 1800-A Voltmeter to better than ±1% accuracy.

Frequency Characteristic: See plot. The multiplier is not recommended for use below 100 kc.

At high frequencies, the multiplier does not affect over-all voltmeter response.

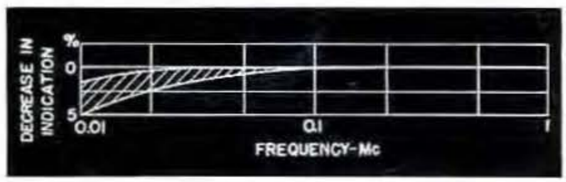
Input Impedance: Equivalent input resistance of voltmeter-multiplier combination is approximately 100 times that of voltmeter alone.

Equivalent parallel capacitance is 1.5 μμf with the probe cap and plug removed. The latter add approximately 0.5 μμf.

Dimensions: (Length) 2⅝ x (diameter) 1⅝ inches, over-all.

Net Weight: 4 ounces.

Type		*Code Word*	*Price*
1800-P2	**Multiplier**	ABODE	**$18.00**



TYPE 1800-P3 LOW-FREQUENCY MULTIPLIER

This multiplier extends the range of the TYPE 1800-A Vacuum-Tube Voltmeter to 1500 volts for both d-c and low-frequency a-c measurements. The multiplier plugs into the binding posts on the voltmeter panel. For d-c measurements a fixed resistance voltage divider is used giving a 10 : 1 reduction in the voltage applied to the voltmeter. For a-c use the multiplier consists of a capacitance-resistance voltage divider.

The TYPE 1800-P3 Low-Frequency Multiplier is not intended for use at frequencies above 100 kc. For frequencies above this value the TYPE 1800-P2 Multiplier should be used.

D-C Multiplication Ratio: 10 : 1 ±1.5%.

Sine-Wave A-C Multiplication Ratio: 10 : 1 ±5%, as furnished, from 20 cycles to 10 kilocycles.

Frequency Characteristic: Adjustments are provided to permit the user to match the multiplier exactly to his TYPE 1800-A Voltmeter at any desired frequency from 20 cycles to 5 Mc. When multiplier is adjusted for zero error at 1 kc and at 15 kc, the frequency error will be less than ±3% from 20 cycles to 20 kilocycles, and less than ±5% up to 100 kilocycles.

The multiplier is not recommended for use above 100 kilocycles unless adjusted for use at a fixed frequency.

Waveform: Errors in multiplication ratio may be as large as the percentage distortion of the signal.

Input Impedance: 10 megohms shunted by 10 μμf.

Dimensions: 5 x 2 x 2 inches, over-all.

Net Weight: 8 ounces.

Type		*Code Word*	*Price*
1800-P3	**Multiplier**	ABHOR	**$25.00**

TYPE 1803-P3 MULTIPLIER

When attached to the probe of the TYPE 1803-A Voltmeter, this multiplier extends the voltmeter range to 1500 volts over the frequency range of 20 cycles to 50 megacycles.

Multiplication Ratio: 10 : 1 ±5%, as received, from 20 cycles to 1 megacycle.

Frequency Characteristic: Adjustments are provided to permit the user to match the multiplier exactly to his TYPE 1803-A Voltmeter at any desired frequency. When multiplier is adjusted exactly at 1500 cycles and at 15 kilocycles, the frequency error will be less than ±3%, from 20 cycles to 1 megacycle, and less than ±5%, from 1 megacycle to 50 megacycles.

Input Impedance: 10 megohms shunted by 16.5 μμf.

Waveform Error: Errors in multiplication ratio may be as large as the percentage distortion of the signal.

Dimensions: (Length) 4 x 2 x 2 inches, over-all. Similar in appearance to TYPE 1800-P3 above.

Net Weight: 8 ounces.

Type		*Code Word*	*Price*
1803-P3	**Multiplier**	ABOMA	**$21.00**

TYPE 1803-A VACUUM-TUBE VOLTMETER

USES: The TYPE 1803-A Vacuum-Tube Voltmeter is a high-quality, low-priced, a-c operated voltmeter for measuring a-c voltages between 0.1 volt and 150 volts, at frequencies up to about 100 megacycles. It is an extremely useful instrument in the electronics laboratory, where most of the measurements to be made do not require the greater frequency range and extra features of more expensive instruments.

DESCRIPTION: The voltmeter is a peak-reading instrument and consists of a diode rectifier mounted in a probe, followed by a d-c amplifier and indicating meter. One diode is used to rectify the a-c voltage under measurement. The other balances the effect of the initial velocity current of the first. The d-c amplifier uses a twin triode in a degenerative, balanced circuit. A-C power supply is built in, and the entire assembly is housed in a cabinet of heavy-gauge aluminum.

FEATURES: ➔ Meter is large and easily read.

➔ Provision is made for storing the probe on the side of the cabinet. When probe is thus mounted, voltages to be measured can be connected directly to its terminals.

➔ Probe is completely shielded to eliminate the effect of extraneous pickup.

➔ Zero adjustment is common to all ranges.

➔ Balanced circuit minimizes variation of indication with line-voltage changes.

➔ Simple construction results in low price without sacrifice of quality.

SPECIFICATIONS

Voltage Range: 0.1 to 150 volts, ac, in five ranges (1.5, 5, 15, 50, and 150 volts, full scale).

Accuracy: ±3% of full scale on all ranges, for sinusoidal voltages, subject to frequency correction above 50 megacycles. Correction curve supplied in instruction book (see accompanying plot).

Waveform Error: The instrument is peak reading and indicates r-m-s value of a sine wave or peak value of a complex wave. On distorted waveforms the percentage deviation of the reading from the r-m-s value may be as great as the percentage of harmonics present.

Frequency Error: The accompanying plot gives the frequency correction for several different voltage levels. At low voltages the transit-time and resonance effects tend to cancel, while at higher voltages the error is almost entirely due to resonance. The resonant frequency is about 110 Mc.

At low frequencies the response drops off because of the increasing reactance of the series capacitance of the input circuit. At 20 cycles per second the drop is 2% or less.

Input Impedance: The equivalent a-c input circuit is a resistance in parallel with a capacitance. At low frequencies the equivalent parallel resistance is 7.7 megohms. At high frequencies this resistance is reduced by losses in the shunt capacitance. The equivalent parallel capacitance at radio frequencies is 10 μμf. At audio frequencies the capacitance increases to 11.5 μμf. The plot on page 167 gives the high-frequency variation of R_P.

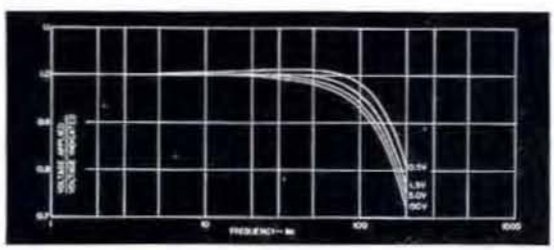
Accessories Supplied: One TYPE 274-MB Double Plug; 2 color-coded test leads; 2 test prods; 2 alligator clips.

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles. The power input is about 11 watts.

Tubes: 1—6AL5 1—6SU7-GTY 1—6X5-GT
All are supplied.

Dimensions of Cabinet: (Width) 7¼ x (depth) 6$\frac{7}{16}$ x (height) 11¾ inches, over-all. Probe in storage position adds 1 inch to width.

Net Weight: 9¼ pounds.



Frequency response for various voltage levels.

Type		*Code Word*	*Price*
1803-A	Vacuum-Tube Voltmeter	ABOOM	$155.00

TYPE 1802-A CRYSTAL VOLTMETER

USES: The Crystal Voltmeter, while not so accurate as vacuum-tube types, extends the range of direct voltage measurements upward in frequency by a factor of 2 to 1. It can be used for rapid voltage measurements at frequencies up to 1000 megacycles, provided the simple correction shown on the next page is applied, and thus covers all frequencies of interest to television manufacturers. In the u-h-f laboratory, its direct-reading feature is invaluable, and where greater accuracy is desired, corrections can be accurately determined by comparison with bolometer measurements.

DESCRIPTION: Functionally, this instrument consists of a crystal rectifier and a d-c vacuum-tube amplifier. The crystal rectifier is built into a small shielded probe, and a cable carries the rectified voltage to the d-c amplifier and indicating meter in the cabinet. The probe is provided with a number of removable fittings, including 10 : 1 and 100 : 1 multipliers, a coaxial adaptor, and a 50-ohm terminating resistor. The d-c amplifier uses a triode in a degenerative cathode-follower circuit.

Cathode and plate power is obtained from self-contained batteries. The cabinet has a storage compartment at the top for housing the probe and accessories.

FEATURES: → The voltmeter scale is approximately linear.

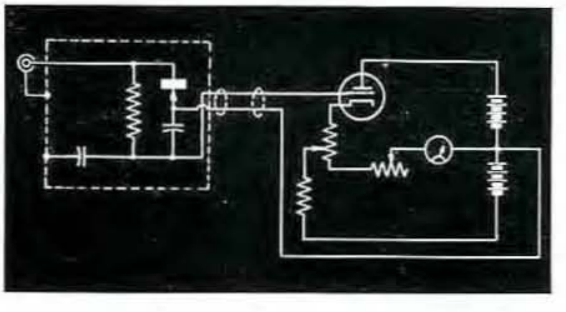
→ Voltages up to 100 volts can be measured by using the convenient multipliers that are provided.

→ The normal variations in tube characteristics and battery voltages do not appreciably affect the meter indication.

→ The variety of probe terminations make the voltmeter adaptable to many types of measurement.

→ Batteries have an operating life of approximately 200 hours.

→ The calibration can be checked and adjusted in terms of a voltage obtained from a 40- to 60-cycle a-c power line.



SPECIFICATIONS

Voltage Range: 0.1 to 1 volt, direct reading; 1 to 10 volts and 10 to 100 volts direct reading with multipliers supplied.

Accuracy: ±5% of full scale on sinusoidal voltages, subject to frequency correction.

Multiplier Accuracy: All multipliers are adjusted to have a multiplying factor within ±5% of the nominal value.

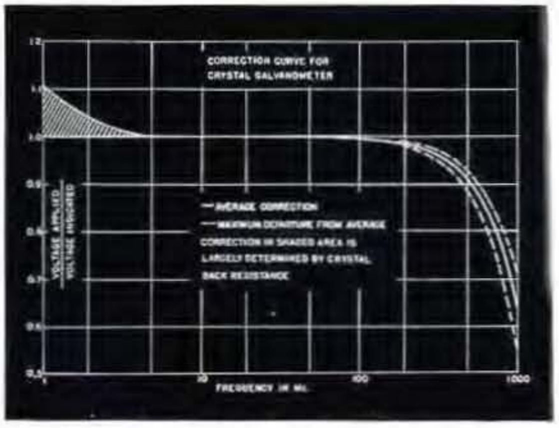
Waveform Error: The meter response approaches that of a peak voltmeter, but the scale is calibrated in r-m-s values for a sine-wave input. On distorted waveforms the percentage deviation of the reading from the r-m-s value may be as large as the percentage of harmonics present.

Frequency Error: The upper limit of usefulness is determined by the frequency of series resonance in the crystal probe, which varies among different crystals by some 10 or 15%. With a 1N21B crystal in the probe, the resonant frequency is between 1650 and 2000 Mc; with the 10 : 1 multiplier attached, between 1700 and 2200 Mc; and with the 100 : 1 multiplier attached, between 1350 and 1650 Mc.

The effect of resonance on the meter indication becomes appreciable at about 200 megacycles and causes the meter indication to be high. Correction can be made for this error by multiplying the meter indication by cos $(\pi f/2f_0)$, where f is the operating frequency and f_0 is the resonant frequency. (The factor $1 - (f/f_0)^2$ is useful as an approximate correction when the frequency is much below resonance.) The correction as a function of frequency for the average of a number of crystals is given in the accompanying plot. The dotted lines represent the maximum deviations to be expected in individual crystals and may amount to ±20% of the indicated voltage at 1000 Mc. These corrections are for the voltage at the face of the probe with no probe terminals.

At frequencies below a nominal value between 10 and 30 Mc, the indication falls off as a result of the small series capacitance in the probe. The frequency at which this effect becomes noticeable depends upon the characteristics of the individual crystal, particularly the back resistance. Because the multipliers are capacitance voltage dividers, the limiting frequency is higher when they are used.

Input Impedance: The input capacitance is nearly independent of the standard crystal used, but the input conductance depends on the frequency, voltage level, and the crystal characteristics. For 1N21B crystals, at frequencies below 200 Mc and voltage levels above a few tenths of a volt, representative values are:



Correction curve for the TYPE 1802-A Crystal Galvanometer as a function of frequency. Uncertainties indicated by the shaded area at low frequencies and dotted lines at high frequencies arise from differences among crystals.

Probe:	Capacitance	— 5 $\mu\mu f$
	Conductance	— 100 μmhos
10 : 1 Multiplier:	Capacitance	— 2.5 $\mu\mu f$
	Conductance	— Less than 25 μmhos
100 : 1 Multiplier:	Capacitance	— 1.6 $\mu\mu f$
	Conductance	— Less than 10 μmhos

Power Supply: The necessary batteries, one Burgess Z30NX and one Burgess 2F, are supplied.

Vacuum Tube: One 1R5 vacuum tube is supplied.

Crystal: One 1N21B crystal is supplied.

Mounting: Black crackle aluminum panel mounted in a shielded walnut cabinet. The cable and probe are stored in the cabinet. The carrying handle can be set as a convenient support for the instrument when placed on a bench with the panel tilted back.

Accessories Supplied: One TYPE 1802-P1 10 : 1 Multiplier, one TYPE 1802-P2 100 : 1 Multiplier, one 50-ohm terminating resistor, fitting for plugging into TYPE 874 Coaxial Connector.

Dimensions: 7 x 7 x 10½ inches, over-all.

Net Weight: 10½ pounds.

Type		*Code Word*	*Price*
1802-A	**Crystal Galvanometer**	CONIC	**$230.00**

PATENT NOTICE. See Notes 3 and 4, page vi.

The TYPE 874-VI Voltmeter Indicator and TYPE 874-VR Voltmeter Rectifier described on page 118 are useful for measuring and monitoring voltage especially in coaxial systems at frequencies up to about 2500 megacycles.

TYPE 727-A VACUUM-TUBE VOLTMETER

(BATTERY OPERATED)

USES: This is a general-purpose vacuum-tube voltmeter for use at frequencies up to about 100 megacycles. Because it is battery operated and portable, it has many applications in the field, where an a-c power line is not always available.

DESCRIPTION: A diode rectifier circuit is employed as in the TYPE 1800-A Voltmeter but with a more sensitive two-stage d-c amplifier, permitting the measurement of a-c voltages down to 50 millivolts over the entire frequency range. The high-voltage limit is also extended, to 300 volts.

FEATURES: The high input impedance, wide voltage range, and wide frequency range of this instrument combined with its convenience and portability make the TYPE 727-A Vacuum-Tube Voltmeter an extremely useful meter for the communications laboratory, as well as for field work.

SPECIFICATIONS

Range: 0.05 volt to 300 volts ac, in seven ranges (0.3, 1, 3, 10, 30, 100, 300 volts, full scale).

Accuracy: With sinusoidal voltages applied, the accuracy is ±3% of full scale on the 0.3-volt range and ±2% of full scale on all other ranges. An additional error of ±5% of indicated voltage may eventually occur on the 30-, 100-, and 300-volt ranges, because of long-period aging of the divider resistors. If the full-scale sensitivity is checked occasionally, correction can then be made to eliminate the effect of any such aging.

Waveform Error: The instrument is calibrated to read the r-m-s value of a sinusoidal voltage. On the higher voltage ranges, however, it is essentially a peak reading device, calibrated to read 0.707 of the peak value of the applied voltage, and on distorted waveforms the percentage deviation of the reading from the r-m-s value may be as large as the percentage of harmonics present. On the lower ranges the instrument approximates a true square-law device.

Frequency Error: Less than 1% between 20 cycles and 30 Mc. At higher frequencies, the error is about +5% at 65 Mc and about +10% at 100 Mc.

Input Impedance: The input capacitance is approximately 16 μμf. The parallel input resistance (at low frequencies) is about 5 megohms on the lower ranges and about 3 megohms on the 30-, 100-, and 300-volt ranges. The curves on page 167 give the variation of R_p with frequency.

Zero Adjustment: A zero adjustment is provided on the panel. The setting is the same for all ranges.

Vacuum Tubes: Two 1S5 tubes and one 957 tube are used and are supplied with the instrument.

Batteries: Two Burgess W20P1, one Burgess W5BP, and three Burgess 2F batteries are required, and are supplied with the instrument. Battery life is approximately 250 hours of intermittent operation.

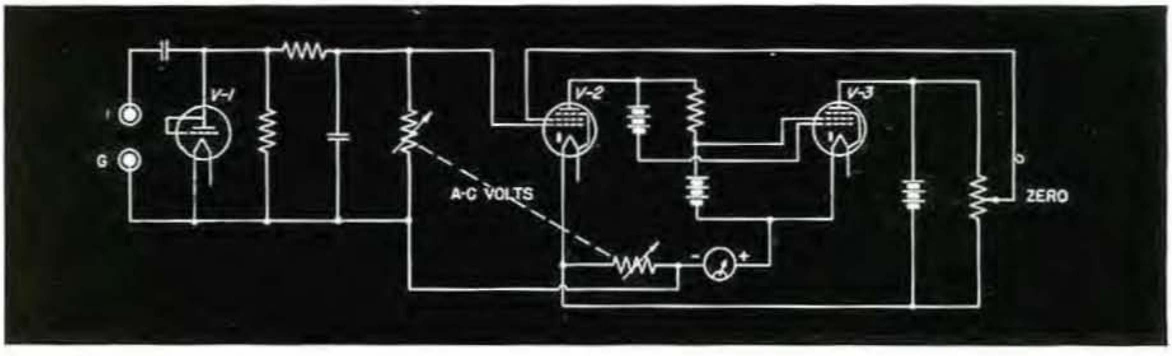
Mounting: The instrument is supplied in a shielded walnut case with cover and carrying handle and is mounted on an engraved black crackle-finish aluminum panel.

Dimensions: 11 x 6⅝ x 5⅞ inches, over-all (cover closed).

Net Weight: 10⅞ pounds, including batteries.

Type		*Code Word*	*Price*
727-A	Vacuum-Tube Voltmeter	PIGMY	$205.00

PATENT NOTICE. See Note 24, page vi.



TYPE 728-A VACUUM-TUBE VOLTMETER
(BATTERY OPERATED)

USES: This voltmeter is intended for measuring d-c voltages in low-power circuits where no appreciable power can be taken by the meter. It is particularly useful for measuring electrode voltages on vacuum tubes and cathode-ray oscillographs.

DESCRIPTION: The circuit is that of a degenerative d-c amplifier. The voltage to be measured is applied directly to the grid on the lower ranges, and through a high resistance voltage divider for the high ranges. The instrument is portable and power supply is obtained from self-contained batteries.

FEATURES: ➔ Extremely high input resistance, greater than 1000 megohms, is available on all ranges.

➔ Wide range — 0.05 to 3000 volts.

➔ Superimposed a-c voltages of considerable magnitude have no effect on the meter indication, thus making possible the measurement of fixed electrode voltages in the presence of signal voltages.

➔ Either the positive or the negative terminal of the source under measurement can be grounded to the panel by the use of the reversing switch provided on the panel.

SPECIFICATIONS

Range: 0.05 to 3000 volts in seven ranges (3, 10, 30, 100, 300, 1000, 3000 volts, full scale). Scale is approximately linear.

Accuracy: Within ±3% of full scale on all ranges. An additional error of ±3% of the indicated voltage may eventually occur on the 100-, 300-, 1000- and 3000-volt ranges because of long-period aging of the divider resistors. The effect of such aging can be eliminated if the full-scale sensitivity is checked occasionally, and any necessary corrections made. Battery aging can cause an additional error of 2% of full scale on the 3-volt range.

Input Resistance: 1000 megohms on the higher voltage ranges (100, 300, 1000, 3000 volts, full scale). Greater than 5000 megohms on the low voltage ranges.

Terminals: Two sets of input terminals are provided on the panel. One set is used for measurements at the low voltage end of the range (0 to 30 volts) and the other set is used for the higher voltage measurements (30 to 3000 volts).

Polarity: A reversing switch on the panel permits measurements with either the positive or the negative terminal of the source grounded to the panel of the instrument.

Effect of AC: Superimposed a-c voltages of less than 200 volts have a negligible effect on the meter indication.

Tube: The tube, a 1L4, is supplied.

Batteries: The batteries required are three Burgess W30BPX or equivalent and one Burgess F2BP or equivalent. A compartment is provided in the case of the instrument for holding all batteries. A set of batteries is supplied with the instrument. Battery condition can be checked by pushing a button on the panel.

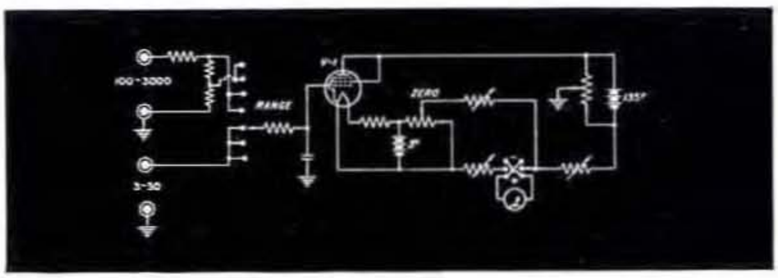
Mounting: The instrument is supplied in a walnut case with cover and is mounted on an engraved black crackle-finish aluminum panel.

Dimensions: With cover closed, (length) 11 x (width) 6⅝ x (height) 5⅞ inches, over-all.

Net Weight: 9¾ pounds, including batteries.

Type		*Code Word*	*Price*
728-A	**D-C Vacuum-Tube Voltmeter........**	PILOT	**$175.00**

Elementary schematic diagram for Type 728-A D-C Vacuum-Tube Voltmeter.



TYPE 729-A MEGOHMMETER

(BATTERY OPERATED)

USES: This megohmmeter is a battery-operated design particularly intended for applications where portability is required. It is well adapted for field use in the measurement of the leakage resistance of cables and insulation. The wide range of resistance covered by this instrument makes it suitable for use as a moisture content indicator for such materials as lumber, paper, and leather, where a definite relationship exists between moisture content and electrical conductivity.

DESCRIPTION: The circuit employed is that of a conventional ohmmeter. The necessary sensitivity for measuring high resistance is obtained by using a vacuum-tube voltmeter as the indicating element.

The highest resistance standard (1000 megohms) is especially treated to prevent surface leakage. This treatment insures that the readings of the instrument are essentially independent of humidity.

FEATURES: → A very wide range of resistance values can be measured simply and quickly with the TYPE 729-A Megohmmeter.

→ Good accuracy is obtained, and the circuit used is so stabilized that the accuracy of calibration is maintained independent of tube characteristics.

→ Treatment of the high-resistance standard to prevent surface leakage eliminates difficulties normally caused by high humidity.

→ This megohmmeter is particularly valuable for field applications because of its small size and self-contained power supply.

SPECIFICATIONS

Range: 2000 ohms to 50,000 megohms in five overlapping decade ranges.

Scale: The standard direct-reading ohmmeter calibration is used: center scale values are 0.1, 1, 10, 100, and 1000 megohms. Length of scale, 3¼ inches; central decade, 1⅝ inches.

Accuracy: Within ±5% of the indicated value between 30,000 ohms and 3 megohms, and within ±8% of the indicated value between 3 megohms and 3000 megohms when the central decade of the scale is used. Outside the central decade the error increases because of the compressed scale.

Temperature and Humidity Effects: Over the normal range of room conditions (65° Fahrenheit to 95° Fahrenheit; 0 to 95% relative humidity) the accuracy of indication is substantially independent of temperature and humidity conditions. Somewhat reduced accuracy may be expected, however, if the instrument is subjected to temperatures beyond the above range.

Voltage on Unknown: The voltage applied on the unknown does not exceed 22½ volts and varies with the meter indication.

Tube: The tube, a 1L4, is supplied.

Batteries: The batteries required are two Burgess W30BP or equivalent and one Burgess 2F2H or equivalent. A compartment is provided in the case of the instrument for holding all batteries, and a set of batteries is supplied with the instrument. Battery life is approximately 250 hours of intermittent operation.

Mounting: The instrument is supplied in a walnut case with cover and handle and is mounted on an engraved black crackle-finish aluminum panel.

Dimensions: With cover closed: (Length) 11 x (width) 6⅝ x (height) 5⅞ inches, over-all.

Net Weight: 8⅞ pounds, including batteries.

Type		*Code Word*	*Price*
729-A	**Megohmmeter**	PIOUS	**$130.00**

See also TYPE 1862-A Megohmmeter (page 178) and TYPE 544-B Megohm Bridge (page 92)

TYPE 1862-A MEGOHMMETER

USES: The TYPE 1862-A Megohmmeter is a rugged a-c operated instrument that indicates directly on a meter resistance values up to two million megohms. The voltage across the unknown is constant at 500 volts, a value widely accepted as standard for insulation-resistance measurements.

As a consequence, though useful in the more obvious application of measuring common resistors in the megohm range, the TYPE 1862-A Megohmmeter is especially suited for measuring leakage and insulation resistance of electrical machinery, transformer windings, cables, control circuits and other equipment in power plants, communications installations, railway-signal and lighting systems.

The inherent low time constant of the testing circuit and the stabilized power-supply circuits permit rapid and accurate measurement of the parallel resistance of capacitors.

Guard and ground terminals permit measurement of the grounded and ungrounded sections of three-terminal resistors.

DESCRIPTION: As in the conventional ohmmeter, the circuit of the TYPE 1862-A Megohmmeter consists of a power supply, a complement of resistance standards and an indicating meter. To insure a constant voltage across the unknown resistance, the 500-volt power supply is stabilized against line-voltage fluctuations, and the voltage across the resistance standard is made negligibly small compared to the voltage across the unknown. The indicator is a balanced d-c vacuum-tube voltmeter of two-volts full-scale sensitivity and of very high input resistance.

FEATURES:
- ➔ Rugged, direct-reading and simple to use.
- ➔ Constant 500 volts applied to unknown resistance.
- ➔ Voltage can be removed from unknown terminals by setting switch to CHECK or DISCHARGE positions, thus permitting connections to be made without danger of shock.
- ➔ Guard and ground terminals are provided.

- Test leads are furnished.
- Can be used with an external variable voltage source to measure voltage coefficient of resistance.

SPECIFICATIONS

Range: 0.5 megohm to 2,000,000 megohms. There are six decade ranges, as selected by a multiplier switch.

Scale: Each resistance decade up to 500,000 megohms utilizes 90% of the meter scale. Center-scale values are 1, 10, 100, 1000, 10,000 and 100,000 megohms.

Accuracy: The accuracy in per cent of indicated value up to 50,000 megohms is ±3% at the low-resistance end of each decade, increasing to ±12% at the high-resistance end. There can be an additional ±2% error over the top decade.

Voltage on Unknown: The voltage applied to the unknown resistor is 500 volts. Over a 105–125 volt range in supply-line voltage and over the resistance range of the instrument, the variation in voltage across the unknown resistor will be less than ±2%. At resistance values below 0.5 megohms, the applied voltage drops to limit the current to safe values.

Terminals: In addition to terminals for connecting the unknown, ground and guard terminals are provided. At two positions of the panel switch, all voltage is removed from all terminals to permit connection of the unknown in safety. In one of the positions, the UNKNOWN terminals are shunted to discharge the capacitive component of the unknown. All but the ground terminal are insulated.

Calibration Check: A switch position is provided for standardizing the calibration.

Design: Since field applications are more severe than laboratory use, the instrument, including its panel meter was designed to be unusually rugged. The carrying case can be completely closed; accessory power cable and test leads are carried in the case. Controls are simplified for use by untrained personnel.

Tubes: Supplied with the instrument:

1 — 12AU7	1 — 2X2-A
1 — OB2	1 — 6C4
1 — 6X4	1 — 6AU6
1 — 5651	

Controls: A switch for selecting the multiplying factor, a control for standardizing the calibration, a control for setting the meter to the infinity reading and a power switch.

Mounting: The instrument is assembled on an aluminum panel finished in black-crackle lacquer and is mounted in an aluminum cabinet with black-wrinkle finish and with black-phenolic protective sides. The aluminum-cover finish is black wrinkle. The case is provided with a carrying handle.

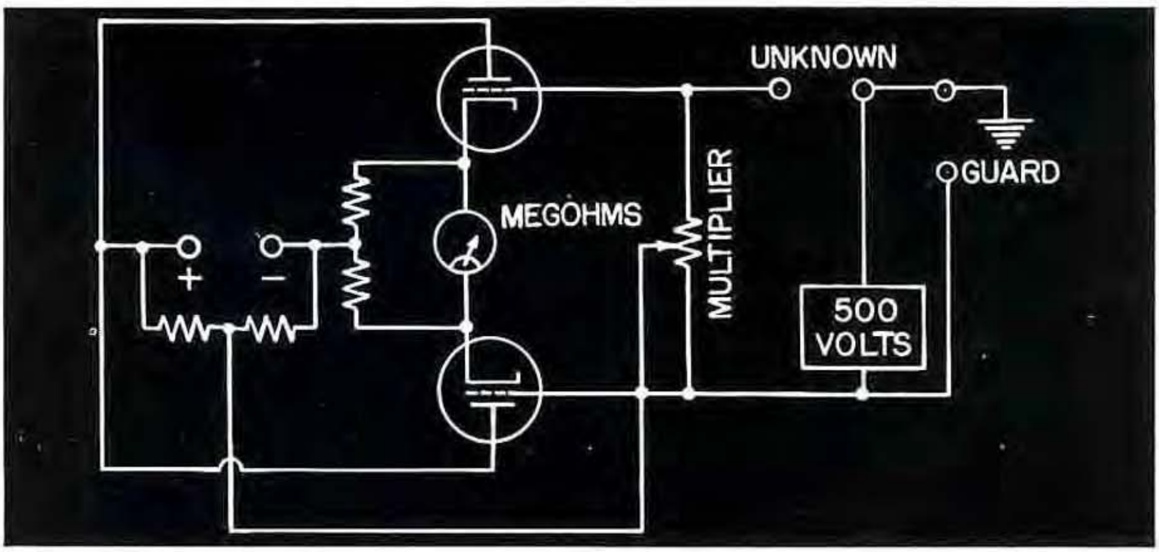
Power Supply: 115 (or 230) volts at 40 to 60 cycles. The power input is approximately 25 watts.

Accessories Supplied: Two color-coded test leads with phone tips, two insulated probes, two alligator clips and a Type 274-MB Plug.

Dimensions: (Height) 10⅛" x (width) 9⅛" x (depth) 11¾", over-all.

Net Weight: 15½ pounds.

Type		*Code Word*	*Price*
1862-A	**Megohmmeter**	JUROR	**$225.00**



A battery-operated megohmmeter, Type 729-A, is described on page 177. Type 544-B Megohm Bridge, a bridge-type instrument for resistance measurements in the megohm range, is described on page 92.

TYPE 583-A OUTPUT-POWER METER

USES: The output-power meter reads directly the amount of audio-frequency power that a source is capable of delivering into any desired load. Thus the effect of load impedance on power delivered can be easily measured, and the characteristic impedance of telephone lines, phonograph pickups, oscillators, and similar equipment can be found by observing the impedance which gives the maximum reading on the instrument.

In testing radio receivers the TYPE 583-A Output-Power Meter is very useful as an output indicator for standard selectivity, sensitivity, band-width, and fidelity tests, and an auxiliary decibel scale is furnished on the meter for this purpose.

DESCRIPTION: This instrument may be considered to be an adjustable load impedance across which is connected a voltmeter that is calibrated directly in watts lost in the load. Actually the input is connected through a multitap transformer and a resistance network to an output meter.

FEATURES: ➔ The power range covered is 50,000 : 1 and the impedance range 8000 : 1.

➔ All readings can be made directly and quickly.

➔ Considerable overloads, for short periods of time, can be handled by the rectifier-type voltmeter used as the indicating element.

SPECIFICATIONS

Power Range: 0.1 to 5000 milliwatts in four ranges (5, 50, 500, 5000 milliwatts, full scale). The copper-oxide meter is calibrated from 1 to 50 milliwatts with an auxiliary scale reading from 0 to 17 decibels above a reference level of 1 milliwatt. With the multiplier the total range is −10 to +37 decibels above 1 milliwatt.

Impedange Range: 2.5 to 20,000 ohms. Forty discrete impedances, distributed approximately logarithmoically, are obtained by means of a ten-step OHMS dial and a four-step MULTIPLIER.

Accuracy: The accuracy of both power and impedance measurements varies with frequency. The maximum error in full-scale power reading does not exceed 0.5 decibel between 150 and 2500 cycles, nor does it exceed 1.5 decibels at 20 and 10,000 cycles. The average error is 0.3 decibel at 30 and 5000 cycles, and 0.6 decibel at 20 and 10,000 cycles.

The maximum error in impedance does not exceed 7% between 150 and 3000 cycles, nor does it exceed 50% at 20 and 10,000 cycles. The average error is 8% at 30 and 5000 cycles and 20% at 20 and 10,000 cycles.

Waveform Error: The indicating instrument used is a copper-oxide rectifier-type meter, calibrated in r-m-s values for a sinusoidal applied voltage. When non-sinusoidal voltages are applied, an error in indication can occur, since the meter is not a true r-m-s indicating device. The error will depend on the magnitude and phase of the harmonics present, but with waveforms normally encountered in communications work, will not be serious.

Mounting: The instrument is mounted on an aluminum panel in a walnut cabinet.

Dimensions: (Length) 10 x (width) 7 x (height) 6 inches, over-all.

Net Weight: 8¼ pounds.

Type		*Code Word*	*Price*
583-A	Output-Power Meter	ABUSE	$145.00

TYPE 783-A OUTPUT-POWER METER

USES: The TYPE 783-A Output-Power Meter is a direct-reading instrument for measuring the power output of audio-frequency circuits.

Some of its specific uses include the testing of amplifiers, transformers, and other networks. It is particularly useful for simulating loud-speaker or other load impedances in testing the output characteristics of high-power audio systems, since it will measure power outputs as high as 100 watts. It is sufficiently sensitive, on the other hand, to be useful for measurements on very low-level circuits.

DESCRIPTION: Functionally the TYPE 783-A Output-Power Meter is equivalent to an adjustable load impedance across which is connected a voltmeter that is calibrated directly in watts dissipated in the load.

FEATURES: ➔ A power range extending to 100 watts is provided by this meter.

➔ Frequency and impedance characteristics are improved over those of the smaller TYPE 583-A Output-Power Meter.

➔ The auxiliary decibel scale is a convenience for many types of measurements.

SPECIFICATIONS

Power Range: 0.2 milliwatt to 100 watts in five ranges (10 and 100 milliwatts, 1, 10 and 100 watts, full scale). An auxiliary decibel scale on the meter reads from −10 to +10 decibels above a reference level of 1 milliwatt. With the multiplier the total range is −10 to +50 decibels above 1 milliwatt.

Impedance Range: 2.5 to 20,000 ohms. Forty discrete impedances, distributed approximately logarithmically, are obtained by means of a ten-step OHMS dial and a four-step MULTIPLIER.

Impedance Accuracy: The input impedance is within ±2% of the indicated value, except at the higher audio frequencies, where the error for the higher impedance settings may exceed this value. At 15,000 cycles the input impedance error is about 5% for impedances from 10,000 to 20,000 ohms.

