CATALOG G

GENERAL RADIO CO.

CAMBRIDGE, MASS.

QUICK INDEX

SUGGESTIONS FOR ORDERING

ORDER BY TYPE NUMBER

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

Make sure that you have ordered any necessary extras (such as calibrations, accessories, tubes, etc.).

SHIPPING INSTRUCTIONS

Unless specific instructions accompany the order we shall use our best judgment as to the method of shipment.

All prices are F.O.B. Cambridge, Massachusetts. There is no domestic packing charge and no charge for shipping cases.

TERMS

Net 30 days or 2 per cent discount for payment within 10 days from the date of shipment. Unless credit has already been established we make all shipments C.O.D.

When cash accompanies the order, we pay transportation charges to any point in Canada and the continental United States (except Alaska) in place of allowing the cash discount.

REMITTANCES

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

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When 10 or more identical items are ordered at the same time for a single shipment, the following quantity discounts are allowed:

10–19	5 per cent
20–99	10 per cent
100 or more	Special discounts quoted on request.

NO TRADE OR EDUCATIONAL DISCOUNTS

Our prices are made on a direct-to-consumer basis which permits of no discounts except cash and quantity discounts.

PRICE CHANGES

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

TAXES

As the apparatus and parts furnished by us, as sold by us, are not subject to the manufacturer's excise tax imposed on certain radio items under Section 607 of Title IV of the Revenue Act of 1932, no tax has been included in the price. If any of these component parts are used by a "manufacturer, producer, or importer" and in a taxable manner, as defined in this Revenue Act, such "manufacturer, producer, or importer" must see that the requisite tax is paid on them. Tubes on which a tax is payable have had this tax paid and the prices given include this tax. Prices are subject to revision as to any sales or excise taxes, either Federal or local, which may hereafter be imposed.

SHIPMENTS TO GENERAL RADIO

When returning instruments for repair, recalibration, or for any other reason, please ask our Service Department for shipping instructions and our RETURNED APPARATUS tags.

REPAIR PARTS

When ordering repair parts, be sure to describe carefully the parts required and give the type number and serial number from the panel of the instrument.

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We have direct telegraph printer connections with Postal and Western Union for the prompt handling of telegraph, cable, and radio messages.

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The items listed in this catalog are of such a nature that they are best distributed on a direct-from-manufacturer-to-consumer basis. Therefore, with the exception of the distribution of certain instruments in particular fields through the Central Scientific Company in Chicago, Illinois, and of a stock of parts for local distribution in New York City carried by Leeds Radio Company of 45 Vesey Street, our instruments are not sold by dealers or brokers. Our own San Francisco office is located at 274 Brannan Street.

Although our domestic sales are made on a direct-to-the-consumer basis, we have arranged with numerous foreign agents for the distribution of our products outside of the United States.

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We are always glad to co-operate with editors and authors by supplying photographs, electrotypes, and descriptive data. Permission to reprint material from this catalog or from the General Radio *Experimenter* can be secured on request.

OTHER GENERAL RADIO PUBLICATIONS

In addition to this catalog we publish a monthly magazine, the General Radio *Experimenter*, for free distribution among interested persons. It contains technical and semi-technical engineering articles which are contributed, for the most part by our engineering staff. Since the choice of subjects is inevitably conditioned by the trend of new developments, those who are already users of General Radio instruments should be particularly interested.

There is no subscription fee. To be placed on the mailing list merely address a request to us containing your name, mailing address, and business affiliation.

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As we announce opposite, we have arranged with numerous foreign agents for the distribution of our products outside of the United States. Throughout British Territory, and also in some European Countries, our exclusive Agents and Technical Representatives are:

CLAUDE LYONS LIMITED
76, Oldhall Street
Liverpool, England

This firm maintains a special Branch Office, devoted almost exclusively to the sale of GENERAL RADIO and other Precision Laboratory Apparatus, at:

40, Buckingham Gate
Westminster
London, S.W.1, England

their Telegraphic Address being "MINMETKEM, SOWEST, LONDON," and their Telephone Number VICtoria 7595. At these offices is filed a more or less complete special technical information service on our line.

Messrs. Claude Lyons Ltd. have represented us for over eight years. They have a wide knowledge of our entire line, and are in a position to give advice upon the selection, installation and operation of our instruments. All orders, technical enquiries or other correspondence should be directed to them, as well as requests in connection with our "Experimenter" monthly magazine, which is mailed gratis and post free, regularly, from their London Offices.

RESISTANCE DEVICES

Resistors may be of the precision type, calibrated for many different kinds of laboratory measurements, or they may be used simply for the control of voltage and current. General Radio manufactures a wide variety in both classes. These include decade resistance boxes, attenuation networks, voltage dividers, volume controls, and rheostats and potentiometers for use with vacuum tubes.

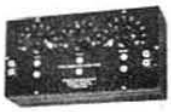
PRECISION TYPE RESISTORS

	Type	*Particular Applications*	*Identifying Features*
	**602**	D-c and high-frequency measurements — Bridge arms — Laboratory standards	Very small changes in resistance with increasing frequency — Shielding — submounted switches
	**510**	Where decade precision resistors are to be built into other equipment	Excellent frequency characteristic — Easy mounting unit assembly
	**500**	Special measuring and testing equipment—Artificial line terminations	Brown bakelite case, sealed, and fitted with screw or plug terminals
	**133**	Laboratory standards of resistance	Resistors like those used in TYPE 602 Decade-Resistance Boxes

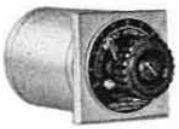
ATTENUATION NETWORK AND VOLTAGE DIVIDERS

	Type	*Particular Applications*	*Identifying Features*
	**249**	Audio- and carrier-frequency attenuation measurements	Key switches — Balanced-H and T-section models
	**329**	Audio- and carrier-frequency attenuation measurements	Rotary switches — Balanced-H section models

ATTENUATION NETWORK AND VOLTAGE DIVIDERS (cont.)

	Type	*Particular Applications*	*Identifying Features*
	**429**	Audio- and carrier-frequency attenuation measurements	Rotary switches — T-section model
	**529**	Audio- and carrier-frequency attenuation measurements	Rotary switches — L-section models
	**654**	A three-stage decade voltage divider	The electrical equivalent of two TYPE 602 Decade-Resistance Boxes in series

VOLUME CONTROLS

	Type	*Particular Applications*	*Identifying Features*
	**552**	Master gain control — Mixer control — attenuation measurements	Step-by-step switch
	**553**	Fader in public address and broadcast electrical transcription systems	Step-by-step switch
	**652**	Compact, inexpensive mixer control	Practically constant impedance in both directions for all settings — One sliding contact
	**642-D**	Gain control working into the grid of a vacuum-tube — Multiplier for vacuum-tube voltmeter	Step-by-step, switch to switch contacts

RHEOSTATS AND POTENTIOMETERS

	Type	*Particular Applications*	*Identifying Features*
	**471**	Gain control — General-purpose current and voltage control	Large form — 4-finger contact — Protected winding — Panel and table mounting

(Continued on page 6)

RHEOSTATS AND POTENTIOMETERS (cont.)

	Type	*Particular Applications*	*Identifying Features*
	**314**	Gain control—General-purpose current and voltage control	Like TYPE 471 but a smaller form
	**371**	Gain control—General-purpose current and voltage control	Large form—Single sliding contact—Panel and table mounting
	**214**	Gain control—General-purpose current and voltage control	Like TYPE 371 but a smaller form
	**301**	Control for vacuum-tube operating voltages	Small size—3-hole panel or table mounting
	**410**	Control for vacuum-tube operating voltages	Same as TYPE 301 but with single-hole panel mounting feature

MISCELLANEOUS RESISTORS

	Type	*Particular Applications*	*Identifying Features*
	**340**	For operating a low-impedance galvanometer from a high-voltage source	Cabinet mounted—9 steps
	**125**	Dummy antenna resistor for transmitters and power oscillators	Large power dissipation

GENERAL INFORMATION ON PRECISION RESISTORS

General Radio precision resistors are built up around several types of units which have been developed in the course of the company's fifteen years of experience in this field. These units have no considerable change in resistance over ordinary temperature ranges, and the calibration changes only slowly with time.

Permanence of original calibrated values is assured by the use of low-temperature-coefficient materials and careful aging in order to relieve strains set up in winding. Winding forms are designed for permanence so as to resist any deformation which would impose stresses in the windings.

Permanence of calibration with time and temperature is not sufficient, however, for resistors which are to be used at high frequencies. The General Radio Company has designed units which are to a large degree free from reactance effects and whose resistance is independent of frequency between wide limits. All of these units may be used throughout the audio-frequency range (0 to 10 kilocycles) without regard to frequency effects, and those of smaller resistance values are free from serious errors well into the radio-frequency region.

These desirable results come from the use of several types of winding described below.

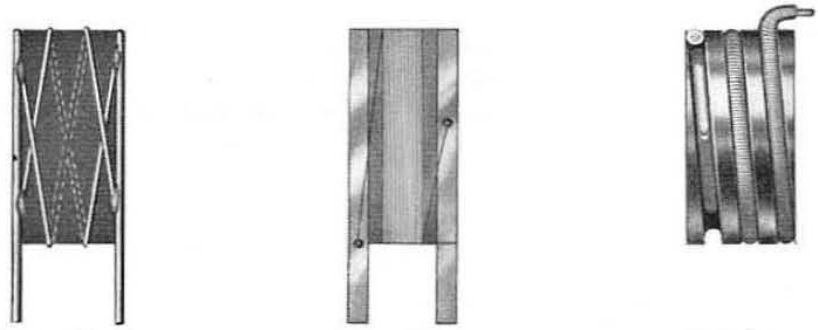
(*a*) *Ayrton-Perry Method.* (Used on low-resistance precision cards.) On a thin bakelite strip a single wire is wound, leaving a space between turns equal to the diameter of the wire. A second wire is wound in the space between turns, parallel with the first wire but in the opposite direction, so that units wound by this method are nearly non-inductive. Unlike the usual non-inductive bifilar winding, their distributed capacitance is also very small, because adjacent wires are at nearly the same potential.

(*b*) *Mica-Card Method.* (Used on high-resistance precision cards.) The wire is closely wound in a single layer on a thin mica form, the ends of which are reinforced by copper terminal strips. The small wire and the thin form give units made by this method an exceptionally low phase angle at high frequencies. Modifications of this design are used successfully on the attenuation networks used in our standard-signal generators at frequencies as high as 25 megacycles.

(*c*) *Bifilar Method.* (Used only on 0.1-ohm precision units.) This method of winding consists of a short length of ribbon bent sharply back upon itself. An assembly of resistors using this method is shown at the left-hand side of the illustration on page 11.

(*d*) *Fish-Line Method.* (Used on the high-resistance elements of voltage dividers and attenuation networks.) The resistance wire is wound on a small core of treated silk and the resulting "fish line" is wound on cylindrical forms. High resistances can be obtained in a small space and the phase-angle characteristics are entirely satisfactory for these uses.

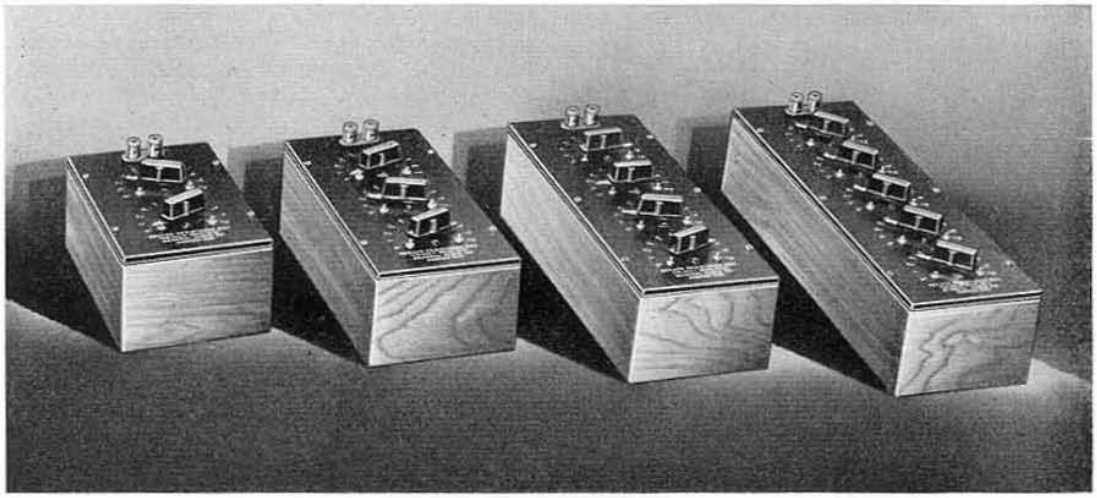
These resistance units are assembled in single dials, and in boxes of several dial combinations as well as voltage dividers, attenuation networks, and similar devices. Our bridges also use the same type of resistors.



Ayrton-Perry Mica-Card Fish-Line

Principal types of construction used in General Radio Precision Resistors

TYPE 602 DECADE-RESISTANCE BOX



The TYPE 602 Decade-Resistance Box is built in 2-, 3-, 4-, and 5-dial models

A convenient assembly of resistance cards with switches in a single unit is a laboratory staple. Such boxes are in constant use in circuits where a wide range of resistance values is required. They are used as laboratory standards, bridge arms, and loads. All General Radio boxes are equally useful on direct or alternating current and maintain their usefulness for many applications into the high radio frequencies.

The methods of assembly of the individual units into a resistance box are of as much importance as the characteristics of the units themselves, for the unit characteristics may be greatly affected by the mounting.

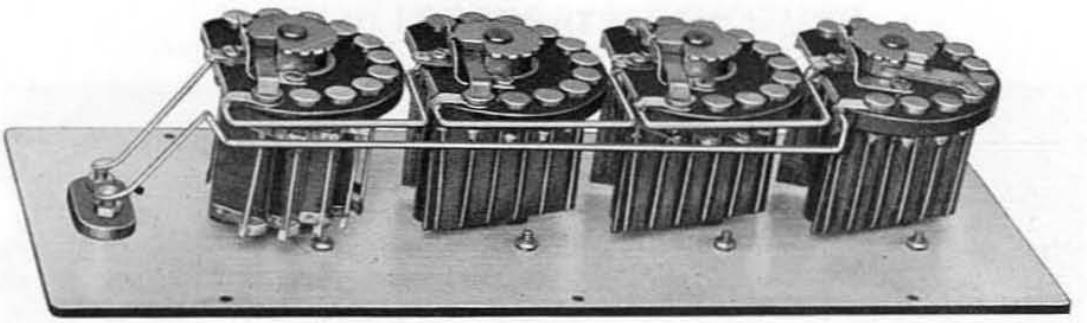
The TYPE 602 Decade-Resistance Box has been designed to provide a convenient assembly of resistance units, to protect the units and switching contacts, and to avoid alteration of the characteristics of the individual units.

Two-, three-, four-, and five-dial decade assemblies are provided. Each decade has eleven contact studs and ten resistance units so that dials overlap. A detent assists in setting squarely on the contacts.

Mechanical and electrical protection of the units is provided by the shielded walnut box and aluminum panel which completely enclose both units and switch contacts.

Quadruple-leaf switch blades running over large contacts insure a low and constant contact resistance. The arrangement of cards and wiring is such as to keep at a minimum the added resistance and reactance which are unavoidable in assembling units into a box.