Power Accuracy: The indicated power is accurate to ±0.25 db at full-scale reading. At the lowest impedance multiplier setting (2.5 to 20 ohms) there may be an additional error of 0.2 db due to switch contact resistance when the power multiplier is set at 10 (10 to 100 watt range).

The over-all frequency characteristic of the power indication is flat within ±0.5 db from 20 cycles to 10,000 cycles; within ±0.75 db to 15,000 cycles.

Waveform Error: The indicating instrument used is a copper-oxide rectifier meter, calibrated in r-m-s values for a sinusoidal applied voltage. When non-sinusoidal voltages are applied, an error in indication can occur, since the meter is not a true r-m-s indicating device. The error will depend on the magnitude and phase of the harmonics present, but, with waveforms normally encountered in measurement circuits at communications frequencies, will not be serious.

Temperature and Humidity Effects: Humidity conditions have a negligible effect on the accuracy of the instrument.

The instrument is calibrated at 77° Fahrenheit and, if the ambient temperature departs widely from this value, additional errors of indication may be expected. At high temperatures (95° Fahrenheit) this additional error may approach the nominal calibration error, particularly at the higher frequencies.

The instrument is so designed that the heat dissipated by the instrument itself has a negligible effect on the accuracy.

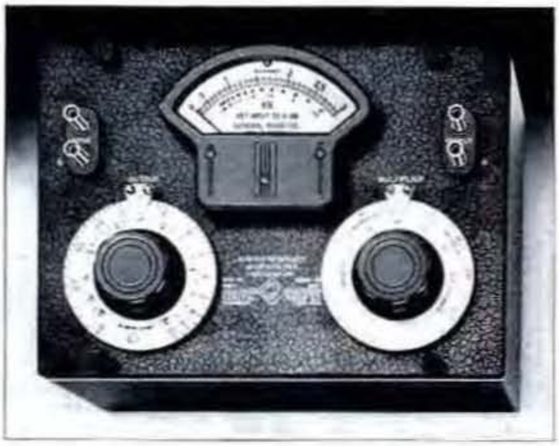
Mounting: The instrument is mounted on a phenolic panel in a walnut cabinet.

Dimensions: 8 x 18 x 7 inches, over-all.

Net Weight: 17 pounds.

Type		*Code Word*	*Price*
783-A	**Output-Power Meter**	ABBEY	**$325.00**

TYPE 546-C AUDIO-FREQUENCY MICROVOLTER



USES: The Type 546-C Audio-Frequency Microvolter used in conjunction with an oscillator is a useful source of small, known, audio-frequency voltages. In measuring the response of amplifiers, transformers, and other audio equipment, such a source of known input voltage is extremely valuable. The microvolter can also be used to measure other small voltages by substitution methods.

DESCRIPTION: This instrument consists, essentially, of a constant impedance attenuator and a voltmeter by means of which the input to the attenuator is standardized. A switch controls the output voltage in decade steps while an individually calibrated dial provides continuous control over each decade.

FEATURES: ➔ An excellent frequency characteristic, extending from very low frequencies up to 100,000 cycles, is available in this instrument.

➔ Excellent accuracy is obtainable for absolute voltage levels as well as for voltage ratios, which are all that are needed in gain or loss measurements.

➔ Decibel scales, in addition to the voltage calibration of the meter and multipliers, are provided. These scales make it possible to obtain relative response characteristics in decibels without calculations.

SPECIFICATIONS

Output Voltage Range: From 0.1 microvolt to 1.0 volt open circuit, when the input voltage is set to the standardized reference value.

Accuracy: For open-circuit output voltages the calibration is accurate within ±(3% + 0.5 microvolt) for output settings above 1 microvolt and for all frequencies between 20 and 20,000 cycles. For higher frequencies up to 100 kc the calibration is accurate within ±5% for output settings above 100 microvolts. These specifications apply only where waveform and temperature errors are negligible (see below).

In calculating ratios of output voltages, at a given frequency, the accuracy of any given reading can be considered to be within ±(2% + 0.5 microvolt), at frequencies up to 100,000 cycles. At the higher frequencies this accuracy applies only at levels above 100 microvolts.

The microvolter can be used on dc if an external meter is used or if the internal meter has been calibrated for dc.

Output Impedance: The output impedance is approximately 600 ohms and is constant with setting within ±5%. This impedance is sufficiently low so that no correction on the output voltage is necessary for load impedances of the order of 100,000 ohms and greater.

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

Waveform Error: The accuracy of the microvolter as a calibrated attenuator or voltage divider is independent of waveform. The absolute accuracy of the output voltage calibration depends on the characteristics of the input copper-oxide rectifier voltmeter, which has a small waveform error that depends in turn on both the phase and the magnitude of harmonics present in the input. This error in the voltmeter can, in general, be neglected when the microvolter is used with ordinary laboratory oscillators. The rectifier-type voltmeter itself introduces some distortion unless the source impedance is very low. With a 600-ohm source the distortion introduced is about 0.2%.

Temperature Error: The accuracy of the calibration is independent of temperature when the microvolter is used as an attenuator or voltage divider. The absolute accuracy is affected slightly by temperature because of change in the voltmeter characteristics. The necessary correction for temperatures from 65° to 95° Fahrenheit is furnished with the instrument. The effects of humidity are negligible.

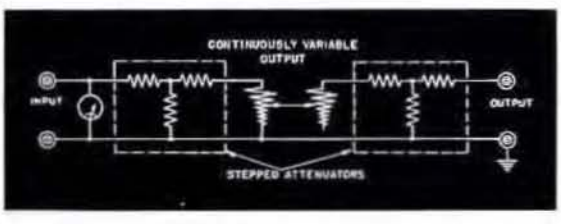
Power Source: The driving oscillator must be capable of furnishing about 2.2 volts across 600 ohms, or about 8 milliwatts.

Terminals: Jack-top binding posts are mounted on standard ¾-inch spacing.

Mounting: The instrument is mounted on an aluminum panel in a shielded walnut cabinet.

Dimensions: (Length) 10 x (width) 7 x (height) 6⅜ inches, over-all.

Net Weight: 6½ pounds.



Type		*Code Word*	*Price*
546-C	**Audio-Frequency Microvolter***	CROWN	**$125.00**

*Reg. U. S. Pat. Off.

TYPE 1501-A LIGHT METER

USES: The General Radio Light Meter is a photographic exposure meter for use primarily with electric flash lamps of the xenon type, commonly called "speedlights" or "strobe lights." It is particularly useful in the professional studio for exposure determinations with Kodachrome and other color films. This meter makes possible in high-speed flash photography the same accurate exposure standardization that the continuous light exposure meter gives for ordinary photography.

The meter measures the light incident on the subject and indicates correct camera aperture for average subjects. In addition, an auxiliary probe is available, which attaches to the ground glass of the camera by means of suction cups, so that the light actually reaching the film can be measured, thus allowing for such indeterminate factors as lens absorption, bellows extension, etc. For this type of measurement, a white card is used as a standard subject. No calibration is supplied for measurements with the probe, but a few test shots will give sufficient data for the user to determine his own calibration.

This light meter can be used to make routine checks on the condition of electric flash bulbs, to measure the output of a light source, and to determine the effectiveness of reflectors.

DESCRIPTION: The elements of the light meter are a light attenuator, a vacuum phototube, an integrating capacitor, and a vacuum-tube voltmeter. Light admitted by the attenuator strikes the photocell, causing current to flow through it. This current charges the capacitor, and the voltage across the capacitor is proportional to the integral of light with respect to time. This voltage is indicated by the vacuum-tube voltmeter, whose reading is a measure of the total light emitted by the flash tube.

The light attenuator consists of two Polaroid discs, one of which can be rotated 90° with respect to the other. The attenuator has two scales, one a proportional scale, the other a scale of *f* numbers.

The meter scale reads in lumen-seconds per square foot (foot-candle-seconds), and has a full-scale range of 200. The scale is direct reading when the light attenuator is set at 1 (*f*/3.5). A figure of 100 lumen-seconds per square foot at *f*/3.5 is taken as normal exposure for professional Kodachrome with average subjects.

FEATURES: ➤ Portable and simple to operate.
➤ Aperture can be read directly from attenuator scale.
➤ Wide range of light intensities can be measured.
➤ Both light incident on the subject and reflected light reaching the camera ground glass can be measured.

SPECIFICATIONS

Light Range: A light range of 64 : 1 can be measured at mid-scale deflection, corresponding to 100 to 6400 lumen-seconds per square foot (foot-candle-seconds). The extreme readable range is about 50 to 12,800 lumen-seconds per square foot.

Attenuator Range: *f*/3.5 to *f*/22 corresponding to a range of 1 to 64 on the proportional scale.

Tubes: One RCA 1P39 and one RCA 1L4.

Batteries: One Burgess 2F, three Burgess XX30E.

Calibration: Meter is standardized at the factory in terms of a calibrated xenon flashtube operated from a known capacitor at a specified voltage. A diffusion disc and aperture is individually fitted to each meter to standardize the reading.

Spectral Characteristics: The phototube has maximum sensitivity in the blue-green portion of the visible spectrum.

Response Speed: For reliable results the flash should be 1/20,000 second (50 microseconds), or more, in duration.

Accessories Supplied: Tubes, batteries, diffusion disc, plug for flash synchronizing circuit.

Other Accessories Available: A probe for light measurements at the camera ground glass is available at extra cost. See price list below.

Mounting: Walnut cabinet with hinged cover. Base of cabinet carries a tripod socket.

Dimensions: (Width) 7 x (height) 6½ x (length) 11 inches, over-all.

Net Weight: 8⅛ pounds.

Type		*Code Word*	*Price*
1501-A	**Light Meter**	COCOA	**$220.00***
1501-P1	**Probe**	DANDY	**26.00***

*Including Federal Tax.
PATENT NOTICE. See Note 6, page vi.

TYPE 1500-B COUNTING-RATE METER

USES: The Counting-Rate Meter with its Geiger-Mueller counter is a complete instrument for measuring the rate of random radiations from radio-active materials. As such, it is a basic tool in nuclear physics, where applications are developing rapidly in many scientific and industrial fields.

Two familiar applications are the quantitative measurement of radio-active materials in hospitals, and cosmic ray research. A most promising field is in conjunction with radio-active isotopes, several hundred of which are now being produced in relatively large quantities. The radio-activity of such isotopes provides a tracer by means of which their course in chemical and physical processes can be followed with the counter. The present applications of this technique include problems in medicine, chemistry, geology, metallurgy and agriculture. Basically a laboratory measurement device, rather than a survey instrument, this meter is particularly useful where it is desirable to have a permanent graphical record of changes in rate over a considerable period of time, since a pen recorder, such as the Esterline Angus 5-milliampere model, can be operated directly from the counting-rate-meter output. A continuous visual indication of rate is also provided on a panel meter so that the instrument can be adapted to a great many measurement problems. The advantage of the counting-rate meter over the scaling-circuit method of rate determination lies in its ability to indicate *directly* not only the rate, but changes in the rate as well.

DESCRIPTION: The counting-rate meter consists of a probe containing a quenching preamplifier and a socket in which the counter tube is normally mounted, a second amplifier, a circuit which standardizes the shape of the pulses without affecting their number, a frequency measuring circuit whose response is proportional to the pulse (or count) rate and a meter which is calibrated directly in counts per minute. This rate may also be recorded simultaneously on a pen and ink recorder. Five ranges are provided, and the total range of indication is from 5 to 20,000 counts per minute. The internal power supply system operates from the a-c line, and adequate voltage regulation is provided.

FEATURES: ➔ The panel meter is direct reading in counts per minute for *all* ranges.

➔ Counting accuracy not affected by ±10 per cent line voltage changes.

➔ There are four response speeds for much greater flexibility in application.

➔ Counter circuit voltage is calibrated and continuously adjustable.

➔ The output is adequate for operating a 5 ma pen recorder such as the Esterline-Angus Model AW Recorder.

➔ Both the high- and low-voltage power supplies are stabilized.

➔ An internal calibration check and adjustment are provided on the panel.

➔ A loudspeaker on the panel, with volume control, operates as an aural monitor.

➔ A tank circuit shunt aids in speeding up meter changes.

➔ A quenching preamplifier, designed for great adaptability, is supplied.

➔ High input sensitivity permits the use of a long cable to the counter tube.

SPECIFICATIONS

Range: Full-scale values of 200, 600, 2000, 6000 and 20,000 counts per minute are provided. The minimum rate that can be read on the meter scale is 5 counts per minute.

Accuracy: The instrument has been calibrated with a generator of equally spaced pulses to yield an accuracy of ±3% of full scale on all ranges.

The resolving time of the instrument is adequate for random counts up to 20,000 per minute.

Preamplifier: The Type 1500-P10 Preamplifier is a hand-probe design at the end of a 6-foot cable. It is fitted with a ¼-20 thread for mounting on a camera tripod or on the Type 1500-P11 Mount. The preamplifier circuit permits the use of either self-quenched or externally quenched counter tubes. The preamplifier is designed primarily for use with 4-pin based counter tubes; however, an adaptor is supplied to permit the use of any counter-tube design.

Response: There are four response speeds available, starting at about one second at all rates and covering a speed spectrum of over 100 to one. The actual values are also a function of the counting rate.

Counter Circuit Voltage: The voltage applied to the counter circuit is continuously adjustable from 400 to 2000 volts. The value of the voltage is read from an eight-position switch and a calibrated dial which covers the 200-volt interval between switch points. A means is provided for standardizing the voltage so that the accuracy of the voltage readings is within ±5% of the actual value. The power supply is well regulated so that line-voltage fluctuations do not cause changes in the high-voltage supply.

Counter Tube: No counter tube is supplied with the instrument but self-quenching beta-gamma mica-end-window Geiger-Mueller counter tubes are available as shown in the price list below. The density of the mica window on the Type 1500-P4 is between 3 and 4 milligrams per square centimeter, for use with relatively high-energy emitters. The window of the Type 1500-P5 is thinner (less than 2 milligrams per square centimeter) for greater efficiency in detecting low-energy emitters such as carbon 14 and sulphur 35. Both types have 4-pin bases.

Output: The output of the trigger circuit is available at terminals at the rear of the instrument. The 400- to 2000-volt variable high-voltage supply is also available at the rear of the instrument.

Recorder: A panel jack is provided for connecting a 5-ma recorder into the meter circuit.

Aural Monitor: A small loudspeaker is mounted on the panel for use as an aural monitor. A control, with an off position, is provided for adjusting the volume.

Power Supply: 105 to 125 volts, 50 to 60 cycles. By a simple change in connections on the power transformer, a 210- to 250-volt line can be used.

Power Input: 60 watts.

Accessories Supplied: Plug for connecting recorder, counter-tube adaptor, line connector cord, and spare fuses.

Accessories Required: A counter tube must be obtained separately (see price list below).

Other Accessories Available: Probe Mounting Stand (see photo).

Vacuum Tubes:

3 — 6SJ7	2 — 6J5
1 — 6AG7	1 — 6C6
1 — 6X5-GT	2 — 991
1 — 2X2-A	2 — 0C3
1 — 6SH7	1 — 6AU6
1 — 2LAG-4	

All are supplied.

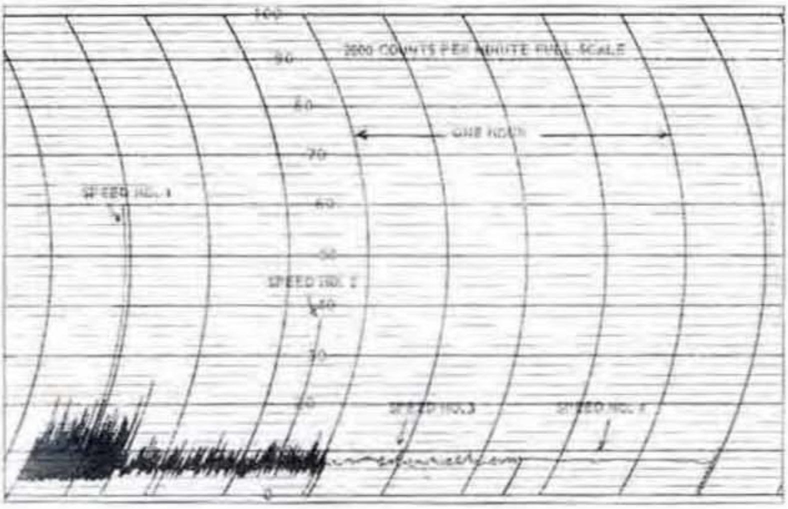
Mounting: The instrument is shipped with end frames for table mounting. For relay-rack mounting, simply remove the end frames.

Dimensions: Panel, (length) 19 x (height) 8¾ inches; depth behind panel, 13 inches.

Net Weight: 38½ pounds.

Type		*Code Word*	*Price*
*1500-B	Counting-Rate Meter	WORRY	$540.00
1500-P4	Beta-Gamma-Ray Counter Tube†	WORRYLOBBY	40.00
1500-P5	Beta-Gamma-Ray Counter Tube†	WORRYLOCAL	50.00
1500-P11	Probe Mounting Stand	WORRYSTAND	12.50

*Without counter tubes. † See *Counter Tube* in specifications, above. PATENT NOTICE. See Notes 2, 26, page vi.



Graphical record of response range of Type 1500-B Counting-Rate Meter to background and to a radio-active sample passing the counter tube. Speed No. 4 gives the most accurate background indication, while Speed No. 1 gives the most pronounced response to the sudden pulse from the sample.

RADIO STATION MONITORS

Radio transmitting stations engaged in various broadcasting services are required by regulations of the Federal Communications Commission to use monitoring equipment that gives continuous indications of the frequency and the modulation level of the emitted signal. The General Radio Company was the pioneer in developing measuring instruments for broadcasting stations, having supplied specialized frequency measuring equipment as early as 1924 and modulation measuring equipment in 1931. Later, when station monitors were first required by the FCC, automatic, continuously indicating instruments were made available by General Radio.

Frequency Monitors: The function of the frequency monitor is to indicate the deviation of the transmitter frequency from its assigned channel. Fundamentally, it consists of a frequency standard and a means of indicating the difference between the transmitter frequency and that of the standard. For convenience in measuring the difference frequency, the frequency of the standard is usually offset from that of the assigned channel. The deviation indicator is calibrated directly in cycles (or kilocycles) off channel.

Modulation Monitor: Percentage modulation for A-M transmitters is measured by a system in which the modulated signal from the transmitter is rectified in a linear diode rectifier to produce an a-c voltage proportional to the instantaneous value of the carrier envelope and a d-c voltage proportional to the average carrier amplitude. The effective ratio of the voltages is continuously indicated by a voltmeter whose scale is calibrated in modulation percentage. A limit circuit is also included which flashes a lamp whenever the modulation exceeds a predetermined percentage.

Standard Broadcast Band: For the standard broadcast frequencies, 540 to 1550 kilocycles, the Type 1181-A Frequency Deviation Monitor (page 187) and the Type 1931-A Modulation Monitor (page 188) are used. These instruments, which operate on the principles outlined above are fully described on the pages indicated.

F-M Broadcast: For F-M service, the frequency and modulation monitors are combined in a single instrument. While portions of the systems used are basically the same as with a-m monitoring, the circuits are considerably more complex, partly because of the higher frequencies involved and partly because of the stringent performance specifications that F-M monitors must meet. Operating principles of this monitor are thoroughly described on page 190.

Television: The Type 1183-T Television Station Monitor is available for monitoring both the aural and visual transmitters in the television station. This monitor, which can be supplied for both v-h-f and u-h-f channels, consists of a Type 1170-AT F-M Monitor, a Type 1171-A Visual-Transmitter Frequency Monitor, and a Type 1176-AT Frequency Deviation Meter. Complete specifications and prices will be furnished on request.

High-Frequency Broadcast, Municipal, and Other A-M Services: For A-M services in the high-frequency range, the Type 1175-B Frequency Monitor (page 192) is available, which can be used with the Type 1176-A Frequency Meter (page 214) as a deviation indicator.

Mobile F-M Transmitters: For this service, FCC regulations do not require station monitors, but the specifications on center frequency and frequency deviation make necessary their frequent measurement and adjustment. Equipment recommended for this purpose consists of the Type 1110-A Interpolating Frequency Standard and the Type 720-A or Type 620-A Heterodyne Frequency Meter, which are described in the Frequency Measurements section of this catalog, on pages 208, 210, and 212.

OTHER BROADCASTING STATION MEASUREMENTS

Distortion: The FCC Standards of Good Engineering Practice specify maximum permissible percentage of distortion for various broadcast services. The Type 1932-A Distortion and Noise Meter (page 159) and the Type 1301-A Low Distortion Oscillator (page 146) are designed to measure transmitter distortion, as well as carrier noise, rapidly and accurately. The Distortion and Noise Meter operates from the output of either the Type 1931-A Modulation Monitor or the Type 1170-A (or AT) F-M Monitor. The test tone is supplied by the oscillator.

A-M Noise in F-M Transmitters: A convenient self-calibrating A-M Detector, the Type 1932-P1 (see page 161) can be used with the Distortion and Noise Meter to measure A-M noise level in F-M transmitters.

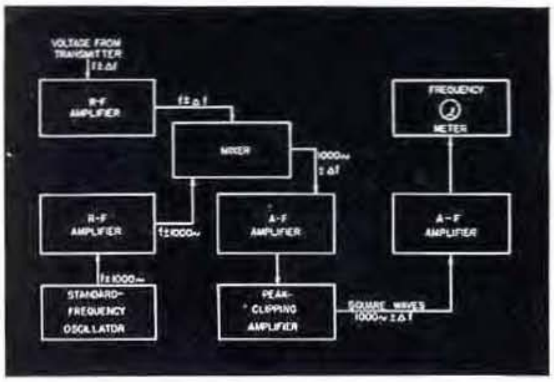
Antennas, Lines, Etc.: The General Radio Company manufactures an extensive line of bridges and other impedance-measuring equipment suitable for determining the impedance of antennas, lines, and phasing and matching networks. For various frequency bands, the following instruments are recommended:

		Page
50 kc–5 Mc	Type 916-AL R-F Bridge...	80
400 kc–60 Mc	Type 916-A R-F Bridge....	80
10–165 Mc	Type 1601-A V-H-F Bridge.	84
50 Mc–1500 Mc	Type 1602-A Admittance Meter................	86
300 Mc–3000 Mc	Type 874-LB Slotted Line..	113

TYPE 1181-A FREQUENCY DEVIATION MONITOR FOR A-M TRANSMITTERS

USES: The TYPE 1181-A Frequency Deviation Monitor indicates directly the magnitude and direction of the frequency deviation of a broadcast transmitter from its assigned channel frequency. A monitor of this general type is required for each station by the Federal Communications Commission, and Approval Number 1467 has been issued by the Commission for the TYPE 1181-A.

DESCRIPTION: The elements of the monitor are shown in the accompanying schematic block diagram. Voltages from a temperature-controlled piezo-electric oscillator (frequency $f \pm 1000$ cycles) and the transmitter to be monitored (frequency $f \pm \Delta f$) are amplified and fed to a mixer from which their difference frequency ($1000 \pm \Delta f$) is obtained. This audio frequency is amplified, its peaks are clipped to produce an essentially square waveform, which is applied to an audio-frequency meter. The indicator is calibrated to read zero when the audio beat is exactly 1000 cycles. Deviations from 1000 cycles (Δf) are indicated directly as the frequency deviation of the transmitter in cycles.



The monitor is a-c operated and is mounted on a single relay-rack panel.

FEATURES: ➔ Simple to install—easy to maintain.

➔ Deviation indication is unaffected by amplitude modulation.

➔ Deviation indication is independent of r-f input level, over a wide range.

➔ Very low r-f input power.

➔ Positive indication of failure of transmitter carrier is provided by signal-level pilot lamps. A push-button test indicates whether or not the monitor crystal voltage is adequate. Other pilot lamps indicate heater-thermostat and power circuit operation.

➔ External deviation-indicating meter can be connected.

SPECIFICATIONS

Deviation Range: ±30 cycles, readable to one cycle.

Carrier Frequency Range: 500 to 2000 kc.

Accuracy: When received, within ±10 parts per million. An adjustment is provided to bring the reading into agreement with monitoring station measurements.

Stability: Better than one part in a million under normal operating conditions. Adjustments are provided to correct the indicated frequency in terms of standard-frequency transmissions whenever necessary.

Vacuum Tubes: The following tubes are required and supplied with the instrument:

3—6SJ7	1—5V4-G
2—6AC7	1—6B4-G
2—6H6	1—0C3 VR105
2—6SQ7	1—2050
1—6V6	

Coupling to Transmitters: A few inches of wire serving as an antenna is usually sufficient. A minimum of 50 millivolts is required into a high-impedance grid circuit.

Accessories Supplied: Quartz plate, line connector cord, spare fuses, and plug for connecting an external meter.

Power Supply: 105 to 125 (or 210 to 250 volts), 50 to 60 cycles.

Power Input: 25 watts for heater circuits, 100 watts for monitor circuits.

Mounting: 19-inch relay-rack panel.

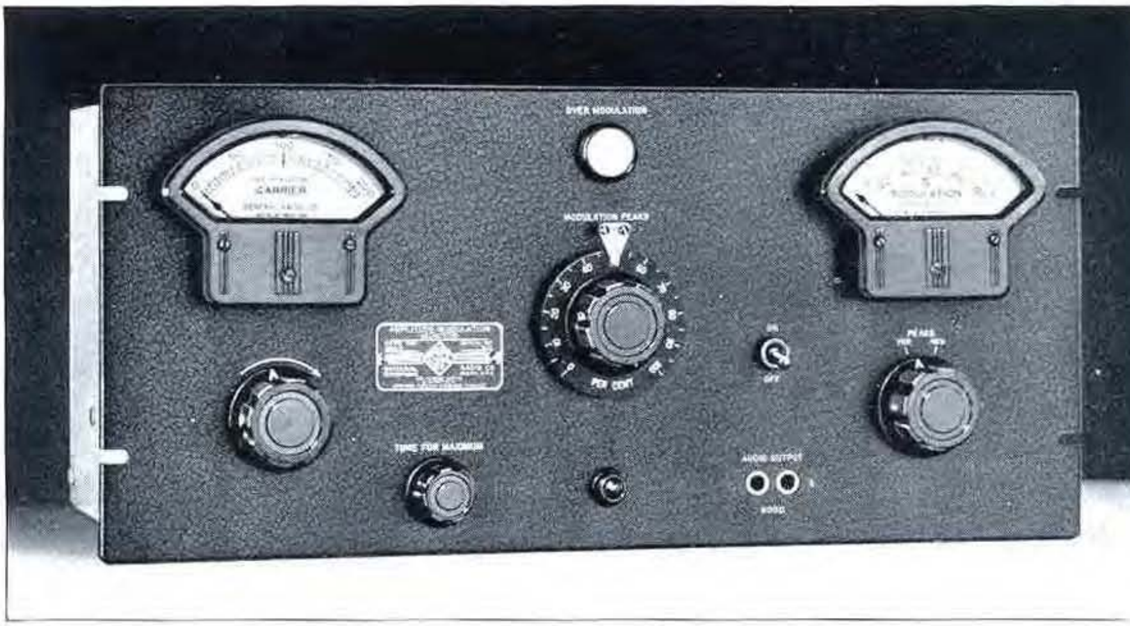
Panel Finish: Standard General Radio black crackle. Certain standard grays which can be processed in quantity can also be supplied.

Dimensions: Panel (length) 19 x (height) 15¾ inches. Depth behind panel, 13 inches.

Net Weight: 51 pounds.

Type		*Code Word*	*Price*
1181-A	Frequency Deviation Monitor........	MALAY	$775.00

PATENT NOTICE. See Notes 2, 5, 8, 21, 22, page vi.



TYPE 1931-A AMPLITUDE-MODULATION MONITOR

USES: The modulation monitor is used to measure and to indicate continuously the percentage modulation of broadcast and other radio-telephone transmitters. The TYPE 1931-A Modulation Monitor performs the following specific functions:

1. Measurement of percentage of modulation on either positive or negative peaks.
2. Overmodulation indication.
3. Program level monitoring.
4. Measurement of carrier shift when modulation is applied.
5. Measurement of transmitter audio-frequency response.

DESCRIPTION: TYPE 1931-A Modulation Monitor consists of three essential elements: (1) a linear diode rectifier which gives an instantaneous output voltage proportional to the carrier envelope, (2) a semi-peak voltmeter which gives a continuous indication of the peak modulation, and (3) a trigger circuit which flashes a light whenever the negative modulation peaks momentarily exceed any previously set value.

The linear rectifier is designed for operation at a low power level, which greatly simplifies the coupling to the transmitter. In the output of the linear rectifier is a d-c meter, which indicates the carrier level at which the instrument is operating and also shows any carrier shift during modulation.

In addition, two auxiliary audio output circuits operating from a separate diode rectifier are provided. One of these, at 600 ohms, is intended for audible monitoring; the other, a high-impedance circuit, gives a faithful reproduction of the carrier envelope with less than 0.1% distortion and can be used for distortion and noise-level measurements.

FEATURES: → Speed and simplicity of operation, essential for monitoring instruments, are available in this instrument. It operates over a wide carrier-frequency range, and a tuned input circuit is provided to facilitate coupling to the transmitter.

→ The r-f power input is only a fraction of that required by older models.

→ The flashing lamp is extremely useful as a monitoring device. It is set to flash with moderate frequency when the transmitter is operating normally. If the flashing rate changes markedly the operator is made aware that the average level of modulation has changed.

→ The flashing circuits are so designed that the indication is unaffected by moderate changes in carrier amplitude.

→ Terminals are provided so that remote percentage modulation indicators can be connected to the instrument externally.

→ FCC Approval No. 1555 has been issued for this monitor.

SPECIFICATIONS

Range: Modulation percentage, 0 to 110%, indicated by meter on positive peaks, 0 to 100% on negative peaks. The flashing lamp is adjustable to operate from 0 to 100% on negative peaks.

Carrier-Frequency Range: The monitor will operate at any carrier frequency from 0.5 to 60 megacycles. A single set of coils (either 0.5 to 8 megacycles or 3 to 60 megacycles) is supplied with each instrument, unless both sets are specifically ordered.

Carrier-Frequency Input Impedance: About 75 ohms in the broadcast band, increasing slightly at higher carrier frequencies and varying somewhat with input tuning.

Accuracy: The over-all accuracy of measurement at 400 cycles is ±2% of full scale at 0% and 100%, and ±4% of full scale at any other modulation percentage.

Detector Linearity: The distortion in the diode detector is very low for frequencies up to 7500 cycles. Above this frequency, a small amount of negative peak clipping occurs, reaching 5% at the extreme high end of the audio range at 15,000 cycles and 100% modulation.

R-F Power: In the broadcast range the maximum r-f power requirement is about 0.5 watt.

Vacuum Tubes: The following tubes are used:

2—6SN7	1—2050
2—6SJ7	2—0D3
1—6AL5	1—6X5GT

Warning Lamp Circuit: The OVERMODULATION lamp will flash whenever the negative modulation peaks exceed the setting of the MODULATION PEAKS dial by approximately 2% modulation, for audio frequencies between 30 and 7500 cycles. For higher audio frequencies, the percentage overmodulation required to flash the lamp increases slightly.

The accuracy of the dial calibration is approximately ±2% of full scale.

Meter Circuit: The response of the PERCENTAGE MODULATION meter circuit is flat, within ±0.25 db, between 50 and 15,000 cycles, and within ±0.1 db between 100 and 10,000 cycles.

Either positive or negative modulation peaks may be read. Calibration in db below 100% modulation is provided.

The meter dynamic characteristic meets FCC specifications for modulation monitors.

Audio Monitoring Output: The audio output amplifier is flat, within ±1.0 db, from 30 to 45,000 cycles. The internal impedance is 600 ohms. Distortion is less than 0.2%. Open-circuit output voltage is about 300 millivolts.

Fidelity-Measuring Output: Flat within ±1.0 db between 30-30,000 cycles with TYPE 1932-A Distortion and Noise Meter connected.

Output level varies inversely with setting of MODULATION PEAKS dial, thus providing reasonably uniform input to distortion meter at all modulation levels. Average output level, approximately 1.5 volts.

Residual noise and hum level will not exceed −80 db.

Auxiliary Output: A multipoint connector at the rear of the instrument provides a means of connecting:

1. A remote Percentage Modulation Meter.
2. To a 600-ohm output for audio monitoring.
3. The TYPE 1932-A Distortion and Noise Meter.

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles. Power input is approximately 50 watts.

Accessories Supplied: Multipoint connector, line connector cord, spare fuses, and one set of input tuning coils (specify frequency range desired).

Mounting: The instrument is relay-rack mounted. End frames are available for table mounting. (See price list below.)

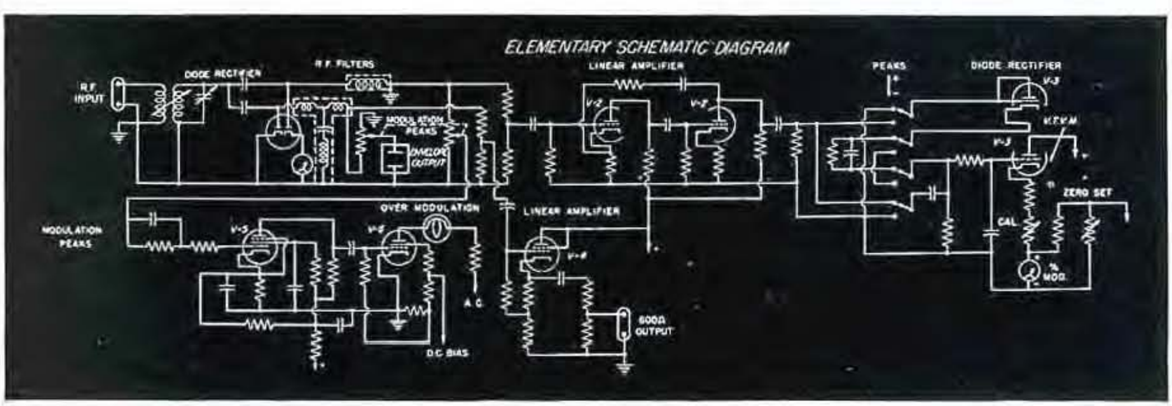
Panel Finishes: Standard General Radio black crackle. Certain standard grays which can be processed in quantity can also be supplied.

Dimensions: Panel (length) 19 x (height) 8¾ inches. Depth behind panel, 10 inches.

Net Weight: 32¾ pounds.

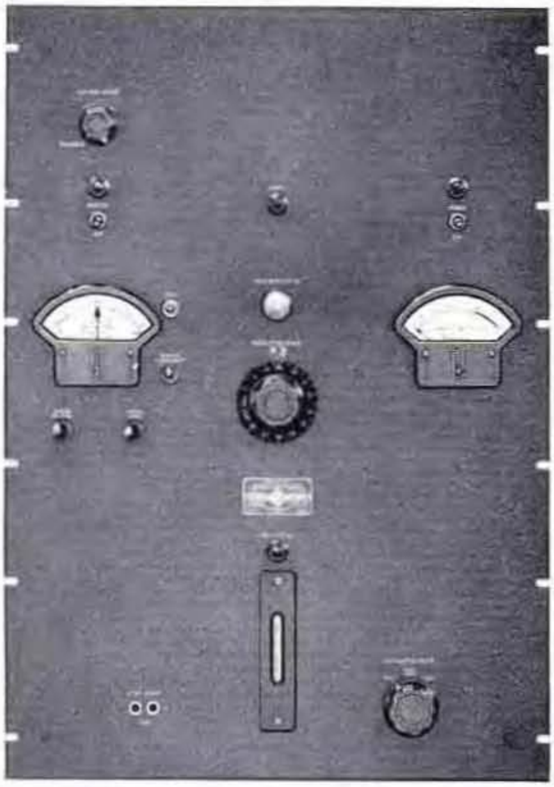
Type		*Code Word*	*Price*
1931-A	Modulation Monitor, 0.5 to 8 Mc......	TARRY	$440.00
1931-A	Modulation Monitor, 3 to 60 Mc......	TOPIC	440.00
1931-P5	Extra Tuning Coils, 0.5 to 8 Mc......	TABBY	16.50
1931-P6	Extra Tuning Coils, 3 to 60 Mc......	TOTEM	16.50
FRI-510	End Frames......................	ENDFRAMEAT	12.00 Pair

PATENT NOTICE. See Notes 1, 12, 18, 19, 21, page vi.