These resistors are adjusted to have their specified values at their own terminals and not at the terminals of the box. The resistance measured at the box terminals will, therefore, be high by the switch contact and wiring resistance, which amounts to about 0.002 ohm per dial. This method of adjustment has been adopted primarily because no method in which the switch resistance is absorbed in some one unit of a decade can give the correct value of the total resistance for all settings of the various decades. There are also many types of measurement (voltage divider measurements, for example) in which the difference in two settings of a resistance box is significant. This difference is given correctly only when the individual resistors have been adjusted independently of switch resistance. The



The unique constructional features of these new boxes are shown in this interior view of a TYPE 602-J, 4-dial box. Note the aluminum panel, the large contact surface on the switches, and the detent device

wiring also adds a small inductance, about 0.1 microhenry per decade.

When the boxes are used on alternating currents, particularly as the frequency is raised, the box wiring and the switch capacitances affect the value of resistance between the box terminals by adding to the frequency effect in the cards themselves. These effects vary with frequency and are generally greater for the larger dials. They do not appear at audio frequencies but do affect resistance values at carrier and radio frequencies.[1]

Generally speaking, the 1-, 10-, and 100-ohm dials are most satisfactory at high frequencies.

When the boxes are used in tuned circuits only changes in resistance due to skin effect and, in some high-resistance cards, to effective capacitance need be considered. When the boxes are used as drop wires, the reactance of wiring and cards at high frequencies will affect the apparent impedance of the box. Data on those effects will be found in the specifications under "Frequency Characteristics."

[1] See the General Radio *Experimenter* for February, 1932, for data on the performance of these boxes at high frequencies.

SPECIFICATIONS

Type of Winding: The non-reactive precision resistors, described on page 6, are used: Bifilar type on the 0.1-ohm units; Ayrton-Perry on 1-, 10-, and 100-ohm decades; and the unifilar mica type on the 1000- and 10,000-ohm decades.

Switches: Quadruple-leaf, phosphor-bronze switches bear on contact studs $\frac{3}{8}$ inch in diameter. Switch brushes are bent so as not to be tangent to the arc of travel, thus avoiding cutting. A cam-type detent is provided. There are eleven contact points (0 to 10 inclusive).

Temperature Coefficient: The temperature coefficient is $\pm 0.002\%$ per degree C. except on the 10,000-ohm cards where it is $\pm 0.01\%$ per degree C.

Maximum Current: The upper limit of temperature rise is 40 degrees C. Values of current for 20 degrees C. and 40 degrees C. rises follow.

TABLE I
Current for Temperature Rise of 20° C. and 40° C.

Decade	*20° C. Rise*	*40° C. Rise*
0.1-ohm steps	1 a	1.5 a
1 -ohm steps	600 ma	1 a
10 -ohm steps	170 ma	250 ma
100 -ohm steps	50 ma	80 ma
1000 -ohm steps	5 ma	23 ma
10,000 -ohm steps	5 ma	7 ma

Accuracy of Adjustment: All cards are adjusted to within 0.1% of the stated value between card terminals, except the 1-ohm cards which are adjusted to within 0.25% and the 0.1-ohm cards which are adjusted to within 1%. Where necessary, add 0.002 ohm for each dial to allow for contact and wiring resistance.

TABLE II
Percentage Error in Resistance for Maximum Setting of Each Decade as a Function of Frequency

Decade	*Frequency in kc*						
	50	100	200	500	1000	2000	5000
0.1-ohm steps	0	0.1%	0.2%	1.5%	5 %	—	—
1 -ohm steps	0	0	0.1%	0.3%	1 %	4 %	—
10 -ohm steps	0	0	0	0.1%	0.5%	2 %	11%
100 -ohm steps	0	0	0	0.1%	0.3%	0.8%	4%
1000 -ohm steps	0	0	0	0.3%	1 %	4 %	—
10,000 -ohm steps	0	0.2%	2 %	6 %	—	—	—

TABLE III
Impedance (as a percentage of nominal resistance) for Maximum Setting of Each Decade as a Function of Frequency

Decade	*Frequency in kc*						
	50	100	200	500	1000	2000	5000
0.1-ohm steps	0.2%	0.7%	2 %	—	—	—	—
1 -ohm steps	0.1%	0.2%	1 %	5 %	—	—	—
10 -ohm steps	0	0	0.1%	0.2%	2 %	—	—
100 -ohm steps	0	0	0	0.1%	0.3%	1%	5%
1000 -ohm steps	0	0.1%	0.5%	2 %	6 %	—	—
10,000 -ohm steps	5 %	20 %	—	—	—	—	—

Frequency Characteristics: There is no serious frequency error below 50 kc. At higher frequencies the error results from changes in resistance and the appearance of reactance in the cards, and from the inductance of the box wiring (about 0.1 μh per dial). Table II lists changes in resistance for single decades, as a percentage error of the stated value of resistance as a function of frequency.

Table III lists high-frequency impedance for single dials as a percentage error of the stated resistance as a function of frequency.

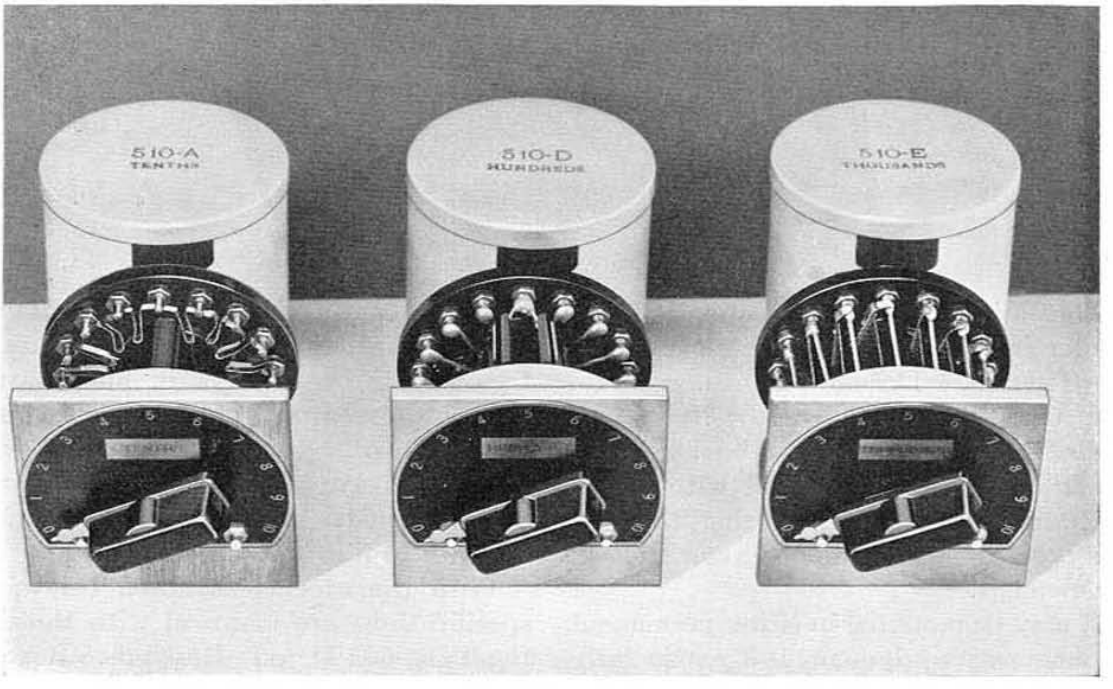
Mounting: A copper-lined walnut cabinet, with aluminum panel, completely encloses switches and resistance units. The panel finish is black crackle lacquer.

Dimensions: Panel length depends on the number of dials (see price list), being 7¾ for 2-dial, 10⅜ for 3-dial, 13 for 4-dial, and 15⅝ inches for 5-dial boxes. Panel width, 5 inches. Over-all height, 5 inches.

Net Weight: 3¼ for 2-dial, 4¼ for 3-dial, 5 for 4-dial, and 6¼ pounds for 5-dial boxes.

Type	*Resistance*	*No. of Dials*	*Code Word*	*Price*
602-D	**11 ohms, total, in steps of 0.1 ohm**	2	DECOY	**$25.00**
602-E	**110 ohms, total, in steps of 1 ohm**	2	DECRY	**25.00**
602-F	**111 ohms, total, in steps of 0.1 ohm**	3	DELTA	**35.00**
602-G	**1110 ohms, total, in steps of 1 ohm**	3	DIGIT	**35.00**
602-K	**1111 ohms, total, in steps of 0.1 ohm**	4	DEFER	**45.00**
602-J	**11,110 ohms, total, in steps of 1 ohm**	4	DEBIT	**50.00**
602-N	**11,111 ohms, total, in steps of 0.1 ohm**	5	DEMON	**62.00**
602-M	**111,110 ohms, total, in steps of 1 ohm**	5	DEMIT	**70.00**
602-L	**111,100 ohms, total, in steps of 10 ohms**	4	DECAY	**58.00**

TYPE 510 DECADE-RESISTANCE UNIT



Three typical TYPE 510 Units with the shields removed. The small panels are wooden blocks used as a protection in shipping

One or more decade-resistance dials are frequently incorporated in a permanent assembly with other apparatus when the cabinet and panel of a TYPE 602 Decade-Resistance Box cannot be used. The individual decades used in these boxes are available, listed as the TYPE 510 Decade-Resistance Units. The resistance dials are enclosed in an aluminum shield and etched dial plates are included.

The following specifications show the details in which a TYPE 510 Unit differs from the TYPE 602 Decade-Resistance Box previously described.

SPECIFICATIONS

Mounting: The units are designed for panel mounting with an aluminum shield. A combination dial plate and drilling template are provided. They may be mounted on a ¼-inch or ⅜-inch panel.

Dimensions: Shield, (diameter) 3 1/16 x (length) 3 1/16 inches.

Net Weight: 11 ounces.

Type	*Resistance*			*Code Word*	*Price*
510-A	**1 ohm, total, in steps of**	**0.1**	**ohm**	ELATE	**$8.50**
510-B	**10 ohms, total, in steps of**	**1**	**ohm**	ELDER	**8.50**
510-C	**100 ohms, total, in steps of**	**10**	**ohms**	ELEGY	**8.50**
510-D	**1000 ohms, total, in steps of**	**100**	**ohms**	ELBOW	**8.50**
510-E	**10,000 ohms, total, in steps of**	**1000**	**ohms**	ELECT	**13.00**
510-F	**100,000 ohms, total, in steps of**	**10,000**	**ohms**	ELVAN	**16.00**

TYPE 500 RESISTOR

Screw-terminal model

Plug-terminal model

This unit contains a non-inductive card similar in construction to those used on the TYPE 602 Decade-Resistance Boxes and the TYPE 510 Decade-Resistance Units. Each resistor is contained within a moulded bakelite case filled with an impregnating wax, thus assuring the stability of the electrical characteristics of the element.

It may be mounted in either permanent or temporary equipment. It is particularly useful in special measuring or testing equipment. It will also be noted that the resistors have values suitable for use as terminating impedances in lines having any of the commonly used characteristic impedances.

They are available with either screw or plug terminals. The latter can be stacked in order to put units in parallel.

With the exceptions noted below, all specifications are identical with those of the TYPE 602 Decade-Resistance Boxes.

SPECIFICATIONS

Maximum Current: All units will dissipate 1 watt, corresponding to maximum current as follows:

Resistance	*Current*
1 ohm	1 a
10 ohms	300 ma
50 ohms	140 ma
100 ohms	100 ma
200 ohms	70 ma
500 ohms	45 ma
600 ohms	40 ma
1000 ohms	30 ma
10,000 ohms	10 ma

Accuracy: All units are adjusted to be within 0.5% of the stated value.

Terminals: Units are available fitted either with screw terminals or with plug-and-jack terminals on the standard General Radio spacing of ¾ inch.

Mounting: Each resistor is sealed in a moulded case of brown bakelite with an impregnating wax.

Dimensions: (Length) 2½ x (width) 1¼ x (height) 1 inch, over-all.

Net Weight: 2 ounces.

SCREW-TERMINAL MODELS

Type	*Resistance*	*Code Word*
500-A	**1 ohm**	RESISTBIRD
500-B	**10 ohms**	RESISTDESK
500-C	**50 ohms**	RESISTFORD
500-D	**100 ohms**	RESISTFROG
500-E	**200 ohms**	RESISTGIRL
500-F	**500 ohms**	RESISTGOAT
500-G	**600 ohms**	RESISTGOOD
500-H	**1000 ohms**	RESISTHYMN
500-J	**10,000 ohms**	RESISTMILK

PLUG-TERMINAL MODELS

Type	*Resistance*	*Code Word*
500-AP	**1 ohm**	RESISTMOAT
500-BP	**10 ohms**	RESISTMUSH
500-CP	**50 ohms**	RESISTPALM
500-DP	**100 ohms**	RESISTPOKE
500-EP	**200 ohms**	RESISTRACK
500-FP	**500 ohms**	RESISTSEAT
500-GP	**600 ohms**	RESISTSHOE
500-HP	**1000 ohms**	RESISTSLOE
500-JP	**10,000 ohms**	RESISTTOAD

PRICES, ALL SIZES, BOTH MODELS, $2.00

TYPE 133 STANDARD RESISTANCE

A TYPE 133-K Standard Resistance having a resistance of 25,000 ohms tapped at the four, 5000-ohm points

This resistor is similar in construction to individual units of the TYPE 602 Decade-Resistance Boxes and all specifications are identical with those boxes except as noted below.

TYPE 133-K is tapped at four points, giving 5000-ohm steps. This covers the usual range of the plate resistance of vacuum tubes. Other combinations between 1000 ohms and 25,000 ohms may be obtained by suitable series and parallel connections.

SPECIFICATIONS

Range: These resistors are made in the eight single-resistance shown in the price list as well as in the tapped 25,000-ohm unit shown in the accompanying illustration.

Accuracy of Adjustment: 0.1%.

Maximum Current: Values corresponding to a temperature rise of 20 degrees C. and 40 degrees C. are given in the price list.

Mounting: Units are enclosed in moulded bakelite cases.

Dimensions: Diameter, 3¾ inches; depth, 2½ inches, over-all.

Net Weight: ¼ pound for all units except TYPE 133-K which weighs ¾ pound.

Type	*Resistance*	*Maximum Current* 20° C.	40° C.	*Code Word*	*Price*
133-A	1 ohm	900 ma	1.35 a	RECUR	$6.00
133-B	5 ohms	380 ma	560	REFER	6.00
133-C	10 ohms	270 ma	400 ma	REGAL	6.00
133-D	50 ohms	125 ma	190	RELAX	6.00
133-E	100 ohms	90 ma	170	RELIC	6.00
133-F	500 ohms	40 ma	65	REPAY	6.00
133-G	1000 ohms	30 ma	50 ma	REPEL	7.00
133-H	10,000 ohms	10 ma	15 ma	PETAL	8.00
133-K	25,000 ohms	10 ma	15 ma	PASHA	15.00

TYPES 249, 329, and 429 ATTENUATION BOXES

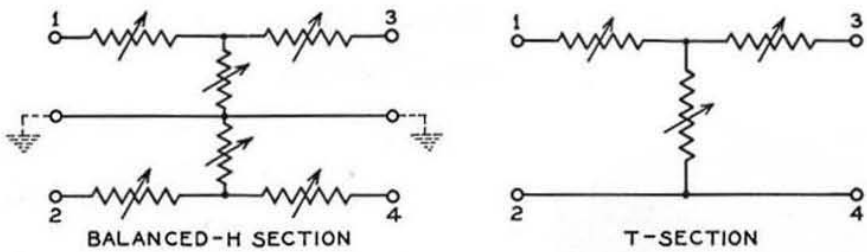
Balanced-H and T-section precision attenuation networks are made in 3 types.
Left to right: TYPE 249-T, TYPE 329-J, and TYPE 429-H

General Radio manufactures precision attenuation networks under three type numbers; distinguished by the type of section (T or balanced-H) and by the switching mechanism. TYPE 249 has key switches, TYPES 329 and 429 have rotary switches. The latter style is usually preferred, although many engineers make the claim that the key switch is faster to operate.

An attenuation network is a combination of resistance elements so arranged that it introduces a definite and known amount of power loss when put into a circuit between certain specified values of external input and output impedance. These three factors completely specify its performance at all frequencies for which the effects of reactance in the resistors and spurious admittances between them can be considered negligible.

These networks, when constructed with a switching mechanism for changing the amount of attenuation, are called "attenuation boxes" and have long been in common use throughout the communication engineering industries for making all kinds of transmission-efficiency and power-level measurements. Their value is now becoming well known in other fields as accessories of the vacuum-tube voltmeter and amplifier. They permit the use of substitution methods which eliminate the need for calibrated low-range-indicating instruments, difficult things to obtain for high-frequency work.

In one sense they are similar in use to the shunts and multipliers used with galvanometers, ammeters, and voltmeters, but it is more common practice to treat them as non-reactive, artificial transmission lines. In fact, most of the terminology for attenuation networks is the same as for telephone transmission lines. Accurate measurements of gain or loss in amplifiers, filters, and similar devices require networks whose loss can be adjusted over wide limits without changing the impedance across either the input or output terminals of the instruments.



Balanced-H section networks are used when impedances must be matched in both directions and balanced to ground. T-type sections maintain constant impedance in both directions, but they are not balanced to ground. Both are used in TYPE 552 Volume Controls as well as in precision attenuation boxes

SPECIFICATIONS

Attenuation Range: Boxes having a maximum attenuation range of 22 db, 55 db, and 110 db are listed in the price list. Other ranges can be built to order.

Type of Section: T-section and balanced-H-section models are available. Both present a constant impedance in both directions, but the balanced-H should be used where both sides of the circuit must be balanced to ground.

Type of Windings: All resistors are of the precision type described on page 7: Ayrton-Perry for the low-resistance elements; mica cards for the medium-resistance elements; and "fish-line-type" for the high-resistance elements.

Terminal Impedance: Boxes to operate between 600-ohm impedances are listed. Boxes for other impedance values can be made on special order.

Accuracy of Adjustment: Each individual resistor is adjusted to within 0.25% of its correct value, so that the entire box is accurate to within 0.5% at frequencies up to at least 50 kc.

Switching: TYPE 249 has 8 key switches to control the 8 network sections.

TYPES 329 and 429 have multiple blade switches and a positive detent which centers the switch blades on the contact points at each step.

Mounting: TYPES 249-H and 249-T are mounted in walnut cabinets, with aluminum panels finished in black crackle lacquer.

The TYPE 329 and TYPE 429 Boxes have walnut cabinets with engraved bakelite panels.

Dimensions: TYPE 249: Panel, (length) 16 x (width) 5¼ in. Cabinet, (depth) 5¼ in., over-all.

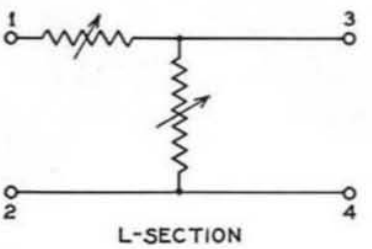
TYPE 329: Panel, (length) 16⅞ x (width) 10¾ inches. Cabinet, (depth) 6 inches, over-all.

TYPE 429: Panel, (length) 14 x (width) 7 inches. Cabinet, (depth) 5 inches, over-all.

Net Weight: TYPE 249, 7⅛ pounds; TYPE 329, 12 pounds; TYPE 429, 11½ pounds, approximately.

Type	*Attenuation Range*	*Impedance*	*Type of Section*	*Code Word*	*Price*
249-H	**110 db in steps of 1.0 db**	600 ohms	Balanced-H	NETWORKROD	**$120.00**
249-T	**110 db in steps of 1.0 db**	600 ohms	T	NETWORKTOP	**100.00**
329-J	**55 db in steps of 0.5 db**	600 ohms	Balanced-H	TENUTORPIG	**155.00**
329-N	**22 db in steps of 0.2 db**	600 ohms	Balanced-H	TENUTORBOY	**165.00**
429-H	**55 db in steps of 0.5 db**	600 ohms	T	ADMIT	**150.00**

TYPE 529 ATTENUATION BOX
OR AUDIBILITY METER



The TYPE 529 Attenuation Box is made as an L-type section which maintains constant impedance at the 1–2 terminals

Audibility is commonly measured by reducing the received sound until it can be barely heard. The amount of reduction required to reach this "threshold" value is taken as a measure of the audibility of the sound. A calibrated shunt is required which will not affect circuit conditions as it is varied. The TYPE 529 Attenuation Box is calibrated in decibels, the now generally accepted unit of audibility, and replaces the arbitrarily-calibrated TYPE 164 Audibility Meter.

SPECIFICATIONS

Range: 60 db in steps of 2 db.

Type of Section: Available in the L-type section which maintains constant impedance in one direction only.

Type of Winding: Random winding on bakelite cards.

Accuracy of Adjustment: ±0.25%.

Frequency Error: An accuracy of 2% is maintained up to a frequency of 10 kc.

Mounting: Mounted in hand rubbed walnut cabinet with engraved bakelite panel.

Dimensions: Panel, (length) 8 x (width) 8 inches. Cabinet, (depth) 4 inches, over-all.

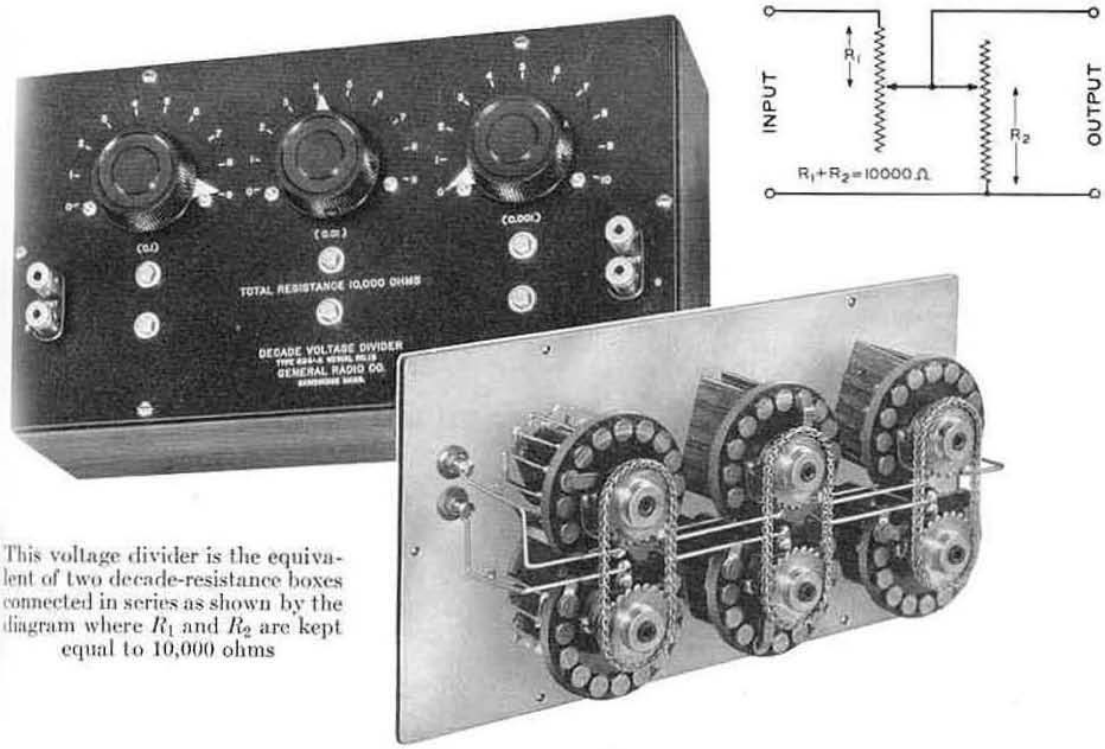
Net Weight: 2⅜ pounds.

Type	*Attenuation Range*	*Impedance*	*Type of Section*	*Code Word*	*Price*
529-A	**60 db in steps of 2 db**	600 ohms	L	ADULT	**$34.00**
529-B	**60 db in steps of 2 db**	6000 ohms	L	AFFIX	**34.00**

TYPE 654-A DECADE-VOLTAGE DIVIDER

This precision, decade-voltage divider yields ratios of 0.001 to 1.000 in steps of 0.001. The resistance across the input terminals is constant at 10,000 ohms for all settings of the dials. The instrument is similar in general characteristics to the TYPE 602 Decade-Resistance Boxes.

The specifications are identical in every respect with those for the TYPE 602 Decade-Resistance Boxes, except as noted.



This voltage divider is the equivalent of two decade-resistance boxes connected in series as shown by the diagram where R_1 and R_2 are kept equal to 10,000 ohms

SPECIFICATIONS

Range: Voltage ratios of 0.001 to 1.000 in steps of 0.001 can be obtained by setting up the desired result on the three switches.

Dimensions: Panel, (length) 13 x (width) 7 inches. Cabinet, (depth) 5¼ inches, over-all.

Net Weight: 8¼ pounds.

Type		*Code Word*	*Price*
654-A	.....	ABACK	**$85.00**

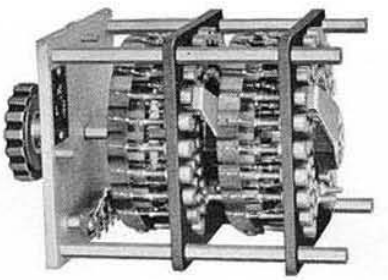
TYPE 552 VOLUME CONTROL
MASTER GAIN CONTROL

This unit has been designed primarily as a master gain control in high-grade broadcast transmission, sound-recording and projection, and public-address systems. Where the very finest equipment is being installed its use is also recommended in mixer circuits. Because of its accuracy, excellent frequency characteristic, and compactness, it will be found useful in measuring circuits where the expense of our highly precise attenuation networks is not justified.

The design of the individual resistors makes a very rigid mechanical construction. The whole assembly is built to withstand the most severe service requirements. A metal shield which covers the terminals minimizes electrical disturbances.

No slide-wire contacts are used; the action is entirely step by step. This increases the reliability of the unit, at the same time making exact duplication of attenuation settings easily possible. The step-by-step contacts used in this volume control also have a lower noise level than any type of sliding contact. Contacts have

TYPE 552 Volume Controls are regularly supplied with 20 steps of 1.5 db each



This photograph of a TYPE 552-HB Volume Control with the shield removed shows the construction of the TYPE 552 and TYPE 553 Volume Controls

been run for 200,000 operations without showing signs of appreciable wear.

The noise level is extremely low and this unit may be used at power levels as low as −80 to −90 decibels without introducing objectionable noise.

SPECIFICATIONS

Range: One range, 0 db to 30 db, in steps of 1.5 db is carried in stock, but special ranges can be built to order.

Type of Section: T-section and balanced-H-section models are available. Both maintain constant impedance in both directions, but the balanced-H-section is used where the transmission circuit must be balanced to ground.

Type of Winding: Unifilar winding on bakelite strips as shown in the accompanying illustration.

Terminal Impedance: Units for working in 200-ohm and 500-ohm circuits are carried in stock, but others can be built to order.

Accuracy: All resistors are adjusted to within 2%, which makes the error in attenuation less than 1 db at all settings up to 20 kc.

Maximum Current: Any of these units can be used at power levels up to +20 db.

Switch: A multiple blade switch is used.

Mounting: The entire unit is supported on a square aluminum sub panel that can be mounted on a panel by means of the same four machine screws that hold the etched-metal dial plates.

Terminals: A terminal strip mounted with soldering lugs is mounted behind the sub panel.

Dimensions: Sub panel, 4 x 4 inches; depth behind panel: 3, for T-section models; 5¼ inches for balanced-H-section models.

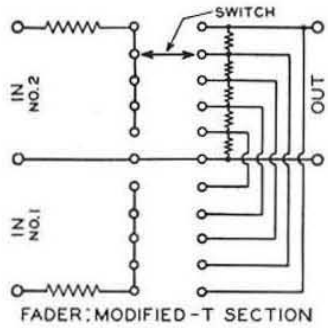
Net Weight: 2 pounds for T-section, 3 pounds for balanced-H-section models.

Type	*Attenuation*	*Impedance*	*Section*	*Code Word*	*Price*
552-TB	**30 db in steps of 1.5 db**	200 ohms	T	ALIEN	**$34.00**
552-TC	**30 db in steps of 1.5 db**	500 ohms	T	ALARM	**34.00**
552-HB	**30 db in steps of 1.5 db**	200 ohms	Balanced-H	ALBUM	**48.00**
552-HC	**30 db in steps of 1.5 db**	500 ohms	Balanced-H	AGAIN	**48.00**

TYPE 553 VOLUME CONTROL
FADER

This is a fader of the same general construction as the TYPE 552 Volume Control previously described. It is designed for transferring an amplifier system, or fading, between two microphones or phonograph pickup units, at the same time providing a volume control for the unit in use.

All design details are essentially similar to those mentioned in the preceding description of the TYPE 552 Volume Control.



The TYPE 553 Volume Control is a fader. *Left,* the dial plate; *right,* the schematic diagram

SPECIFICATIONS

Range: One range, 0 db to 30 db, in steps of 2 db is carried in stock, but special ranges can be built to order.

Type of Section: Modified-T-type shown in the accompanying diagram. With this network the output impedance varies between 30% low and 20% high from the specified impedance value when going from minimum to maximum attenuation. At the same time the internal input impedance in the direction of the pickup or microphone varies from 0% to 27% low. These errors, unavoidable in this type of network, are usually not sufficient to interfere with the performance of the system.

Dimensions: Sub panel, 4 x 4 inches; depth behind panel, 3½ inches.

Net Weight: 2 pounds.

Type	*Attenuation*	*Impedance*	*Section*	*Code Word*	*Price*
553-FB	**30 db in steps of 2 db**	200 ohms	Modified-T	ALDER	**$28.00**
553-FC	**30 db in steps of 2 db**	500 ohms	Modified-T	ALERT	**28.00**

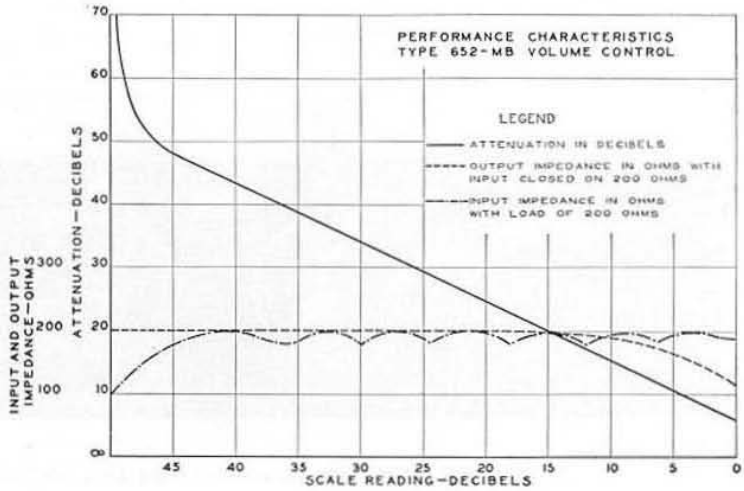
TYPE 652 VOLUME CONTROL
MICROPHONE MIXER

This is a compact unit employing an entirely new circuit and mechanical construction which makes it have excellent electrical mechanical properties at a very low price.