TYPE 1170 F-M MONITOR

FOR TELEVISION SOUND AND F-M BROADCAST



USES: This monitor gives a continuous indication of center-frequency and percentage modulation (frequency deviation) of f-m transmitters. It also furnishes a high-fidelity output for measuring distortion and noise, and a 600-ohm output for audio monitoring. The monitor is designed to operate at frequencies between 30 and 900 megacycles, covering both the f-m broadcasting bands and the frequencies used for audio transmitters in television broadcasting. It meets the requirements of the Federal Communications Commission for these services.

DESCRIPTION: The accompanying block diagram shows the functional operation of the monitor. A harmonic of a standard-frequency oscillator beats with the transmitter frequency to produce a nominal intermediate frequency of 150 kc plus or minus the transmitter frequency deviations. This signal is then passed through amplifiers and limiters which change the waveform to steep, square-topped pulses of constant amplitude, which are applied to a counter-type discriminator. The d-c output of the discriminator is used to operate the center-frequency indicator. The a-c output, suitably amplified and filtered, operates the modulation indicators and is available at two output circuits: a 100,000-ohm circuit for distortion and noise measurements and a 600-ohm circuit for audio monitoring.

FEATURES: ➔ The use of a low intermediate frequency and a counter-type discriminator results in a high degree of stability, so that a continuous indication of center frequency is achieved without reference to a second crystal for setting zero.

➔ Highly stable crystal oscillator.

➔ Because the counter-type discriminator is inherently linear, accurate center-frequency indications are obtained even in periods of heavy modulation.

➔ Discriminator is linear to better than 0.1%, permitting accurate distortion measurements.

➔ Can be operated at 25 kc = 100% modulation, for television audio channels.

➔ Distortion-and-noise-measuring output includes 75 microsecond de-emphasis circuit.

➔ Residual noise level is down at least 75 db referred to ±75 kc deviation, and 65 db for ±25 kc (television) deviation.

➔ Modulation meter reads positive, negative, or peak-to-peak, as selected by a switch.

➔ Overmodulation lamp flashes when modulation exceeds level as set by a dial.

➔ R-F sensitivity is 1.0 volt or better.

➔ Adjustable input attenuator, with meter.

➔ Pilot lamp indicates adequate input level.

➔ Terminals are provided for connecting external meters and overmodulation indicators.

➔ Regulated power supply.

➔ Chassis arranged for maximum heat dissipation and easy servicing.

➔ A zero correction is provided to compensate for long-time drift.

SPECIFICATIONS

Transmitter Frequency Range: TYPE 1170-A, 88 to 108 Mc; TYPE 1170-AT1, 44 to 88 Mc; TYPE 1170-AT2, 160 to 220 Mc; TYPE 1170-AT3, 470 to 890 Mc.

R-F Input Impedance: High impedance, channels 2–13, with TYPE 774 Coaxial Connector. A capacitance attenuator is provided for adjusting the input level. Low impedance, in u-h-f range, with adjustable loop coupling input. The monitor can be used with standard RMA transmitter monitoring output.

Input Sensitivity: 1 volt r-f, or better, on high-impedance input; 500 milliwatts, or less, on low impedance

Input Level Indicators: A meter for indicating r-f input level is provided at the rear of the chassis. Signal pilot lamp and center-frequency-meter pilot glow only when input level is adequate.

Intermediate Frequency: 150 kc.

Discriminator: Pulse-counter type, linear to better than 0.1% over a range of ±100 kc.

Center Frequency:

Indication: Meter is calibrated in 100-cycle divisions from −3000 to +3000 cycles per second for F-M broadcast, and T-V channels 2–6; 200-cycle divisions from −6000 to +6000 cycles for T-V channels 7–13 and for the 470-890 Mc range. No zero set is necessary for each reading and no second crystal is required for this purpose.

Accuracy: Crystal frequency, when monitor is received, is within ±10 parts per million of specified channel frequency. Center-frequency reading is adjustable over ±3000-cycle range to bring monitor into agreement with frequency-measuring service. Center-frequency indication then is accurate to ±200 cycles.

Stability: ±1.5 parts per million, ±200 cycles or better, over-all, for long periods.

Percentage Modulation:

Indication: Meter is calibrated from 0 to 133%. Additional db scale is provided. Switch selects positive or negative peaks, or full-wave (peak-to-peak) indication. 100% modulation corresponds to ±75 kc deviation for f-m bands, 25 kc for television. Meter ballistics meet FCC requirements.

Accuracy: ±5% modulation.

Overmodulation Indicator: Lamp flashes when predetermined modulation level, as set on a dial, is exceeded. Range of dial is 0 to 120% modulation.

Output Circuits:

1. Distortion and Noise Measurements: Terminals are provided for connecting a Type 1932 Distortion and Noise Meter, and a gain control is provided.

Residual Distortion: Less than 0.2% at 100-kc deviation.

Response: 50 to 30,000 cycles per second ±½ db. Standard 75 microsecond de-emphasis circuit is included.

Maximum Output: 1.5 volts into 100,000 ohms.

Residual Noise Level: −75 db or better referred to ±75 kc deviation; −65 db or better for ±25 kc deviation.

Sensitivity: Full output can be obtained down to ±6 kc deviation. Sensitivity varies with modulation frequency in accordance with standard de-emphasis characteristics.

2. Audio Monitoring Output:

Impedance: 600 ohms, unbalanced.

Output: Zero dbm at 75 kc deviation.

Response: 50 to 15,000 cycles per second ±¼ db.

Crystal Oscillator: General Radio high-stability circuit. Crystal is temperature-controlled at (60 ±0.15)° C. Temperature coefficient of crystal is 2 parts per million or less per degree C. Crystal oscillator output level can be read on panel meter by pressing a push-button switch.

Remote Indicators: Circuits and terminals are provided for connecting the following external indicators:

Center-frequency indicator
Percentage-modulation meter
Over-modulation lamp
600-ohm unbalanced aural monitor

Vacuum Tubes: All tubes are furnished.

Accessories Supplied: Coaxial connector for r-f input, power line connection cord, spare fuses, extension meter plug.

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles. Rated power input 300 watts.

Mounting: 19-inch relay-rack panel. Shielding cabinet permanently installed in rack allows easy removal of monitor for inspection and maintenance.

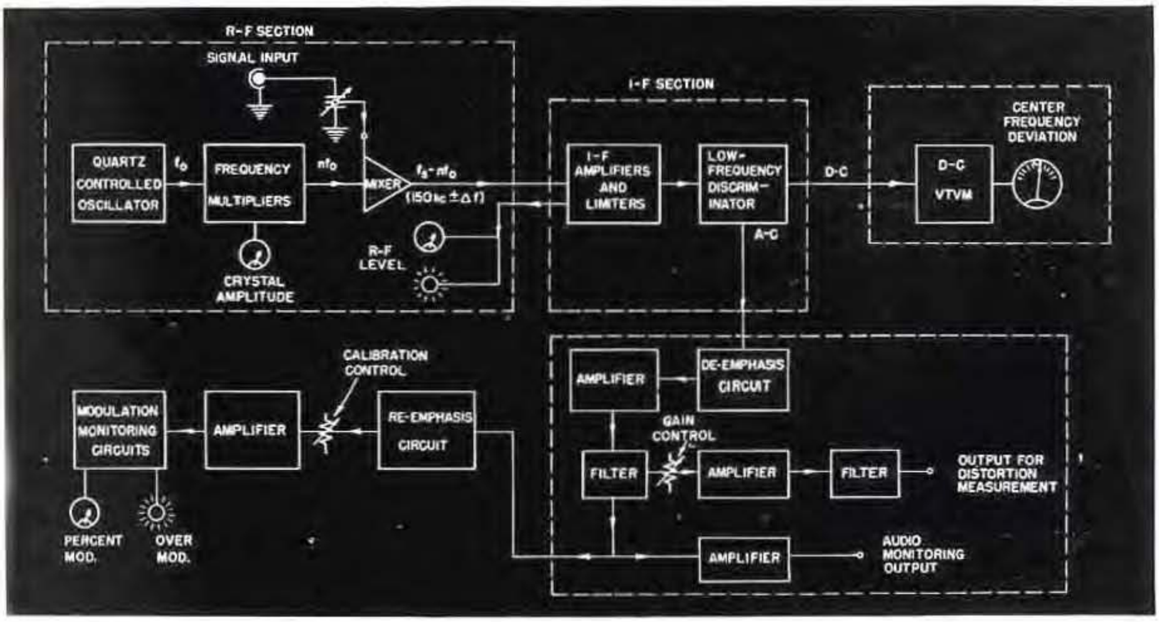
Panel Finish: Standard General Radio black crackle lacquer. Certain standard grays which can be processed in quantity can also be furnished.

Dimensions: Panel, 19 x 26¼ inches, depth behind panel, 13¼ inches, over-all.

Net Weight: 98 pounds.

Type		*Code Word*	*Price*
1170-A	**F-M Monitor (for F-M Broadcast Service)**	AHEAD	**$1750.00**
1170-AT1	**F-M Monitor (for TV Channels 2-6)**	ADULT	**1750.00**
1170-AT2	**F-M Monitor (for TV Channels 7-13)**	AIROL	**1750.00**
1170-AT3	**F-M Monitor (for UHF — TV)**	AFFIX	**Price on request**

PATENT NOTICE. See Notes 1, 2, 5, 8, 12, 18, 19, 22, page vi.



TYPE 1175-B FREQUENCY MONITOR

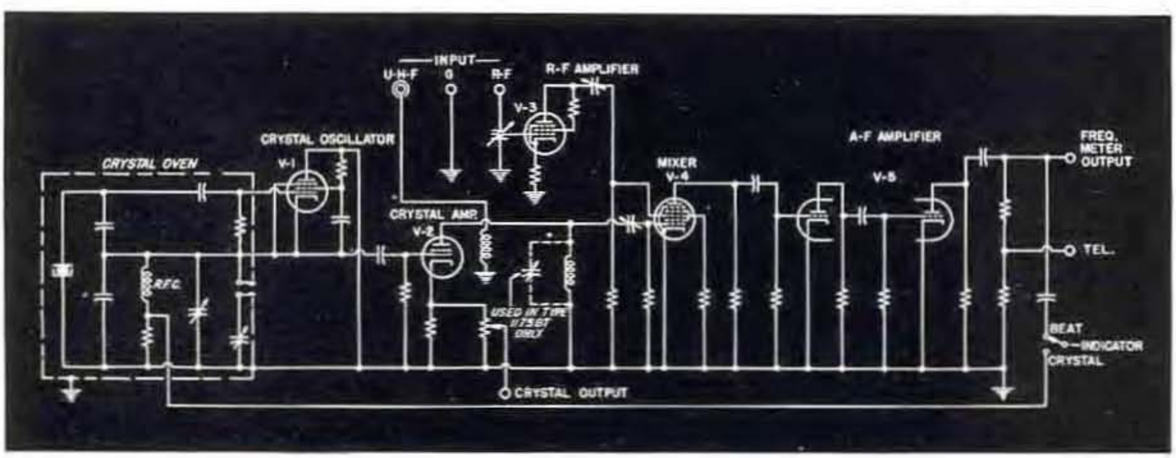
USES: The Type 1175-B Frequency Monitor is designed to monitor the carrier frequency of amplitude-modulated radio transmitters in the high-frequency range, particularly those operated by police, fire, and other municipal departments. It is a high-sensitivity monitor at frequencies below 100 Mc, and hence can be used to monitor high-frequency mobile transmitters from a short distance as well as for monitoring the main transmitter.

Used either singly or in groups, it provides an excellent means of monitoring the frequencies used by airlines and airports.

A voltage of the audio beat frequency between transmitter and monitor crystals is available at an output jack. Where a continuous indication of frequency deviation is desired, the Type 1176-A Frequency Meter should be used.

DESCRIPTION: The monitor consists of a temperature-controlled piezo-electric oscillator with mounting facilities for 4 crystals; 2 buffer amplifiers, one for the crystal frequency and one for the transmitter frequency; a mixer; and an audio-frequency amplifier.

The crystal oscillator circuit is one developed in the General Radio laboratories specifically for use in monitoring where a high degree of stability and reliability is required. No tuned elements are used in the circuit except the crystal itself. The crystal operates



much nearer to its true series resonant frequency than is possible in conventional circuits, and the stability achieved is correspondingly higher.

The beat-frequency output is available at a telephone jack on the panel, and the output of the crystal oscillator is available at panel terminals for calibrating or adjusting other equipment, such as receivers and mobile transmitters.

A panel switch allows the monitor to be kept in a stand-by condition, where the vacuum-tube circuits are not operating but temperature control is maintained.

FEATURES: ➔ The sensitivity of the monitor makes it possible to use it for low-power services and remote monitoring, when provided with an external tuned antenna.

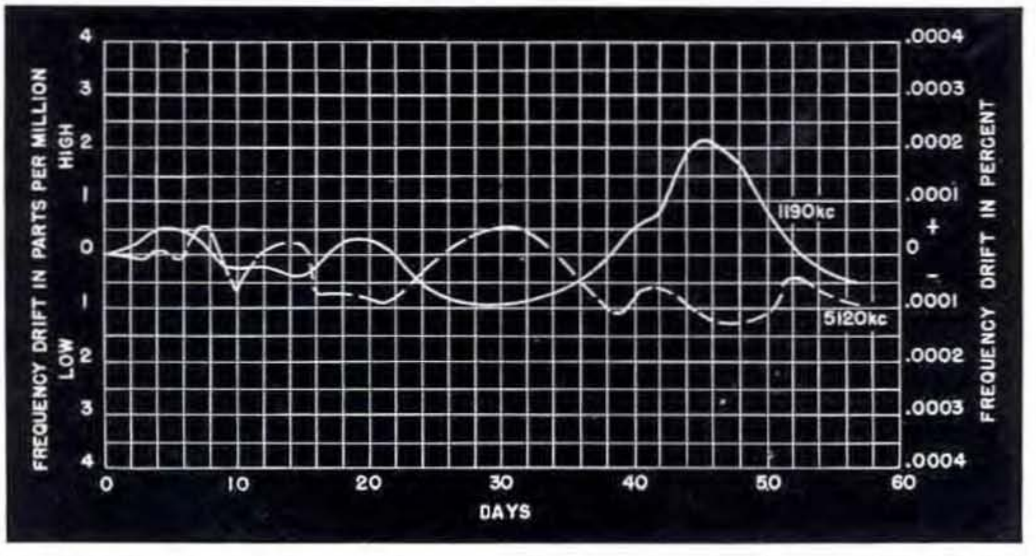
➔ Crystal oscillator output is available at panel terminals and an output level control is provided.

➔ Two buffer stages are used, one for the crystal oscillator and one for the transmitter input.

➔ Stand-by operation is available by simply turning a switch on the panel.

➔ A test for deviation direction is provided, as well as tests for crystal and beat output.

➔ Deviation frequency magnitude, completely unaffected by amplitude modulation of the transmitter carrier, is given directly when a Type 1176-A Frequency Meter is used with the monitor.



Actual records of crystal oscillator stability over a period of several weeks. The frequencies indicated on the plot are fundamentals; harmonics are used for monitoring.

SPECIFICATIONS

Carrier Frequency Range: 1600 kc to 162 Mc.

Accuracy: With Type 376-M Quartz Plate, 0.001%.

Quartz Plate: No crystals are included in the price. See price list below. Crystals are ground to an integral submultiple of the channel frequency, unless offset operation is specified.

Number of Monitoring Channels: Four.

Power Supply: 105 to 125 volts, 50 to 60 cycles. By changing connections on the power transformer, the monitor can be operated from a 210-250-volt line.

Power Input: 75 watts, including temperature control.

Accessories Supplied: Line connector cord, spare fuses, multipoint connector, and coaxial connector for r-f input.

Vacuum Tubes:

1—6AC7	1—6SJ7
1—6AG7	1—6X5GT/G
1—6E5	1—6BE6
1—6SN7-GT	1—0D3

All vacuum tubes are supplied.

Panel Finish: Standard General Radio black crackle. Certain standard grays which can be processed in quantity can also be supplied.

Mounting: Standard 19-inch relay-rack panel. Walnut end frames are available for adapting the instrument for table mounting. (See price list below.)

Dimensions: Panel, 19 x 7 inches; depth behind panel, 11¼ inches.

Net Weight: 18½ pounds.

Type		*Code Word*	*Price*
1175-B	Frequency Monitor 1600 kc to 162 Mc	TIPSY	$325.00
376-M	Quartz Plate	LABOR	70.00
FRI-410	End Frames for Type 1175-B	ENDFRAMDAY	10.00 Pair

PATENT NOTICE. See Notes 2, 5, 8, 21, page vi.

FREQUENCY AND TIME

The determination of frequency directly in terms of time is a fundamental measurement, since frequency is the *time* rate of recurrence of a cyclical phenomenon. A *primary* standard of frequency is, therefore, defined as one whose frequency is determined directly in terms of time. A *secondary* standard is one whose frequency is determined by comparison with a primary standard, or by comparison with other secondary standards, some one of which was originally compared with a primary standard.

It is to be noted that the above classifications of frequency standards have nothing to do with the *accuracies* of the standards. In fact the same standard is logically classed as a primary standard if checked directly against time, and as a secondary standard if checked against standard frequency transmissions (representing a distant primary standard).

In practice, the responsibility of establishing and maintaining accurate time determinations by astronomical observations is not assumed by the individuals desiring a primary standard of frequency. The time determinations are carried out by observatories especially equipped for the purpose. The results are made available to a large number of users by radio and wire transmission. In the United States, the U. S. Naval Observatory transmits high-precision time signals by radio through the facilities of the U. S. Naval Radio Service. Transmissions on several frequencies are available several times a day and can be received nearly all over the world. A similar service is provided in Canada by the Dominion Observatory.

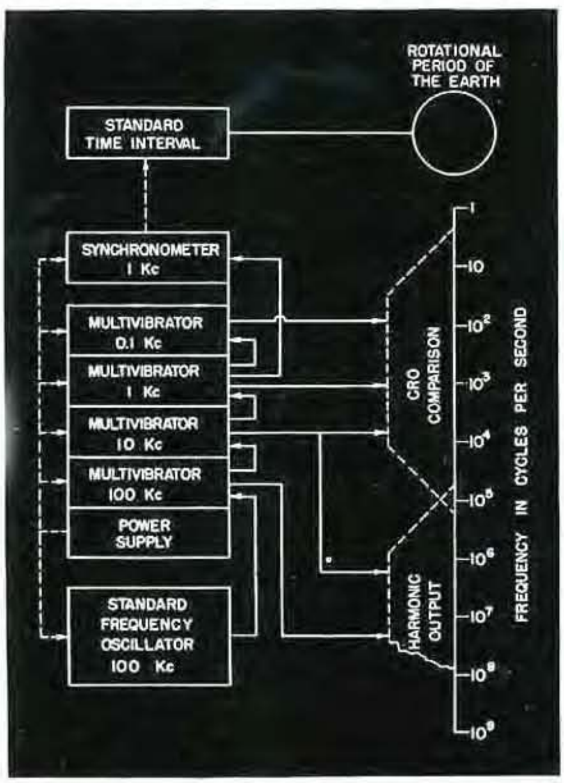


FIGURE 1. Block diagram showing the functional arrangement of the TYPE 1100-AP Primary Frequency Standard and the range of output frequencies available from it.

The user of a primary frequency standard can then conveniently determine the frequency of the standard in terms of the standard time interval sent to him by radio. In the General Radio equipment means are provided for quickly and easily making this comparison. For the most precise results, the errors of the transmitted time signal must be taken into account. Correction data may be obtained by applying to the Superintendent, U. S. Naval Observatory, Washington, D. C.

Since the astronomical clocks now used at the Naval Observatory are piezo-electric oscillators, similar to those used in accurate frequency standards and since, through close cooperation of the U. S. Naval Observatory and the National Bureau of Standards, the piezo-electric oscillators of the latter's primary frequency standard are checked in the same way as the former's astronomical clocks, the comparison with time is, in effect, carried out by the observatory. The standard frequency transmissions sent out by the Bureau of Standards consequently represent a primary standard of high precision available to all who can receive the transmissions. Where such transmissions can be received, it is generally more convenient and much quicker to make the comparison by frequency than by time. For information and schedules of transmission of standard frequencies, apply to the Radio Division, Bureau of Standards, Department of Commerce, Washington, D. C.

A calibration against transmitted radio frequencies yields a *pseudo-instantaneous* frequency value of the standard; while a calibration against transmitted time signals yields an *average* frequency value of the standard during the period between successive observations which, for precision, must be an interval of several hours.

Because of the vagaries of high frequency transmission, many users rely on checks against time as a reserve. They also use the primary standard as a high-precision clock for laboratory timing purposes.

As so far considered, the precision oscillator is a single-frequency device. For practical utility it is necessary to obtain from this single frequency many other frequencies, both above and below the standard frequency, for convenience in measurements. Since most of the precision oscillators operate in the region of 50 to 100 kc, it is necessary to divide the frequency to obtain a value such that a synchronous motor can be used to count the number of cycles executed by the precision oscillator in a standard interval of time. For measurements of high radio frequencies, it is necessary to multiply the standard frequency to obtain useful frequencies in the range of the frequency being measured. Both of these operations are readily performed by a controlled relaxation oscillator, known as a multivibrator.

THE PRIMARY FREQUENCY STANDARD TYPE 1100-AP

The elements of a primary frequency standard, General Radio Type 1100-AP, are shown in Figure 1.

The frequency of the precision oscillator is 100 kc, which is divided successively by factors of 10 to obtain multivibrator fundamental frequencies of 10, 1, and 0.1 kc. A fourth multivibrator operating at a fundamental frequency of 100 kc, provides a large number of harmonics at 100 kc intervals for use at high radio frequencies. Harmonics of the 10 kc multivibrator are similarly used. In the audio-frequency and low-frequency range (up to one or two hundred kc) a cathode ray oscilloscope is used to obtain hundreds of known frequencies. This is simpler than trying to make use of harmonics of the low standard frequencies.

The range of useful output frequencies obtainable from the General Radio Primary (or Secondary) Frequency Standard is indicated in Figure 1. Complete specifications are given on pages 197 to 199.

This frequency standard is the result of many years of continuous development in the

Figure 2. View of the Type 1190-A Quartz Bar used in Type 1100-A Frequency Standard, with cover removed, showing the spring suspension.

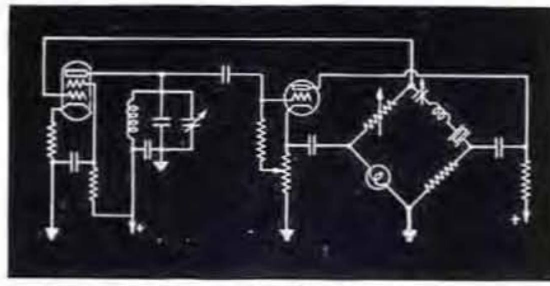


Figure 3. Elementary circuit of the bridge-type piezo-electric oscillator used in the Type 1100-A Frequency Standards.

General Radio laboratories. The quartz bar (and mounting), the oscillator circuit, and the temperature-control system used in the standard make possible a stability of a few parts in 10^8 over periods of several months, and a short-period stability of approximately 2 parts in 10^9. The quartz bar and its mounting are shown in Figure 2. The bar vibrates in its second-harmonic extensional mode, and is held at its two nodes in a spring suspension mounting in such a manner as to introduce a minimum of damping. Electrodes are formed directly on the surfaces of the quartz. The cross-sectional dimensions of the bar have been so chosen that the temperature coefficient of frequency is zero in the vicinity of the operating temperature of 60° C.

The temperature-control system holds the temperature of the quartz bar constant to better than 0.01° C. The principles of operation of the temperature-control system were outlined in an article entitled "Notes on the Design of Temperature Control Units," by J. K. Clapp, *General Radio Experimenter*, August 1944.

A bridge-type oscillator circuit is used, shown in schematic form in Figure 3. In this circuit, the crystal vibrates at its series resonant frequency and the amplitude of oscillation is constant. For an analysis of the circuit, see J. K. Clapp, "A Bridge-Controlled Oscillator," *General Radio Experimenter*, April 1944, and May 1944.

THE SECONDARY FREQUENCY STANDARD TYPE 1100-AQ

In the past there was a useful field for frequency standards of less than the best possible precision, such standards being checked frequently against standard frequency transmissions. These standards could be manufactured at a lower cost than the more precise standards and consequently were used in many applications where price was a governing consideration.

At present the demand for more accurate secondary standards, coupled with less expensive designs for primary standards, makes it

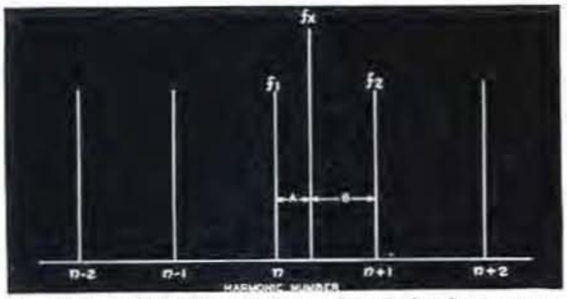


FIGURE 4. This diagram shows the relation between an unknown frequency and a standard harmonic series.

undesirable to make two types of standard. Consequently, the same component units are offered for use as a secondary standard—the precision oscillator, and multivibrator and power supply unit, but without the synchronometer unit. (This latter unit can be added later, if desired.)

FREQUENCY MEASUREMENT

The next step, after establishing a series of standard frequencies embracing a portion of the frequency spectrum in which measurements of frequency are to be made, is to evaluate any unknown frequency in terms of one of the standard frequencies. Any unknown frequency will lie between two of the standard-frequency harmonics as shown in Figure 4. The simplest process is to determine the difference in frequency between the unknown frequency and the nearest of the standard frequencies. This difference is added to the standard frequency if the unknown lies above the standard, or subtracted if the unknown lies below the standard frequency.

For evaluating the frequency difference, *A* or *B*, (Figure 4) a convenient method consists of beating the standard and unknown frequencies in a detector, and measuring the beat frequency with a calibrated audio oscillator as indicated in Figure 5.

The TYPE 1105-A Frequency Measuring Equipment is an assembly of the necessary instruments for measuring unknown frequencies in terms of standard-frequency harmonics obtained from the TYPE 1100 Frequency Standard. This assembly includes an interpolation oscillator and comparison oscilloscope for measuring audio and beat frequencies, as well as the necessary radio-frequency detectors and calibrated oscillators used in measuring the higher frequencies. For a complete description, see pages 200 to 207.

WIDE-RANGE FREQUENCY METERS

For many applications it is not necessary to have the accuracy provided by a frequency standard, nor is it always possible to use conveniently such a relatively large piece of apparatus. Accordingly several different types of frequency-measuring instruments have been developed to supplement the standard over various frequency and accuracy ranges. The simplest of these is the time-honored resonant-circuit wavemeter, which is still a valuable tool for general experimental work or for making preliminary adjustments on oscillators and transmitters. Several models of wavemeters differing in frequency ranges, accuracies, and resonance indicators are described in detail on pages 216 to 218.

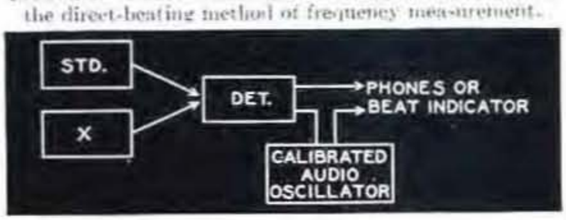
The heterodyne frequency meter is capable of making measurements more accurately than the wavemeter and still is small enough so that portability and simplicity are not lost. One model, the TYPE 620-A, described on page 210, contains a one-megacycle crystal calibrator which makes possible frequency measurements to an accuracy of 0.01%. The TYPE 720-A (page 212) is a 0.1% instrument for use up to 3000 megacycles. The direct-reading dials on these instruments make rapid measurements possible.

The TYPE 1110-A Interpolating Frequency Standard, page 208, is a new type of instrument designed particularly for use with heterodyne frequency meters to extend accurate frequency measurements up to 2000 or 3000 megacycles. This instrument is essentially a crystal-controlled frequency standard variable over the range from 1000 to 1010 kilocycles. Two multivibrator units give 100-kc and 1-Mc harmonics. The fact that the oscillator and multivibrator outputs are variable over a 1% range means that this instrument can be used with a heterodyne frequency meter such as the TYPE 720-A to provide an accurate check point at any point on the dial of the TYPE 720-A. Thus the accuracy of measurements made with the TYPE 720-A Heterodyne Frequency Meter is improved to at least 25 parts per million.

AUDIO FREQUENCIES

For the direct measurement of audio frequencies, two instruments are available, the TYPE 1176-A Frequency Meter, a direct-indicating device for measuring frequencies up to 60 kc, and the TYPE 1141-A Audio-Frequency Meter, a null-type Wien Bridge with a direct-reading dial from 20 cycles to 20 kc.

FIGURE 5. Functional diagram showing the operation of the direct-beating method of frequency measurement.



TYPE 1100-A FREQUENCY STANDARDS

The TYPE 1100-A Frequency Standards are highly precise standards of frequency, operating on the principles outlined on pages 194 and 195. Two models are available, the TYPE 1100-AP Primary Standard and the TYPE 1100-AQ Secondary Standard. The same basic elements are used in each, and there is no difference in accuracy and stability between the two assemblies.

The primary standard is provided with a Syncronometer (synchronous motor clock) for evaluating its frequency directly in terms of standard time. The secondary standard has no syncronometer. All other specifications are identical with those for the primary standard.

Harmonic series based on fundamentals of 0.1, 1, 10 and 100 kilocycles are available at its output terminals to furnish usable standard frequencies over a wide range. The accuracy of all output frequencies is the same and is better than five parts in ten million over periods of several months.

Unless otherwise specified, each assembly is supplied in a floor-type relay rack.

A functional layout of the standard is shown on page 194. Brief descriptions of the individual units are given on the following page, and complete specifications on page 199.

A newly designed assembly of frequency measuring equipment for use with these standards is described on pages 200 to 202.

General Radio Frequency Standards are known the world over for reliability and accuracy. They are used by governmental agencies, industrial plants, military services, and research laboratories. Current models have all the features of earlier ones, plus many additional advantages in convenience, size, weight, performance and appearance, that result from General Radio's continuous program of research and development in the field of frequency measurement and standardization.

The primary standard is an excellent national standard of frequency for communications ministries, and with the TYPE 1105-A Frequency Measuring Equipment, can be used to monitor or to measure the frequencies of radio stations. It is also suitable for use as a standard clock by observatories. Research laboratories and radio manufacturing plants should use the primary standard whenever

Close-up view of the TYPE 1100-AP Primary Frequency Standard. Lower part of the floor-type relay rack is not shown. The complete rack is similar to that shown in the photograph on page 200. When the standard is to be mounted on a bench or table, a bench-type rack can be supplied, if specified in the order.

the requirements make it advisable to have an independent check against time.

For many uses the timing feature of the primary standard is not needed, and the secondary standard, which offers the same stability at a lower price, can be used. With the secondary standard, an accurate check upon its frequency can be made by a comparison with standard-frequency radio transmissions such as those of the National Bureau of Standards at Washington. This comparison is adequate to evaluate the frequency of the standard to a few parts in one hundred million.

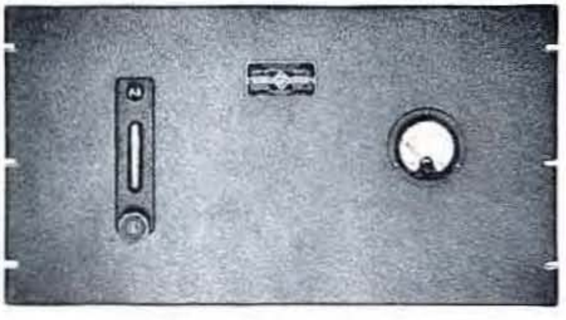
Shown below are the individual panels that make up the standard, with brief descriptions of their characteristics. Additional details of circuit and construction will gladly be supplied upon request. Specifications and prices are listed on page 199.

TYPE 1103-A SYNCRONOMETER

This panel includes a 1000-cycle synchronous motor for effectively counting the number of cycles executed by the standard piezo-electric oscillator in a standard time interval. A large, illuminated, 24-hour dial with a long sweep hand makes for easy visibility. A microdial contactor, operating once each second, and calibrated in hundredths of a second, is provided for comparison with time signals. The microdial mechanism can be phased by means of a panel control. Comparison of the syncronometer reading with standard time can be made on the microdial scale to one part in ten million over a 24-hour interval. The 1000-cycle synchronous motor is started by a 60-cycle motor controlled by a push-button on the panel.

TYPE 1102-A MULTIVIBRATOR AND POWER SUPPLY UNIT

This unit contains four multivibrators of 100, 10, 1, and 0.1 kc frequencies, the power supply for the entire standard, and the control circuits of the temperature-control system of the TYPE 1101-A Piezo-Electric Oscillator. Concentric shielded connectors are provided for 100-kc and 10-kc harmonic outputs, for radio frequency measurements, and 10 kc, 1 kc and 0.1 kc for audio frequency measurements. These connections are all mounted on the rear of the assembly. All tubes are accessible from the rear, without removal of any dust covers. The four multivibrators are mounted on the rear panel, which is removable without disconnecting any wiring. Mounting spacers and servicing cable are supplied to operate the multivibrators when the panel is reversed, giving access to all components of the multivibrator assembly.



TYPE 1101-A PIEZO-ELECTRIC OSCILLATOR

This oscillator operates with a TYPE 1190-A Quartz Bar, which is mounted in the temperature-control unit, located at the left behind the panel. The temperature is controlled by a compensated thermostat circuit and is maintained within 0.01° C for all ordinary ambient temperatures. The oscillator circuit assembly is mounted at the right behind the panel. All tubes are accessible from the rear without removing any dust covers.

A view of the TYPE 1190-A Quartz Bar is shown on page 195.

TYPE 480-PA CABINET RACK

(not shown above, see page 200 for photo)

A floor-type cabinet rack is supplied to house the complete frequency standard unless a bench-type rack is specifically ordered. When the TYPE 1105-A Frequency Measuring Equipment is ordered with the standard, the complete assembly is mounted as shown on page 200. Openings, with removable finished covers, are provided for connections between the standard and the measuring equipment.

SPECIFICATIONS

Frequency Range: Standard frequencies ranging from one pulse per second to frequencies of several megacycles can be obtained from this equipment.

The output frequencies are as follows: The upper frequency limit depends upon the method used to detect and utilize the harmonics. The values here quoted are easily reached when using the Type 1106 Frequency Transfer Units.

From 100-kc multivibrator, 100 kc and its harmonics up to 50 megacycles.

From 10-kc multivibrator, 10 kc and its harmonics up to 10 megacycles.