Both input and output impedances are approximately constant over the entire range of attenuation between 0 and 45 decibels. There is only one sliding contact, thereby reducing, by one-half, noise and contact troubles.

Another feature of this unit is the gradual increase in attenuation to infinity beyond the 45-decibel point, thus providing a means for cutting off the circuit noiselessly.

The TYPE 652 Volume Control may be used in any voice circuit but is particu-



The TYPE 652 Volume Control has only one sliding contact, yet the impedances are practically constant and the attenuation curve is linear until complete cut-off is approached

larly recommended for uses in microphone mixer circuits. The noise level is extremely low and it may be used in circuits at levels as low as −60 to −70 decibels without introducing objectionable noise.

The TYPE 652 Volume Control is compact and requires little panel space

SPECIFICATIONS

Range: 0 db to infinity. The variation in attenuation with pointer setting is linear from 0 to 45 db. Beyond 45 db the attenuation increases rapidly to infinity. Attenuation is continuously adjustable.

Type of Section: A ladder-type structure gives this unit its excellent impedance characteristic and freedom from noise.

Type of Winding: Unifilar winding on bakelite strips.

Terminal Impedance: 50-, 200-, or 500-ohm units are carried in stock, but others can be built to order. The shaft is electrically dead.

Shielding: A black japanned aluminum cover is provided as a protection against dust and dirt and as an electrostatic shield. The windings are protected against damage when the outer shield is removed by a concentric aluminum tube surrounding them.

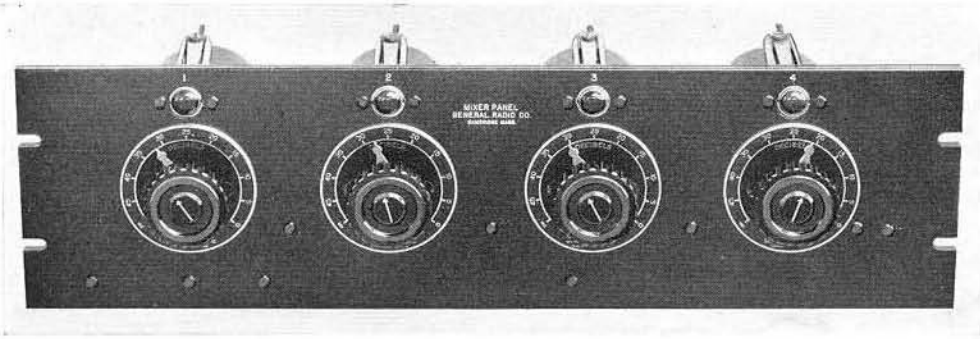
Switch: The slider contact is made from Advance metal, the same material used to wind the resistors. This removes the noise due to difference of contact potential.

Mounting: The unit is arranged for panel mounting, by means of the two screws holding the etched-metal nameplate in place. Mounting screws supplied with these units are long enough to permit mounting them on panels up to $\frac{3}{8}$ inch in thickness. Holes are spaced $1\frac{1}{2}$ inches apart.

Dimensions: Shield, (diameter) $2\frac{3}{4}$ x (back-of-panel depth) 4 inches, over-all.

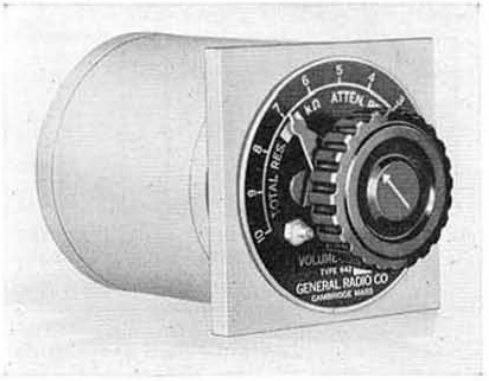
Net Weight: $2\frac{1}{2}$ pounds.

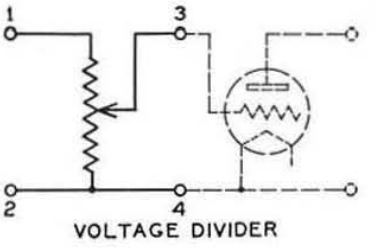
Type	*Impedance*	*Code Word*	*Price*
652-MA	50 ohms	CANTO	$12.50
652-MB	200 ohms	CAPER	12.50
652-MC	500 ohms	CAPON	12.50



A four-channel mixer panel assembled from TYPE 652 Volume Controls

TYPE 642-D VOLUME CONTROL





VOLTAGE DIVIDER

This high-impedance voltage divider is suitable for use as an interstage volume control or as a multiplier for a vacuum-tube voltmeter

This high-impedance voltage divider can be used as a gain-control potentiometer in the grid circuit of voice-frequency amplifiers or as a multiplier for vacuum-tube voltmeters. It is compact, ruggedly constructed, and is free from contact noise. In normal use it is accurate to within 0.1 decibel at all frequencies up to 20,000 cycles. Special sizes can be built to order.

SPECIFICATIONS

Range: One range, 0 db to 30 db, in steps of 3 db is carried in stock, but other sizes can be built to order.

Type of Section: Voltage divider for working into a high-impedance circuit such as the grid of a tube.

Type of Winding: Individual random-wound, non-inductive resistors are used.

Terminal Impedance: When connected as shown in the accompanying diagram, the input impedance is 200,000 ohms.

Accuracy: All resistors are adjusted to within 1%, which makes attenuation ratios accurate to within 0.1 db. If capacitance of tube, socket, and wiring are less than 20 $\mu\mu$f, as is usually the case, the rated accuracy limit of 0.1 db holds to approximately 20,000 cycles.

Maximum Current: Although normally used in circuits drawing no current, a current of 4 ma will not cause a temperature rise sufficient to affect the rated accuracy.

Switch: The switch arm is constructed of four-leaf phosphor bronze, which provides for long wear and exceptionally low contact noise. The cam-type detent may be easily removed if smooth switch action is required.

Mounting: This unit is similar in construction to the TYPE 510 Decade-Resistance Units. The form supporting the resistors and the switch is made of moulded bakelite, and this is attached to a panel by the same two screws which hold the etched metal dial plate.

Terminals: Three soldering lugs are placed at the end of the unit for making connections, and the shield has a small opening for connecting wires.

Dimensions: Shielded diameter, 3 1/16 inches; depth behind panel, 3 1/16 inches.

Net Weight: 11 ounces.

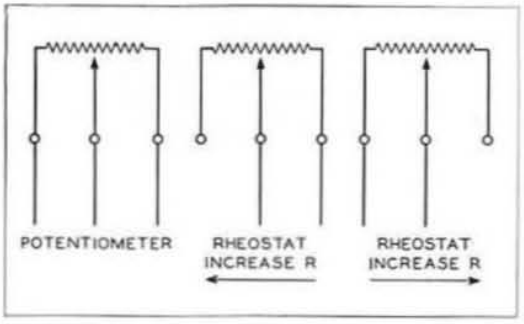
Type	*Attenuation Range*	*Impedance*	*Type of Section*	*Code Word*	*Price*
642-D	**30 db in steps of 3 db**	20,000 ohms	Voltage Divider	EXALT	**$25.00**

RHEOSTATS AND POTENTIOMETERS

The control of current and voltage requires a compact rugged unit conservatively rated, with adequate contact surfaces. The General Radio Company offers a large group of wire-wound resistance devices of this class. Three wattage ratings and resistances from 0.5 ohm to 100,000 ohms are listed.

Listed in this catalog, for the first time, is a new group of high-resistance units in which a wide quadruple-wiper contact arm is used. Another convenient type for many applications is that having a tapered form, giving a non-linear relation between rotation and resistance.

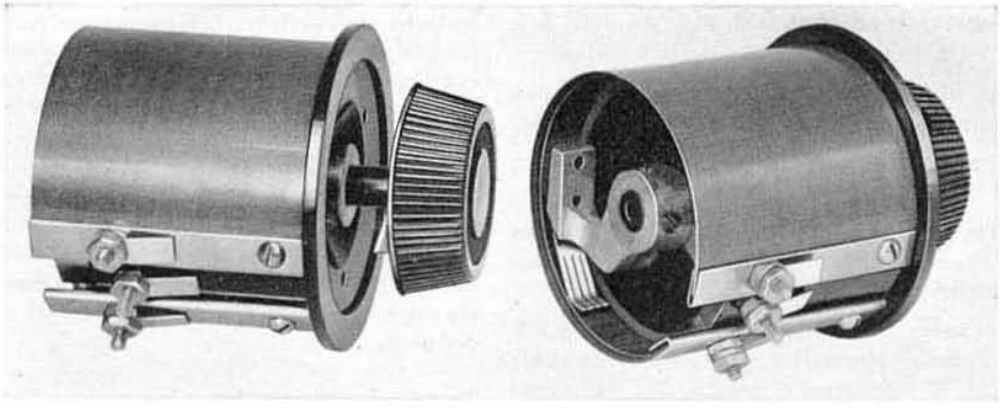
All these resistance units are wound on thin bakelite duck cards mounted on moulded bakelite forms.



A potentiometer can also be used as a rheostat for either direction of rotation. All General Radio rheostats and potentiometers are, unless otherwise noted, made only as potentiometers

All resistors are wound to within 10 per cent of specified values. Sizes listed are carried in stock; others can be built to order.

TYPE 471-A RHEOSTAT AND POTENTIOMETER



The TYPE 471-A Potentiometer is distinguished by the large winding form, 4-finger wiping contact, protecting bakelite case, and the bakelite shaft

There is a wide use for a wire-wound high resistance as a voltage control in vacuum-tube circuits.

Since the volume control is commonly connected in the input side of an amplifier, any noises originating in it are liable to considerable amplification. A high-resistance unit using very small wire requires particular attention to contacts.

TYPE 471-A (as well as TYPE 314-A described in the next section) has a wide, quadruple contact, wiping the inside surface of the unit. A smooth working, quiet control is thus assured. An insulated shaft prevents any introduction of hum into the circuit from the hand of the operator. To protect the fine wire, a bakelite protecting strip surrounds the unit.

SPECIFICATIONS

Power Rating: 12 watts. The values of maximum current corresponding to this rating are given in the price list.

Mounting: Supplied for three-hole panel mounting, but can easily be converted for base-board mounting. Machine screws, nuts, and drilling template furnished.

Dimensions: Over-all radius, including terminals, $1\frac{11}{16}$ inches; depth behind panel, $2\frac{3}{8}$ inches; shaft, $\frac{3}{8}$ inch.

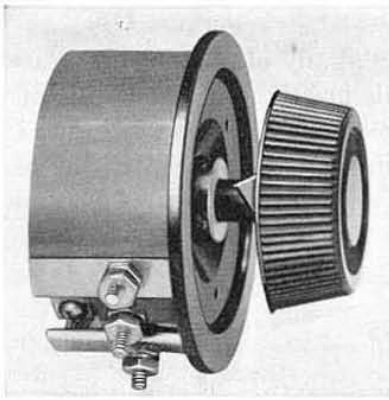
Angle of Rotation: 320°. No off position is provided.

Knob: TYPE 537-K.

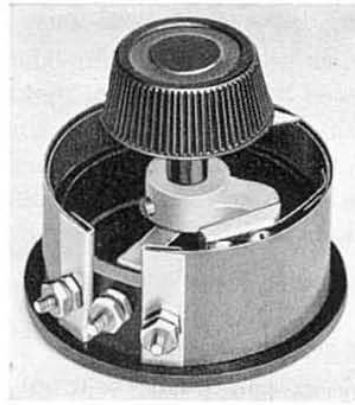
Net Weight: 9 ounces.

Type	*Resistance*	*Maximum Current*	*Code Word*	*Price*
471-A	**50,000 ohms**	14.7 ma	ERODE	**$6.00**
471-A	**100,000 ohms**	10.4 ma	ERUPT	**6.00**
471-A	**200,000 ohms**	7.3 ma	ESKER	**6.00**

TYPE 314-A RHEOSTAT AND POTENTIOMETER



A TYPE 314-A Potentiometer is identical with a TYPE 471-A Potentiometer except for the shorter winding form



All General Radio potentiometers (except TYPE 410) can be converted into table-mounting models by a moment's work with a screw driver

This unit is similar in general construction to the TYPE 471-A Potentiometer, previously described, but it has a narrower winding form and, therefore, a lower power rating. It has the four-finger contact and the bakelite shaft.

SPECIFICATIONS

Power Rating: 6 watts. Values of maximum current corresponding to this rating are given in the price list.

Mounting: Supplied for three-hole panel mounting, but can easily be converted for base-board mounting. Machine screws, nuts, and drilling template furnished.

Dimensions: Over-all radius, including terminals, $1\frac{3}{4}$ inches; depth behind panel, $1\frac{1}{4}$ inches; shaft, $\frac{3}{8}$ inch.

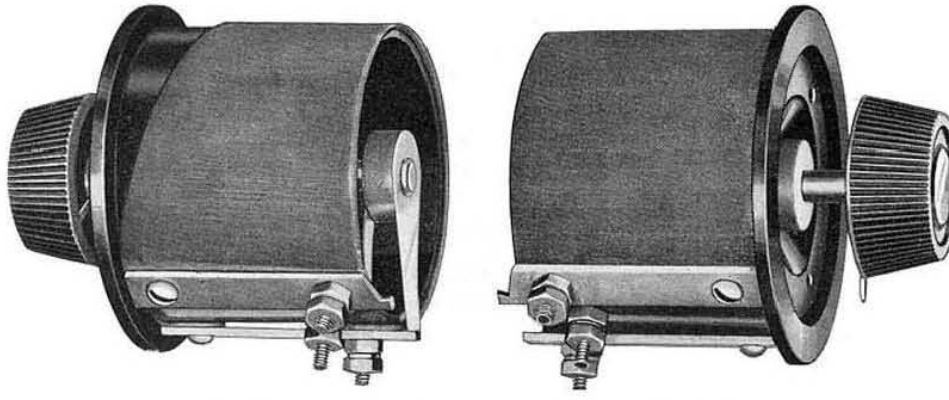
Angle of Rotation: 315°. No off position is provided.

Knob: TYPE 537-K.

Net Weight: 6 ounces.

Type	*Resistance*	*Maximum Current*	*Code Word*	*Price*
314-A	**200 ohms**	165 ma	ENATE	**$4.00**
314-A	**600 ohms**	95 ma	ENDOW	**4.00**
314-A	**2000 ohms**	52 ma	ENEMY	**4.00**
314-A	**6000 ohms**	30 ma	ENJOY	**4.00**
314-A	**20,000 ohms**	16 ma	ENROL	**4.00**

TYPE 371-A RHEOSTAT AND POTENTIOMETER



The TYPE 371 Potentiometer uses the large winding form.
Left: TYPE 371-T, tapered model; *right,* TYPE 371-A, linear model

Except when used in a high-impedance circuit followed by amplification, a potentiometer using the conventional single contact on the edge of the winding is perfectly satisfactory for most purposes. This potentiometer has the greatest power rating of any of our single contact units.