From 1-kc multivibrator, 1 kc and its harmonics in the audio-frequency range.

From 100-cycle multivibrator, 100 cycles and its harmonics in the lower audio range.

From the synchronometer unit, one-second contactor. The time of occurrence of the contact may be phased to occur at any instant over a range of one second.

This contact is open for about 50 and closed for 950 milliseconds.

If a suitable high-frequency receiver is used to detect them, 100-kc harmonics up to 75 or more megacycles can be utilized directly. For work at higher frequencies, harmonics of an auxiliary oscillator whose fundamental is monitored against the standard at a lower frequency can be used.

Output Voltage: The harmonic outputs of the 100 and 10 kc are at low impedance (65 ohms). The r-m-s voltages, measured at the terminals of the frequency standard, across a 65-ohm load, are: at 100 kc, 0.2 volt; and 10 kc, 1.2 volts. The audio-frequency outputs are at low impedance (600 ohms). The r-m-s voltages measured at the terminal strip of the standard, across a 10,000-ohm load, are: 10 kc, 20 volts; 1 kc, 25 volts; 100 cycles, 20 volts. These voltages are representative only; they are not guaranteed values.

Frequency Adjustment: The frequency of the quartz bar in its oscillator circuit is adjusted to within 1 part in ten million of its specified frequency in terms of standard time. Slight changes in frequency may occur during shipment but a control is provided for adjusting the frequency after installation.

Accuracy: When the assembly is operated in accordance with instructions, and after an aging period of a month, the rate of drift of the frequency will remain below 5 parts in 10^8 per day and this will decrease with time to about 0.5 part in 10^8 per day at the end of one year's operation.

Frequency Stability: The standard is designed so that ordinary changes in air pressure, ambient temperature, and line voltage have practically no effect on the frequency. The temperature coefficient of frequency of the quartz bar is less than 1 part in 10^7 per degree C. The temperature control is within $\pm 0.01°$ C. The voltage coefficient of frequency of the crystal-controlled oscillator is approximately 2 parts in 10^8 for line voltage changes of 10%. The average frequency variation from this cause will be substantially less.

The fluctuations of frequency of the standard over short periods, such as those required in making frequency measurements are less than 1 part in 10^9.

Output Terminals: The various output frequencies are made available at Type 874 Coaxial Connectors at the rear of the assembly. Since all necessary wiring, for all interconnections between units of the assembly, is provided in the form of cables, no connections need be made by the user other than power-supply connections, and a connection to the point where the standard frequencies are to be used.

Vacuum Tubes: The following tubes are required and are supplied with the assembly:

1—6AC7	1—1N51 (G.E. Co.)
10—6SN7-GT	1—6K6-GT/G
1—5R4-GY	1—2 LAP-430

Power Supply: 105 to 125 (or 210 to 250) volts, 50 to 60 cycles.

Power Input: For the Type 1100-AQ Secondary Standard, the power *demand* from the supply line is approximately 155 watts; with heaters off, the power required is approximately 125 watts. For the Type 1100-AP Primary Standard, the corresponding figures are 175 and 145 watts, respectively.

Accessories Supplied: Complete set of tubes, spare sets of fuses, fusible links, pilot lights. All connecting cables, including power-supply leads, servicing cable, and complete operating instructions.

Mounting: All units are mounted on standard 19-inch relay-rack panels finished in black crackle lacquer, dress panel construction. A floor-type cabinet rack, black wrinkle finish, is supplied for mounting the units of the assembly. Blank panels are supplied to fill unused portion of rack.

Dimensions: The over-all dimensions of the assembly in floor-type cabinet rack are (height) 76⅛ x (width) 22 x (depth) 20½ inches, over-all. The available panel space is 40 rack units or 70 inches.

Net Weight: In floor-type racks, Type 1100-AP, 335 pounds, Type 1100-AQ, 300 pounds; in bench-type racks, Type 1100-AP, 230 pounds, Type 1100-AQ, 190 pounds.

Type		Code Word	Price
1100-AP	**Primary Frequency Standard**	EXCEL	**$2390.00**
1100-AQ	**Secondary Frequency Standard**	EXACT	**1690.00**

PATENT NOTICE. See Notes 1, 2, 3, 4, 5, 8, 16, 23, 25, page vi.

NOTE: Type 1100-A Frequency Standards are normally supplied in floor-type relay racks. If a bench-type rack is desired, be sure to specify in ordering.

TYPE 1105-A FREQUENCY MEASURING EQUIPMENT

View of Type 1105-A Frequency Measuring Equipment with Type 1100-AP Primary Frequency Standard. The measuring equipment assembly is supplied with *one* floor-type relay rack, and the Type 1107-A Interpolation Oscillator mounts in the frequency standard rack, below the standard.

The Type 1105-A Frequency Measuring Equipment includes all the auxiliary equipment necessary for measuring unknown frequencies in terms of the Type 1100-A Frequency Standards. The general arrangement of equipment and the method of measurement is shown in the functional block diagram, page 202. When this assembly is used in conjunction with either model of the Type 1100-A Frequency Standard, measurements can be made directly at frequencies up to 100 Mc. Measurements at higher frequencies can be made by using auxiliary equipment, such as receivers or oscillators, to transfer the unknown in harmonic steps to a frequency below 100 Mc. Where the frequency range to be used is smaller or the type of measurement to be made is specialized, simpler assemblies can be furnished, and quotations will be made upon request.

The individual instruments comprising the Type 1105-A Frequency Measuring Assembly are available separately, and all are described in detail in the following pages.

The general method of measurement is outlined in the diagram on page 202. At radio frequencies between about 100 kc and 100 Mc, the unknown frequency is brought into the measuring system through the detector section of a frequency transfer unit or through an external radio receiver. The direct-reading scale of the frequency transfer unit gives the approximate value of the unknown frequency. For a precise determination, the beat frequency between the unknown and a standard frequency harmonic is measured by comparison with the interpolation oscillator, the comparison being made on the oscilloscope.

Above 100 Mc, external frequency meters such as the Type 720-A and Type 620-A can be used to establish a harmonic relation between the unknown and the standard frequency. Other types of stable oscillators can also be used for this purpose.

At audio frequencies, the interpolation oscillator is matched directly to the unknown frequency. A harmonic of the unknown can be used at low audio and sub-audible frequencies.

Between about 5 kc and 100 kc, the interpolation oscillator is used to produce a variable frequency circular sweep on the oscilloscope. The unknown frequency is then determined from the oscilloscope pattern.

The accuracy of measurement that can be easily realized is ± 0.1 cycle in determining the difference between unknown and standard frequencies. The fractional accuracy varies with the frequency being measured ranging from 2 in 10^5 at low frequencies to 1 in 10^8 at high frequencies.

By reversing the procedure of measurement, a precisely known frequency of any value between 100 kc and 200 Mc can be generated. The desired frequency is available at the output terminals of a frequency transfer unit. At audio frequencies, from the interpolation oscillator, audio frequencies between 0 and 5000 cycles are available.

This equipment is the result of a quarter century of continuous development, and, simplicity of operation has, next to accuracy, been the guiding principle in its design.

TYPE 1109-A COMPARISON OSCILLOSCOPE

This unit contains a cathode ray oscilloscope, with its power supply: selecting, smoothing and phase-shifting networks for circular sweeps at line frequency, 0.1, 1, and 10 kc standard frequencies, and at a variable frequency obtained from the interpolation oscillator; and a selector providing for all necessary and convenient comparisons required in making frequency measurements. Most patterns are presented on a circular sweep by radial deflection.

For complete description, see page 207.

TYPE 1106-A, -B, -C FREQUENCY TRANSFER UNITS

(3 Panels)

Each of these units contain a heterodyne frequency meter and heterodyne detector, with direct-reading scales. Ranges are as follows:

TYPE 1106-A	100 kc to 2000 kc
TYPE 1106-B	1 Mc to 10 Mc
TYPE 1106-C	10 Mc to 100 Mc

The harmonic output of the frequency meter can be used at frequencies higher than those covered by the dial ranges, as explained in the operating instructions. The output of the frequency meter is adjustable by a panel control, as is the regeneration of the heterodyne detector.

For complete description, see page 203.

TYPE 1108-A COUPLING PANEL

This unit is the centralized control point at which all switching and level adjustments necessary for using the various combinations of measuring equipment can be easily and quickly carried out.

For complete description, see page 206.

TYPE 1107-A INTERPOLATION OSCILLATOR

This unit is a direct-reading audio-frequency oscillator covering frequencies from 0 to 5000 cycles. It is used to measure the audio-frequency difference between the unknown frequency and a standard 10-kc harmonic. Provision is made, on two scales, so that results can be obtained by addition only, avoiding subtraction. A mixer circuit is provided with controls for output of the interpolator and for the unknown frequency, so that a maximum beat amplitude can be obtained. A meter indicates output voltage and can be used as a beat indicator for matching the interpolator and unknown frequencies.

For complete description, see page 205.

TYPE 480-MA RELAY RACK

The individual units, *with the exception of the* TYPE 1107-A *Interpolation Oscillator*, are mounted in the TYPE 480-MA Relay Rack. At the base of the rack is mounted a TYPE 1105-P1 Speaker for audible monitoring of beat tones.

All connections between standard and measuring assembly are made by means of patch cords, which are supplied.

Each of the instruments comprising the TYPE 1105-A Frequency Measuring Equipment is available separately. All are completely described in the following pages, and those descriptions should be consulted for further details of design and construction, net weight, dimensions, etc.

TYPE 1105-A FREQUENCY MEASURING EQUIPMENT

SPECIFICATIONS

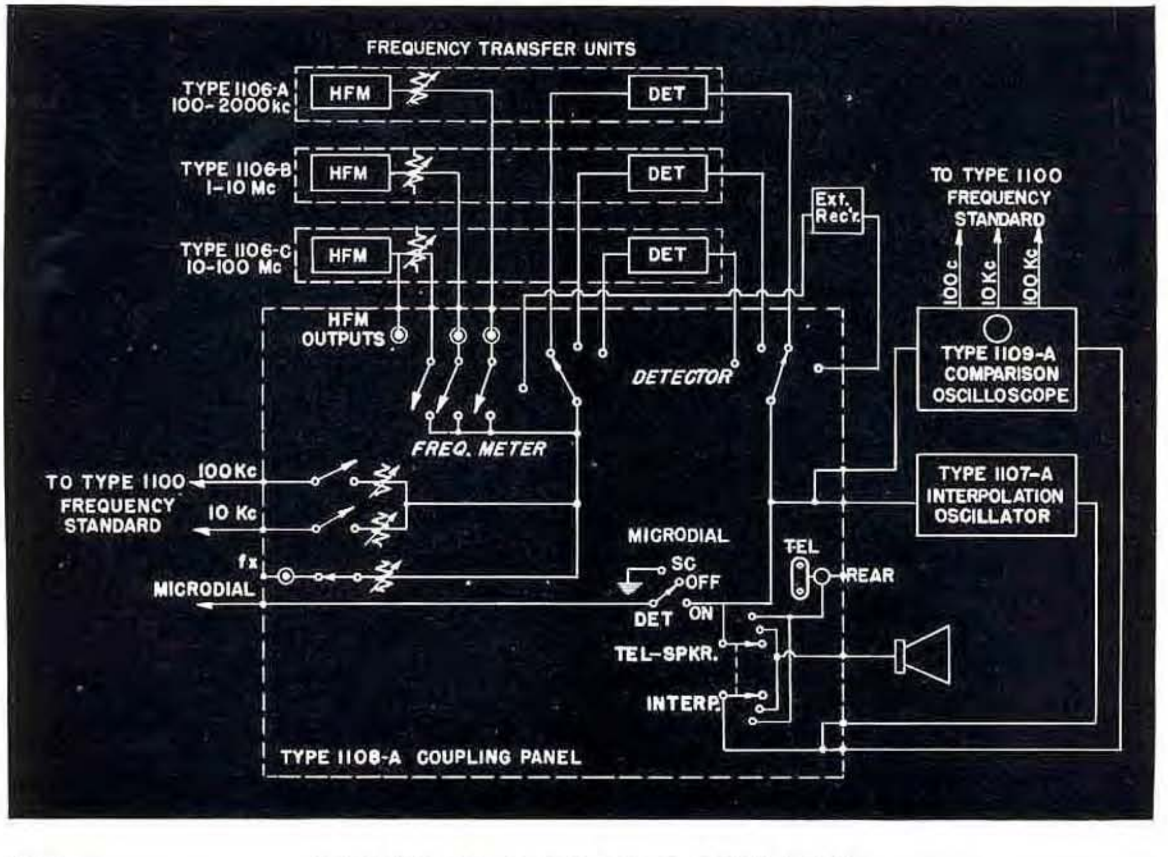
Terminals and Connections: All instruments are equipped with Type 874 Coaxial Connectors on the rear of each unit. Suitable connecting cords are supplied.
Power Supply: 105 to 125 (or 210 to 250) volts, 50-60 cycles. Other voltages or frequencies on special order only.
Power Input: 200 watts.
Accessories Supplied: Spare sets of fuses; blank panels; connecting cables, including power supply cords.
Mounting: The complete assembly, with the exception of Type 1107-A Interpolation Oscillator, mounts in a standard 19-inch Type 480-MA Cabinet Rack. This rack includes service outlets for each instrument. *The interpolation oscillator mounts in the frequency standard rack, as shown in the photograph on page 200.*
Dimensions: (Height) 76⅛ x (width) 22 x (depth) 20½ inches, over-all. Total rack space is 40 rack units, or 70 inches.
Net Weight: 370 pounds, including rack.

Type		*Code Word*	*Price*
1105-A	**Frequency-Measuring Equipment**	MITER	**$4480.00**

PATENT NOTICE. See Notes 2, 3, 4, page vi.

This diagram shows in functional form the operation of the Type 1105 Frequency Measuring Assembly. The Type 1108 Coupling Panel is the central unit from which all operations are controlled.

The unknown frequency f_x and a series of standard frequency harmonics are applied through attenuators to the detector in the frequency transfer unit. The unknown frequency can then (1) be estimated quickly from the calibration of the detector, (2) be determined more accurately by use of the heterodyne frequency meter, or (3) be measured precisely by use of the interpolation oscillator.



TYPE 1106 FREQUENCY TRANSFER UNITS

USES: The Type 1106 Frequency Transfer Units are utilized in transferring an unknown frequency for measurement against a frequency standard, or for transferring a frequency of known value (determined against the standard) to an output circuit. The direct-reading frequency calibrations will give the approximate value of an unknown frequency, or the approximate value of a desired frequency in the output circuit.

When used with a frequency standard, these units provide means for rapidly identifying the harmonics of the standard; for accurately matching the heterodyne frequency meter to the unknown frequency; for use as a substitute source in measuring frequencies under conditions of noise, fading or of intermittent operation of the transmitter; and for obtaining a frequency of any desired value, accurately known in terms of the frequency standard.

The Frequency Transfer Units can also be used as general purpose calibrated frequency meters and detectors.

DESCRIPTION: The Types 1106-A, 1106-B and 1106-C Frequency Transfer Units are identical except for their frequency ranges which are:

Type 1106-A	100 kc to 2000 kc
Type 1106-B	1 Mc to 10 Mc
Type 1106-C	10 Mc to 100 Mc

Each consists of a heterodyne frequency meter (with harmonic generating circuits and output control) and a heterodyne detector (with audio-frequency amplifier and regeneration control).

The heterodyne frequency meter oscillator circuit is a highly stable oscillator having a frequency range of 2 to 1 in two (1106-A) or three steps (1106-B, -C). A direct-reading frequency scale is provided for the fundamental and selected harmonic ranges, covering 10 to 1 in frequency (20 to 1 on 1106-A). The harmonic output can be used at frequencies higher than those covered on the dial ranges; for example, using the fundamental frequency scales and reading ten times the scale value gives the coverage of the tenth harmonic. Full details of operation are given in the instructions.

The heterodyne detector has range-switching and direct-reading frequency scales covering the rated range of the unit. The detector can be operated either in the non-oscillating or oscillating condition by use of the regeneration control. When oscillating, it is especially useful in obtaining an exact zero beat setting between the frequency meter and a signal frequency, by the three-oscillator method, the detector serving as the third oscillator. When not oscillating, it produces the beat between the standard harmonic and the unknown frequency. An audio-frequency amplifier with an output impedance of approximately 600 ohms is provided.

On both the heterodyne frequency meter and detector direct-reading frequency scales, nearly 360 degree rotation of the drum dials is used. Both are approximately straight-line-frequency in calibration. Operation of the range selectors automatically sets the pointers so that the likelihood of error in reading one of the several scales on the dial is greatly reduced.

FEATURES: ➔ Dials are direct-reading in frequency for both the frequency meter and the detector.

➔ Range dials are illuminated and are mounted behind panel and viewed through a window.

➔ Range switching for both frequency meter and detector.

➔ The heterodyne frequency meter is designed for a high degree of frequency stability, and drift is negligible for the specified conditions of use.

SPECIFICATIONS

Frequency Range:

Type 1106-A	100 kc to 2000 kc	(9 ranges)
Type 1106-B	1 Mc to 10 Mc	(10 ranges)
Type 1106-C	10 Mc to 100 Mc	(10 ranges)

The heterodyne frequency meters all have 2 : 1 fundamental ranges, with calibrated direct-reading harmonic scales. The heterodyne detectors all have fundamental ranges covering the specified band.

Calibration: The heterodyne frequency meter dials are calibrated as follows:

Type 1106-A	1 kc intervals	100 to 400 kc
	5 kc intervals	400 to 1000 kc
	10 kc intervals	1000 to 2000 kc
Type 1106-B	5 kc intervals	1.00 to 2.00 Mc
	10 kc intervals	2.00 to 10.00 Mc
Type 1106-C	20 kc intervals	10.0 to 20.0 Mc
	100 kc intervals	20.0 to 50.0 Mc
	200 kc intervals	50.0 to 100.0 Mc

The heterodyne detector dials are calibrated with somewhat greater frequency intervals, but the intervals permit reasonable estimation of frequency.

Accuracy: The accuracy of the heterodyne frequency meter calibration permits positive identification of harmonics, when used with a frequency standard. Used individually, the calibration can be relied upon to ±0.1 per cent.

Frequency Stability: The circuits of the oscillators used for the heterodyne frequency meters are designed for high stability against changes in supply voltage or changes in tube capacitances. The heterodyne detector stability is not as good, but is sufficiently high so that no difficulty is encountered from variations in making frequency measurements.

Input and Output Circuits: The harmonic output of the heterodyne frequency meters is available at shielded coaxial connectors for use with 50-65 ohm concentric cable. Harmonics of the fundamental frequency to at least the 10th are usable. The radio-frequency input and the audio-frequency output connections of the heterodyne detector are shielded coaxial connectors. The input circuit is suitable for use with 50-65 ohm cable; the output impedance is approximately 600 ohms.

Power Supply: 105 to 125 (or 210 to 250) volts, 50-60 cycles. Other voltages or frequencies on special order only.

Power Input: 40 watts.

Tubes: Supplied with instruments:

Type 1106-A, -B	Type 1106-C
3—6SJ7	1—6SJ7
1—6J5GT	1—6J5GT
1—6SN7GT	1—6SN7
1—1N51 (G.E.Co.)	1—6X5GT
1—6X5GT	1—9001
1—0D3	1—0D3
	2—9002

Accessories Supplied: Fuses; line connector cord; coaxial connectors.

Controls: Power ON-OFF switch; heterodyne frequency meter PLATE supply switch; heterodyne frequency meter and heterodyne detector RANGE (coil selector) switches; frequency controls; heterodyne frequency meter OUTPUT control; heterodyne detector REGENERATION control.

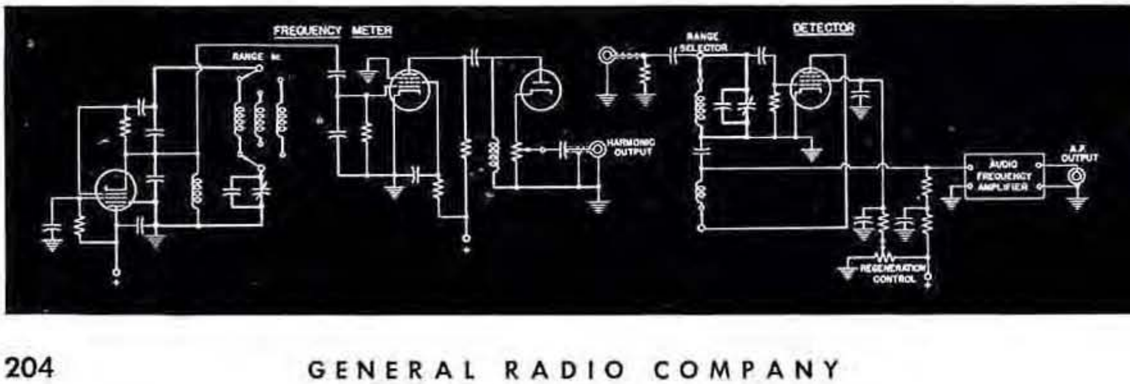
Mounting: Standard 19-inch relay-rack mounting; dress-panel construction; black crackle lacquer.

Dimensions: Panel (length) 19 x (height) 10½ inches; behind panel, (length) 17 x (height) 10¼ x (depth) 12¾ inches.

Net Weight: 47¾ pounds.

Type		*Code Word*	*Price*
1106-A	**Frequency Transfer Unit 100-2000 kc.**	ABOUT	**$900.00**
1106-B	**Frequency Transfer Unit 1-10 Mc . . . .**	ACTOR	**900.00**
1106-C	**Frequency Transfer Unit 10-100 Mc. .**	ADEPT	**900.00**

PATENT NOTICE. See Notes 2, 3, 4, page vi.



TYPE 1107-A INTERPOLATION OSCILLATOR

USES: The principal use of the TYPE 1107-A Interpolation Oscillator is, in connection with a frequency standard, to measure the difference between the unknown frequency and a known standard harmonic. The direct-reading linear scales of 0 to 5000, and 5000 to 10,000 cycles make possible the rapid evaluation of the frequency difference, by *addition* only, with high accuracy. While the dials are marked as described, the actual frequency range is 0–5000 cycles.

The linear scale of this oscillator also makes it useful for other types of work where accurate frequency increments are desired.

DESCRIPTION: The oscillator is of the beat-frequency type, with the radio-frequency oscillators operating in the region of 45–50 kc. The circuits are designed for exceptional stability of frequency against supply voltage changes, tube capacitance changes and tube replacements. A tube plate-supply regulator is then employed as a further safeguard.

The variable-frequency oscillator frequency is controlled by a precision variable air capacitor; the fixed oscillator frequency by a fixed air capacitor. The inductors of both oscillator circuits are wound on ceramic forms and are shielded, effectively eliminating unwanted coupling and reducing the effects of changes in ambient temperature.

An output voltmeter is provided that can also be used as a beat indicator for matching the oscillator output frequency to an unknown audio frequency. Individual controls are provided for the oscillator output and unknown frequency voltages in order to secure the maximum beat amplitude at any level. The oscillator output voltage is practically constant over the whole range of frequency.

FEATURES: ➔ The fixed oscillator is provided with a switch which permits changing the frequency by exactly 5000 cycles. By thus changing the frequency the oscillator can be fitted with a scale reading 5000–10,000 cycles. When measuring an unknown frequency lying below the standard frequency, the beat frequency need not be subtracted from the standard frequency to obtain the unknown frequency. Instead the 5000–10,000 cycle scale is used and the reading is *added* to the frequency of the next lower standard frequency harmonic.

➔ An indicator light operated by the switch indicates the proper scale to be read.

➔ Stability of output frequency, and linear, easily read scales are features of great convenience in use.

➔ For measuring very small frequency increments, two direct-reading incremental frequency dials (one for the 0–5000 scale and one for the 5000–10,000 cycle scale) are provided.

SPECIFICATIONS

Actual Frequency Range: 0-5000 cycles per second.

Dial Calibrations: DIRECT: 0-5000 cycles, with the oscillator frequency increasing from 0 to 5000 divisions on the scale. REVERSE: 5000-10,000 cycles with the oscillator frequency decreasing from 5000 cycles to zero while scale reading goes from 5000-10,000 divisions. Δf REVERSE and Δf DIRECT: ±10 cycles.

Accuracy: The instrument is aligned to agree with the linear direct-reading scales to within ±2 cycles.

The variable capacitor is provided with a precision worm drive so that precise frequency settings can be made. Small residual errors are easily and quickly removed in the region of any frequency in the range by fine adjustment of the zero with reference to a frequency standard having a 1-kc or 0.1-kc output, or both. For evaluating very small frequency differences, independent, direct-reading frequency increment dials are provided.

Output: The output voltage is adjustable up to 15 volts. The output circuit impedance is approximately 600 ohms.

Mixer Circuit: A mixer circuit, with volume control, is provided for injecting a frequency to be measured into the amplifier circuit. Beats may be observed on the output meter, or by means of head telephones or speaker.

Power Supply: 105 to 125 (or 210 to 250) volts, 50-60 cycles. Other voltages or frequencies on special order only.

Power Input: 50 watts, approximately.

Controls: ON-OFF switch; DIRECT and REVERSE scale switch; Two Δf and zero-set controls; main FREQUENCY control; OUTPUT and INPUT (mixer) volume controls.

Meters: Output voltmeter; used also as a beat indicator.

Terminals: Terminals, both on panel and at rear, are provided for both mixer input and oscillator output. Panel terminals are universal for two pin or coaxial connectors. Rear terminals are for coaxial connectors.

Tubes: Furnished with instruments:

2—6AC7	1—0D3	2—6SN7GT
3—6J5GT		1—6X5GT

Accessories Supplied: Fuses; power cord; coaxial connectors.

Mounting: Standard 19-inch relay-rack; dress panel construction; black crackle finish

Dimensions: Panel (length) 19 x (height) 12¼ inches; behind panel, (length) 17¼ x (height) 12 x (depth) 12 inches

Net Weight: 41½ pounds.

Type		*Code Word*	*Price*
1107-A	**Interpolation Oscillator**	BARON	**$850.00**

PATENT NOTICE. See Notes 3, 4, page vi.

TYPE 1108-A COUPLING PANEL

USES: This coupling panel is designed specifically for use as the centralized control panel in a frequency measuring equipment employing a TYPE 1100-AP Primary Frequency Standard (or TYPE 1100-AQ Secondary Frequency Standard). The panel carries the necessary switches and volume controls for all operations in making frequency measurements.

DESCRIPTION: The instrument contains the following controls: FREQUENCY METER, for selecting and combining the frequency meter outputs of 1106-A, 1106-B and 1106-C heterodyne frequency meter sections; STANDARD FREQUENCY HARMONIC selector, selecting 100-kc or 10-kc harmonic outputs, or combination; individual volume controls; DETECTOR selector, for selecting input and output circuits of 1106-A, 1106-B, 1106-C or an external detector (or receiver); an ON-OFF switch and volume control for frequency being measured; MICRODIAL switch; TEL-SPEAKER switch for transferring between telephones and speaker and between detector and interpolator outputs.

SPECIFICATIONS

Terminals: At rear, by 24 shielded coaxial connectors to all sources and instruments required; rear telephone connection for use when adjusting standard against standard frequency transmissions. At front, by shielded coaxial connectors, harmonic output circuits of 1106-A, 1106-B, and 1106-C heterodyne frequency meter sections; input connection for frequency being measured. By two-point or standard telephone jack, connections for telephone receivers.

Mounting: Standard 19-inch relay-rack mounting; dress panel construction; black crackle finish.

Dimensions: Panel (length) 19 x (height) 7 inches; behind panel, (width) 17¼ x (height) 6¾ x (depth) 6½ inches.

Net Weight: 16 pounds.

Type		*Code Word*	*Price*
1108-A	**Coupling Panel**	BATTY	**$250.00**

PATENT NOTICE. See Notes 3, 4, page vi.

TYPE 1109-A COMPARISON OSCILLOSCOPE

USES: This instrument is particularly intended for use with a TYPE 1100-AP Primary Frequency Standard (or TYPE 1100-AQ Secondary Frequency Standard) as an aid in making interpolations or checking calibrations with high accuracy. With such standards and associated measuring equipment, the TYPE 1109-A Comparison Oscilloscope provides a convenient means of measuring audio and carrier frequencies, or of calibrating oscillators in these frequency ranges.

DESCRIPTION: The TYPE 1109-A Comparison Oscilloscope contains a 3-inch, radial deflection cathode-ray tube, and its power supply. Selective amplifiers with power supply, phase-shift networks, and controls are provided for obtaining circular sweeps at frequencies of the power line, and 0.1, 1, and 10 kc from the frequency standard, and at variable frequency obtained from the TYPE 1107-A Interpolation Oscillator. A radial deflection amplifier is provided, for displaying the input signal on the circular sweep base. Switching is provided for selecting the sweep frequencies and for selecting any one of the several operations normally involved in making frequency measurements or calibrations.

FEATURES: → The general use of circular sweeps provides symmetrical and readily interpretable patterns.

→ By overloading the deflection amplifier it is possible to identify easily frequency ratios involving much higher integers than can be identified in Lissajous patterns.

→ Ordinarily in the use of calibrated oscillators, it is not necessary to identify a pattern, it is only necessary to adjust the oscillator so that the pattern stands still. A system of known frequencies is easily established on the basis of the *type* of pattern obtained. When used on base frequencies 10 or 100 times higher, the *same types* of pattern correspond to frequencies just 10 or 100 times higher than the original system of known frequencies.

SPECIFICATIONS

Frequency Range: Useful patterns can be obtained over the frequency range from very low audio frequencies to radio frequencies of a few hundred kilocycles. In the range up to 100 kilocycles, an input voltage of 0.5 volt gives full radial deflection. Larger voltages give very useful square-wave radial deflections.

Controls: ON-OFF switch; BRILLIANCE, FOCUS, and CENTERING adjustments for cathode-ray tube; sweep DIAMETER and SHAPING controls; FREQUENCY selector for circular sweep; SELECTOR for sources to be compared.

Terminals: At rear, by coaxial connectors for standard frequencies, and for sources to be compared: on panel by universal two-point and coaxial connector to source being measured or calibrated (0 to 100 kc or more).

Power Supply: 105 to 125 (or 210 to 250) volts, 50-60 cycles. Other voltages or frequencies on special order only.

Power Input: 30 watts, approximately.

Tubes Supplied: 1—Type 3DP1A, 3" radial deflection Cathode-Ray Oscilloscope

2—6SN7GT	1—2X2A	1—6X5-GT
1—6J5GT		1—6SJ7

Accessories Supplied: Spare fuses; line connector cord; TYPE 874 Coaxial Connectors; one TYPE 274-MB Double Plug.

Mounting: Standard 19-inch relay-rack mounting; dress panel construction; black crackle finish.

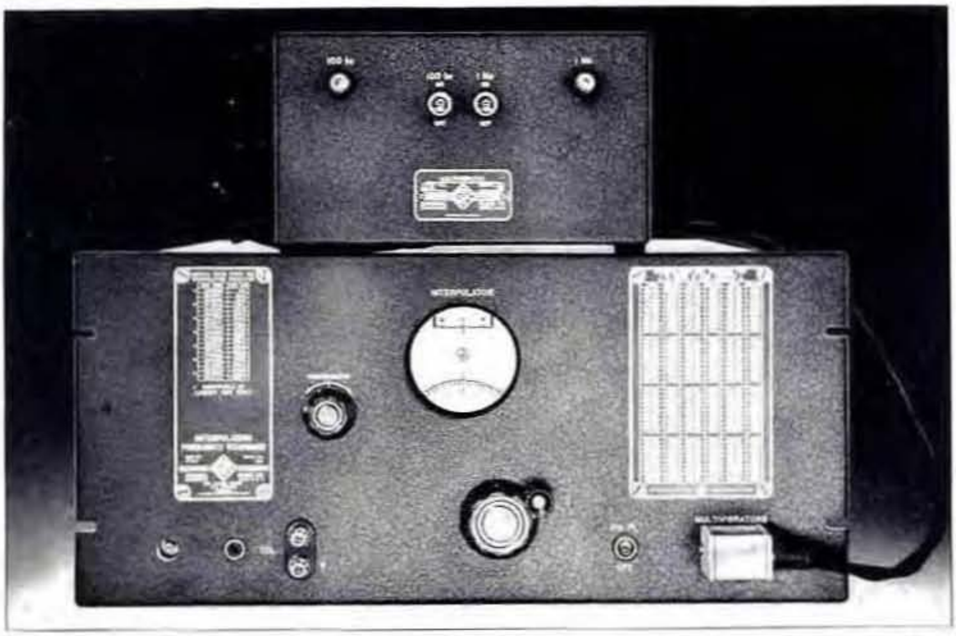
Dimensions: Panel (length) 19 x (height) 7 inches; behind panel, (width) 17¼ x (height) 6¾ x (depth) 12½ inches.

Net Weight: 35 pounds.

Type		*Code Word*	*Price*
1109-A	**Comparison Oscilloscope**	BASIN	**$450.00**

PATENT NOTICE. See Notes 3, 4, page vi.

TYPE 1110-A INTERPOLATING FREQUENCY STANDARD



USES: This instrument is a precision interpolator for use with heterodyne frequency meters, such as the TYPE 720-A, in making frequency measurements in the ultra-high-frequency range, up to 2000 or 3000 Mc, and with the TYPE 620-A Heterodyne Frequency Meter in making frequency measurements from 10 Mc up to several hundred Mc. It can also be used for frequency measurements in conjunction with high-frequency receivers provided their frequency calibrations are sufficiently good to identify frequencies separated by as little as 1%. The TYPE 1110-A Interpolating Frequency Standard and the TYPE 720-A Heterodyne Frequency Meter are particularly well suited for making measurements of center frequency and frequency swing on mobile F-M transmitters.

DESCRIPTION: The block diagram indicates the essential elements of the instrument: (1) a frequency standard, variable over a range of 1000 to 1010 kc, or 1%, and (2) a multivibrator unit for frequencies of 1 Mc and 100 kc.*

The frequency standard consists of a 950-kc crystal-controlled oscillator, a highly stable 50–60 kc bridge-type variable frequency L-C oscillator, a modulator, and filter for selecting the sum of the two frequencies as the final output. The dial of the variable oscillator has 1000 divisions to cover 10 kc.

The 1% range of the output frequency means that the frequency range of any multivibrator harmonic is also 1%. The 100th harmonic of the 1-Mc multivibrator can therefore be adjusted continuously from 100 Mc to 101 Mc, giving complete coverage over this interval. At 101 Mc and higher harmonics, the range from any multiple of 1 Mc to the next higher multiple is less than 1% and so these ranges are covered by less than full-scale variation on the variable frequency oscillator dial.

When the 100-kc multivibrator is used, the 100th harmonic again has a range of 1% as the standard frequency is changed over the full range of the dial, covering 10.0 to 10.1 Mc, and for all higher multiples the range from one multiple to the next higher is covered by less than full-scale range of the variable frequency oscillator dial.

The multivibrator harmonics give complete frequency coverage from 100 Mc upward, for the 1 Mc unit, and from 10 Mc upward, for the 100 kc unit. When the Interpolating Frequency Standard is used with the TYPE 720-A and TYPE 620-A Heterodyne Frequency Meters, having ranges of 100–200 and 10–20 Mc respectively, only the harmonics from the 100th to the 200th are used.

The dial of the TYPE 720-A, for example, covers 100–200 Mc with calibration marks at each megacycle. With the dial of the variable frequency oscillator at zero, the standard output frequency is 1 Mc exactly, and all harmonics are therefore standard frequencies, which can be used to check the heterodyne frequency meter at any scale graduation.

If the heterodyne frequency meter has been set to zero beat with a frequency to be meas-

*General Radio Experimenter, Vol. XVIII, No. 9, February 1944, "Continuous Interpolation Methods Part II—Method IV."

ured, an approximate reading of the unknown frequency is given at once on the dial. As an example, suppose the reading to be 162.3 Mc. Using the Interpolating Frequency Standard, the 1-Mc multivibrator output is coupled to the frequency meter. The oscillator dial is then advanced from zero until the 162nd harmonic (identified by the 720-A dial reading) is advanced from 162.0 Mc to 162.3 Mc approximately where zero beat is set. The increment in frequency is determined from the variable oscillator dial and is added to 162.0 Mc to give the final result.

FEATURES: ➔ This instrument is designed for operation by zero beat adjustments only, overcoming the need for wide-band circuits or wide-band interpolating methods.

➔ All frequency increments are taken as positive, avoiding all need for subtraction or determining the sign of frequency increments.

➔ Means are provided for checking the alignment of the variable frequency oscillator calibration in terms of the 950-kc crystal frequency.

➔ Since harmonics of the multivibrators fall at all standard frequencies transmitted by the U. S. Bureau of Standards (WWV) it is possible to check the absolute accuracy, including the frequency of the 950-kc crystal, by use of a suitable receiver.

➔ To permit bringing the multivibrator output close to high-frequency equipment, the multivibrator unit is connected to the standard frequency unit by means of a cable. The small multivibrator unit can then be moved around without moving the larger unit.

SPECIFICATIONS

Frequency Range: The output frequency range of the 1110-A Interpolating Frequency Standard is from 1000 to 1010 kc. The output frequencies of the 1110-P1 Multivibrator Unit are 1.0- and 0.1-Mc fundamentals with harmonics up to 200 or more.

Calibration: The variable frequency oscillator dial has 1000 divisions corresponding to 0.001 per cent or 10 parts per million per division.

A list of check settings is provided on the panel. This check can be made at any time by simply plugging a set of headphones into the jack or binding posts provided on the panel. A trimmer control on the panel provides for adjusting the oscillator to agreement with the crystal.

To facilitate conversion of the dial readings from their basic percentage or parts per million values of frequency increment to fractions of a megacycle or of 0.1 Mc (100 kc), a table listing the number of dial divisions for frequency increments of 1.0 Mc and 0.1 Mc at each harmonic from 100 to 220 is given on the panel. A simple slide-rule ratio then gives the desired frequency increment.

Crystal Oscillator: The crystal oscillator is adjusted to within 1 part in a million of correct frequency at room temperature. It should be reliable to within ±10 parts per million at ordinary room temperatures. The crystal frequency can be checked and adjusted in terms of standard frequency transmissions from WWV using an external receiver, maintaining the variable oscillator at exactly 50 kc in terms of the crystal.

Accuracy of Measurement: The over-all accuracy of measurement is ±25 parts per million using the oscillator dial directly. If the oscillator is carefully trimmed in terms of the crystal, the over-all accuracy is limited principally by the error of the crystal.

Vacuum Tubes: The following tubes are supplied:

2 — 6AC7	3 — 6J5GT
4 — 6SN7-GT	1 — 5R4GY
1 — 6SJ7	1 — 9001
1 — 6SA7	1 — 2LAP-430 (Bridge Circuit Lamp)

Power Supply: Either 105-125 or 210-250 volts, 50 to 60 cycles.

Power Input: 85 watts from 115-volt, 60-cycle line.

Mounting: TYPE 1110-A, standard 19-inch relay rack; dress panel construction; black crackle finish. TYPE 1110-P1 (attached to 1110-A by cable), small metal cabinet.

Accessories Supplied: Line connector cord; TYPE 1110-P1 Multivibrator Unit with 5-foot connecting cable; spare fuses; Quartz Plate (shipped installed).

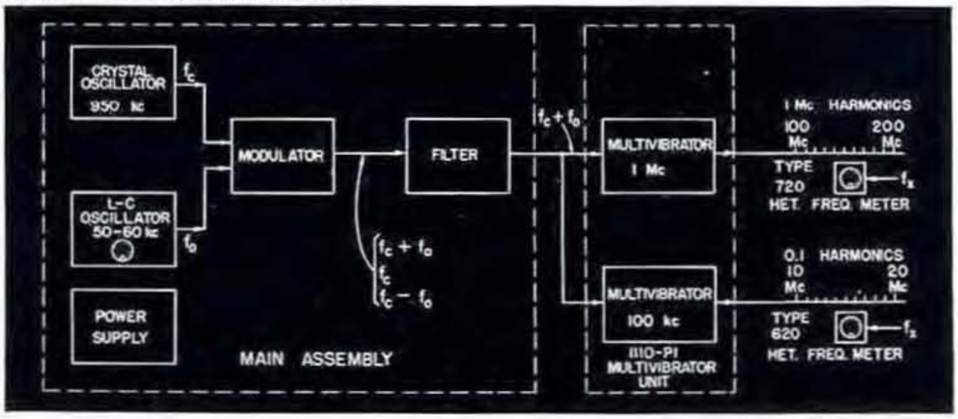
Accessories Required: Head telephones.

Dimensions: 1110-A Panel (length) 19 x (height) 8¾ inches; behind panel, (length) 17¼ x (height) 8⅜ x (depth) 14 inches. 1110-P1 (length) 9¼ x (height) 5¼ x (depth) 5¼ inches.

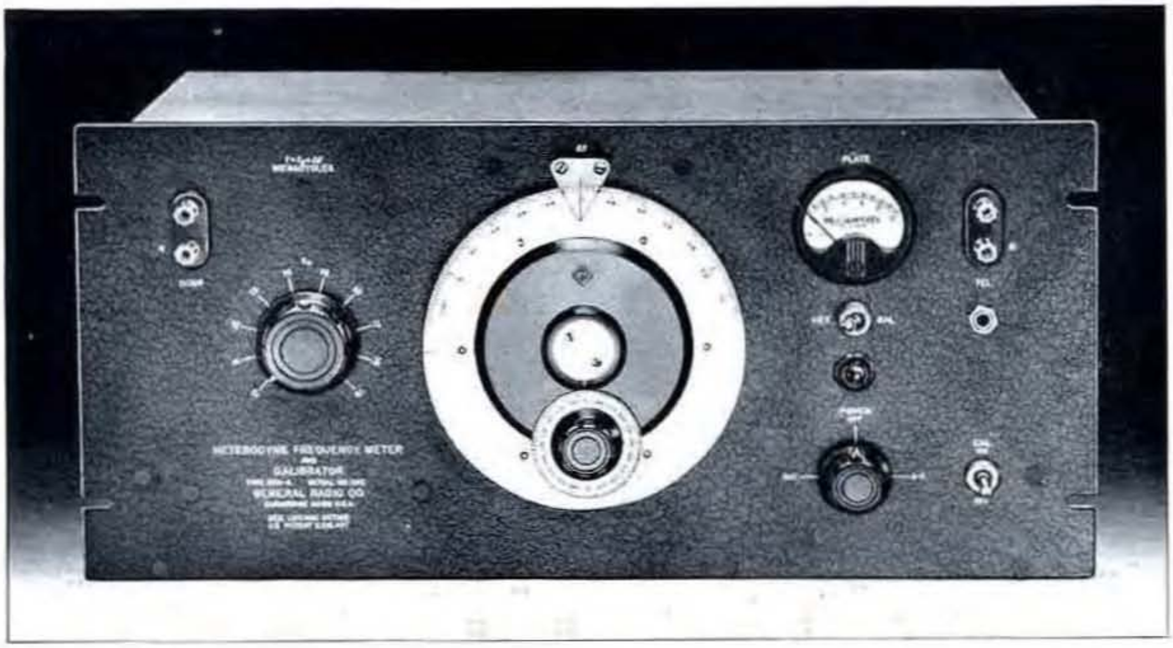
Net Weights: TYPE 1110-A assembly, 40 pounds; TYPE 1110-P1 Multivibrator Unit, 7½ pounds.

Type		*Code Word*	*Price*
1110-A	**Interpolating Frequency Standard . . . .**	RAVEN	**$725.00**

PATENT NOTICE. See Notes 1, 2, 5, 25, page vi.



TYPE 620-A HETERODYNE FREQUENCY METER AND CALIBRATOR



USES: Although designed primarily for measuring high and very high frequencies, this instrument can also be used to measure frequencies down to a few hundred kilocycles, provided the signal being measured is sufficiently strong. For communication companies it provides an excellent means of rapidly measuring the frequencies of a large number of transmitters (either local or remote) in addition to its use in calibrating and servicing receiving equipment. Receiver manufacturers will find it useful in checking the ranges of receivers and oscillators. It is suitable for monitoring the frequencies of radio transmitters where the allowable frequency tolerance is ±0.02% or greater.

DESCRIPTION: The schematic diagram shows the essential elements of the instrument: (1) a heterodyne frequency meter, (2) a crystal calibrator, and (3) a detector and audio amplifier.

The heterodyne frequency meter is direct reading, an important operating convenience, particularly when using harmonics. The fundamental frequency range is 10 to 20 Mc. This range is divided into 10 steps of 1 Mc each, and the desired step is selected by means of a coil switch. The main tuning capacitor covers a range of 1 Mc for each coil, the dial being engraved to read hundredths of megacycles directly. An auxiliary dial, which drives the main dial through a reduction gear train, carries a scale that subdivides the main scale divisions, the smallest division being 0.001 Mc or 1 kc. The frequency of the heterodyne frequency meter is given by the sum of the coil switch and capacitor dial readings, subject to any scale correction as determined by the crystal calibrating points.

For checking the calibration of the heterodyne frequency meter, a piezo-electric calibrator, employing a one-megacycle low-temperature-coefficient quartz plate, is provided. Several points on each coil range of the heterodyne frequency meter may be checked.

The procedure in making measurements is simple. When the unknown frequency is within the fundamental range of the heterodyne, the heterodyne frequency is set to zero beat with the unknown, and the frequency is read directly from the dial. When the unknown is above or below the heterodyne fundamental range, the dial reading must be multiplied or divided by the harmonic number.

FEATURES: ➔ A very wide range of frequencies can be measured with the TYPE 620-A Heterodyne Frequency Meter and Calibrator.

➔ Excellent accuracy has been combined with simplicity of operation.

➔ The direct-reading frequency scale makes convenient and rapid measurements possible.

➔ A high degree of frequency stability in the oscillator is obtained by careful design and construction. Ball bearings are used in the variable air capacitor and the inductors are wound on steatite forms to keep losses and temperature coefficient low.

➔ Either batteries or the built-in a-c power supply can be used.

Closeup view of the tuning dial, showing details of the scale.

SPECIFICATIONS

Frequency Range: The fundamental frequency range is from 10 to 20 megacycles, in 10 ranges of 1 Mc each. By harmonic methods frequencies between 300 kc and 300 Mc are easily measured.

Frequencies up to about 300 Mc can be measured by setting a harmonic of the heterodyne frequency meter to zero beat with the unknown. In general, the beat is obtained in the detector, but for the very highest frequencies it is advisable to use an auxiliary receiver. For frequencies below 10 Mc and down to about 300 kc, harmonics of adequate strength for measurement can be generated in the detector tube provided a sufficiently strong signal is applied to the instrument. For weak signals, a local oscillator as a harmonic-generating means is necessary.

Calibration: The capacitor dials are graduated to read decimal fractions of megacycles directly, the smallest division corresponding to 0.001 Mc (1000 cycles).

Calibrator: A 1-Mc piezo-electric oscillator, employing a low-temperature-coefficient quartz plate, is provided for checking the calibration of the frequency meter. Harmonics of 1 Mc fall at the upper and lower limits of the dial, giving a bracketing check on each coil range of the heterodyne frequency meter. Harmonics of the heterodyne also produce beats with harmonics of the calibrator, giving checking points at multiples of ½, ⅓, ¼, and ⅕ Mc, etc., over the dial range. Since these points occur at the same dial readings for each range, checking is made very simple and convenient.

Accuracy: The over-all accuracy of measurement is ±0.01% or better when the frequency meter is checked in terms of the crystal calibrator and the resulting correction applied to the dial reading.

Vacuum Tubes: The following tubes are used and are supplied with the instrument:

1 — 954   1 — 84   3 — 955

Power Supply: Either 105 to 125 (or 210 to 250) volts, 50 to 60 cycles, or 6 and 180 volts dc. A switch on the panel selects the type of power supply desired. The a-c operated power supply is built in. Batteries are not supplied.

Power Input: 15 watts from 115-volt, 60-cycle supply.

Mounting: Standard 19-inch relay-rack panel, finished in black-crackle lacquer.

Accessories Supplied: One-megacycle quartz plate; line connector cord; spare fuses; two multipoint connectors.

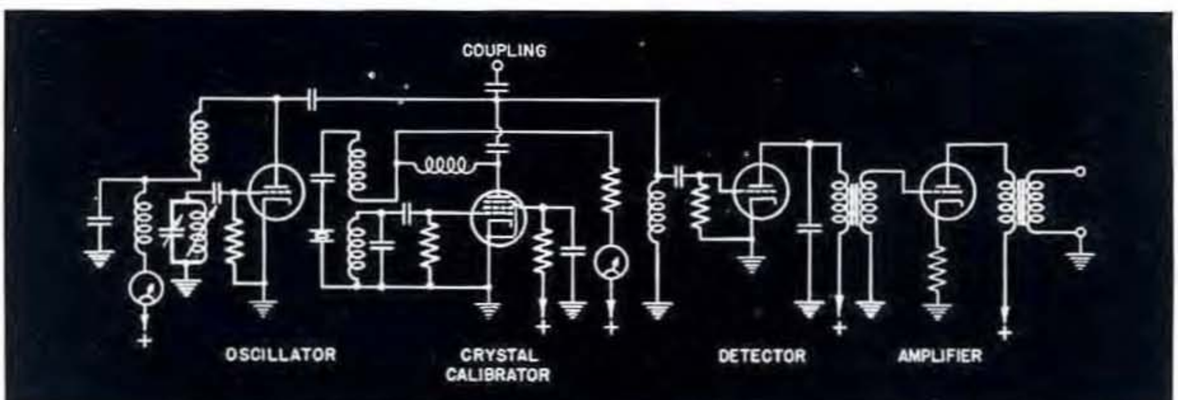
Accessories Required: Head telephones, which can be connected either at the panel or at the rear of the instrument.

Dimensions: Panel, (length) 19 x (height) 8¾ inches; behind panel, (length) 17¼ x (height) 8⅜ x (depth) 11¾ inches.

Net Weight: 32¾ pounds.

Type		*Code Word*	*Price*
620-A	**Heterodyne Frequency Meter and Calibrator**	DAISY	**$625.00**

PATENT NOTICE. See Notes 2, 5, 17, page vi.



TYPE 720-A HETERODYNE FREQUENCY METER

USES: The Type 720-A Heterodyne Frequency Meter is used for the measurement of frequency in the v-h-f and u-h-f bands. It extends the field of the familiar heterodyne method of measurement up to about 3000 Mc.

In conjunction with the Type 1110-A Interpolating Frequency Standard, this frequency meter is useful in measuring center frequency and frequency swing in F-M mobile transmitters.

DESCRIPTION: The principal elements of the instrument are a calibrated oscillator, a crystal detector and an audio amplifier. The frequency-determining element of the oscillator is a butterfly circuit, in which the capacitance and the inductance are varied simultaneously. The movable part of the circuit rotates in ball bearings. No sliding contacts are used, and no current is carried by the bearings. This permits a smooth and stable adjustment of frequency. The oscillator frequency is adjustable between 100 and 200 Mc. Harmonics of the oscillator are used to measure frequencies above 200 Mc, and harmonics of the unknown are used at frequencies below 100 Mc.

The detector is a standard silicon crystal, so mounted that it is easily accessible for replacement. A spare is furnished.

The three-stage audio amplifier has an effective band width of 50 kc. The output of the amplifier operates a panel meter and a built-in loudspeaker. A jack is provided as well for head telephones.

The entire assembly is battery-operated, completely self-contained, and mounted in a portable, fabric-covered cabinet. Complete operating instructions are mounted in the cover of the cabinet.

FEATURES: → The sensitivity obtainable with the heterodyne method of measurement permits this instrument to be used on comparatively weak signals.

→ No direct connection to the source under measurement is usually required, because of the adjustable antenna mounted on the panel. However, provision is made for connecting an additional pickup wire if necessary.

→ A wide range of frequencies can be measured with the single fundamental frequency band, and the dial arrangement is such that small frequency increments can be measured precisely.

→ The butterfly type of tuned circuit avoids most of the difficulties inherent in variable-frequency elements at ultra-high frequencies.

→ Either batteries or an a-c power supply can be used with the instrument.

SPECIFICATIONS

Frequency Range: The fundamental frequency range is from 100 to 200 megacycles. This range is covered in a single band with approximately logarithmic frequency distribution. By harmonic methods frequencies between 10 megacycles and 3000 megacycles can be measured. Since harmonics of the internal oscillator are considerably stronger than harmonics of the unknown as generated in the detector, the sensitivity of the instrument for frequencies below the range of the oscillator fundamental is considerably less than that at frequencies equal to or above the oscillator fundamental.

Beat Indication: With strong signals a strong beat note will be heard in the small dynamic speaker in the front panel. For weaker signals a pair of headphones should be used. In addition to the audible beat, a visual indication is obtained by the deflection of the panel meter. Since the band width of the detector circuit is 50 kilocycles, the panel meter will deflect even when the frequency measured is unstable and does not produce a steady audible beat note.

Calibration: The main dial is calibrated in frequency, each division corresponding to one megacycle.

The vernier dial is geared to the tuning unit to make one-half turn of the dial correspond to approximately 1% change in frequency over the entire tuning range. The vernier dial carries 200 uniform divisions.

Accuracy: The over-all accuracy of measurement is ±0.1%. For measurements requiring greater accuracy, the frequency meter can be used with the Type 1110-A Interpolating Frequency Standard, page 208.

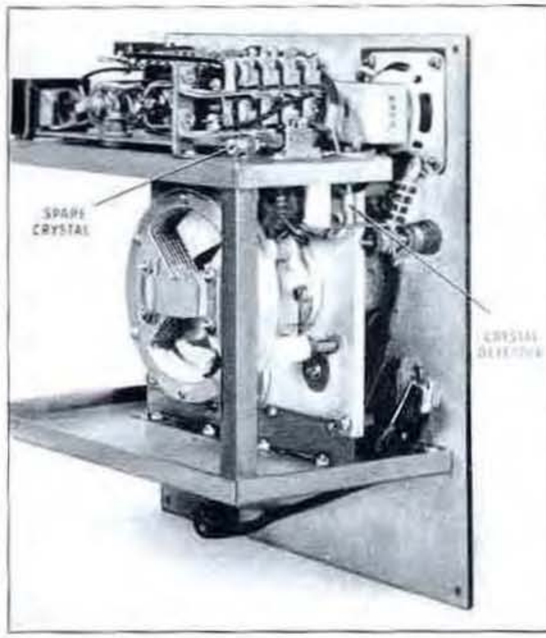
Temperature and Humidity Effects: Over the range of room conditions normally encountered, temperature and humidity do not affect the accuracy of the instrument.

Input Terminal: A short adjustable rod serves as antenna to pick up the unknown signal. Additional length of wire can be attached.

Vacuum Tubes: The following tubes are used and are supplied with the instrument:

1 — 1N5-GT/G
1 — 1D8-GT
1 — 958

Power Supply: A Burgess 6TA60 Battery is supplied with the instrument. For a-c operation the Type 1261-A Power Supply can be used (see page 101), but must be ordered separately.



View of the butterfly-type tuned circuit used in the Type 720-A Heterodyne Frequency Meter.

Mounting: The Type 720-A Heterodyne Frequency Meter is mounted in a shielded carrying case of durable airplane-luggage construction. Complete operating instructions are attached to the cover, and a complete wiring diagram, with circuit constants, is attached to the inside of the cabinet. Panel is finished in black crackle lacquer.

Accessories Supplied: One 1N21-B Crystal is supplied as a spare in addition to the one in the instrument.

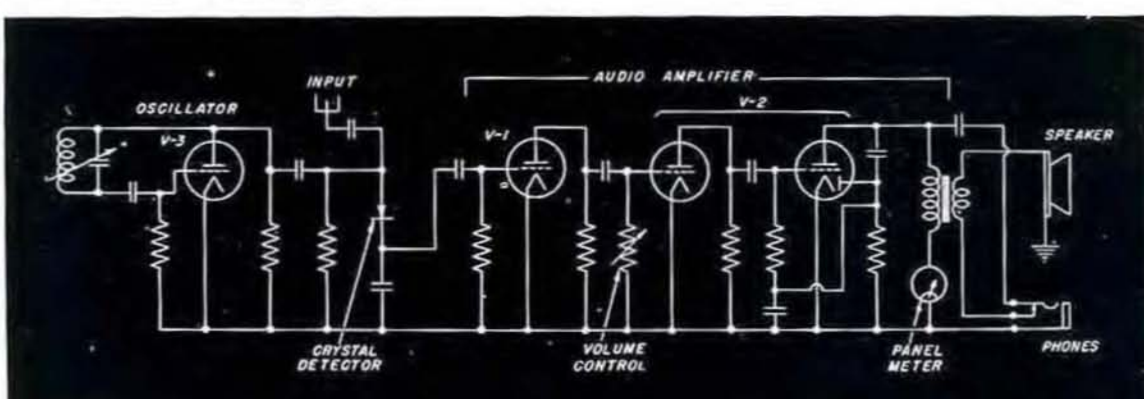
Accessories Recommended: Headphones which can be plugged in on the front panel, and which can be stored in the cover of the instrument.

Dimensions: (Height) 14 x (width) $12\frac{1}{2}$ x (depth) $10\frac{1}{2}$ inches, over-all, including cover and handle. Panel, $10\frac{3}{4}$ x $11\frac{3}{4}$ inches.

Net Weight: $27\frac{1}{2}$ pounds, with battery.

Type		*Code Word*	*Price*
720-A	**Heterodyne Frequency Meter**	FANCY	**$395.00**
1261-A	**A-C Power Supply**	NUTTY	**120.00**

PATENT NOTICE. See Note 10, page vi.



TYPE 1176-A FREQUENCY METER

USES: The Type 1176-A Frequency Meter can be used as a general-purpose instrument for determining the frequency of an unknown source, or continuously monitoring the frequency of a system.

For the electronics laboratory it provides a convenient means of measuring audio and supersonic frequencies up to 60 kc, regardless of waveform. For monitoring radio transmitters, it can be used in conjunction with a crystal monitor, such as the Type 1175-B (see page 192), to indicate continuously the deviation from assigned channel frequency.

DESCRIPTION: The circuit consists of (1) an input amplifier followed by (2) a series of clipping and limiting amplifiers, and (3) a frequency-indicating circuit composed of a capacitor, a diode, and a d-c microammeter. The function of the clippers and limiters is to convert the input signal to a square waveform so that the indication is not affected by changes in amplitude or waveform of the input signal.

FEATURES: ➔ Direct-reading scales, and a single range-selector switch, permit rapid frequency measurements to be made.

➔ A well-regulated power supply eliminates all effects of line voltage changes.

➔ Individual scale calibration adjustments are provided for each range.

➔ An external meter can be connected to the instrument through a multipoint connector on the rear of the unit.

➔ Two sets of input terminals are provided on the panel and, on the rear of the unit, a multipoint connector provides a means of attaching more permanent connections. Plugging into the W. E. panel jacks automatically disconnects the rear terminals.

SPECIFICATIONS

Range: 25-60,000 cycles per second in six ranges. Full-scale values are 200, 600, 2000, 6000, 20,000, 60,000 cycles.

Accuracy: ±(2% of full scale + 2 cycles), for all ranges. When operating on the 60,000-cycle range, with less than 0.5 volt input, the accuracy becomes ±3% of full scale.

Input Voltages: 0.25-150 volts.

Input Resistance: 500,000 ohms, for all ranges. One side grounded.

Input Waveform: The readings are substantially independent of waveform, so long as the dissymmetry of the positive and negative portions of the wave is less than 8:1.

Power Supply: 105-125 (or 210 to 250) volts, 50-60 cycles.

Power Input: 50 watts.

Vacuum Tubes:

1—6H6	1—6SN7-GT
1—6SQ7	1—6J5-GT
1—6X5	2—6SJ7
1—6V6	1—0A3

1—Amperite 3-4

All vacuum tubes are supplied.

Mounting: Standard 19-inch relay-rack panel; aluminum end frames are available to convert to table mounting. (See price list below.)

Panel Finish: Standard General Radio black crackle. Certain standard grays which can be processed in quantity can also be supplied.

Accessories Supplied: Line connector cord and multipoint connector; spare fuses.

Dimensions: Panel, 19 x 5¼ inches; depth behind panel, 11¼ inches.

Net Weight: 19½ pounds.

Type		*Code Word*	*Price*
1176-A	**Frequency Meter**	TIMID	**$285.00**
FRI-310	**End Frames for Type 1176-A**	ENDFRAMCAT	**10.00 pair**

PATENT NOTICE. See Notes 2, 22, page vi.

TYPE 1141-A AUDIO-FREQUENCY METER

USES: The Type 1141-A Audio-Frequency Meter is a convenient instrument for measuring the frequency of oscillators and other audio-frequency signal sources. In radio-frequency measurements it can be used to measure the frequency of the audio beat between the unknown frequency and a 10-kilocycle standard-frequency harmonic.

DESCRIPTION: This meter uses the Wien bridge frequency-selective circuit with a null method of identification. The bridge circuit contains only capacitances and resistances. The calibrated dial controls a ganged assembly of two precision variable resistors, while the changes in range are accomplished by switching the fixed capacitors.

FEATURES:
- ➔ Wide frequency range.
- ➔ High accuracy.
- ➔ Direct-reading dial.
- ➔ Logarithmic scale.
- ➔ Negligible magnetic pickup.

SPECIFICATIONS

Frequency Range: 20 to 20,000 cycles in three ranges, 20 to 200 cycles, 200 to 2000 cycles, and 2000 to 20,000 cycles.

Accuracy: ±0.5% over the entire frequency range. The null point is sharp enough so that the dial can be set to 0.1% provided the waveform is reasonably pure and the supply voltage or detector sensitivity is sufficiently high to provide the necessary over-all sensitivity.

Dial: The 6-inch dial, which has a slow-motion drive, turns through an angle of about 320° giving a scale length of about 17 inches for each 10 to 1 frequency range. The total scale length is thus over 4 feet.

Input Impedance: 3 to 10 kilohms, the smaller value corresponding to the higher frequencies.

Input Voltage: 110 volts rms, maximum.

Output Impedance: 1 to 4 kilohms, the smaller value corresponding to the higher frequencies.

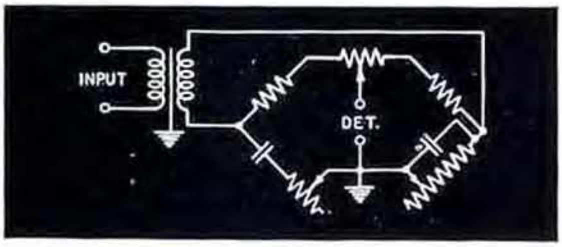
Controls: Frequency dial, range selector switch, and resistance-balance control.

Accessories Required: A null detector is needed to operate the meter. Head telephones, such as the Western Electric 1002-C, or an amplifier-meter combination, such as the Type 1231-B Amplifier and Null Detector, can be used. Even with head telephones an amplifier will prove useful.

Mounting: The instrument is mounted on a black-crackle-finished aluminum panel in a shielded cabinet.

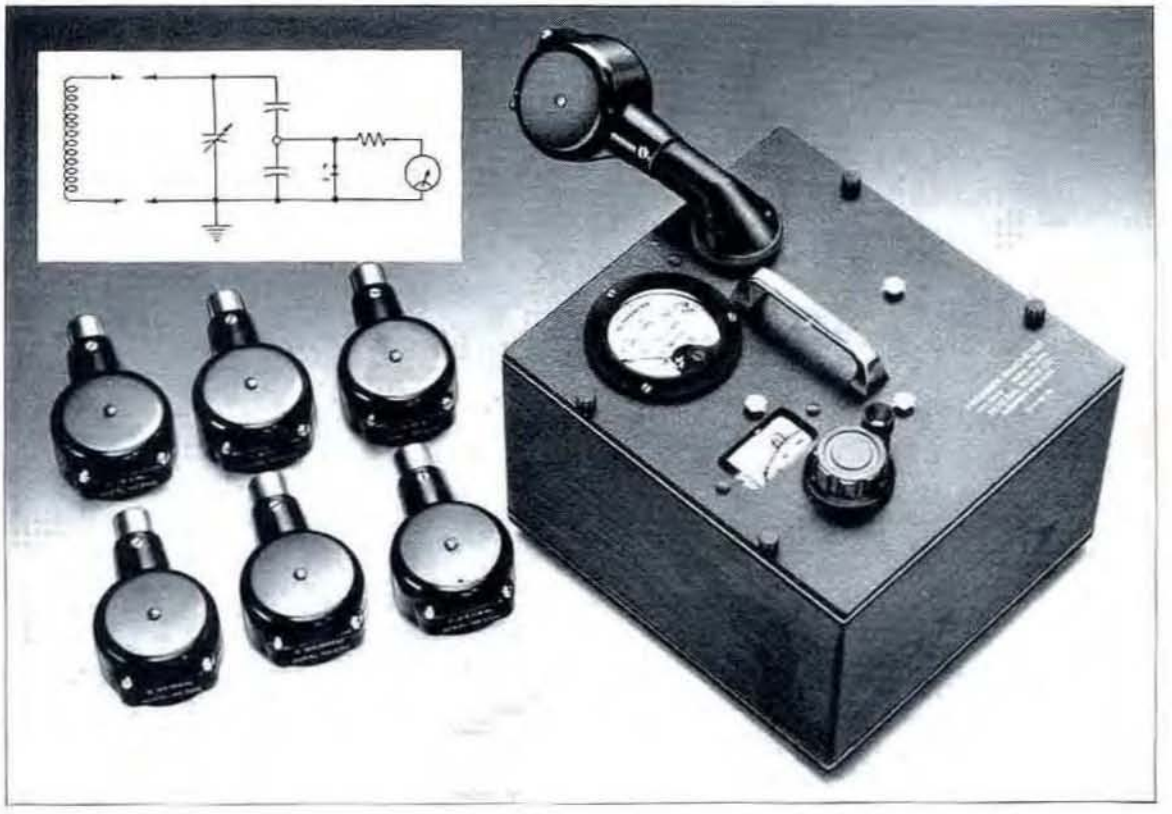
Dimensions: (Length) 12 x (width) 8¾ x (height) 9 inches, over-all.

Net Weight: 18 pounds.



Type		*Code Word*	*Price*
1141-A	Audio-Frequency Meter............	COLOR	$255.00

PATENT NOTICE. See Note 15, page vi.



TYPE 724-B PRECISION WAVEMETER

USES: The precision wavemeter fills a definite need in the field of frequency measurement. Its accuracy is sufficient for many measurements which require a fairly close knowledge of the frequency, but where more precise heterodyne methods are neither necessary nor convenient. Among these applications is the preliminary lining up of radio transmitters and checking the frequency span of oscillators.

DESCRIPTION: The TYPE 724-B Precision Wavemeter is a tuned-circuit instrument, consisting of a precision capacitor, a resonance indicator, and a set of inductors. The capacitor is similar in constructional details to TYPE 722. (See page 46.)

FEATURES: ➔ No cumbersome calibration curves are needed because of the straight-line-frequency capacitor. The calibration data are in tabular form, and specific frequencies are found by interpolating between the points in the table.

➔ All inductors have been designed to have very low losses and a high degree of stability.

➔ The plug-in coil mounting allows the coil to be rotated to obtain different degrees of coupling. This feature is a considerable convenience in operation, making it unnecessary to hold the wavemeter in awkward positions to couple it to oscillator tuned circuits.

➔ A germanium crystal rectifier is used as the resonance indicator with a microammeter.

SPECIFICATIONS

Frequency Range: 10 kilocycles to 50 megacycles.
Accuracy: ±0.25%.
Calibration: The calibration is supplied in the form of a table of calibrated points. Linear interpolation between these points is used to obtain settings for other frequencies. At least 13 points per coil are given.
Capacitor: Precision worm-drive type similar to TYPE 722. The capacitor setting is indicated on the dial and drum and is controlled from the front of the panel. There are 7500 divisions for the entire 270-degree angular rotation of the capacitor rotor. The precision of setting is better than one part in 25,000. The plates are shaped to give an approximately linear variation in frequency with scale setting.
Inductors: Coils are wound on steatite forms and enclosed in molded phenolic cases. Seven coils are used to cover a frequency range between 16 kilocycles and 50 megacycles, with adequate overlap.
Resonance Indicator: A germanium crystal rectifier is used with a microammeter to indicate resonance. The indicator is coupled to the tuned circuit through a capacitive voltage divider.
Crystal: A 1N34 germanium crystal rectifier is used.
Mounting: Capacitor is mounted in an aluminum panel

finished in black crackle lacquer. Cabinet is of walnut shielded. A wooden storage case, fitted with lock and carrying handle, is furnished. This has compartments for holding the capacitor, inductors, and calibration charts.

Dimensions: Carrying case, 16⅞ x 13 x 12½ inches, over-all.

Net Weight: With carrying case, 34 pounds; without carrying case, 18 pounds.

Type		*Code Word*	*Price*
724-B	Precision Wavemeter	WOMAN	$295.00

TYPE 566-A WAVEMETER

USES: The TYPE 566-A Wavemeter is a wide-range, general-purpose, absorption-type instrument intended for rapid frequency checks in the laboratory or the field.

DESCRIPTION: The wavemeter consists of a variable air capacitor mounted in a walnut cabinet, a set of five plug-in inductors, and an incandescent lamp, which is used to indicate resonance. A friction-type slow-motion-drive dial is provided on the capacitor and carries three scales calibrated directly in frequency.

FEATURES: ➔ Compactness and moderate price are important features of this wide-range wavemeter.

➔ The plug-in terminals are so arranged that the inductor can be rotated to vary the coupling to the source under measurement.

➔ A rack is provided on the side of the cabinet for storing the coils when the wavemeter is not in use.

SPECIFICATIONS

Frequency Range: 0.5 to 150 Mc (600 to 2 meters) using the five plug-in inductors furnished with the instrument. The capacitor dial is direct reading in frequency.

Accuracy: The accuracy of dial indication is ±2%, 0.5 to 16 Mc; and ±3%, 16 to 150 Mc.

Accessories Supplied: One spare indicator lamp.

Mounting: Phenolic panel; walnut cabinet.

Dimensions: 4¾ x 5⅞ x 5¾ inches, over-all.

Net Weight: 3 pounds.

Type		*Code Word*	*Price*
566-A	Wavemeter	WAGON	$75.00

TYPE 758-A WAVEMETER

USES: In the very-high-frequency range, 56 to 400 Mc, this wavemeter provides a convenient and accurate means of measuring the frequencies of oscillators.

DESCRIPTION: TYPE 758-A Wavemeter is a tuned-circuit absorption type of instrument, in which the capacitance and inductance are varied simultaneously. This permits a wide range of frequency to be covered with a single coil. The coil is connected permanently into the circuit. The resonance indicator is an incandescent lamp.

FEATURES: ➔ A wide frequency range is covered without the bother of changing coils.

➔ A transparent material is used to enclose the circuit elements so that they can be seen at all times. This feature is of help in coupling the wavemeter to a circuit.