This unit is also manufactured with a tapered winding form which gives an approximate square law variation of resistance with angle of setting. It is known as TYPE 371-T.

SPECIFICATIONS

Power Rating: 25 watts, except for the tapered model (TYPE 371-T) which is 15 watts.

Mounting: Supplied for three-hole mounting, but can easily be converted for base-board mounting. Machine screws, nuts, and drilling template furnished. The TYPE 318 Dial Plate (etched metal scale) will fit this unit.

Dimensions: Over-all radius, including terminals, $1\frac{11}{16}$ inches; depth behind panel, $2\frac{3}{8}$ inches; shaft, $\frac{1}{4}$ inch.

Angle of Rotation: 320°. No off position.

Knob: TYPE 537-C.

Net Weight: 6 ounces.

Type	*Resistance*	*Maximum Current*	*Code Word*	*Price*
371-A	**1 ohm**	5 a	RALLY	**$4.00**
371-A	**5 ohms**	2.2 a	RELAY	**4.00**
371-A	**1000 ohms**	150 ma	REDAN	**4.00**
371-A	**2500 ohms**	100 ma	REFIT	**4.00**
371-A	**5000 ohms**	70 ma	ROTOR	**4.00**
371-A	**10,000 ohms**	50 ma	ROWDY	**4.00**
371-A	**18,000 ohms**	37 ma	RULER	**4.00**
371-A	**50,000 ohms**	22 ma	SATYR	**4.00**
371-T	**10,000 ohms**	40 ma	SULLY	**5.00**

TYPE 214-A RHEOSTAT AND POTENTIOMETER

TYPE 214-A is similar to TYPE 371-A, except that it has the short winding form

This is a unit very similar in construction to the TYPE 371-A Potentiometer, previously described, except that the winding form is narrower and the maximum power dissipation is, accordingly, smaller.

SPECIFICATIONS

Power Rating: 12 watts. The values of current corresponding to this rating are given in the price list.

Mounting: Supplied for three-hole panel mounting, but it can be easily converted into a table-mounting model by the customer. Machine screws, nuts, and drilling template furnished.

Dimensions: Over-all radius, including terminals, 1¾ inches; depth behind panel, 1¼ inches; shaft ¼ inch.

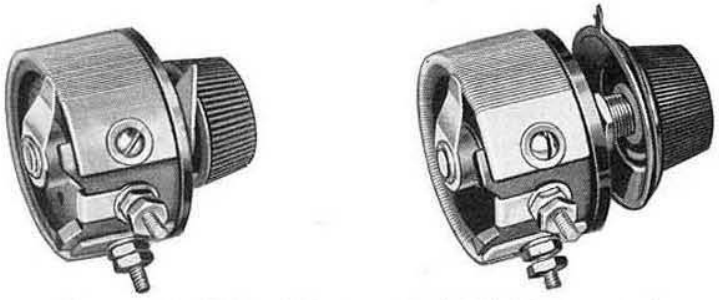
Angle of Rotation: 315°. No off position.

Knob: TYPE 137-D with pointer.

Net Weight: 5 ounces.

Type	*Resistance*	*Maximum Current*	*Code Word*	*Price*
214-A	**0.75 ohm**	4 a	SHINY	**$1.50**
214-A	**2 ohms**	2.5 a	RUDDY	**1.50**
214-A	**7 ohms**	1.3 a	RURAL	**1.50**
214-A	**20 ohms**	0.75 a	RAZOR	**1.50**
214-A	**50 ohms**	0.50 a	RAPID	**1.50**
214-A	**400 ohms**	175 ma	ROSIN	**1.50**
214-A	**2500 ohms**	70 ma	SYRUP	**1.50**

TYPE 301-A RHEOSTAT AND POTENTIOMETER



TYPE 301-A (*left*) and TYPE 410-A (*right*) Rheostats and Potentiometers are small size units made as rheostats and as potentiometers

This is another unit much smaller in size than either of the two single contact models previously described. It occupies little space on the panel or base board and is much in demand where a power rating of six watts is sufficient. Quantities are used in General Radio instruments as filament controls for small vacuum tubes.

Three sizes are made as rheostats, the fourth as a potentiometer as shown in the price list.

SPECIFICATIONS

Power Dissipation: 6 watts. The values of current corresponding to this rating are given in the price list.

Mounting: It is supplied for two-hole panel mounting, but it can easily be converted for base-board mounting. Machine screws and nuts furnished.

Dimensions: Over-all radius, including terminals, $1\frac{5}{16}$ inches; depth behind panel, $1\frac{1}{8}$ inches; shaft, $\frac{1}{4}$ inch.

Angle of Rotation: 255°. No off position on potentiometer.

Knob: TYPE 137-J with pointer.

Net Weight: 2 ounces.

Type	*Resistance*		*Maximum Current*	*Code Word*	*Price*
301-A	**6 ohms**	**Rheostat**	1 a	PALSY	**$1.00**
301-A	**12 ohms**	**Rheostat**	0.7 a	REMIT	**1.00**
301-A	**25 ohms**	**Rheostat**	0.5 a	RENEW	**1.00**
301-A	**200 ohms**	**Potentiometer**	175 ma	REBUS	**1.00**

TYPE 410-A RHEOSTAT AND POTENTIOMETER

These are exactly like the TYPE 301 Potentiometers, except that they are designed for a single-hole mounting by means of a threaded bushing.

SPECIFICATIONS

Power Dissipation: 6 watts. The values of current corresponding to this rating are given in the price list.

Mounting: Single-hole panel-mounting type. Outside diameter of bushing, $\frac{3}{8}$ inch. Maximum thickness of panel, $\frac{3}{8}$ inch.

Dimensions: Same as for TYPE 301-A.

Net Weight: 2 ounces.

Type	*Resistance*		*Maximum Current*	*Code Word*	*Price*
410-A	**6 ohms**	**Rheostat**	1 a	SABOT	**$1.00**
410-A	**12 ohms**	**Rheostat**	0.7 a	SALON	**1.00**
410-A	**25 ohms**	**Rheostat**	0.5 a	SALTY	**1.00**
410-A	**200 ohms**	**Potentiometer**	175 ma	SATIN	**1.00**

TYPE 340 RHEOSTAT

This rheostat is useful in connecting a low-impedance instrument, such as the TYPE 338 String Oscillograph or Vibration Galvanometer, to a high-voltage source, in cases where the use of a step-down transformer would introduce waveform distortion, or where the source is direct-current voltage.

SPECIFICATIONS

Range: Total resistance 100,000 ohms; tapped at 30, 100, 300, 1000, 3000, 10,000, 30,000, and 100,000 ohms as well as open circuit.

Type of Winding: 10,000 ohms and less, unifilar winding on cards; 30,000 and 100,000 ohms, lavite spool (graphite moulded into a spiral groove cut in a porcelain cylinder).

Accuracy of Adjustment: Not particularly important for uses specified. Wire-wound units, about 1%; lavite, about 10%.

Maximum Current: Below 1000 ohms, 50 ma; 1000-3000 ohms, 20 ma; above 3000 ohms, 10 ma.

Finish: Switch and resistances mounted on bakelite panel and enclosed in hand-rubbed walnut cabinet. All metal parts (except faces of contact points) nickel plated.

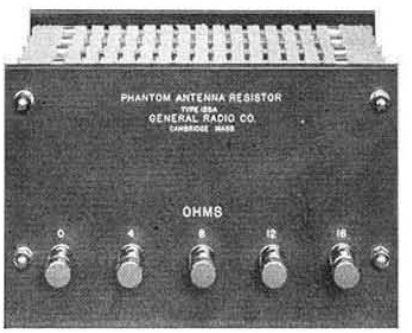
Dimensions: (Width) 3¾ x (length) 3½ x (depth) 3½ inches, over-all.

Net Weight: 1⅜ pounds.

Type		*Code Word*	*Price*
340	.....	SURLY	**$20.00**

TYPE 125 PHANTOM-ANTENNA RESISTOR

The TYPE 125 Phantom-Antenna Resistor is useful for tests on radio transmitters where it is desired to replace the antenna by a local circuit whose constants are more easily determined. By this means interference with other stations is prevented. This instrument is also useful about the laboratory where a reasonably accurate resistor of high current-carrying capacity is required.



SPECIFICATIONS

Maximum Power Dissipation: 400 watts, total, for TYPE 125-A; 900 watts, total, for TYPE 125-G.

Accuracy of Adjustment: 0.5%.

Temperature Coefficient: ± 0.002% per degree C.

Mounting: Ribbon wound on asbestos-board cards held vertically between bakelite end plates.

Type	*No. of Sections*	*Resistance per Section*	*Current per Section*	*Dimensions*	*Net Weight*	*Code Word*	*Price*
125-A	4	4 ohms	5 a	7¾ x 6 x 4¼ in.	3¼ lb.	RAVEN	**$18.00**
125-G	2	2 ohms	15 a	10¾ x 7⅝ x 5½ in.	7 lb.	REBEL	**28.00**

CONDENSERS

General Radio manufactures condensers to meet a wide variety of needs in electrical communications and general experimental work. The following table classifies the standard stock designs and serves as a summary of the data presented on succeeding pages.

VARIABLE AIR CONDENSERS

	Type	*Particular Applications*	*Identifying Features*
	222-F 222-L	Impedance bridges — Heterodyne-frequency meters — Oscillators. Anywhere that precision and stability of calibration are paramount	Micrometer drive
	222-M	The above, but especially in the bridge method of capacitance measurement by substitution	Micrometer drive with direct-reading calibration
	246	General laboratory measurements	Like TYPE 222 but without micrometer drive
	539	General laboratory measurements and experimental use	Direct drive — especially well adapted to unusual and special plate shapes
	247	Experimental use	Hard rubber end plates. Mounted models have an approximate direct-reading capacitance calibration
	334 335	Experimental and amateur transmitter use	Metal end plates. Some models have wide plate spacing for high-voltage circuits

PATENT NOTICE. General Radio Condensers which incorporate the following special features are manufactured under United States Patents as noted: Soldered plates, No. 1,542,995; plates other than of semicircular shape, No. 1,258,423; plates with wide angle of rotation, No. 1,525,778.

VARIABLE AIR CONDENSERS (cont.)

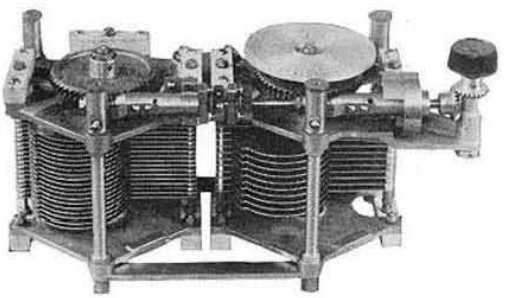
	Type	*Particular Applications*	*Identifying Features*
	568	Ultra high-frequency transmitters and receivers	Small size, isolantite end plates, removable insulated shaft
	368	Balancing or vernier use in experimental circuits	Small size

CONDENSERS WITH PAPER AND MICA DIELECTRIC

	Type	*Particular Applications*	*Identifying Features*
	380	For use where TYPE 219 Condensers are required in a panel-mounted assembly	Separate decade condenser units from which TYPE 219 Condensers are assembled
	219	Laboratory uses requiring adjustable calibrated condensers of large capacitance	Condensers adjustable in decade steps

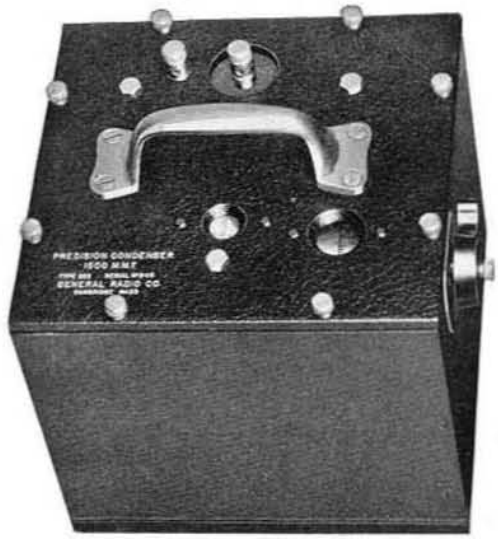
SPECIAL CONDENSERS FOR SPECIAL NEEDS

We can design and build to order condensers having special plate shapes or different capacitance ranges than the stock models described here. Many designs are already on file, especially in accurate straight-line-frequency plate shapes. Inquiries are invited.



TYPE 222 Precision Condensers can be built to order for special purposes. Note the tandem drive. Special plate shapes can also be obtained

TYPE 222-F and TYPE 222-L PRECISION CONDENSERS



TYPE 222 Precision Condensers have the worm-type micrometer drive operated by the knob at the right. The main scale and micrometer drive are observed through the two windows in the panel

This condenser is for use in measurements where the very highest order of calibration stability, precision of setting, and electrical performance are essential. Yet it is rugged enough for general laboratory work by students. It is used as a reference standard of capacitance, as the calibrated variable in bridge circuits, in oscillators, wavemeters, and heterodyne-frequency meters,[1] etc.

The losses are low and constant with setting, and calibrations can be relied on for long periods of time. Any setting can, with care, be duplicated to within one part in 10,000.

Low and constant losses are secured by using as little supporting dielectric as possible (consistent with mechanical rigidity) and by placing it in a weak and unvarying field whose intensity is independent of rotor position. This feature is especially important when the condenser is to be used for determining dielectric loss by the bridge-substitution method.[2]

The excellent precision of setting is made possible by the micrometer-type drive. The worm is lapped into place and held against the wheel by a spring, a method used in precision dividing engines for reducing backlash.

A TYPE 222 Precision Condenser will hold its calibration over long periods of time to better than 1 part in 1500. The plates are of thick aluminum, widely separated by accurately turned (not cast) spacers. They are clamped on the stator rods and rotor shaft, and the dead weight of the entire assembly is carried by the three supporting pillars attached to both end plates.

The effectiveness of this construction in maintaining stability of calibration is shown by the performance record of a TYPE 222-L Precision Condenser that has been in almost daily use in our laboratories. This condenser has been submitted to the U. S. Bureau of Standards for calibration at regular intervals and at no time in the last six years has the calibration changed by more than one micromicrofarad. Performance of this same high order is not uncommon.

The following paragraphs give the more important detailed specifications.

[1] See pages 50 and 58 for some examples.

[2] See the discussion of condenser losses in the Appendix and the section on impedance bridges.

SPECIFICATIONS

Capacitance Range: Two sizes, 1500 $\mu\mu$f and 500 $\mu\mu$f, nominal maximum capacitance are carried in stock, but other ranges can be built to order.

Rotor Plate Shape: Semicircular, to give linear variation in capacitance with angle of rotation.

Isolantite Supports: Six bars of isolantite, specially treated to prevent absorption of moisture, support the stator assembly.

Low Losses: $R\omega C^2$ is approximately 0.06×10^{-12} based on measurements at 1000 cycles, the exact value being given on the calibration chart. (See the Appendix for a discussion of $R\omega C^2$ as a figure of merit for variable air condensers.)

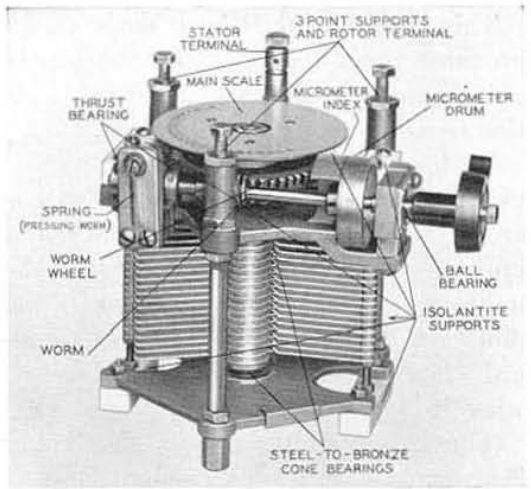
Drive: Gear and spring-pressed worm lapped in position to remove backlash. The micrometer drum is engraved with 100 divisions spaced approximately $\frac{1}{16}$th inch apart, 25 turns of which turn the rotor through 180°. Settings can be duplicated to within one part in 10,000 by estimating to $\frac{1}{4}$ of one division.

Backlash is less than $\frac{3}{4}$ of one division. It should be as small as possible for operating convenience, but if the desired setting is always approached in the direction of increasing scale reading, no calibration error will result.

Calibration: A mounted chart giving the capacitance to the nearest $\mu\mu$f for the twenty-six 100-division points is supplied with each condenser. The capacitance difference for each pair of adjacent settings is also given on the chart to facilitate interpolation.

Mounting: Each condenser is mounted on an aluminum panel finished in black crackle lacquer and is enclosed in a walnut cabinet.

Shielding: The aluminum panel and a copper lining in the cabinet are an effective electrostatic shield. The rotor is grounded to the shield.



A TYPE 222 Precision Condenser without the panel and cabinet

Terminals: Two binding posts are provided. The stator (high potential) terminal is brought out through a mica window, and the rotor terminal is in contact with the grounded panel.

Maximum Voltage: This condenser is not intended for high-voltage service, but it can be safely used at 800 volts, peak.

Storage Case: Each condenser is supplied with a wooden storage case fitted with a lock and carrying handle.

Dimensions: Panel, (length) $9\frac{1}{2}$ x (width) $8\frac{1}{4}$ inches. Cabinet, (height) $9\frac{3}{8}$ inches, over-all. Storage case, (length) $11\frac{5}{8}$ x (width) 10 x (height) $12\frac{5}{8}$ inches, over-all.

Net Weight: 15 pounds for the mounted condenser only; 25 pounds with storage case and calibration chart.

Type	*Nominal Capacitance*			*Code Word*	*Price*
	Maximum	*Minimum*			
222-L	**1500 $\mu\mu$f**	50 $\mu\mu$f	.....	COPAL	**$90.00**
222-F	**500 $\mu\mu$f**	40 $\mu\mu$f	.....	CORAL	**85.00**

TYPE 222-M PRECISION CONDENSER

This condenser has been designed to provide a direct-reading, adjustable standard of capacitance for use in the substitution measurement[1] of capacitance.

In this method, which is ideal for small values of capacitance, the calibrated standard is connected in parallel with the unknown. Two balances are required, the unknown capacitance being given by the difference between the values of the standard when the unknown is connected and when it is disconnected.

The TYPE 222-M Precision Condenser is arranged so that the capacitance difference may be read directly from the engraved scale, thus eliminating the use of a calibration chart and the computation of the unknown capacitance by subtraction. Zero scale reading corresponds to nearly maximum capacitance (about 1200 micromicrofarads), the first bridge balance being taken with this setting. The scale reading for the second balance may extend to a maximum difference capacitance of 1000 micromicrofarads, corresponding to an actual capacitance of about 200 micromicrofarads.

The micrometer drum is divided into 100 divisions, each corresponding to a change in capacitance of 1 micromicrofarad. Ten turns of the drum cover the range (1000 micromicrofarads).

The mechanical construction of the condenser is similar to that of the TYPE 222 Precision Condenser, described on the preceding page. The differences consist in the use of a 25 : 1 worm, a reduced number of plates, and means for the adjustment (in our laboratory) of two of these plates to give the desired calibration.

The following specifications list the details in which TYPE 222-M differs from the TYPES 222-F and 222-L Precision Condenser described on the preceding page.

[1] See the section on impedance bridges for details.

SPECIFICATIONS

Capacitance Range: Total change in capacitance 1000 $\mu\mu$f; capacitance at zero scale reading (maximum capacitance) about 1200 $\mu\mu$f, the exact value being given with each instrument.

Drive: Ten turns of the worm cover the entire range of the condenser, about 144°. Backlash is less than ½ of one division. For other drive details consult the preceding description of TYPES 222-L and 222-F.

Calibration: Each of the 100 divisions on the micrometer drum corresponds to 1 $\mu\mu$f. Each condenser is individually adjusted in our laboratory so that all values of incremental capacitance are accurate to within 1 $\mu\mu$f or 0.1% of the maximum.

Type	*Capacitance Change*		*Code Word*	*Price*
222-M	**1000 $\mu\mu$f**	.....	COBRA	**$100.00**

TYPE 246 VARIABLE AIR CONDENSER

The TYPE 246 Condenser is like the TYPE 222 Precision Condenser but it has no micrometer drive

This condenser is for use in measuring and experimental circuits requiring a high-grade unit in which extreme precision of setting and accuracy of calibration are not required: as the "balancing condenser" in the substitution method of capacitance measurement,[1] for example.

Electrically it is identical with the TYPE 222 Precision Condenser, the micrometer drive of the latter being replaced by a spur-gear slow-motion drive. It cannot be set with as great precision, but once set it should hold a setting almost as well.

The following detailed specifications show the points on which this condenser differs from TYPES 222-F and 222-L.

[1] See the section on impedance bridges for details.

SPECIFICATIONS

Capacitance Range: Three sizes, 1500 $\mu\mu$f, 3000 $\mu\mu$f, and 5000 $\mu\mu$f, are carried in stock.

Drive: A spur-gear slow-motion drive having a ratio of 10:1 is an auxiliary control for the large knob and dial mounted on the rotor shaft.

Calibration: No calibration is supplied with this condenser, but a mounted calibration curve accurate to within 0.5% of full-scale or a mounted calibration table for 11 points, accurate to 0.5% of full-scale, can be prepared to order. See the price list.

Maximum Voltage: TYPE 246-L and TYPE 246-M are conservatively rated at 800 volts, peak; TYPE 246-P, 500 volts, peak.

Storage Case: No storage case is supplied.

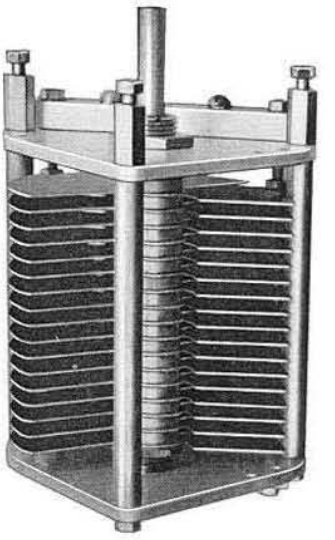
Dimensions: Panel, 7½ x 7½ inches. Cabinet, (height) for TYPE 246-L, 8⅜ inches; for TYPES 246-M and 246-P, 11⅜ inches, over-all.

Net Weight: TYPE 246-L, 11¼ pounds; TYPES 246-M and 246-P, 15 pounds.

Type	*Nominal Capacitance* — *Maximum*	*Minimum*	*Code Word*	*Price*
*246-L	1500 $\mu\mu$f	55 $\mu\mu$f	CEDAR	$38.00
*246-M	3000 $\mu\mu$f	70 $\mu\mu$f	CHAOS	45.00
*246-P	5000 $\mu\mu$f	72 $\mu\mu$f	CHARY	54.00
	Mounted Calibration Curve		CURVE	4.00
	Mounted 11-point Calibration Table		CHART	3.50

*Calibrations supplied only when ordered. Use compound code words, *e.g.*, CEDARCHART, CHAOSCHART, etc.

TYPE 539 VARIABLE AIR CONDENSER



The stator stack in a TYPE 539 Condenser is supported by two blocks of treated isolantite

This condenser is for use in laboratory measurements where the design refinements of TYPE 222 and TYPE 246 Condensers are not required. It has lower losses than either of our other laboratory-type condensers, but the losses ($R\omega C^2$) do not remain so nearly constant with setting nor is the stability of calibration quite so good. For a great many purposes this is no drawback and one can profit by the lower price.

Three brass rods, extensions of which serve as mounting pillars, rigidly support the two end plates on each of which is a block of isolantite carrying the two rods to which the stator is attached. This method insures low losses and facilitates the use of special plate shapes, like those in the TYPE 539-T (straight-line frequency, 270° angle of rotation) Condenser and the ones used as tuning controls in the General Radio TYPE 513-B and TYPE 613-A Beat-Frequency Oscillators.

The TYPE 539 Condenser is supplied either unmounted or mounted in a cabinet and with straight-line capacitance or straight-line-frequency plates. The straight-line-frequency model can also be supplied with a rotor that is insulated from the end plates and ground.

The following specifications describe the principal features.

SPECIFICATIONS

Capacitance Range: Four capacitance ranges are available in stock.

Rotor Plate Shape: Semicircular rotor plates giving a linear capacitance variation with setting are used on the following 6 models: TYPES 539-A, 539-B, 539-C, 539-J, 539-K, and 539-L.

Rotor plates for TYPES 539-T and 539-TA are cut to give a linear frequency variation with setting over 250° of a possible 270° angle of rotation when a capacitance of 25 $\mu\mu$f is connected in parallel with the condenser. They are assembled on the shaft so that counter-clockwise rotation produces an increase in frequency. The resulting frequency ratio is 3 : 1 starting from a setting corresponding to a condenser capacitance of 33 $\mu\mu$f, approximately.

Isolantite Supports: Two bars of isolantite, treated to prevent absorption of moisture, support the stator assembly.

Low Losses: $R\omega C^2$ is approximately 0.03×10^{-12} based on measurements at 1000 cycles. See the

Appendix for a discussion of $R\omega C^2$ as a figure of merit for variable air condensers.

Drive: The three cabinet models have a 100-division, TYPE 503-F (friction drive) Dial attached to the rotor shaft.

Dials are not supplied with the five unmounted models. Suitable knobs and dials are described in another section of this catalog. Note that all TYPE 539 Condensers have 3/8-inch shafts and that TYPES 539-T and 539-TA require a scale spread over 270°.

Calibration: The maximum and minimum values of capacitance accurate to within 0.5% of full-scale are engraved on the nameplate of each mounted model. If desired, a calibration, accurate to within 0.5% of full-scale can be supplied for the eleven 10-division points between 0 and 100 divisions. An extra charge (see price list) is made for this work.

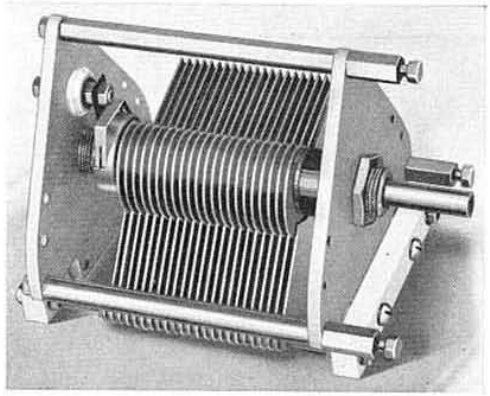
Calibrations cannot be supplied for the unmounted models, because the absence of a shield makes the capacitance variable with respect to the position of nearby objects.

Mounting: TYPES 539-A, 539-B, and 539-C are mounted in a polished walnut cabinet on an aluminum panel finished in black crackle lacquer.

The remaining four models are unmounted.

Shielding: The aluminum panel and a copper lining in the cabinet are an effective electrostatic shield for all mounted models. The rotor is grounded to this shield.

Terminals: Two binding posts are provided on all cabinet models. The stator (high potential terminal) is brought out through an isolantite bushing, and the rotor terminal is in contact with the grounded panel.



The TYPE 539-TA Condenser has straight-line-frequency rotor plates insulated from both the shaft and end plates

Soldering lugs for connections are mounted on the lower isolantite dielectric support of all unmounted models except TYPE 539-TA. The rotor connection for this condenser is brought out through an isolantite bushing in the back end plate.

Maximum Voltage: TYPE 539-A and TYPE 539-J are conservatively rated at 1100 volts, peak; TYPE 539-B and TYPE 539-K, at 800 volts, peak; TYPES 539-C, 539-L, 539-T, and 539-TA at 550 volts, peak.

Dimensions: For all mounted models: Panel, 6 1/2 x 6 1/2 inches. Cabinet, (height) 8 3/8 inches, over-all.

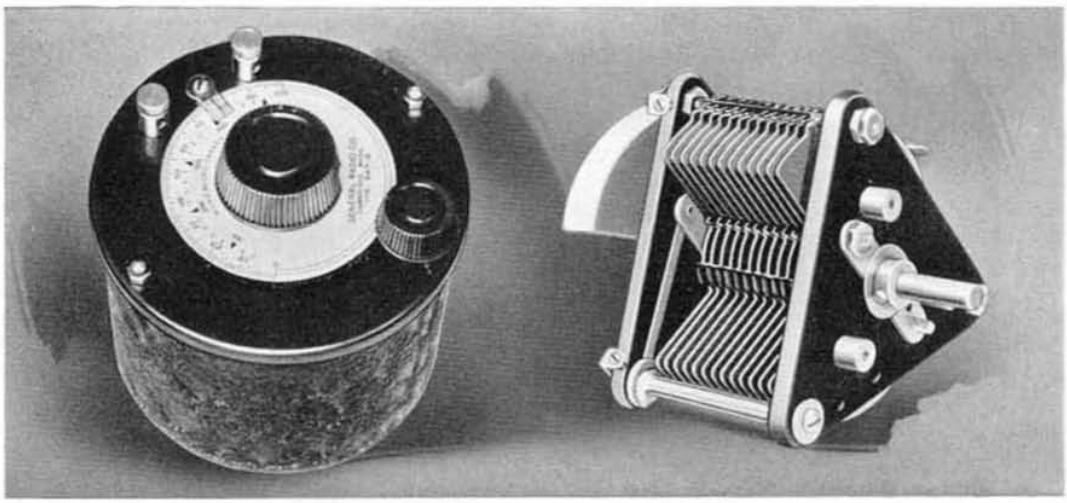
Unmounted models, when mounted on a panel, occupy a space 4 15/16 inches in diameter. The shaft protrudes 1 1/32 inch and the condenser extends 5 15/16, both dimensions measured from the back face of the panel.

Net Weight: Mounted models weigh approximately 6 3/4 pounds; unmounted models, approximately 2 3/4 pounds.

	Nominal Capacitance				
Type	*Maximum*	*Minimum*	*Description*	*Code Word*	*Price*
*539-A	500 μμf	50 μμf	Straight-line capacitance, cabinet	ASSAY	$22.00
*539-B	1000 μμf	55 μμf	Straight-line capacitance, cabinet	ASSET	23.00
*539-C	2000 μμf	60 μμf	Straight-line capacitance, cabinet	ASTER	24.00
539-J	500 μμf	50 μμf	Straight-line capacitance, unmounted	ATLAS	10.00
539-K	1000 μμf	55 μμf	Straight-line capacitance, unmounted	ATONE	11.00
539-L	2000 μμf	60 μμf	Straight-line capacitance, unmounted	ATTIC	12.00
539-T	500 μμf	30 μμf	Straight-line frequency, unmounted	CLOSE	12.00
539-TA	500 μμf	30 μμf	Straight-line frequency, unmounted, insulated rotor	CLOTH	15.00
	11-point Calibration Chart (for mounted models)			CHART	3.50

*Calibrations supplied only when ordered. Use compound code words, ASSAYCHART, ASSETCHART, OR ASTERCHART.