➔ The indicator lamp will glow when measuring the frequency of an oscillator with about two watts output. For low-power oscillators the reaction on the plate or grid current can be used to indicate resonance.

SPECIFICATIONS

Range: 56 Mc to 400 Mc, direct reading.

Accuracy: ±2%.

Temperature and Humidity: The accuracy of this wavemeter is completely independent of temperature and humidity effects over the ranges normally encountered.

Resonance Indicator: Incandescent lamp.

Accessories Supplied: Two spare indicator lamps.

Mounting: Transparent case with hexagonal black phenolic end pieces.

Dimensions: 5 x 5 x 4¾ inches, over-all.

Net Weight: 1⅝ pounds.

Type		*Code Word*	*Price*
758-A	**Wavemeter**	WITTY	**$40.00**

TYPE 1140-A U-H-F WAVEMETER

USES: This instrument fills the need for a frequency measuring instrument of moderate accuracy in the ultra-high frequency range. It will measure to ±2% the frequency of oscillators and other sources between 250 and 1200 megacycles.

DESCRIPTION: The frequency-determining element in the TYPE 1140-A Wavemeter is a butterfly circuit in which capacitance and inductance are varied simultaneously by a single control. The resonance-indicating circuit consists of a crystal detector and a microammeter. These elements, together with the direct-reading drum-type frequency scale and a slow-motion drive, are mounted in a convenient molded phenolic case.

FEATURES: ➔ Low losses and permanence of calibration are assured by the butterfly circuit, which requires no moving contacts.

➔ A wide frequency range is covered by a single rotation of the dial.

➔ The small detector cartridge is easily replaced, if burned out or damaged, without affecting the calibration.

➔ Sensitivity is sufficient to give a meter reading with oscillators having only 20 milliwatts output.

SPECIFICATIONS

Range: 250 to 1200 Mc. **Accuracy:** ±2%.

Temperature and Humidity: The accuracy of this wavemeter is independent of temperature and humidity effects over the range of room temperatures and humidities normally encountered in the laboratory.

Detector: The detector is mounted in a standard cartridge and can be replaced if damaged by overloading. A 1N22 Silicon crystal detector is used.

Dimensions: 4 x 4½ x 7⅛ inches, over-all.

Net Weight: 3 pounds.

Type		*Code Word*	*Price*
1140-A	**Wavemeter**	WAGER	**$80.00**

PATENT NOTICE. See Note 10, page vi.

PARTS AND ACCESSORIES

Many of the parts used in laboratory instruments must be designed with different objectives in view from those that govern the design of parts for radio receivers and similar assemblies. Long life, unfailing reliability, convenience of connection, and known electrical characteristics are a few of these. Because of these considerations, many of the parts used in General Radio instruments are manufactured by the General Radio Company. Recognizing the general need for high-quality parts for use in laboratory setups and in high-quality equipment, GR has also made these parts available for general sale.

Since the quantities needed are relatively small, economy in manufacture can only be achieved by designing each item to be as universal as possible in application, and adaptable to a wide range of uses. Design emphasis, therefore, has been not only on high-quality materials and workmanship, but also on producing integrated groups of basic elements that fit together mechanically, work together electrically, and have a unity of appearance.

An excellent example of the integrated line is found in General Radio binding posts, plugs and jacks, and coaxial elements. The TYPE 938 Binding Post uses high-quality material—brass with Bright-Alloy plate for high conductivity, polystyrene insulation for high resistance and low power factor, either red or black for color coding. It can be mounted on metal or insulating panels, of a thickness from zero to 5/16 inch. The captive top will clamp a spade terminal or any size wire up to No. 10 without shearing, and will accept a TYPE 274 Plug or a TYPE 838 Alligator Clip. The plug seats with a taper into the chamfered binding-post body to assure mechanical stability. The binding post has the same height above panel as the TYPE 874 Coaxial Connector, whose center will take a TYPE 274 Plug, so that a grounded binding post can be mounted adjacent to the coaxial connector to fit a TYPE 274-MB Double Plug. Insulators are keyed to binding post and to panel for positive register. The insulators will also mount a TYPE 938 Jack. Both binding post and jack have soldering tips—no lugs are used.

Flat insulators (TYPE 938-Z) mounting two binding posts are also available and are particularly useful and easy to assemble for the home experimenter having drills no larger than ½ inch.

The TYPE 874 Coaxial Connector is designed specifically for use in measurement circuits. It has excellent electrical characteristics, and, by virtue of its universal character, no separate plug and jack types are necessary. This results in an economy of parts within the measurement setup, while adaptors are available to connect to external systems using other standard types of connectors. TYPE 874 Coaxial Connectors are listed in a separate section (see pages 112-125).

General Radio plugs and jacks are designed for positive and reliable contact. The plug seats firmly in the jack so that the plug springs are not depended on for mechanical stability. Double plugs (TYPE 274-MB) can be stacked, and polystyrene insulation is used, which prevents the hand from touching metal when they are plugged in.

A complete system of laboratory test leads is also available (see page 228). Test prods can be stacked, i.e., plugged one into another to make a longer prod. Tips are pointed to pierce insulation. Test leads and alligator clips plug easily into prods. The clips are Bright-Alloy plated, over high-quality phosphor bronze. They have narrow jaws to clip into binding-post tops and can therefore be used with both insulated and uninsulated types.

General Radio dials are made for 3/8-inch shafts but sleeves are furnished to adapt them for ¼-inch shafts. Models with either etched or engraved scales are available. Models include direct-drive, friction-drive, and gear-drive types. Dial material is 51-S aluminum alloy with attractive matte finish.

Knobs are durable phenolic, and are available separately in a variety of models and sizes, consistent in style with the binding posts.

Variable air capacitors, the TYPES 1427 and 1428, are designed specifically for instrument use. These high-quality, rugged, low-loss units are supplied in several different capacitance ranges.

TYPE 941 Transformer is a general purpose impedance matching transformer useful as a laboratory accessory or for building into audio and supersonic equipment. It will match 600-ohm lines to circuits ranging in impedance from 37½ ohms to 9600 ohms. It has an excellent frequency characteristic, spanning four decades.

TYPE 1428 VARIABLE AIR CAPACITOR

USES: The TYPE 1428 Variable Air Capacitors are well-designed, ruggedly constructed, and stable capacitors, suitable for use in laboratory-type measuring equipment.

DESCRIPTION: Both rotor and stator are insulated from the frame, and contact to the rotor is made by a slip ring and 4-fingered brush. Rotor and stator stacks are made of brass plates soldered into single units and nickel plated. Rotor is mounted in specially designed, self-aligning ball bearings, which are mounted on metal endplates, rigidly supported by four metal corner rods. Stator supports are small ceramic cones. Rotor is insulated from 3/8-inch steel shaft by two low-loss thermoplastic collars.

FEATURES: ➔ Rigid construction and self-aligning ball bearings assure mechanical stability.

➔ Soldered plate construction keeps ohmic resistance low.

➔ Insulated rotor and stator make the capacitor usable as either a 3-terminal or a 2-terminal element.

➔ Capacitance from stator to frame and from rotor to frame has been kept low.

SPECIFICATIONS

Capacitance Range: Three unmounted models and one mounted model are listed below.

Calibration: The TYPE 1428-BM has a dial direct-reading in capacitance to ±(1% + 5 μμf).

Plate Shape: Semicircular straight-line capacitance plates on all models.

Dielectric Losses: The figure of merit *DC* (dissipation factor times capacitance) is approximately 0.02 μμf for all types.

Supports: All models have metal endplates with small ceramic cones supporting the stator. The rotor is insulated from the shaft by two low-loss thermoplastic collars.

Maximum Voltage: 1100 volts peak for TYPE 1428-A, and 700 volts peak for all others.

Shaft: 3/8-inch solid steel shaft on all models.

Drive: No knobs or drives are supplied except on the TYPE 1428-BM which has a direct-reading dial.

Terminals: Soldering lugs on unmounted models; standard jack-top binding posts on mounted model.

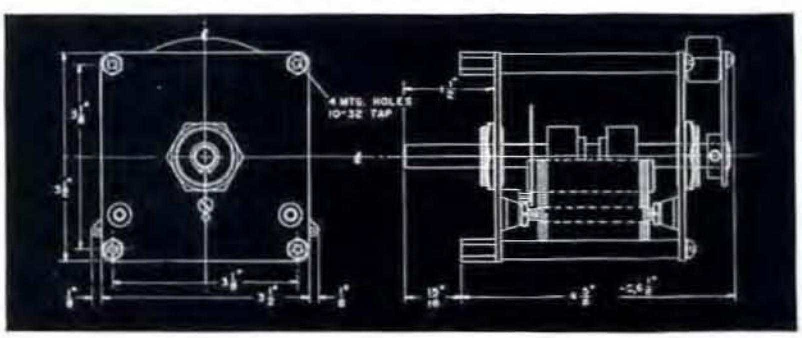
Mounting: TYPE 1428-BM is mounted on an aluminum panel in a shielded cabinet. All other models are unmounted.

Dimensions: TYPE 1428-BM mounted model, 5½ x 5½ inches, x (height) 7 inches, over-all. Unmounted models, see accompanying sketch.

Net Weight: TYPES 1428-A and -B, 2⅜ pounds; TYPE 1428-C, 3½ pounds; TYPE 1428-BM, 8½ pounds.

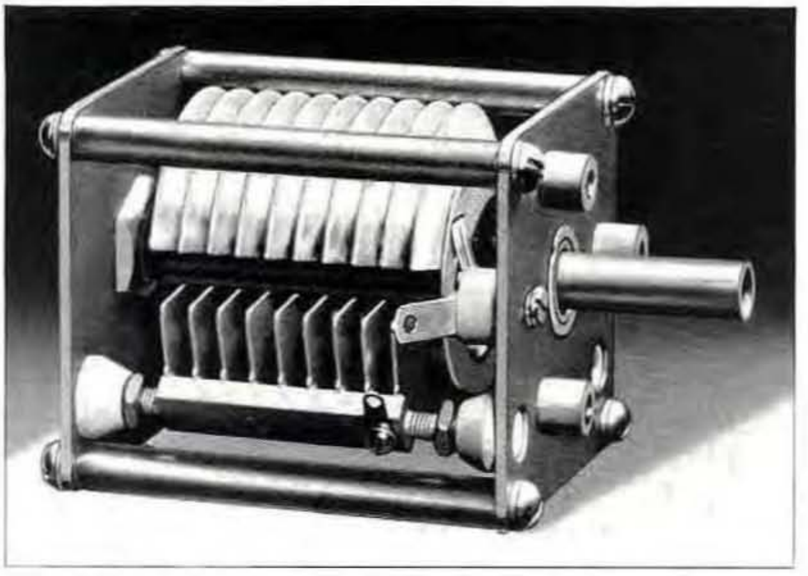
	Nominal Capacitance — Rotor Grounded		*Nominal Maximum Capacitance to Frame*			
Type	*Maximum*	*Minimum*	*Rotor*	*Stator*	*Code Word*	*Price*
1428-A	**550 μμf**	**20 μμf**	**15 μμf**	**12 μμf**	CAMEL	**$28.00**
1428-B	**1100 μμf**	**20 μμf**	**15 μμf**	**12 μμf**	CALIF	**31.00**
1428-BM*	**1100 μμf**	**22 μμf**	......	......	CRISP	**57.00**
1428-C	**2100 μμf**	**29 μμf**	**18 μμf**	**16 μμf**	CREST	**40.00**

*Cabinet-mounted model with dial direct-reading in capacitance.



Mounting dimensions for TYPE 1428 Variable Air Capacitor.

TYPE 1427 VARIABLE AIR CAPACITOR



USES: The TYPE 1427 Variable Air Capacitor, similar in design and construction to the TYPE 1428 described on the preceding page, is available in lower-capacitance models. This capacitor is a high-quality unit, suitable for use in measuring equipment.

DESCRIPTION: In general design and construction, this capacitor is similar to the TYPE 1428. Bearings and insulation are the same, plates are soldered, and both rotor and stator are insulated from the frame.

SPECIFICATIONS

Capacitance Range: Three models are listed below.

Plate Shape: Semicircular straight-line capacitance on all models.

Dielectric Losses: The figure of merit *DC* (dissipation factor times capacitance) is approximately 0.02 μμf for all types.

Supports: All models have metal endplates with small ceramic cones supporting the stator. All rotors are insulated from the shafts by low-loss thermoplastic collars. Maximum nominal capacitance of rotor to frame is 13 μμf, and stator to frame 11 μμf.

Maximum Voltage: 1500, 1400, and 1100 volts peak, for the TYPES 1427-A, -B, and -C, respectively.

Shaft: 3/8-inch solid steel shaft on all models.

Terminals: Tinned copper soldering lugs are provided.

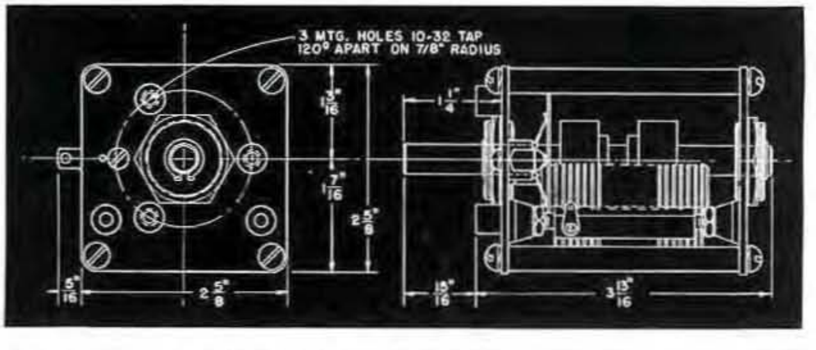
Mounting: See sketch below. Three mounting screws are furnished.

Dimensions: See sketch below.

Net Weight: All models, 1 3/8 pounds.

Type	*Nominal Capacitance — Rotor Grounded* *Maximum*	*Minimum*	*Code Word*	*Price*
1427-A	75 μμf	15 μμf	CAPER	$22.00
1427-B	110 μμf	16 μμf	CAPON	23.00
1427-C	220 μμf	16 μμf	CARAT	23.00

Mounting dimensions for TYPE 1427 Variable Air Capacitor.



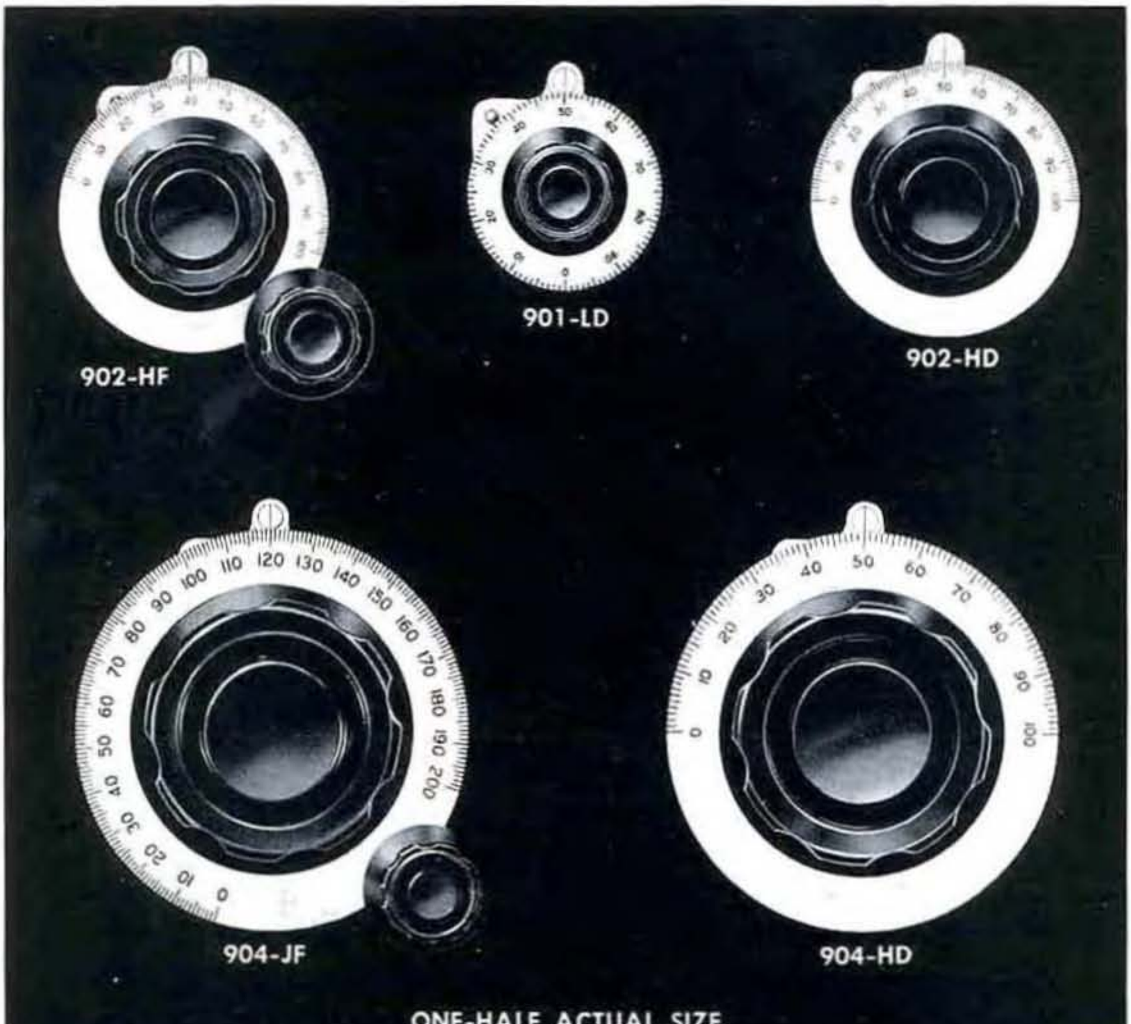
FRICTION-DRIVE AND DIRECT-DRIVE DIALS

These dials are attractive in appearance, with accurate, photo-etched scales, and are intended for uses where precisely cut scales and precision drives are not needed. Dial plates are of aluminum, with anodized finish. Three different diameters are available.

The smallest dials, TYPE 901, are available only with direct drive, but the TYPES 902 and 904 are available with both direct and friction drives. The friction-drive mechanism consists of a thin disc, which is mounted on the back of the dial plate, gripped and driven by two small discs attached to the friction-drive shaft. This drive shaft is mounted in an eccentric manner so that the tension of the drive can be easily adjusted after the dial and drive are mounted.

All of the dials have the dial plates insulated from the shaft. Knobs are secured to their shafts by the use of two setscrews separated by 90°, and are supplied bored to receive a ⅜-inch shaft. Bushings are provided so that the dials can be easily arranged for mounting on ¼-inch shafts.

The indicators shown in the photographs are designed to remain flush with the surface of the dial, thus eliminating parallax and absorbing any slight eccentricities of the main shaft. The indicators, necessary mounting screws, drive knobs, and drilling templates are furnished with the dials.



ONE-HALF ACTUAL SIZE

Type	Dial Arc	Dial Divisions	Drive	Net Weight	Code Word	Price
→ 4-INCH DIAMETER — TYPE 904 DIALS						
904-HD	180°	100	Direct	5 oz.	DIPAR	$3.25
904-JD	270°	200	Direct	5 oz.	DIPOD	3.25
904-HF	180°	100	Friction, 5 : 1	8 oz.	DIPEN	4.25
904-JF	270°	200	Friction, 5 : 1	8 oz.	DIPUT	4.25
→ 2¾-INCH DIAMETER — TYPE 902 DIALS						
902-HD	180°	100	Direct	2½ oz.	DIMAP	$2.75
902-JD	270°	100	Direct	2½ oz.	DIMID	2.75
902-HF	180°	100	Friction, 3.3 : 1	4 oz.	DIMOB	3.75
902-JF	270°	100	Friction, 3.3 : 1	4 oz.	DIMUG	3.75
→ 2-INCH DIAMETER — TYPE 901 DIALS						
901-HD	180°	100	Direct	2 oz.	DILOG	$2.75
901-JD	270°	100	Direct	2 oz.	DILAP	2.75
901-LD	360°	100	Direct	2 oz.	DILID	2.75

PATENT NOTICE. See Note 14, page vi.

TYPE 907 AND TYPE 908 GEAR-DRIVE PRECISION DIALS

The Type 907 and 908 Gear-Drive Precision Dials have aluminum dial plates with anodized finish. Scales are individually engraved on an automatic, self-indexing engraving machine. The fine, radial, accurately located lines divide the complete circumference into 360 divisions numbered from 0 to 360.

Settings can consistently be duplicated to one-fifth of a division, allowing a precision of resetting of better than 0.06% of full scale. Parallax is eliminated by the use of an indicator that always remains flush with the surface of the dial, and which at the same time absorbs, through the flexibility of its mounting arm, any slight eccentricities of the main shaft.

The ring gear and drive pinion are precision cut gears, spring pressed to eliminate any backlash. The drive ratio is 10 : 1, and it is possible to use a calibrated vernier or increment dial on the pinion shaft if desired. Any standard Type 901 dial (page 222) can be adapted for use on the pinion shaft. The drive pinion is held in a stainless steel collet which runs in a phosphor-bronze bushing. The collet allows the drive to be adjusted for any panel thickness up to 5/16 inch.

The main dials are set permanently and securely to their shafts through the use of two set-screws 90° apart; this procedure

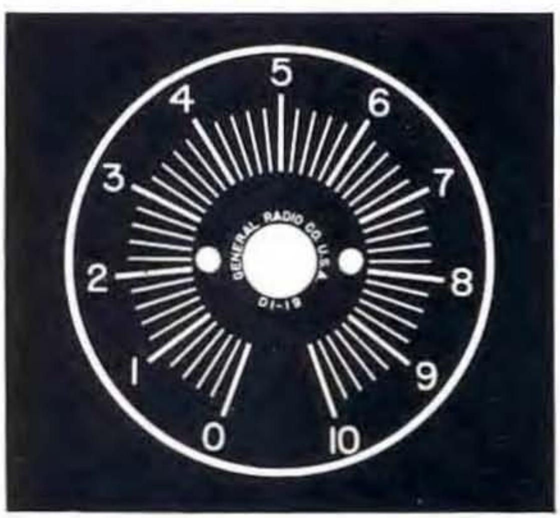
Below, Type 907-LA Gear-Drive Precision Dial. *At right*, Type 908-LA.

Left, TYPE 908-LB Gear-Drive Precision Dial. *Above*, TYPE 907-LB.

eliminates any dial backlash which might otherwise occur. The dial hubs are bored to receive a ⅜-inch shaft, but a split bushing is provided for use with ¼-inch shafts. The 360-division dial plate is held by three screws, and can be easily replaced with other 4-inch dial plates such as the TYPE 904 (page 222). The dial indicator, knob, and all necessary mounting parts are supplied, as are complete drilling and mounting instructions.

Type	*Mounting*	*Dial Arc*	*Dial Divisions*	*Max. Panel Thickness*	*Total Panel Area*	*Net Weight*	*Code Word*	*Price*
4-INCH DIAMETER GEAR-DRIVE PRECISION DIALS								
907-LA	Front-of-Panel	**360°**	**360**	——	4 x 5 inches	11 oz.	DITAB	**$10.50**
907-LB	Back-of-Panel	**360°**	**360**	5/16 inch	4 x 5 inches	11 oz.	DITOP	**10.50**
6-INCH DIAMETER GEAR-DRIVE PRECISION DIALS								
908-LA	Front-of-Panel	**360°**	**360**	——	6 x 7½ inches	21 oz.	DIVAT	**$14.50**
908-LB	Back-of-Panel	**360°**	**360**	5/16 inch	6 x 7½ inches	19 oz.	DIVIM	**14.50**

PATENT NOTICE. See Note 14, page vi.



TYPE 318-D DIAL PLATE

This dial plate can be used with General Radio rheostat-voltage dividers (all types), Variacs (TYPES 200-B, V-5, V-10), and for other equipment where a 0 to 10 scale is desired. It is designed for use with the following knobs (see page 225): KNSP-6, KNSP-8, KNSP-10, and KNB-2. Has two-hole mounting as shown in photo; hole spacing is one inch on centers; diameter of center hole, ½ inch.

Type		*Code Word*	*Price*
318-D	**Dial Plate**	DIPAL	**$0.50**

TYPE KN FLUTED KNOBS

TYPE KNB-1 15/16-INCH SKIRT DIAMETER — WITH BAR

Bar-type extension makes knob especially convenient on switches. Molded pointer is filled with white.

Code Word: BARKNOBONE *Net Weight for 5:* 3¾ oz.

Quantity	5*-19	20-199	200-399	400-1999	2000 up
Unit Price†	**$0.65**	**$0.55**	**$0.52**	**$0.49**	**$0.47**

TYPE KNB-2 1 5/16-INCH SKIRT DIAMETER—WITH BAR

Larger bar type with pointer.

Code Word: BARKNOBTWO *Net Weight for 5:* 6 oz.

Quantity	5*-19	20-199	200-399	400-1999	2000 up
Unit Price†	**$0.75**	**$0.65**	**$0.61**	**$0.58**	**$0.55**

TYPE KNSP-6 1 5/16-INCH SKIRT DIAMETER—WITH POINTER

Code Word: NURLNOBSIX *Net Weight for 5:* 5½ oz.

Quantity	5*-19	20-199	200-399	400-1999	2000 up
Unit Price†	**$0.60**	**$0.50**	**$0.47**	**$0.44**	**$0.42**

TYPE KNSP-8 1 15/16-INCH SKIRT DIAMETER—WITH POINTER

Code Word: NURLNOBATE *Net Weight for 5:* 8 oz.

Quantity	5*-19	20-199	200-399	400-1999	2000 up
Unit Price†	**$0.75**	**$0.65**	**$0.61**	**$0.58**	**$0.55**

TYPE ZKNU-3 1 15/16-INCH SKIRT DIAMETER—WITH SPINNER

This knob has an auxiliary finger spinner so that knob can be spun rapidly with the index finger. Particularly useful with slow-motion drives.

Code Word: SPINNOBTRE *Net Weight:* 2¾ oz.

Unit Price **$2.00**

TYPE KNSP-10 2⅜-INCH SKIRT DIAMETER—WITH POINTER

Code Word: NURLNOBTEN *Net Weight for 5:* 12½ oz.

Quantity	5*-19	20-199	200-399	400-1999	2000 up
Unit Price†	**$1.05**	**$0.95**	**$0.90**	**$0.85**	**$0.80**

TYPE KNS-12 2⅞-INCH SKIRT DIAMETER—WITHOUT POINTER

Code Word: NURLNOBDOZ *Net Weight for 5:* 17 oz.

Quantity	5*-19	20-199	200-399	400-1999	2000 up
Unit Price†	**$1.10**	**$1.00**	**$0.95**	**$0.90**	**$0.85**

PATENT NOTICE. See Note 14, page vi.

*Minimum quantity sold.

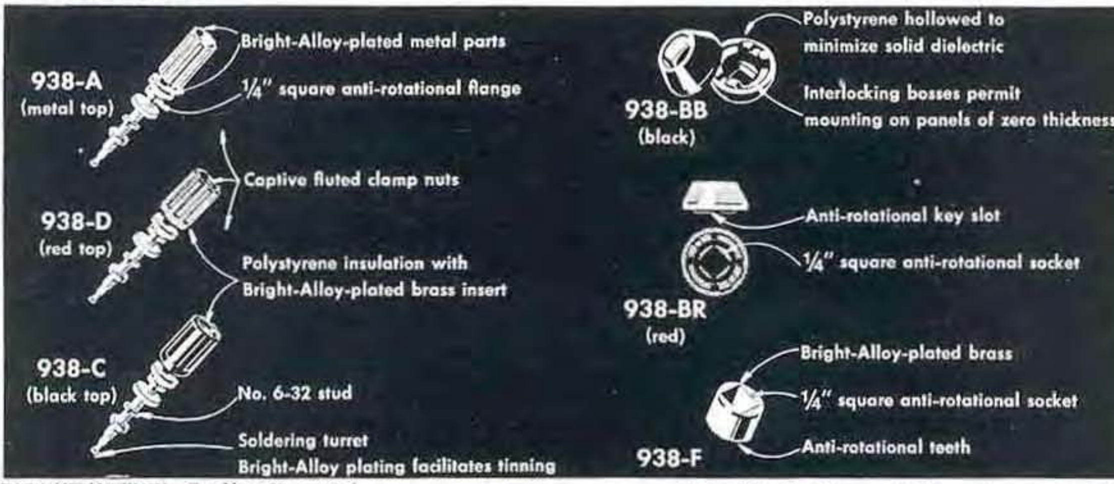
†Net. No further quantity discounts.

The TYPE KN Fluted Knobs are shown approximately three-eighths actual size in the photograph.

These molded phenolic knobs are used on General Radio laboratory instruments. They are molded in one piece with a brass insert bored for a ⅜-inch shaft. A bushing is furnished with each knob to adapt it to a ¼-inch shaft. Knob is clamped to shaft by two setscrews spaced 90° apart, except in TYPE KNSP-6, which has 135° spacing. TYPE KNB-1 has single set screw.

TYPE 938 BINDING POSTS

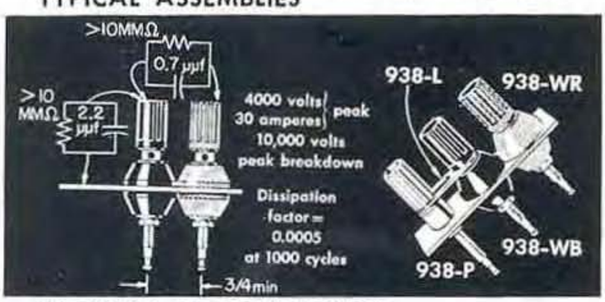
BASIC PARTS



PATENT NOTICE. See Note 29, page vi.

Type		*Code Word*	*Unit Prices*† 10*–99	100–999	1000–1999	2000–9999	10,000 up
938-A	Metal-Top B. P.	STANPARASP	$0.30	$0.26	$0.24	$0.23	$0.22
938-C	Black-Top B. P.	STANPARAWL	0.40	0.34	0.32	0.30	0.29
938-D	Red-Top B. P. .	STANPARARM	0.40	0.34	0.32	0.30	0.29
938-BB	Black Ins. (Pair)	STANPARAUK	0.125	0.11	0.105	0.10	0.095
938-BR	Red Ins. (Pair)	STANPARATE	0.125	0.11	0.105	0.10	0.095
938-F	Spacer . . .	STANPARBON	0.025	0.02	0.02	0.02	0.02
938-L	Shorting Link .	STANPARBET	0.10	0.09	0.085	—	—

TYPICAL ASSEMBLIES



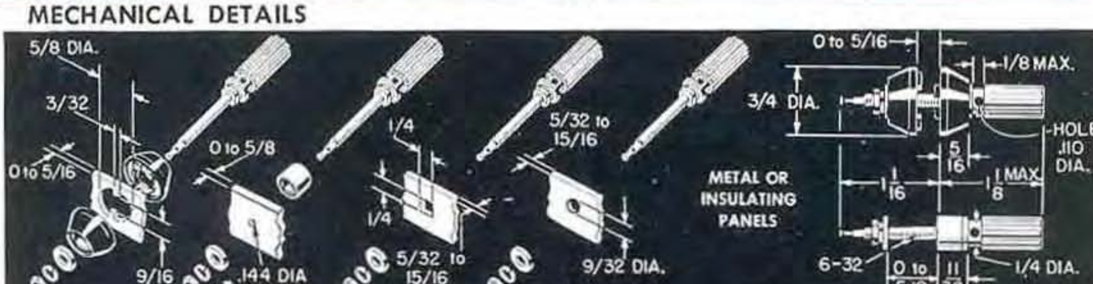
Type		*Code Word*
938-P	Metal top, 938-F Spacer	STANPARDOT
938-W	Metal top, black ins. .	STANPARANT
938-WB	Black top and ins. . .	STANPARBAN
938-WR	Red top and ins. . . .	STANPARCUB

Type	*Unit Prices*† 10*–99	100–999	1000–1999	2000–9999	10,000 up
938-P	$0.325	$0.28	$0.26	$0.25	$0.24
938-W	0.425	0.37	0.35	0.33	0.31
938-WB	0.525	0.45	0.425	0.40	0.38
938-WR	0.525	0.45	0.425	0.40	0.38

*Minimum quantity sold.
†Net prices. No further quantity discounts.

METHODS OF CONNECTION

MECHANICAL DETAILS



Locking keys in ⅝-inch mounting holes can be omitted if locking feature is not wanted.

PLUGS AND JACKS

TYPE 274 PLUGS AND JACKS

TYPE 274 Plugs and Jacks, originated by General Radio in 1924 are almost universally used in electronics and communications laboratories for connecting equipment in temporary or semi-permanent setups and for connecting plug-in elements in tuning systems and other laboratory instruments. All TYPE 274 Plugs and Jacks are rated at 15 amperes. For insulated single and double plugs, see page 228.

TYPE 274-P PLUG

Banana plug, nickel-plated brass stud, beryllium-copper spring. Furnished with nut and soldering lug.
Code Word: STANPARCAT

Quantity	*Price*†
10*–99	**$1.25** per ten
100–999	**10.50** per hundred
1000–1999	**87.00** per thousand
2000–19,999	**85.00** per thousand

TYPE 274-X PLUG

Similar to TYPE 274-P, (above) but with tubular rivet head.
Code Word: STANPARTIN

Quantity	*Price*†
10*–99	**$0.85** per ten
100–999	**6.70** per hundred
1000–1999	**61.00** per thousand
2000–19,999	**57.50** per thousand

TYPE 274-U PLUG

Plug with ¼-28 threaded stud. Jack top accepts TYPE 274 Plug.
Code Word: STANPARGOT

Quantity	*Price*†
10*–99	**$1.50** per ten
100–999	**13.00** per hundred
1000–1999	**123.50** per thousand

TYPE 274-SB SHORT-CIRCUIT PLUG

Handy for shorting two terminals. Consists of two TYPE 274-U Plugs connected by two plated links.
Code Word: STANPARZIP

Price: **$0.75**

TYPE 274-J JACK

Jack, to fit TYPE 274 Plugs. Nickel-plated brass.
Code Word: STANPARTOP

Quantity	*Price*†
10*–99	**$0.75** per ten
100–999	**4.95** per hundred
1000–1999	**46.75** per thousand
2000–19,999	**44.00** per thousand

TYPE 674 JUMBO PLUGS AND JACKS

Heavy-duty parts, designed for 35 amperes. Similar in design to TYPE 274, but larger. Nickel-plated brass, with beryllium copper springs. Nuts and soldering lugs included.

TYPE 674-P JUMBO PLUG

Code Word: STANPARAPE

10*–99	**$0.25 each**
100–199	**.24 each**
200–999	**.225 each**

TYPE 674-J JUMBO JACK

Code Word: STANPARAYE

10*–99	**$0.22 each**
100–199	**.21 each**
200–999	**.20 each**

TYPE 938 JACKS

A jack and jack assembly using TYPE 938-BB Insulators. Jack is similar to TYPE 274-J Jack, but with longer shank. Fits TYPE 274 Plugs.

TYPE 938-J JACK

Code Word: STANPARACT

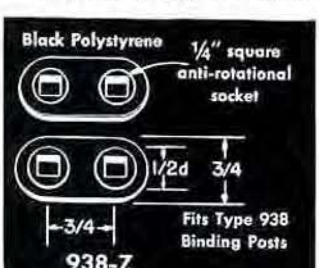
Quantity	*Unit Price*†
10*–99	**$0.175**
100–999	**0.15**
1000–1999	**0.14**

TYPE 938-X JACK ASSEMBLY

Code Word: STANPARART

Quantity	*Unit Price*†
10*–99	**$0.30**
100–999	**0.26**
1000–1999	**0.245**

TYPE 938-Z REPLACEMENT BINDING POST INSULATOR



The TYPE 938-Z Insulators fit the TYPE 938 Binding Posts, as well as the obsolete TYPE 138 Binding Posts. Since, in addition to the above, the TYPE 938-Z insulators mount in the same (1½" diameter) holes as the obsolete TYPE 138 insulators, they serve as replacements for the TYPE 138 insulators or to mount TYPE 938 binding posts in place of TYPE 138 binding posts.

			Price† *per pair*				
Type		*Code Word*	5*–99	100–999	1000–1999	2000–9999	10,000 up
938-Z	**Insulator**	STANPARHOD	**$0.175**	**$0.165**	**$0.155**	**$0.145**	**$0.14**

*Minimum quantity sold. †Net prices. No further quantity discounts.

TYPE 274 AND TYPE 838 CONNECTORS

BASIC LEADS

Type		Code Word	Unit Price† 5*–9	10–19	20–99	100 up
838-AB6	6" Black Test Lead . .	STANPARLAP	$0.40	$0.38	$0.36	$0.34
838-AB12	12" Black Test Lead . .	STANPARLEG	.40	.38	.36	.34
838-AB30	30" Black Test Lead . .	STANPARLID	.45	.43	.41	.38
838-AR6	6" Red Test Lead . .	STANPARLOG	.40	.38	.36	.34
838-AR12	12" Red Test Lead . .	STANPARLOT	.40	.38	.36	.34
838-AR30	30" Red Test Lead . .	STANPARLUG	.45	.43	.41	.38

*Minimum quantity sold. †Net; no further quantity discounts.

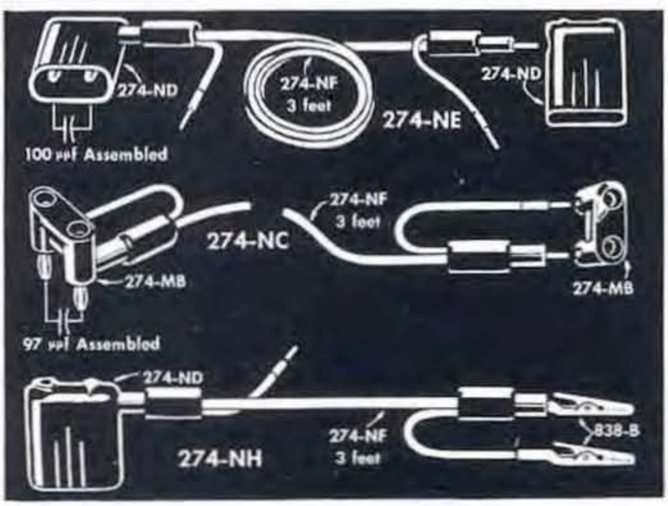
274-NF	Shielded Cable	STANPARGAG	$2.50 each

LEAD TERMINATIONS

Type		Code Word	Unit Price† 1–9	10–99	100–199	200–999	1000 up
838-C	Red Test Prod	STANPARPIN	$1.00	$0.95	$0.90	—	—
838-D	Black Test Prod	STANPARPEG	1.00	0.95	0.90	—	—
274-MB	Double Plug	STANPARBUG	0.65	0.55	0.52	$0.49	$0.47
274-DB1	Insulated Single Plug (black)	STAPLUGANT	0.50	0.40	0.38	0.36	0.34
274-DB2	Insulated Single Plug (red)	STAPLUGARC	0.50	0.40	0.38	0.36	0.34
838-B	Alligator Clip	STANPARNIP	—	0.20*	0.19	0.18	0.17

*Minimum quantity sold. †Net; no further quantity discounts.

274-ND	Shielded Double Plug . .	STAPLUGDOG	$1.50 each



COMPLETE LEAD ASSEMBLIES

SHIELDED LEAD ASSEMBLY WITH UNSHIELDED TERMINALS

Type	Code Word	Price
274-NC	STANPARZOO	$3.80

SHIELDED LEAD ASSEMBLY WITH SHIELDED TERMINALS

Type	Code Word	Price
274-NE	STAPLUGEYE	$5.50

SHIELDED LEAD AND PLUG ASSEMBLY WITH ALLIGATOR CLIPS

Type	Code Word	Price
274-NH	STANPARMAP	$4.25

TYPE 941-A TOROIDAL TRANSFORMER

USES: This transformer is designed for use as an impedance-matching or bridging transformer in low-level 600-ohm communication circuits. It is especially useful where either a high degree of astaticism or an ultra-wide frequency range is desired.

DESCRIPTION: The core is toroidal, consisting of high-permeability-alloy tape wound in a spiral. On the core are two identical semi-circumferential inner windings, over which are two identical outer windings. Terminals are brought out from each winding. By connection in series and parallel combinations, various impedance ratios can be obtained.

The transformer is housed in a rectangular aluminum case. Two double-drilled mounting blocks permit mounting (1) on the large face, (2) on the small face opposite the terminal panel, or (3) projecting through a hole $3\frac{1}{8}$ x $1\frac{5}{8}$ inches in an assembly chassis.

FEATURES: ➔ Toroidal core is inherently astatic, minimizing pickup and induction field.

➔ Coupling is closer than is possible with the conventional shell-type core, and the resulting lower leakage reactance extends the high-frequency characteristic by about a decade.

➔ Connection diagrams for various impedance and frequency ranges are printed on case.

➔ Easily mounted in any assembly.

SPECIFICATIONS

TABLE I

Circuit	*Terminating Impedances* Ω	Ω	*Connect* *Inner Windings*	*Outer Windings*	*Frequency for 1 db drop*	*Flat Insertion Loss Less than*
1	600	9600	Parallel	Series	80 c — 100 Kc	0.3 db
2	600	2400	Series	Series	20 c — 135 Kc	0.2 db
3	600	2400	Parallel	Parallel	80 c — 340 Kc	0.2 db
4	600	600	Series	Parallel	20 c — 200 Kc	0.1 db
5	150	600	Series	Series	5 c — 50 Kc	0.7 db
6	150	600	Parallel	Parallel	20 c — 200 Kc	0.2 db
7	37.5	600	Parallel	Series	5 c — 50 Kc	0.8 db

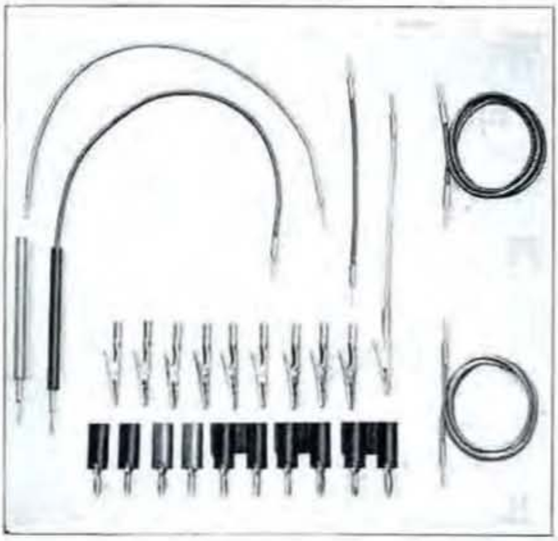
Impedance Range: See Table I.
Frequency Range: See Table I.
Initial Inductance: Inner windings, in series, 5 to 6 henrys; outer windings, in series, 20 to 24 henrys.
Operating Level: See Table II.
Distortion: See Table II.
Resistance: Inner windings, in series, 9 ohms; outer windings, in series, 34 ohms.
Dimensions: Aluminum case, $3\frac{5}{8}$ x $3\frac{1}{8}$ x $1\frac{5}{8}$ inches. Mounting blocks project $\frac{9}{32}$ inch beyond case in $3\frac{1}{8}$ inch dimension.
Mounting Dimensions: $3\frac{3}{8}$ inches on centers. Mounting holes are drilled for clearance with 10-32 machine screws.
Net Weight: $13\frac{1}{2}$ ounces.

TABLE II

Level *Watts*	*VU*	*60-cycle r-m-s distortion*
1.26	31	<1%
1	30	<0.5%
0.5	27	<0.2%
0.032	15	<0.1%

Type		*Code Word*	*Price*
941-A	**Toroidal Transformer**	TRANTORCAT	**$35.00**

TYPE 838-K TEST LEAD KIT



No laboratory should be without this handy kit of test leads and terminations. Consists of

1 — Type 838-C Red Test Probe
1 — Type 838-D Black Test Probe
3 — Type 838-AR Red Test Leads, 6", 12", and 30"
3 — Type 838-AB Black Test Leads, 6", 12", and 30"
10 — Type 838-B Alligator Clips, of phosphor bronze
3 — Type 274-MB Double Plugs
4 — Type 274-DB Insulated Single Plugs

These are all high-quality parts. Pin terminals on test leads all plug into prods, into alligator clips, and into double plugs. Alligator clips have narrow jaws to clip into jack tops of insulated plugs as well as on to wires and other terminals.

Net Weight: 7¼ ounces.

Type		*Code Word*	*Price*
838-K	**Test Lead Kit.......................**	KIOSK	**$7.75**

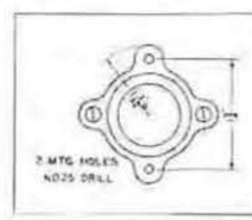
TYPE 119 RADIO-FREQUENCY CHOKE

This choke is useful in vacuum-tube circuits and also as an inductance element in filters and tuned circuits.

The winding is the so-called helical type, composed of a large number of thin, spiral-wound pies. Type 119-B uses a dust-type core. The coil is mounted in a molded phenolic housing which is effectively sealed against moisture penetration.

FEATURES: ➔ There is only one significant point of resonance, all minor resonances being practically eliminated by the method of winding and assembling.

➔ The shunt capacitance is low, so that the choke can be used at frequencies as high as 40 megacycles.



➔ The use of an iron-dust core in Type 119-B makes possible a high-inductance unit with very little increase in capacitance and resistance. The capacitance and conductance of of the Type 119-A as a function of frequency are shown on page 83.

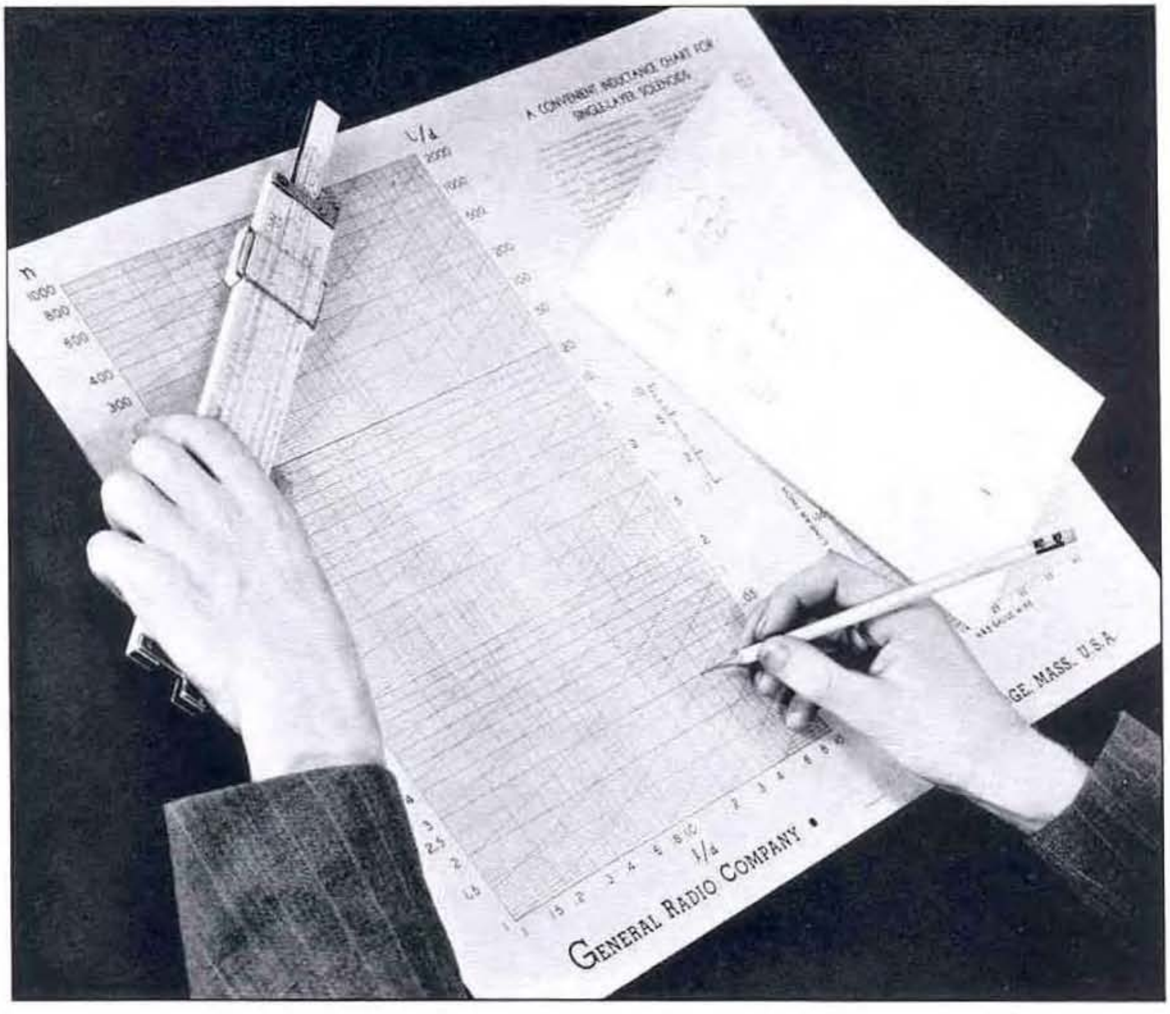
Accuracy of Inductance: ±20%.
Maximum Current: 60 ma.
Net Weight: Type 119-A, 2½ oz.; Type 119-B, 3 oz.

Type		*Inductance*	*Capacitance*	*D-C Resistance*	*Code Word*	*Price*
119-A	**Radio-Frequency Choke..**	**0.25 h**	**4 μμf**	**450 Ω**	IMAGE	**$3.00**
119-B	**Radio-Frequency Choke..**	**0.5 h**	**5 μμf**	**450 Ω**	IMBED	**4.25**

TYPE CAP-35 POWER CORD

This is the power cord supplied with General Radio a-c operated instruments. A high-quality, durable connector, designed for rugged service. Cord is 7 feet long, consisting of two No. 18 stranded conductors, rubber covered. Plug and connector bodies are molded in rubber directly to the rubber sheath of the cable.

Type		*Net Weight*	*Code Word*	*Price*
CAP-35	**Power Cord ....**	**8 oz.**	CORDY	**$1.75**



APPENDIX

REACTANCE CHARTS

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INDUCTANCE CHART

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WIRE CHART

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SMITH CHARTS

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DECIBEL CONVERSION TABLES

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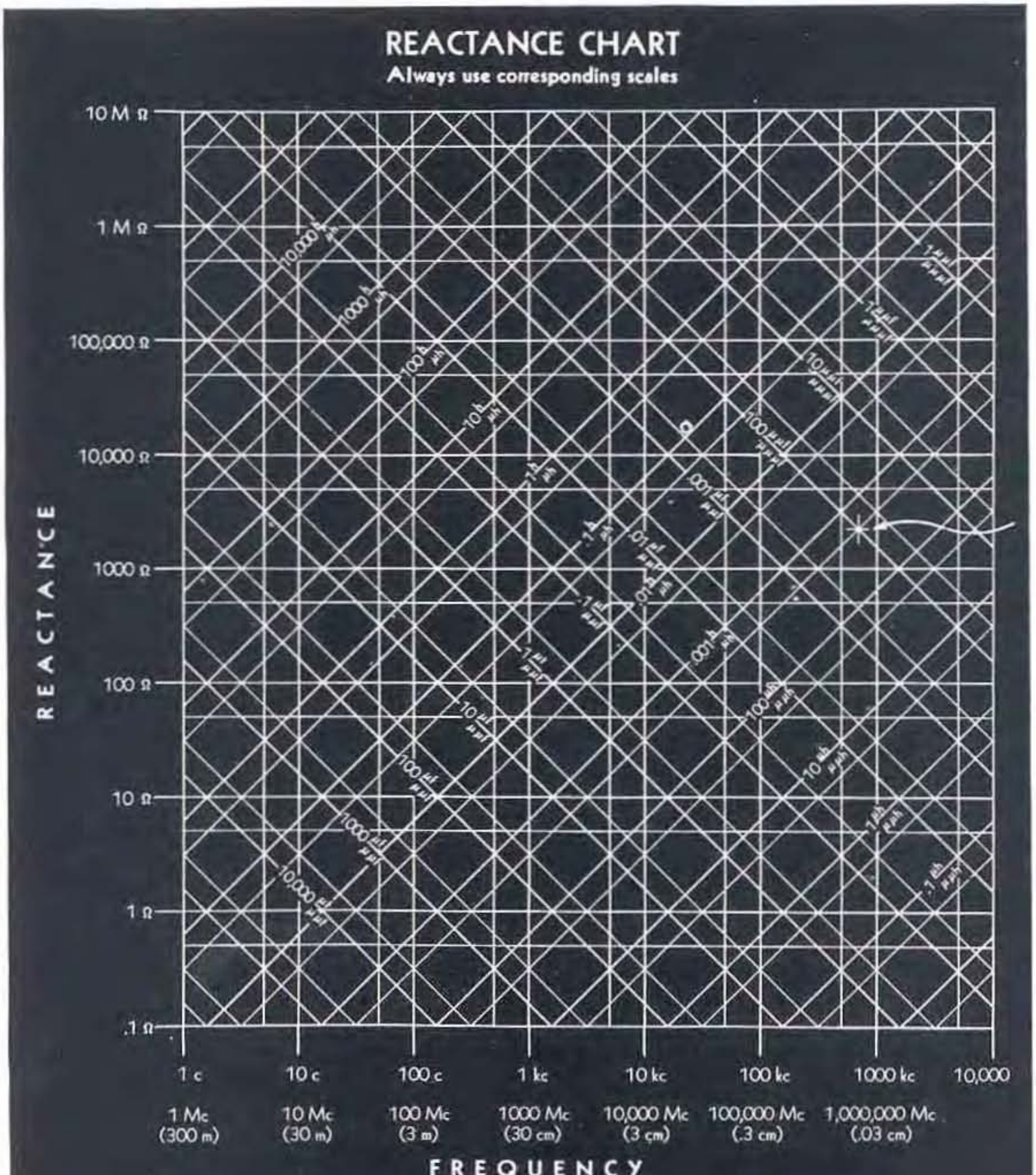


FIG. 1

The accompanying chart may be used to find:

(1) The reactance of a given inductance at a given frequency.

(2) The reactance of a given capacitance at a given frequency.

(3) The resonant frequency of a given inductance and capacitance.

In order to facilitate the determination of magnitude of the quantities involved to two or three significant figures the chart is divided into two parts. Figure 1 is the complete chart to be used for rough calculations. Figure 2, which is a single decade of Figure 1 enlarged approximately 7 times, is to be used where the significant two or three figures are to be determined.

TO FIND REACTANCE

Enter the charts vertically from the bottom (frequency) and along the lines slanting upward to the left (capacitance) or to the right (inductance). Corresponding scales (upper or lower) must be used throughout. Project horizontally to the left from the intersection and read reactance.

Write for Enlarged Copies of These Charts

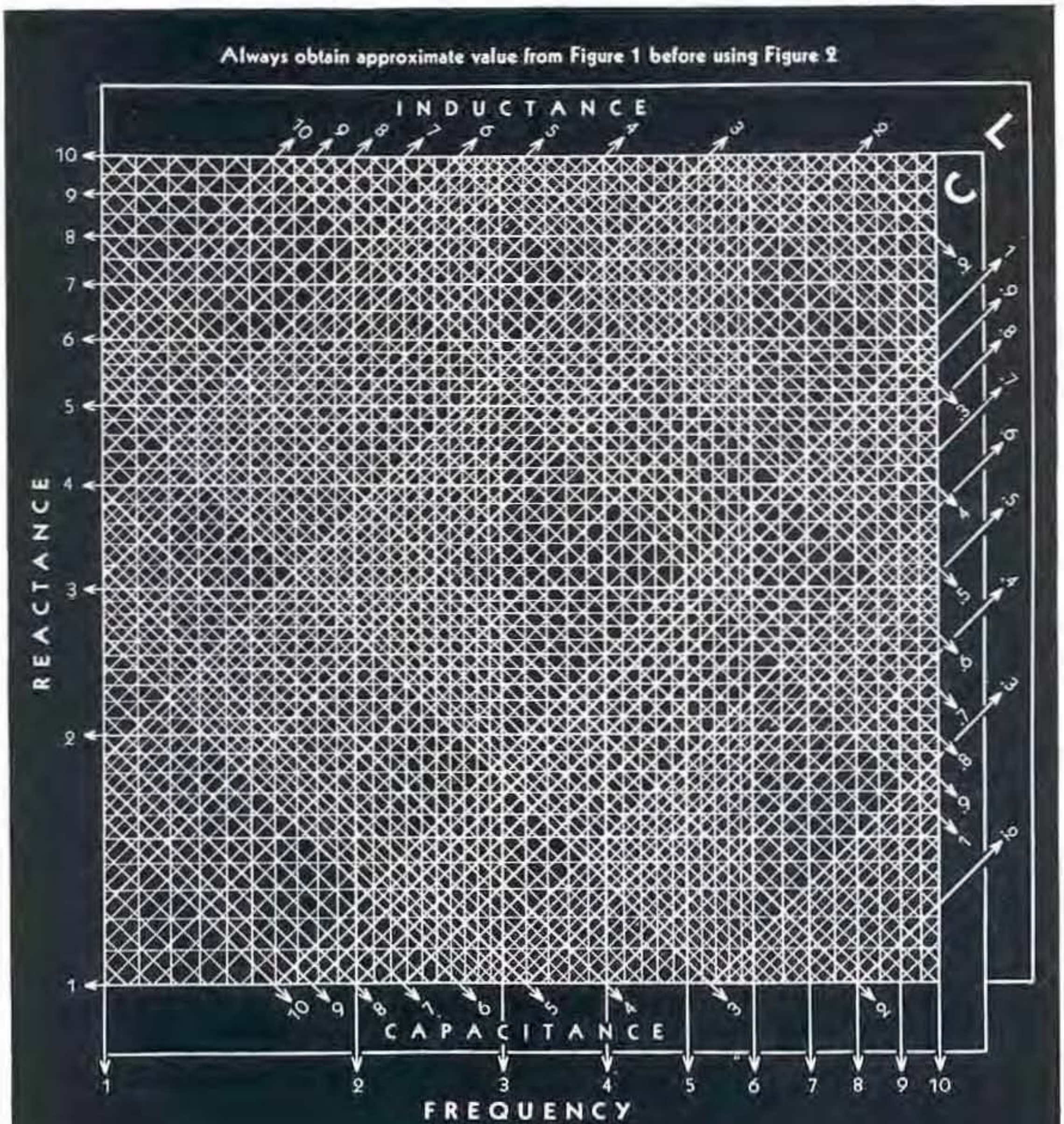


FIG. 2

TO FIND RESONANT FREQUENCY

Enter the slanting lines for the given inductance and capacitance. Project downward from their intersection and read resonant frequency from the bottom scale. Corresponding scales (upper or lower) must be used throughout.

Example: The sample point indicated (Figure 1) corresponds to a frequency of about 700 kc and an inductance of 500 μh, or a capacitance of 100 μμf, giving in either case a reactance of about 2000 ohms. The resonant frequency of a circuit containing these values of inductance and capacitance is, of course, 700 kc, approximately.

USE OF FIGURE 2

Figure 2 is used to obtain additional precision of reading but does not place the decimal point which must be located from a preliminary entry on Figure 1. Since the chart necessarily requires two logarithmic decades for inductance and capacitance for every single decade of frequency and reactance, unless the correct decade for L and C is chosen, the calculated values of reactance and frequency will be in error by a factor of 3.16.

Example: (Continued.) The reactance corresponding to 500 μh or 100 μμf is 2230 ohms at 712 kc, their resonant frequency.

A CONVENIENT INDUCTANCE CHART FOR SINGLE-LAYER SOLENOIDS

The chart on the next page is used for determining the number of turns necessary to obtain a given inductance on a given winding form. The chart below is plotted from standard winding data published by wire manufacturers and is used to determine the wire size.

The variables are n, the number of turns, and l/d the ratio of winding length to winding diameter. The ratio of inductance to diameter of winding L/d is used as a parameter.

The curves were computed from the expression given in Circular 74 of the U. S. Bureau of Standards,* which, using the terminology of the chart, may be written,

$$L = \frac{.02508\, n^2 d^2}{l} K \qquad (1)$$

where L is the inductance in μh, K is Nagaoka's constant, and d and l are in inches.

For a given inductance the number of turns is then,

$$n = \sqrt{\left(\frac{L}{d}\right)\left(\frac{l}{d}\right)(39.88)\left(\frac{1}{K}\right)} \qquad (2)$$

This form of the expression is particularly convenient because, in designing coils, the engineer usually starts with a given coil form (l/d known) and needs a given inductance L (L/d easily calculated).

Since Nagaoka's constant depends on the ratio l/d, the use of this ratio for the horizontal scale makes all the curves parallel, so that, in plotting them, only one curve need be calculated. The others can be drawn from a template.

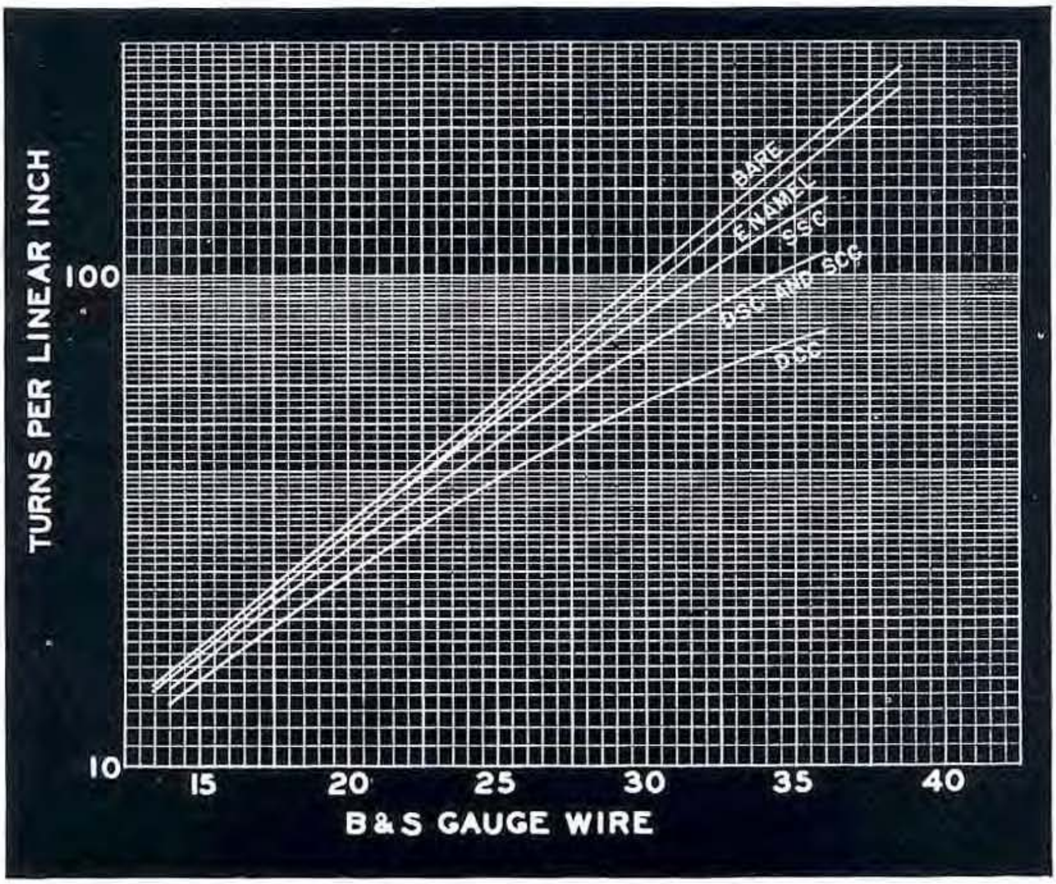
For interpolating between curves, a logarithmic scale covering one decade of L/d is shown at the right of the chart.

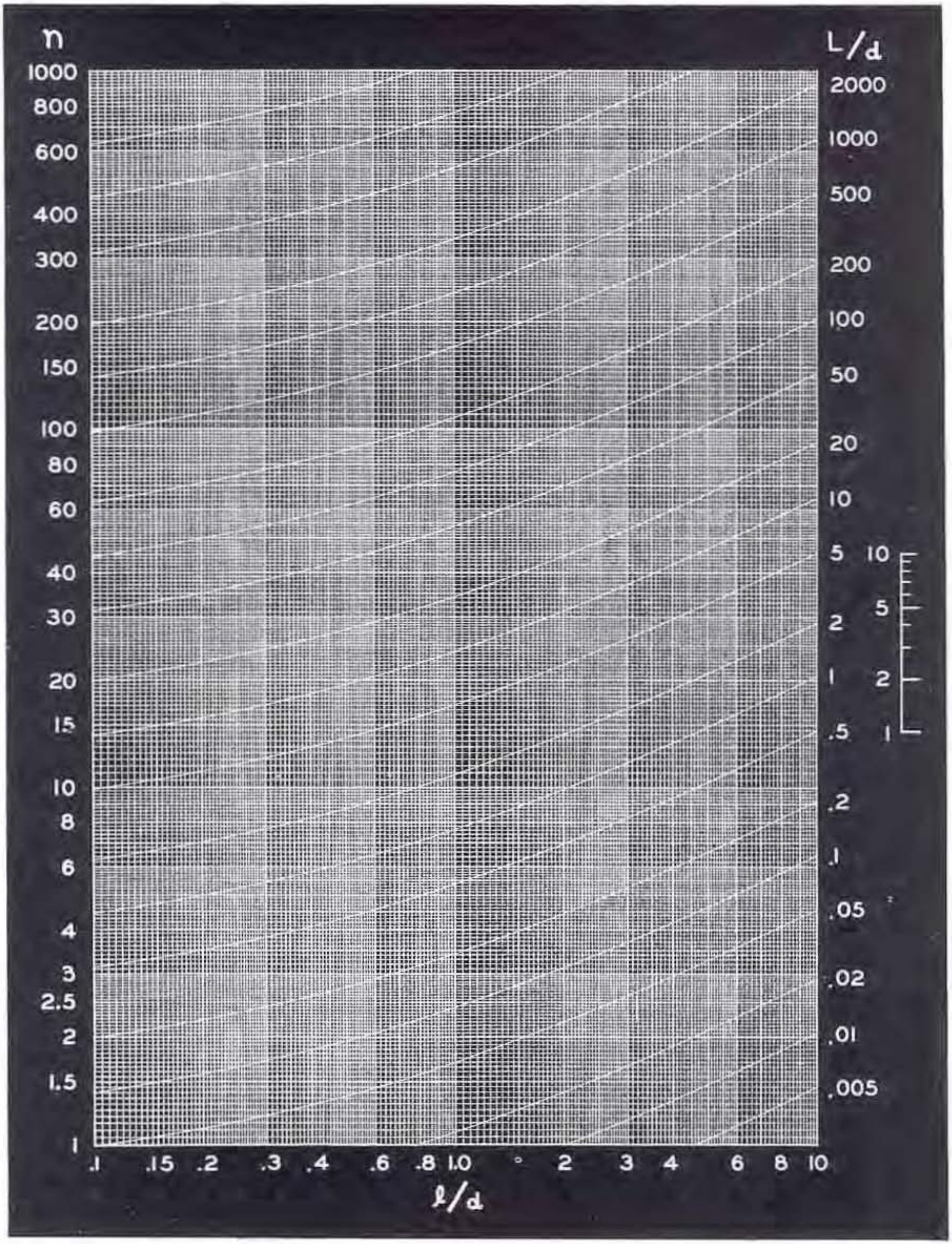
EXAMPLE

As an example of the use of these charts, consider the problem of designing a coil of 100 μh inductance on a winding form two inches in diameter, with an available winding space of two inches. The quantity l/d is unity and L/d is 50. Entering the chart at $L/d = 50$ and following down the curve at the vertical line $l/d = 1$, we find that n, as indicated by the left hand vertical scale, is 54 turns.

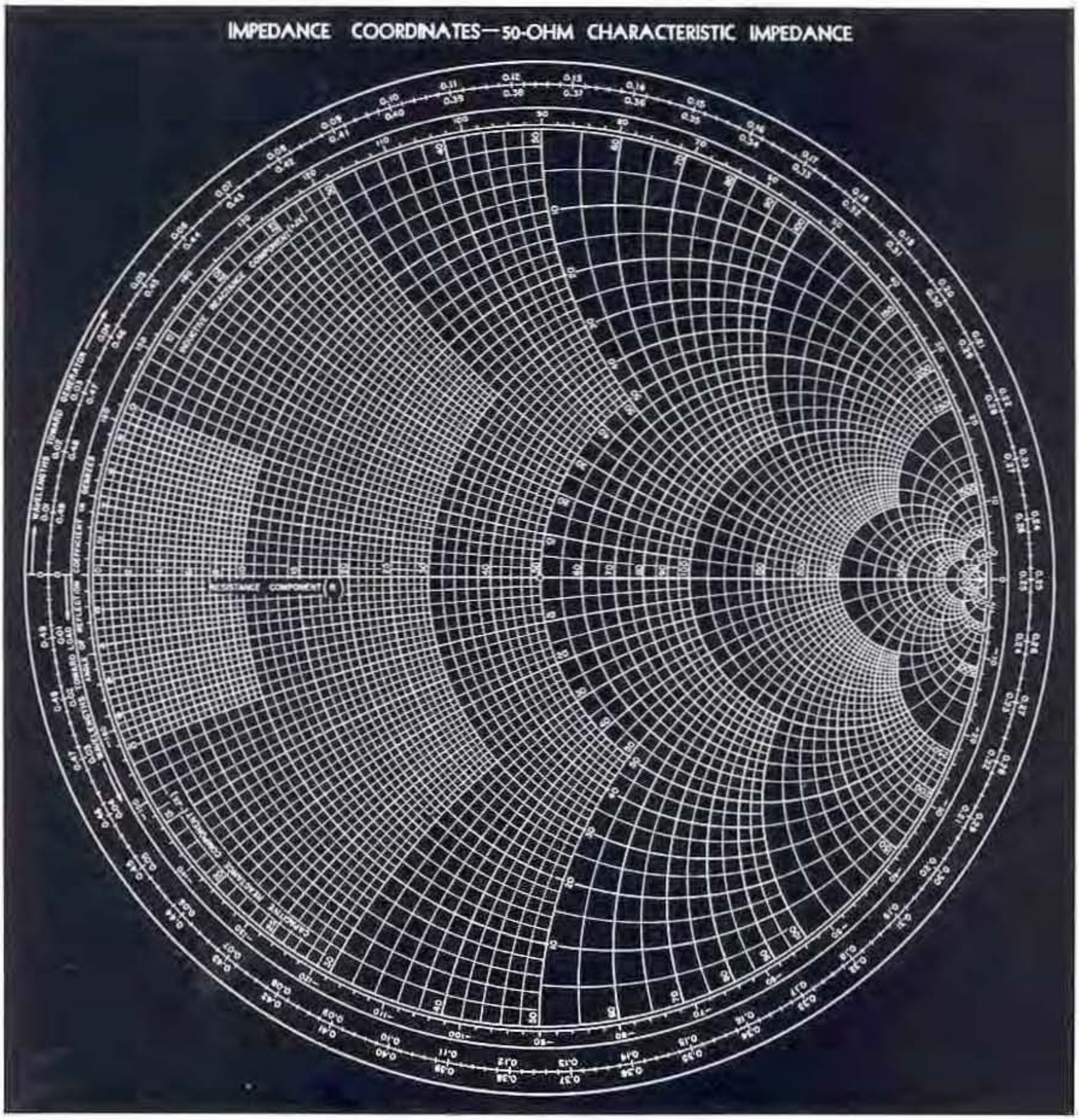
With a winding space of two inches, this is equivalent to 27 turns per linear inch, close wound. The second chart shows that No. 18 enamel or single-silk-, No. 20 double-silk-, or single-cotton- or No. 22 double-cotton-covered wire would be used close wound. No. 25 bare wire, double spaced, could also be used.