TYPE 247 VARIABLE AIR CONDENSER



TYPE 247-G (*left*) has a dial calibrated directly in micromicrofarads and internal construction like TYPE 247-F shown at the right

This is an inexpensive condenser with a number of features that have made it very popular in laboratories where experimental apparatus (radio receivers, testing equipment, etc.) is under development. This is particularly so for the mounted model which has a direct-reading calibrated scale, a distinct convenience in design work. Holes may be drilled through the bottom of the case for fastening it to a base board. This condenser is constructed with brass plates, soldered to make a rugged and low-resistance unit. Losses are kept low by the use of a very small amount of properly placed high-grade hard rubber.

SPECIFICATIONS

Range: Models having a nominal maximum capacitance of 500 $\mu\mu$f are available.

Rotor Plate Shape: TYPE 247-G has semicircular (straight-line capacitance) plates. TYPE 247-F has approximately straight-line wavelength plates.

Hard Rubber Dielectric: Two plates of first quality hard rubber support the rotor and stator plates.

Low Losses: Losses are low, $R\omega C^2$ being about 0.08×10^{-12}.

Drive: TYPE 247-G has an auxiliary slow-motion, pinion-gear drive. Knobs and dial are included. TYPE 247-F is supplied without a dial or knob but any General Radio dial and knob made to fit a $\frac{1}{4}$-inch shaft is suitable.

Calibration: The dial of the TYPE 247-G has a direct-reading calibration, accurate to within 4%, as shown in the illustration. TYPE 247-F is not calibrated.

Mounting: TYPE 247-G is mounted on a hard rubber panel in a drawn steel case. TYPE 247-F has 3 threaded studs for attaching to a panel, see illustration. Machine screws and drilling template are supplied.

Terminals: See illustrations.

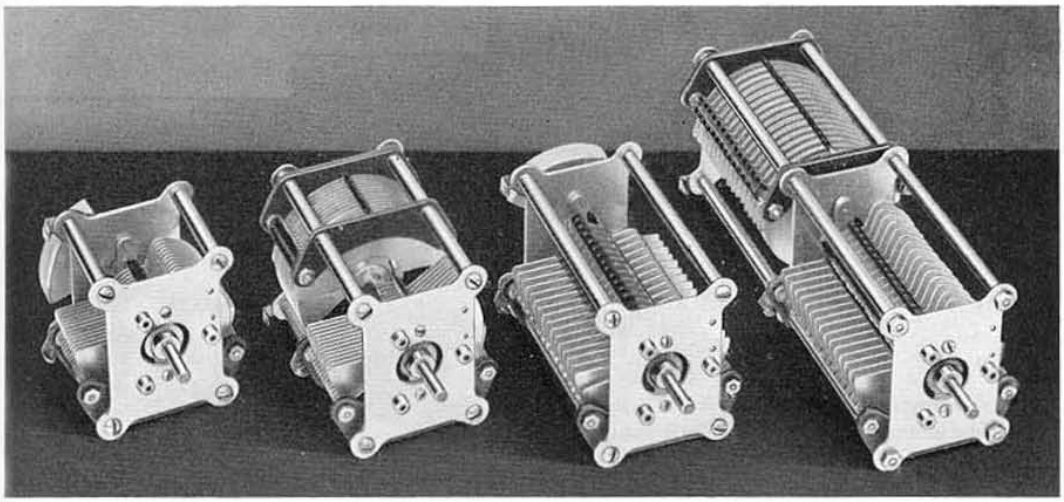
Maximum Voltage: Both models will safely withstand a peak voltage of 500 volts.

Dimensions: TYPE 247-G: Panel, (diameter) 5 inches. Over-all height, $4\frac{1}{2}$ inches. TYPE 247-F, when mounted on a panel, occupies an area $4\frac{1}{4}$ inches in diameter and extends $3\frac{1}{32}$ inches behind panel.

Net Weight: TYPE 247-G, $2\frac{3}{8}$ pounds. TYPE 247-F, $1\frac{3}{8}$ pounds.

Type	*Nominal Capacitance*		*Description*	*Code Word*	*Price*
	Maximum	*Minimum*			
247-G	**500 $\mu\mu$f**	30 $\mu\mu$f	Case mounted	COLIC	**$5.75**
247-F	**500 $\mu\mu$f**	20 $\mu\mu$f	Unmounted	COCOA	**3.00**

TYPES 334 and 335 VARIABLE AIR CONDENSER



Left to right: TYPE 334-F, TYPE 335-Z, TYPE 334-R, and TYPE 334-Z

This is another inexpensive condenser, similar in construction to TYPE 247 previously described, except that it has brass instead of hard rubber end plates. It can be supplied with wide spacing between the plates for high voltage work (amateur transmitters, power oscillators, etc.) as well as with the normal low-voltage spacing for ordinary experimental work.

TYPE 335-Z has a total capacitance change of 1100 micromicrofarads so that it can be used for interpolation purposes with TYPE 380 or TYPE 219 Decade Condensers on the smallest decade.

SPECIFICATIONS

Rotor Plate Shape: Approximately straight-line wavelength for all except TYPE 335-Z which has straight-line capacitance plates.

Hard Rubber Dielectric: Two small sections of first quality hard rubber support the stator.

Low Losses: Losses are low, $R\omega C^2$ being about 0.07×10^{-12} (from measurements at 1000 cycles).

Drive: When mounted on a panel the shaft of any of these condensers will protrude $^{27}/_{32}$ inch, measured from the *back* face of the panel. All have a $^1/_4$-inch shaft.

A counterweight to balance the torque, due to the rotor stack, is supplied with all except TYPE 334-Z and TYPE 335-Z which have balanced rotors.

Mounting: Three tapped inserts attached to one end plate on a $^7/_8$-inch radius are provided for mounting the condenser on a panel of any thickness between $^1/_8$ and $^5/_{16}$ inch. Drilling template and three flat head screws are furnished. See the illustration.

Four removable feet for mounting the condenser on a base board are furnished with each of the double-spaced or high-voltage models.

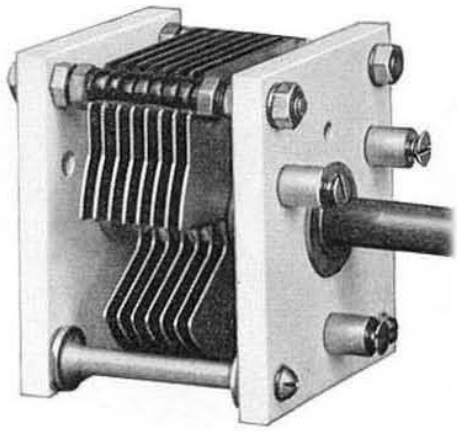
Maximum Voltage: High-voltage models will safely withstand 3500 volts, peak, before breakdown. Low-voltage models are rated at 500 volts.

Dimensions: All of these condensers occupy a panel space approximately $4^5/_8$ inches in diameter.

Type	*Nominal Capacitance* *Maximum*	*Minimum*		*Depth*	*Net Weight*	*Code Word*	*Price*
335-Z	**1150 μμf**	50 μμf	Low-voltage model	$5^1/_4$ in.	$2^1/_8$ lb.	BOGUS	**$6.00**
334-F	**500 μμf**	20 μμf	Low-voltage model	$3^5/_{16}$ in.	$1^1/_2$ lb.	BEGIN	**3.25**
334-N	**350 μμf**	20 μμf	Low-voltage model	$3^1/_8$ in.	$1^3/_8$ lb.	BESET	**3.00**
334-K	**250 μμf**	15 μμf	Low-voltage model	$2^5/_8$ in.	1 lb.	BELOW	**2.75**
334-Z	**500 μμf**	35 μμf	High-voltage model	$10^1/_8$ in.	$3^3/_8$ lb.	BOGEY	**10.00**
334-R	**250 μμf**	30 μμf	High-voltage model	$6^1/_2$ in.	2 lb.	BISON	**5.50**
334-T	**100 μμf**	15 μμf	High-voltage model	$3^1/_4$ in.	$1^1/_8$ lb.	BILLY	**2.75**
334-V	**50 μμf**	10 μμf	High-voltage model	$2^5/_8$ in.	$^5/_8$ lb.	BIPED	**2.50**

TYPE 568 VARIABLE AIR CONDENSER

This is a condenser of rugged construction for use as a tuning element in short-wave receivers, transmitters, and wavemeters. It is designed for tandem mounting, a hollow shaft permitting the use of a single long bakelite or metal shaft for driving several units. The isolantite end plates help to keep the losses at a minimum.



SPECIFICATIONS

Capacitance Range: Two sizes, 175 $\mu\mu$f and 50 $\mu\mu$f, maximum, are available. Each condenser has actual values greater than the nominal maximum and less than the nominal minimum given in the price list.

Rotor Plate Shape: Straight-line capacitance for the TYPE 568-D and straight-line frequency for the TYPE 568-K Variable Air Condensers.

Angle of Rotation: TYPE 568-D requires a dial with a scale spread over 180°; TYPE 568-K requires a dial with a scale spread over 270°.

Isolantite End Plates: End plates are of isolantite, treated to prevent moisture absorption.

Low Losses: Losses are low, $R\omega C^2$ being approximately 0.03 x 10^{-12} based on measurements at 1000 cycles.

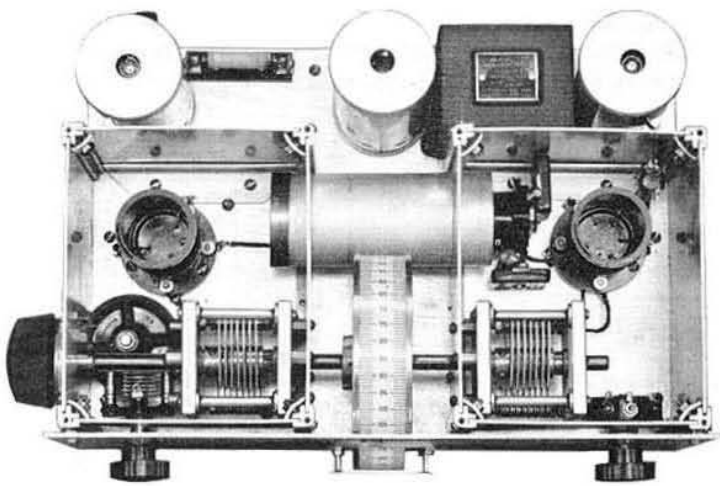
Drive: The rotor is attached to a hollow shaft through which a $\frac{3}{8}$-inch insulating or conducting shaft may be slipped and fastened with two screws. This permits driving several units wh have been mounted in tandem with the same sh A bakelite shaft extending a maximum of $1\frac{5}{8}$ inc from *rear* face of mounting panel is supplied w each condenser. Suitable dials are described i later section.

Mounting: Three tapped inserts attached to end plate on a $\frac{7}{8}$-inch radius are provided for mo ing the condenser on a panel of any thickness tween $\frac{1}{8}$ and $\frac{5}{16}$ inch. Drilling template and th flat head machine screws are furnished.

Dimensions: Panel space, $2\frac{1}{4}$ x $2\frac{5}{8}$ inches. O all depth behind a panel (exclusive of the shaft), inches.

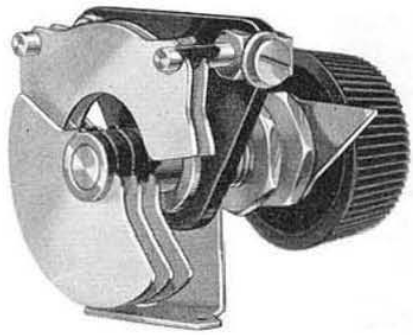
Net Weight: $\frac{3}{4}$ pound.

Type	*Nominal Capacitance* *Maximum*	*Minimum*		*Code Word*	*Price*
568-D	175 $\mu\mu$f	12 $\mu\mu$f	.....	CLOVE	$4.00
568-K	50 $\mu\mu$f	12 $\mu\mu$f	.....	CLOUD	4.00



An amateur short-wave receiver us two TYPE 568 Condensers driven the long bakelite shaft with the k at the left.—Courtesy *QST Maga*

TYPE 368 VARIABLE AIR CONDENSER



The TYPE 368 Condenser is well adapted for use in high-frequency receivers

This condenser is useful as a balancing or vernier condenser in various vacuum-tube circuits, and many amateurs use it as a tuning condenser in receivers for the high-frequency (short-wave) bands. It has a single, hard rubber end plate, single bearing, and can be used for single-hole panel mounting as well as for mounting on a base board by means of the angle bracket.

SPECIFICATIONS

Capacitance Range: Three sizes, 15 $\mu\mu$f, 50 $\mu\mu$f, and 100 $\mu\mu$f, are regularly carried in stock. Each condenser has actual values greater than maximum and less than the minimum nominal values given in the price list.

Rotor Plate Shape: Straight-line capacitance.

Hard Rubber Dielectric: A single, hard rubber end plate supports the entire assembly.

Low Losses: Losses are very low, due to the small amount of solid dielectric in the field, $R\omega C^2$ being approximately 0.004×10^{-12} based on measurements at 1000 cycles.

Drive: A TYPE 137-J Knob (see a later section) is supplied with each condenser.

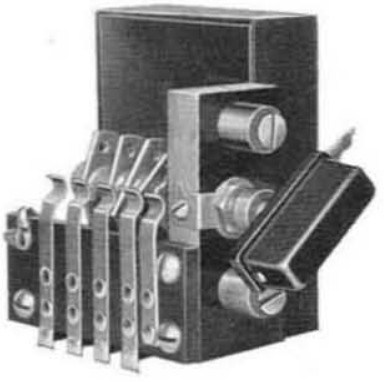
Mounting: The condenser may be mounted on a panel using the single-hole bushing or on a base board using the bracket shown in the illustration.

Dimensions: Panel space, approximately 2 inches in diameter. Each condenser extends behind a panel approximately 2¼ inches.

Net Weight: Approximately 3 ounces.

Type	*Nominal Capacitance*			*Code Word*	*Price*
	Maximum	*Minimum*			
368-A	15 $\mu\mu$f	4 $\mu\mu$f	.....	BULLY	$0.75
368-B	50 $\mu\mu$f	4 $\mu\mu$f	.....	BURIN	1.00
368-C	100 $\mu\mu$f	4 $\mu\mu$f	.....	AZURE	1.75

TYPE 380 DECADE CONDENSER UNIT



Air condensers for the large values of capacitance are so bulky that they would be of little use in the average laboratory even if it were possible to find an economical solution for the mechanical problems involved. TYPE 380 Decade Condensers, made up of carefully constructed paper and mica condensers, offer a satisfactory compromise for most needs.

The TYPE 380 Decade Condenser is an assembly of individual paper or mica condensers and a selector switch arranged so that any one of 10 decade values may be chosen. It is made in three individual decade series, each with 10 steps of 0.001, 0.01, or 0.1 microfarads respectively.