*"Radio Instruments and Measurements," p. 252.





Write for Enlarged Copies of These Charts

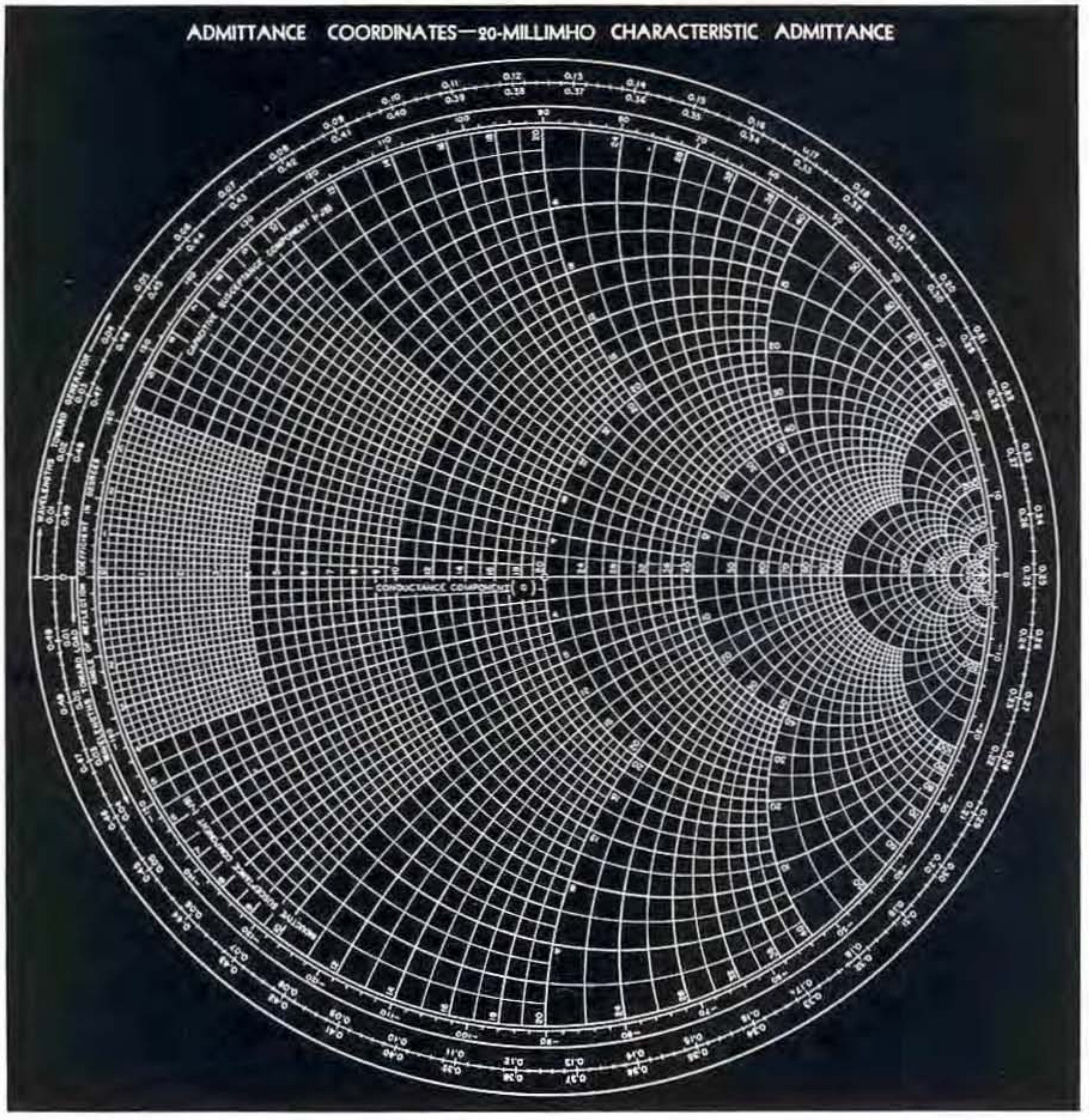


SMITH CHARTS

In measurements on transmission-line circuits, it is often necessary to determine or correct for the impedance transformation produced by a length of line. Transmission-line equations can be used to make the calculation, but the process is laborious. A chart with which the calculations can be made graphically with very little effort has been devised by P. H. Smith[1] and is known as the Smith chart. In many cases valuable information can be gained by directly plotting a series of measurements on the chart. In addition to the application indicated above, the chart can be used to determine the VSWR corresponding to any impedance and to convert from impedance to admittance and vice versa. This chart is very useful for measurements using the Type 1601-A V-H-F Bridge, Type 1602-A U-H-F Admittance Meter, and the Type 874-LB Slotted Line.

Smith charts are usually drawn with

[1] Electronics, Vol. 17, No. 1, pp. 130-133, 318-325, January 1944.



normalized impedance coordinates, so that they can be used with lines of any impedance. For work at a single characteristic impedance, a chart reading directly in impedance is more convenient because it eliminates the normalizing operation. The charts shown above, one in impedance coordinates and the other in admittance coordinates, have been prepared for use with General Radio coaxial equipment, which has 50-ohm characteristic impedance.

Several copies of the appropriate chart are furnished with the Type 874-LB Slotted Line, the Type 1601-A V-H-F Bridge, and the Type 1602-A U-H-F Admittance Meter. Additional copies can be obtained from the General Radio Company at the following prices:

Quantity	*Price*
50	**$2.00**
100	**3.00**
250	**6.25**
500	**11.25**
1000	**20.00**
2000	**37.50**

DECIBEL CONVERSION TABLES

It is convenient in measurements and calculations on communications systems to express the ratio between any two amounts of electric or acoustic power in units on a logarithmic scale. The *decibel* (1/10th of the *bel*) on the briggsian or base-10 scale and the *neper* on the napierian or base-*e* scale are in almost universal use for this purpose.

Since voltage and current are related to power by impedance, both the *decibel* and the *neper* can be used to express voltage and current ratios, if care is taken to account for the impedances associated with them. In a similar manner the corresponding acoustical quantities can be compared.

Table I and Table II on the following pages have been prepared to facilitate making conversions in either direction between the number of *decibels* and the corresponding power, voltage, and current ratios. Both tables can also be used for *nepers* and the *mile of standard cable* by applying the conversion factors from the table on the opposite page.

Decibel — The number of decibels N_{db} corresponding to the ratio between two amounts of power P_1 and P_2 is

$$N_{db} = 10 \log_{10} \frac{P_1}{P_2} \qquad (1)$$

When two voltages E_1 and E_2 or two currents I_1 and I_2 operate in identical impedances,

$$N_{db} = 20 \log_{10} \frac{E_1}{E_2} \qquad (2)$$

and

$$N_{db} = 20 \log_{10} \frac{I_1}{I_2} \qquad (3)$$

If E_1 and E_2 or I_1 and I_2 operate in unequal impedances,

$$N_{db} = 20 \log_{10} \frac{E_1}{E_2} + 10 \log_{10} \frac{Z_2}{Z_1} + 10 \log_{10} \frac{k_1}{k_2} \qquad (4)$$

and

$$N_{db} = 20 \log_{10} \frac{I_1}{I_2} + 10 \log_{10} \frac{Z_1}{Z_2} + 10 \log_{10} \frac{k_1}{k_2} \qquad (5)$$

where Z_1 and Z_2 are the absolute magnitudes of the corresponding impedances and k_1 and k_2 are the values of power factor for the impedances. E_1, E_2, I_1, and I_2 are also the absolute magnitudes of the corresponding quantities. Note that Table I and Table II can be used to evaluate the impedance and power factor terms, since both are similar to the expression for power ratio, equation (1).

Neper — The number of nepers N_{nep} corresponding to a power ratio $\frac{P_1}{P_2}$ is

$$N_{nep} = \frac{1}{2} \log_e \frac{P_1}{P_2} \qquad (6)$$

For voltage ratios $\frac{E_1}{E_2}$ or current ratios $\frac{I_1}{I_2}$ working in identical impedances,

$$N_{nep} = \log_e \frac{E_1}{E_2} \qquad (7)$$

and

$$N_{nep} = \log_e \frac{I_1}{I_2}$$

When E_1 and E_2 or I_1 and I_2 operate in unequal impedances,

$$N_{nep} = \log_e \frac{E_1}{E_2} + \frac{1}{2} \log_e \frac{Z_2}{Z_1} + \frac{1}{2} \log_e \frac{k_1}{k_2} \qquad (8)$$

and

$$N_{nep} = \log_e \frac{I_1}{I_2} + \frac{1}{2} \log_e \frac{Z_1}{Z_2} + \frac{1}{2} \log_e \frac{k_1}{k_2} \qquad (9)$$

where Z_1 and Z_2 and k_1 and k_2 are as in equations (4) and (5).

RELATIONS BETWEEN DECIBELS, NEPERS, AND MILES OF STANDARD CABLE

Multiply	*By*	*To Find*
decibels	.1151	nepers
decibels	1.056	miles of standard cable
miles of standard cable	.947	decibels
miles of standard cable	.109	nepers
nepers	8.686	decibels
nepers	9.175	miles of standard cable

TO FIND VALUES OUTSIDE THE RANGE OF CONVERSION TABLES

Values outside the range of either Table I or Table II on the following pages can be readily found with the help of the following simple rules:

TABLE I: DECIBELS TO VOLTAGE AND POWER RATIOS

Number of decibels positive (+): Subtract +20 decibels successively from the given number of decibels until the remainder falls within range of Table I. *To find the voltage ratio,* multiply the corresponding value from the right-hand voltage-ratio column by 10 for each time you subtracted 20 db. *To find the power ratio,* multiply the corresponding value from the right-hand power-ratio column by 100 for each time you subtracted 20 db.

Example — *Given:* 49.2 db.

49.2 db − 20 db − 20 db = 9.2 db

Voltage ratio: 9.2 db → 2.884

2.884 × 10 × 10 = 288.4 → 49.2 db

Power ratio: 9.2 db → 8.318

8.318 × 100 × 100 = 83180 → 49.2 db

Number of decibels negative (−): Add +20 decibels successively to the given number of decibels until the sum falls within the range of Table I. *For the voltage ratio,* divide the value from the left-hand voltage-ratio column by 10 for each time you added 20 db. *For the power ratio,* divide the value from the left-hand power-ratio column by 100 for each time you added 20 db.

Example — *Given:* −49.2 db

−49.2 db + 20 db + 20 db = −9.2 db

Voltage ratio: −9.2 db → .3467

.3467 × 1/10 × 1/10 = .003467 → −49.2 db

Power ratio: −9.2 db → .1202

.1202 × 1/100 × 1/100 = .00001202 → −49.2 db

TABLE II: VOLTAGE RATIOS TO DECIBELS

For ratios smaller than those in table—Multiply the given ratio by 10 successively until the product can be found in the table. From the number of decibels thus found, subtract +20 decibels for each time you multiplied by 10.

Example—*Given:* Voltage ratio = .0131

.0131 × 10 × 10 = 1.31

From Table II, 1.31 → 2.345 db

2.345 db − 20 db − 20 db = −37.655 db

For ratios greater than those in table—Divide the given ratio by 10 successively until the remainder can be found in the table. To the number of decibels thus found, add +20 db for each time you divided by 10.

Example—*Given:* Voltage ratio = 712

712 × 1/10 × 1/10 = 7.12

From Table II, 7.12 → 17.050 db

17.050 db + 20 db + 20 db = 57.050 db

TABLE I

GIVEN: Decibels **TO FIND: Power and {Voltage / Current} Ratios**

TO ACCOUNT FOR THE SIGN OF THE DECIBEL

For positive (+) values of the decibel—Both voltage and power ratios are greater than unity. Use the two right-hand columns.

For negative (−) values of the decibel—Both voltage and power ratios are less than unity. Use the two left-hand columns.

Example—*Given:* ± 9.1 db. *Find:*

	Power Ratio	*Voltage Ratio*
+9.1 db	8.128	2.851
−9.1 db	0.1230	0.3508

← *−db+* →

Voltage Ratio	*Power Ratio*	*db*	*Voltage Ratio*	*Power Ratio*
1.0000	**1.0000**	**0**	**1.000**	**1.000**
.9886	.9772	.1	1.012	1.023
.9772	.9550	.2	1.023	1.047
.9661	.9333	.3	1.035	1.072
.9550	.9120	.4	1.047	1.096
.9441	.8913	.5	1.059	1.122
.9333	.8710	.6	1.072	1.148
.9226	.8511	.7	1.084	1.175
.9120	.8318	.8	1.096	1.202
.9016	.8128	.9	1.109	1.230
.8913	**.7943**	**1.0**	**1.122**	**1.259**
.8810	.7762	1.1	1.135	1.288
.8710	.7586	1.2	1.148	1.318
.8610	.7413	1.3	1.161	1.349
.8511	.7244	1.4	1.175	1.380
.8414	.7079	1.5	1.189	1.413
.8318	.6918	1.6	1.202	1.445
.8222	.6761	1.7	1.216	1.479
.8128	.6607	1.8	1.230	1.514
.8035	.6457	1.9	1.245	1.549
.7943	**.6310**	**2.0**	**1.259**	**1.585**
.7852	.6166	2.1	1.274	1.622
.7762	.6026	2.2	1.288	1.660
.7674	.5888	2.3	1.303	1.698
.7586	.5754	2.4	1.318	1.738
.7499	.5623	2.5	1.334	1.778
.7413	.5495	2.6	1.349	1.820
.7328	.5370	2.7	1.365	1.862
.7244	.5248	2.8	1.380	1.905
.7161	.5129	2.9	1.396	1.950
.7079	**.5012**	**3.0**	**1.413**	**1.995**
.6998	.4898	3.1	1.429	2.042
.6918	.4786	3.2	1.445	2.089
.6839	.4677	3.3	1.462	2.138
.6761	.4571	3.4	1.479	2.188
.6683	.4467	3.5	1.496	2.239
.6607	.4365	3.6	1.514	2.291
.6531	.4266	3.7	1.531	2.344
.6457	.4169	3.8	1.549	2.399
.6383	.4074	3.9	1.567	2.455
.6310	**.3981**	**4.0**	**1.585**	**2.512**
.6237	.3890	4.1	1.603	2.570
.6166	.3802	4.2	1.622	2.630
.6095	.3715	4.3	1.641	2.692
.6026	.3631	4.4	1.660	2.754
.5957	.3548	4.5	1.679	2.818
.5888	.3467	4.6	1.698	2.884
.5821	.3388	4.7	1.718	2.951
.5754	.3311	4.8	1.738	3.020
.5689	.3236	4.9	1.758	3.090

← *−db+* →

Voltage Ratio	*Power Ratio*	*db*	*Voltage Ratio*	*Power Ratio*
.5623	**.3162**	**5.0**	**1.778**	**3.162**
.5559	.3090	5.1	1.799	3.236
.5495	.3020	5.2	1.820	3.311
.5433	.2951	5.3	1.841	3.388
.5370	.2884	5.4	1.862	3.467
.5309	.2818	5.5	1.884	3.548
.5248	.2754	5.6	1.905	3.631
.5188	.2692	5.7	1.928	3.715
.5129	.2630	5.8	1.950	3.802
.5070	.2570	5.9	1.972	3.890
.5012	**.2512**	**6.0**	**1.995**	**3.981**
.4955	.2455	6.1	2.018	4.074
.4898	.2399	6.2	2.042	4.169
.4842	.2344	6.3	2.065	4.266
.4786	.2291	6.4	2.089	4.365
.4732	.2239	6.5	2.113	4.467
.4677	.2188	6.6	2.138	4.571
.4624	.2138	6.7	2.163	4.677
.4571	.2089	6.8	2.188	4.786
.4519	.2042	6.9	2.213	4.898
.4467	**.1995**	**7.0**	**2.239**	**5.012**
.4416	.1950	7.1	2.265	5.129
.4365	.1905	7.2	2.291	5.248
.4315	.1862	7.3	2.317	5.370
.4266	.1820	7.4	2.344	5.495
.4217	.1778	7.5	2.371	5.623
.4169	.1738	7.6	2.399	5.754
.4121	.1698	7.7	2.427	5.888
.4074	.1660	7.8	2.455	6.026
.4027	.1622	7.9	2.483	6.166
.3981	**.1585**	**8.0**	**2.512**	**6.310**
.3936	.1549	8.1	2.541	6.457
.3890	.1514	8.2	2.570	6.607
.3846	.1479	8.3	2.600	6.761
.3802	.1445	8.4	2.630	6.918
.3758	.1413	8.5	2.661	7.079
.3715	.1380	8.6	2.692	7.244
.3673	.1349	8.7	2.723	7.413
.3631	.1318	8.8	2.754	7.586
.3589	.1288	8.9	2.786	7.762
.3548	**.1259**	**9.0**	**2.818**	**7.943**
.3508	.1230	9.1	2.851	8.128
.3467	.1202	9.2	2.884	8.318
.3428	.1175	9.3	2.917	8.511
.3388	.1148	9.4	2.951	8.710
.3350	.1122	9.5	2.985	8.913
.3311	.1096	9.6	3.020	9.120
.3273	.1072	9.7	3.055	9.333
.3236	.1047	9.8	3.090	9.550
.3199	.1023	9.9	3.126	9.772

TABLE I (continued)

← −db+ →

Voltage Ratio	Power Ratio	db	Voltage Ratio	Power Ratio
.3162	.1000	10.0	3.162	10.000
.3126	.09772	10.1	3.199	10.23
.3090	.09550	10.2	3.236	10.47
.3055	.09333	10.3	3.273	10.72
.3020	.09120	10.4	3.311	10.96
.2985	.08913	10.5	3.350	11.22
.2951	.08710	10.6	3.388	11.48
.2917	.08511	10.7	3.428	11.75
.2884	.08318	10.8	3.467	12.02
.2851	.08128	10.9	3.508	12.30
.2818	.07943	11.0	3.548	12.59
.2786	.07762	11.1	3.589	12.88
.2754	.07586	11.2	3.631	13.18
.2723	.07413	11.3	3.673	13.49
.2692	.07244	11.4	3.715	13.80
.2661	.07079	11.5	3.758	14.13
.2630	.06918	11.6	3.802	14.45
.2600	.06761	11.7	3.846	14.79
.2570	.06607	11.8	3.890	15.14
.2541	.06457	11.9	3.936	15.49
.2512	.06310	12.0	3.981	15.85
.2483	.06166	12.1	4.027	16.22
.2455	.06026	12.2	4.074	16.60
.2427	.05888	12.3	4.121	16.98
.2399	.05754	12.4	4.169	17.38
.2371	.05623	12.5	4.217	17.78
.2344	.05495	12.6	4.266	18.20
.2317	.05370	12.7	4.315	18.62
.2291	.05248	12.8	4.365	19.05
.2265	.05129	12.9	4.416	19.50
.2239	.05012	13.0	4.467	19.95
.2213	.04898	13.1	4.519	20.42
.2188	.04786	13.2	4.571	20.89
.2163	.04677	13.3	4.624	21.38
.2138	.04571	13.4	4.677	21.88
.2113	.04467	13.5	4.732	22.39
.2089	.04365	13.6	4.786	22.91
.2065	.04266	13.7	4.842	23.44
.2042	.04169	13.8	4.898	23.99
.2018	.04074	13.9	4.955	24.55
.1995	.03981	14.0	5.012	25.12
.1972	.03890	14.1	5.070	25.70
.1950	.03802	14.2	5.129	26.30
.1928	.03715	14.3	5.188	26.92
.1905	.03631	14.4	5.248	27.54
.1884	.03548	14.5	5.309	28.18
.1862	.03467	14.6	5.370	28.84
.1841	.03388	14.7	5.433	29.51
.1820	.03311	14.8	5.495	30.20
.1799	.03236	14.9	5.559	30.90
.1778	.03162	15.0	5.623	31.62
.1758	.03090	15.1	5.689	32.36
.1738	.03020	15.2	5.754	33.11
.1718	.02951	15.3	5.821	33.88
.1698	.02884	15.4	5.888	34.67
.1679	.02818	15.5	5.957	35.48
.1660	.02754	15.6	6.026	36.31
.1641	.02692	15.7	6.095	37.15
.1622	.02630	15.8	6.166	38.02
.1603	.02570	15.9	6.237	38.90

← −db+ →

Voltage Ratio	Power Ratio	db	Voltage Ratio	Power Ratio
.1585	.02512	16.0	6.310	39.81
.1567	.02455	16.1	6.383	40.74
.1549	.02399	16.2	6.457	41.69
.1531	.02344	16.3	6.531	42.66
.1514	.02291	16.4	6.607	43.65
.1496	.02239	16.5	6.683	44.67
.1479	.02188	16.6	6.761	45.71
.1462	.02138	16.7	6.839	46.77
.1445	.02089	16.8	6.918	47.86
.1429	.02042	16.9	6.998	48.98
.1413	.01995	17.0	7.079	50.12
.1396	.01950	17.1	7.161	51.29
.1380	.01905	17.2	7.244	52.48
.1365	.01862	17.3	7.328	53.70
.1349	.01820	17.4	7.413	54.95
.1334	.01778	17.5	7.499	56.23
.1318	.01738	17.6	7.586	57.54
.1303	.01698	17.7	7.674	58.88
.1288	.01660	17.8	7.762	60.26
.1274	.01622	17.9	7.852	61.66
.1259	.01585	18.0	7.943	63.10
.1245	.01549	18.1	8.035	64.57
.1230	.01514	18.2	8.128	66.07
.1216	.01479	18.3	8.222	67.61
.1202	.01445	18.4	8.318	69.18
.1189	.01413	18.5	8.414	70.79
.1175	.01380	18.6	8.511	72.44
.1161	.01349	18.7	8.610	74.13
.1148	.01318	18.8	8.710	75.86
.1135	.01288	18.9	8.811	77.62
.1122	.01259	19.0	8.913	79.43
.1109	.01230	19.1	9.016	81.28
.1096	.01202	19.2	9.120	83.18
.1084	.01175	19.3	9.226	85.11
.1072	.01148	19.4	9.333	87.10
.1059	.01122	19.5	9.441	89.13
.1047	.01096	19.6	9.550	91.20
.1035	.01072	19.7	9.661	93.33
.1023	.01047	19.8	9.772	95.50
.1012	.01023	19.9	9.886	97.72
.1000	.01000	20.0	10.000	100.00

← −db+ →

Voltage Ratio	Power Ratio	db	Voltage Ratio	Power Ratio
3.162×10^{-1}	10^{-1}	10	3.162	10
10^{-1}	10^{-2}	20	10	10^{2}
3.162×10^{-2}	10^{-3}	30	3.162×10	10^{3}
10^{-2}	10^{-4}	40	10^{2}	10^{4}
3.162×10^{-3}	10^{-5}	50	3.162×10^{2}	10^{5}
10^{-3}	10^{-6}	60	10^{3}	10^{6}
3.162×10^{-4}	10^{-7}	70	3.162×10^{3}	10^{7}
10^{-4}	10^{-8}	80	10^{4}	10^{8}
3.162×10^{-5}	10^{-9}	90	3.162×10^{4}	10^{9}
10^{-5}	10^{-10}	100	10^{5}	10^{10}

To find decibel values outside the range of this table, see page 239

TABLE II

GIVEN: {**Voltage** / **Current**} **Ratio** **TO FIND: Decibels**

POWER RATIOS

To find the number of decibels corresponding to a given power ratio—Assume the given power ratio to be a voltage ratio and find the corresponding number of decibels from the table. The desired result is exactly one-half of the number of decibels thus found.

Example—*Given:* a power ratio of 3.41. *Find:* 3.41 in the table:

3.41→10.655 db (voltage)
10.655 db × ½ = 5.328 db (power)

Voltage Ratio	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
1.0	**.000**	**.086**	**.172**	**.257**	**.341**	**.424**	**.506**	**.588**	**.668**	**.749**
1.1	.828	.906	.984	1.062	1.138	1.214	1.289	1.364	1.438	1.511
1.2	1.584	1.656	1.727	1.798	1.868	1.938	2.007	2.076	2.144	2.212
1.3	2.279	2.345	2.411	2.477	2.542	2.607	2.671	2.734	2.798	2.860
1.4	2.923	2.984	3.046	3.107	3.167	3.227	3.287	3.346	3.405	3.464
1.5	3.522	3.580	3.637	3.694	3.750	3.807	3.862	3.918	3.973	4.028
1.6	4.082	4.137	4.190	4.244	4.297	4.350	4.402	4.454	4.506	4.558
1.7	4.609	4.660	4.711	4.761	4.811	4.861	4.910	4.959	5.008	5.057
1.8	5.105	5.154	5.201	5.249	5.296	5.343	5.390	5.437	5.483	5.529
1.9	5.575	5.621	5.666	5.711	5.756	5.801	5.845	5.889	5.933	5.977
2.0	**6.021**	**6.064**	**6.107**	**6.150**	**6.193**	**6.235**	**6.277**	**6.319**	**6.361**	**6.403**
2.1	6.444	6.486	6.527	6.568	6.608	6.649	6.689	6.729	6.769	6.809
2.2	6.848	6.888	6.927	6.966	7.005	7.044	7.082	7.121	7.159	7.197
2.3	7.235	7.272	7.310	7.347	7.384	7.421	7.458	7.495	7.532	7.568
2.4	7.604	7.640	7.676	7.712	7.748	7.783	7.819	7.854	7.889	7.924
2.5	7.959	7.993	8.028	8.062	8.097	8.131	8.165	8.199	8.232	8.266
2.6	8.299	8.333	8.366	8.399	8.432	8.465	8.498	8.530	8.563	8.595
2.7	8.627	8.659	8.691	8.723	8.755	8.787	8.818	8.850	8.881	8.912
2.8	8.943	8.974	9.005	9.036	9.066	9.097	9.127	9.158	9.188	9.218
2.9	9.248	9.278	9.308	9.337	9.367	9.396	9.426	9.455	9.484	9.513
3.0	**9.542**	**9.571**	**9.600**	**9.629**	**9.657**	**9.686**	**9.714**	**9.743**	**9.771**	**9.799**
3.1	9.827	9.855	9.883	9.911	9.939	9.966	9.994	10.021	10.049	10.076
3.2	10.103	10.130	10.157	10.184	10.211	10.238	10.264	10.291	10.317	10.344
3.3	10.370	10.397	10.423	10.449	10.475	10.501	10.527	10.553	10.578	10.604
3.4	10.630	10.655	10.681	10.706	10.731	10.756	10.782	10.807	10.832	10.857
3.5	10.881	10.906	10.931	10.955	10.980	11.005	11.029	11.053	11.078	11.102
3.6	11.126	11.150	11.174	11.198	11.222	11.246	11.270	11.293	11.317	11.341
3.7	11.364	11.387	11.411	11.434	11.457	11.481	11.504	11.527	11.550	11.573
3.8	11.596	11.618	11.641	11.664	11.687	11.709	11.732	11.754	11.777	11.799
3.9	11.821	11.844	11.866	11.888	11.910	11.932	11.954	11.976	11.998	12.019
4.0	**12.041**	**12.063**	**12.085**	**12.106**	**12.128**	**12.149**	**12.171**	**12.192**	**12.213**	**12.234**
4.1	12.256	12.277	12.298	12.319	12.340	12.361	12.382	12.403	12.424	12.444
4.2	12.465	12.486	12.506	12.527	12.547	12.568	12.588	12.609	12.629	12.649
4.3	12.669	12.690	12.710	12.730	12.750	12.770	12.790	12.810	12.829	12.849
4.4	12.869	12.889	12.908	12.928	12.948	12.967	12.987	13.006	13.026	13.045
4.5	13.064	13.084	13.103	13.122	13.141	13.160	13.179	13.198	13.217	13.236
4.6	13.255	13.274	13.293	13.312	13.330	13.349	13.368	13.386	13.405	13.423
4.7	13.442	13.460	13.479	13.497	13.516	13.534	13.552	13.570	13.589	13.607
4.8	13.625	13.643	13.661	13.679	13.697	13.715	13.733	13.751	13.768	13.786
4.9	13.804	13.822	13.839	13.857	13.875	13.892	13.910	13.927	13.945	13.962
5.0	**13.979**	**13.997**	**14.014**	**14.031**	**14.049**	**14.066**	**14.083**	**14.100**	**14.117**	**14.134**
5.1	14.151	14.168	14.185	14.202	14.219	14.236	14.253	14.270	14.287	14.303
5.2	14.320	14.337	14.353	14.370	14.387	14.403	14.420	14.436	14.453	14.469
5.3	14.486	14.502	14.518	14.535	14.551	14.567	14.583	14.599	14.616	14.632
5.4	14.648	14.664	14.680	14.696	14.712	14.728	14.744	14.760	14.776	14.791
5.5	14.807	14.823	14.839	14.855	14.870	14.886	14.902	14.917	14.933	14.948
5.6	14.964	14.979	14.995	15.010	15.026	15.041	15.056	15.072	15.087	15.102
5.7	15.117	15.133	15.148	15.163	15.178	15.193	15.208	15.224	15.239	15.254
5.8	15.269	15.284	15.298	15.313	15.328	15.343	15.358	15.373	15.388	15.402
5.9	15.417	15.432	15.446	15.461	15.476	15.490	15.505	15.519	15.534	15.549

TABLE II (continued)

Voltage Ratio	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
6.0	15.563	15.577	15.592	15.606	15.621	15.635	15.649	15.664	15.678	15.692
6.1	15.707	15.721	15.735	15.749	15.763	15.778	15.792	15.806	15.820	15.834
6.2	15.848	15.862	15.876	15.890	15.904	15.918	15.931	15.945	15.959	15.973
6.3	15.987	16.001	16.014	16.028	16.042	16.055	16.069	16.083	16.096	16.110
6.4	16.124	16.137	16.151	16.164	16.178	16.191	16.205	16.218	16.232	16.245
6.5	16.258	16.272	16.285	16.298	16.312	16.325	16.338	16.351	16.365	16.378
6.6	16.391	16.404	16.417	16.430	16.443	16.456	16.469	16.483	16.496	16.509
6.7	16.521	16.534	16.547	16.560	16.573	16.586	16.599	16.612	16.625	16.637
6.8	16.650	16.663	16.676	16.688	16.701	16.714	16.726	16.739	16.752	16.764
6.9	16.777	16.790	16.802	16.815	16.827	16.840	16.852	16.865	16.877	16.890
7.0	16.902	16.914	16.927	16.939	16.951	16.964	16.976	16.988	17.001	17.013
7.1	17.025	17.037	17.050	17.062	17.074	17.086	17.098	17.110	17.122	17.135
7.2	17.147	17.159	17.171	17.183	17.195	17.207	17.219	17.231	17.243	17.255
7.3	17.266	17.278	17.290	17.302	17.314	17.326	17.338	17.349	17.361	17.373
7.4	17.385	17.396	17.408	17.420	17.431	17.443	17.455	17.466	17.478	17.490
7.5	17.501	17.513	17.524	17.536	17.547	17.559	17.570	17.582	17.593	17.605
7.6	17.616	17.628	17.639	17.650	17.662	17.673	17.685	17.696	17.707	17.719
7.7	17.730	17.741	17.752	17.764	17.775	17.786	17.797	17.808	17.820	17.831
7.8	17.842	17.853	17.864	17.875	17.886	17.897	17.908	17.919	17.931	17.942
7.9	17.953	17.964	17.975	17.985	17.996	18.007	18.018	18.029	18.040	18.051
8.0	18.062	18.073	18.083	18.094	18.105	18.116	18.127	18.137	18.148	18.159
8.1	18.170	18.180	18.191	18.202	18.212	18.223	18.234	18.244	18.255	18.266
8.2	18.276	18.287	18.297	18.308	18.319	18.329	18.340	18.350	18.361	18.371
8.3	18.382	18.392	18.402	18.413	18.423	18.434	18.444	18.455	18.465	18.475
8.4	18.486	18.496	18.506	18.517	18.527	18.537	18.547	18.558	18.568	18.578
8.5	18.588	18.599	18.609	18.619	18.629	18.639	18.649	18.660	18.670	18.680
8.6	18.690	18.700	18.710	18.720	18.730	18.740	18.750	18.760	18.770	18.780
8.7	18.790	18.800	18.810	18.820	18.830	18.840	18.850	18.860	18.870	18.880
8.8	18.890	18.900	18.909	18.919	18.929	18.939	18.949	18.958	18.968	18.978
8.9	18.988	18.998	19.007	19.017	19.027	19.036	19.046	19.056	19.066	19.075
9.0	19.085	19.094	19.104	19.114	19.123	19.133	19.143	19.152	19.162	19.171
9.1	19.181	19.190	19.200	19.209	19.219	19.228	19.238	19.247	19.257	19.266
9.2	19.276	19.285	19.295	19.304	19.313	19.323	19.332	19.342	19.351	19.360
9.3	19.370	19.379	19.388	19.398	19.407	19.416	19.426	19.435	19.444	19.453
9.4	19.463	19.472	19.481	19.490	19.499	19.509	19.518	19.527	19.536	19.545
9.5	19.554	19.564	19.573	19.582	19.591	19.600	19.609	19.618	19.627	19.636
9.6	19.645	19.654	19.664	19.673	19.682	19.691	19.700	19.709	19.718	19.726
9.7	19.735	19.744	19.753	19.762	19.771	19.780	19.789	19.798	19.807	19.816
9.8	19.825	19.833	19.842	19.851	19.860	19.869	19.878	19.886	19.895	19.904
9.9	19.913	19.921	19.930	19.939	19.948	19.956	19.965	19.974	19.983	19.991

Voltage Ratio	0	1	2	3	4	5	6	7	8	9
10	20.000	20.828	21.584	22.279	22.923	23.522	24.082	24.609	25.105	25.575
20	26.021	26.444	26.848	27.235	27.604	27.959	28.299	28.627	28.943	29.248
30	29.542	29.827	30.103	30.370	30.630	30.881	31.126	31.364	31.596	31.821
40	32.041	32.256	32.465	32.669	32.869	33.064	33.255	33.442	33.625	33.804
50	33.979	34.151	34.320	34.486	34.648	34.807	34.964	35.117	35.269	35.417
60	35.563	35.707	35.848	35.987	36.124	36.258	36.391	36.521	36.650	36.777
70	36.902	37.025	37.147	37.266	37.385	37.501	37.616	37.730	37.842	37.953
80	38.062	38.170	38.276	38.382	38.486	38.588	38.690	38.790	38.890	38.988
90	39.085	39.181	39.276	39.370	39.463	39.554	39.645	39.735	39.825	39.913
100	40.000	—	—	—	—	—	—	—	—	—

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