The excellence of these units is due, in large measure, to care in manufacture and aging. The mica is carefully selected and the condenser is built to hold its calibration over long periods of time. Mica condensers are moulded in bakelite to help preserve their characteristics. The paper condensers are thoroughly impregnated with molten paraffin during the winding process. Succeeding layers of the conducting foil make contact, thus avoiding the increase in power factor with frequency which occurs when connections are made only at the ends of a winding. They are subjected to heat treatment which makes them practically free from aging effects at normal temperatures.

SPECIFICATIONS

Capacitance: Three sizes are available with decade steps of 1000 $\mu\mu$f, 10,000 $\mu\mu$f, and 100,000 $\mu\mu$f per step. See the price list. The desired value of capacitance is secured by various combinations of four condensers having values of 1, 2, 3, and 4, respectively.

Dielectric: Mica is used for the two smaller sizes and paraffin paper for the largest one.

Maximum Voltage: The maximum peak alternating-current voltage should never be allowed to exceed the rated direct-current voltage, *i.e.*, 300 volts. The losses in any condenser with the solid dielectric are a function of the applied frequency and it is necessary to consider frequency when placing a maximum voltage limit, since excessive heat can cause temperature increases that are disastrous in a calibrated unit. The peak voltage may be kept at the 300-volt maximum for frequencies below 1000 kc for the 0.001-μf decade, below 100 kc for the 0.01-μf decade, and below 1 kc for the 0.1-μf decade. At higher frequencies the voltage should be reduced in direct proportion to the increase in frequency.

Power Factor: $R\omega C$, the power factor, is 0.002, 0.001, and 0.010 for the 0.001-μf, 0.01-μf, and 0.1-μf units, respectively.

Calibration: The shaft of each unit is provided with a detent device to make definite the position of the switch for each setting. The condensers are so adjusted that the capacitance for each setting is accurate to within 1% for the 0.001-μf and 0.01-μf units and to within 2% for the 0.1-μf decades.

Mounting: Individual decades are mounted in brass cans with a bakelite panel.

Dimensions: Panel space, height, 3¾ inches; width, 3$\frac{1}{16}$ inches except each unit extends approximately 3¾ inches behind the panel. TYPE 380-C which is 3$\frac{9}{16}$ inches, over-all. Each unit will extend 3⅞ inches behind the back face of the panel on which it is mounted.

Net Weight: Approximately 1¾ pounds, all sizes.

Type	*Capacitance*	*Code Word*	*Price*
380-A	**1.0 μf total, in steps of 0.1 μf**	ADAGE	**$10.00**
380-B	**0.10 μf total, in steps of 0.01 μf**	ADDER	**20.00**
380-C	**0.010 μf total, in steps of 0.001 μf**	ADDLE	**10.00**

TYPE 219 DECADE CONDENSER

The TYPE 219 Decade Condenser can be supplied in 2- and 3-dial sizes

This consists of TYPE 380 Condenser Units mounted on a panel in a cabinet for convenience in the laboratory. Each one is direct reading in capacitance. They are useful as capacitance standards where work of ordinary commercial accuracy is being done.

The following specifications show the principal features of the instrument. In addition, see the opposite page.

SPECIFICATIONS

Capacitance: Three sizes are available in stock as shown in the price list.

Calibration: The capacitance at the terminals of the unit is accurate to within the same limits as the individual TYPE 380 Decade Condenser Units after allowance is made for the "zero capacitance" of 40 $\mu\mu$f. See page 40, "Calibration."

Power Factor: See the description of the TYPE 380 Decade Condenser Units. When all switches are set at zero, the power factor is 0.05.

Mounting: Units are assembled on an engraved bakelite panel and mounted in a polished walnut cabinet.

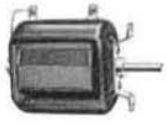
Dimensions: Panel width, 5 inches. Height of cabinet, including knob, 6 inches, over-all. Panel length: for TYPES 219-F and 219-J, 9½ inches; for TYPE 219-G, 12¾ inches.

Net Weight: For TYPES 219-F and 219-J, 5¼ pounds; for TYPE 219-G, 8 pounds.

Type	*Capacitance*	*No. of Dials*	*Code Word*	*Price*
219-F	**1.10 μf total, in steps of 0.01**	2	COVER	**$32.00**
219-G	**1.110 μf total, in steps of 0.001**	3	BRIER	**50.00**
219-J	**0.110 μf total, in steps of 0.001**	2	CRONY	**32.00**

INDUCTORS

The measurement laboratory requires both fixed and variable inductance standards for bridge work. The fixed standards permit a somewhat higher degree of precision and are recommended where the highest precision of measurement is desired. The fixed standards, however, require a bridge with continuously adjustable ratio arms. A variable standard must, of course, be used when the bridge does not have continuously adjustable ratio arms.

	Type	*Particular Application*	*Identifying Features*
	**107**	For all laboratory uses requiring an accurate, adjustable inductor.	Variometer in which rotor and stator can be used separately or connected in series or parallel.
	**106**	Laboratory standard of inductance.	Accurately adjusted — small external field.
	**268**	General-purpose coupling inductor.	Compact, inexpensive.
	**269**	General-purpose variable inductor.	Compact, inexpensive.
	**577**	General-purpose fixed inductor.	Compact, inexpensive, plug-in

TYPE 107 VARIABLE INDUCTOR

This inductor has been completely redesigned. It provides a high-grade variable laboratory inductor. Permanence, low high-frequency resistance, an increased range, and an unusually high current-carrying capacity have been obtained.

Separate terminals are brought out for rotor and stator so that they may be connected in series or in parallel as a self-inductor, or used separately as a mutual inductor. The inductances of rotor and stator have been carefully equalized to eliminate losses due to circulating current when the parallel connection is used.

The inductance variation with scale reading is approximately linear. It is nearly constant over a wide frequency range.

The new TYPE 107 Inductors have an increased range and greater permanence of calibration

SPECIFICATIONS

Inductance Range: Five sizes are available in stock covering a total range of approximately 1.3 μh to 500 mh by the use of both the series and parallel connections. The price list shows nominal maximum values for the series connection and minimum values for the parallel connection in each size. Actual values will be greater than the nominal maximum and less than the nominal minimum, respectively.

A range of approximately 10 to 1 is covered with either connection alone. The inductance with the parallel connection is one-quarter that for the series connection.

Calibration: Values of maximum and minimum inductance for the series connection accurate to within 1% at 1000 cycles are engraved on the nameplate of each instrument.

A mounted calibration curve for the series connection (see price list) accurate to within 1% at 1000 cycles can be obtained on special order. Inductance values for the parallel connection are one-quarter the values for the series connection to within 1% at all settings. The mutual inductance between rotor and stator for any setting is equal to one-half the difference between the series-connection self-inductances for that setting and for the setting where the mutual inductance is zero (approximately 50 scale divisions).

Low Losses: The excellent high-frequency characteristics of this inductor are best expressed by its ratio of reactance to resistance (or Q) at a given frequency. Q is the reciprocal of power factor. Representative values for the series connection are given in the table, next paragraph.

Natural Frequency: See the following table.

Type	*Maximum Inductance*	*Q at f*		*Natural Frequency*
107-J	0.05 mh	110	400 kc	5000 kc
107-K	0.5 mh	140	200 kc	1500 kc
107-L	5 mh	125	60 kc	500 kc
107-M	50 mh	65	20 kc	150 kc
107-N	500 mh	20	7 kc	30 kc

Resistance: D-c resistance for the series connection of each unit at room temperature is engraved on its nameplate. Approximate values are given on the price list. D-c resistance of rotor and stator are approximately equal.

Maximum Current: The maximum allowable current for a dissipation of 15 watts and temperature rise of 40° C. (series connection) is engraved on each nameplate. See price list for a list of values.

Drive: All sizes have a 100-division, 4-inch, TYPE 503-F (friction drive) Dial directly connected to the rotor shaft.

Mounting: All units are mounted on bakelite panels and enclosed in walnut cabinets.

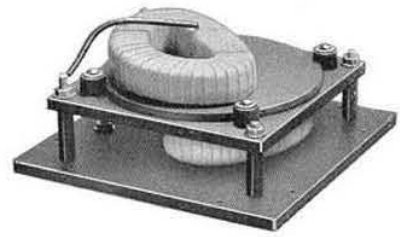
Dimensions: Panel, 6½ x 6½ inches. Cabinet, (height) 8¾ inches, over-all.

Net Weight: 5 pounds, all ranges.

Type	*Inductance Maximum*	*Inductance Minimum*	*D-C Resistance*	*Maximum Current*	*Code Word*	*Price*
*107-J	**0.05 mh**	0.0013 mh	0.17 ohm	8.5 a	HAREM	**$30.00**
*107-K	**0.5 mh**	0.013 mh	0.7 ohm	4.0 a	HARPY	**30.00**
*107-L	**5 mh**	0.13 mh	4 ohms	1.7 a	HARRY	**30.00**
*107-M	**50 mh**	1.3 mh	40 ohms	.60 a	HOTEL	**30.00**
*107-N	**500 mh**	13 mh	64 ohms	.14 a	HOVER	**40.00**
	Mounted Calibration Curve				CURVE	**5.00**

*Calibrations supplied only when ordered. Use compound code words, HAREMCURVE, HARPYCURVE, etc.

TYPE 106 STANDARD INDUCTANCE



This fixed inductor is accurately adjusted

This fixed standard is accurately adjusted at 1000 cycles. Low and nearly constant resistance at audio frequencies is insured by the use of stranded wire having the separate strands insulated from each other.

Interaction between the field of an inductor and external fields is practically eliminated by the use of an astatic form of winding in which the fields of two-coil sections neutralize each other.

Coils are form wound, bound with tape, and impregnated with wax. There is no metal in the concentrated field of the coil.

SPECIFICATIONS

Inductance Calibration: The 0.1 mh size is adjusted to within 1%; all other sizes are adjusted to within 0.1% of their labeled values at 1000 cycles.

Resistance: Resistance at 1000 cycles is the same as the d-c resistance, the value of which, measured at room temperature, is entered on a certificate mounted on the bottom of the cabinet. See price list for approximate values.

Maximum Current: See price list.

Mounting: All units are assembled in walnut cabinets with bakelite panels.

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*	*Resistance*	*Maximum Current*	*Code Word*	*Price*
106-L	**0.1 mh**	0.18 ohm	3.5 a	INNER	**$25.00**
106-G	**1 mh**	1.80 ohms	1.0 a	INERT	**25.00**
106-J	**10 mh**	12.2 ohms	0.5 a	IRATE	**25.00**
106-K	**100 mh**	85.3 ohms	250 ma	ISLET	**25.00**
106-M	**1 henry**	545 ohms	150 ma	ISSUE	**36.00**

TYPE 268 VARIOCOUPLER

This coupling unit, for laboratory and experimental use, can be adapted for base board as well as panel mounting by interchanging the front and back mounting brackets. The rotor and stator forms are readily dismounted for rewinding to meet special requirements and many laboratories keep a stock for this purpose.

SPECIFICATIONS

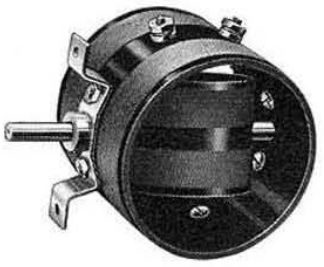
Inductance: Stator, 380 μh; rotor, 106 μh.

Shaft Diameter: ¼ inch.

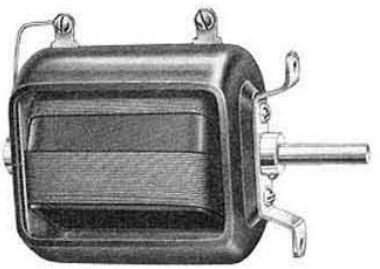
Dimensions: 4 x 4 x 2½ inches.

Net Weight: 6 ounces.

Type		*Code Word*	*Price*
268	.....	VALET	**$2.75**



TYPE 268 Variocoupler



TYPE 269 Variometer

TYPE 269 VARIOMETER

This unit is intended for use as a variable inductor, but it can be used to vary the coupling between two circuits. The coefficient of coupling and the mutual inductance is much greater than in the TYPE 268 Variocoupler.

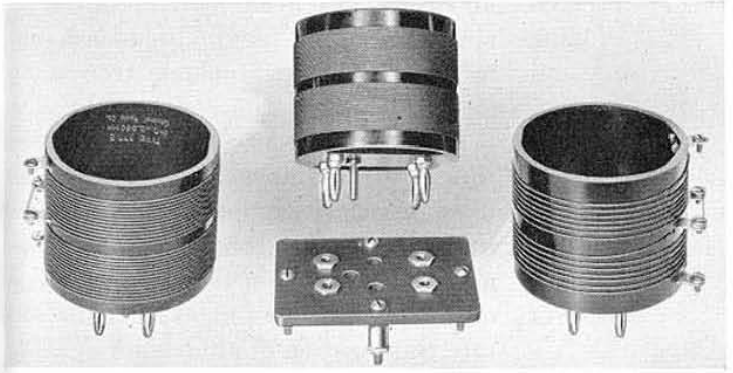
SPECIFICATIONS

Inductance: With rotor and stator connected in series the maximum inductance is approximately 820 μh; the minimum, 100 μh.

Shaft Diameter: ¼ inch.
Dimensions: 4¾ x 3 x 1¾ inches.
Net Weight: 7 ounces.

Type	*Code Word*	*Price*
269	VALID	**$4.00**

TYPE 577 INDUCTOR



These inductors are interchangeable in a TYPE 274-EJ Jack Base, shown lower center. See the section on plugs and jacks for a complete description

This is available in three sizes to meet a need for convenient tuning inductors for the laboratory. The unwound coil form is also available.

SPECIFICATIONS

Mounting: Holes provided for TYPE 274-P Plugs (not furnished with inductors). Drilled to fit TYPE 274-CJ or TYPE 274-EJ Mounting Bases.

Dimensions: 3¼ x 3¼ x 2¼ inches.
Net Weight: 3 ounces.

Type	*Inductance*	*Tuning Range**	*Turns*	*Code Word*	*Price*
577-A	**16 mh**	6000–2000 kc	14	NABOB	**$1.50**
577-B	**60 mh**	3000–1000 kc	27	NABIR	**1.50**
577-C	**190 mh**	1500– 500 kc	55	NAIVE	**1.50**
577-U	Unwound Coil Form			NATAL	**.70**

*With a 500 $\mu\mu$f condenser.

FREQUENCY- AND TIME-MEASURING DEVICES

CONSULT BULLETIN A

for detailed descriptions and uses for General Radio precision time- and frequency-measuring equipment:

Primary standards
Secondary standards
Heterodyne frequency meters
Interpolation equipment
Frequency monitors

Everything is listed in the following pages, but when you want detailed data ask us to mail you a copy of Bulletin A, now in preparation and available after November 30, 1932.

Your copy of Bulletin A will be sent by parcel post the same day your request is received. If, however, your need is urgent, we'll send it special handling, on request.

Several years ago the General Radio Company began a comprehensive research program for the purpose of developing high precision standards of frequency and apparatus for the measurement of frequency. Since frequency and time are fundamentally related, it follows that frequency standards and frequency-measuring devices have many applications in the measurement of time intervals. The standard-frequency assembly is an example of this idea.

The development of the standard-frequency assembly has opened up the wide field of frequency measurement by heterodyne methods, leading to the development of many kinds of auxiliary equipment in order to provide means for the accurate measurement of frequency over the entire communication spectrum.

In addition, monitoring equipment for radio channels between 50 and 25,000 kilocycles has been manufactured. The apparatus is in use in broadcast, commercial, and government transmitting stations.

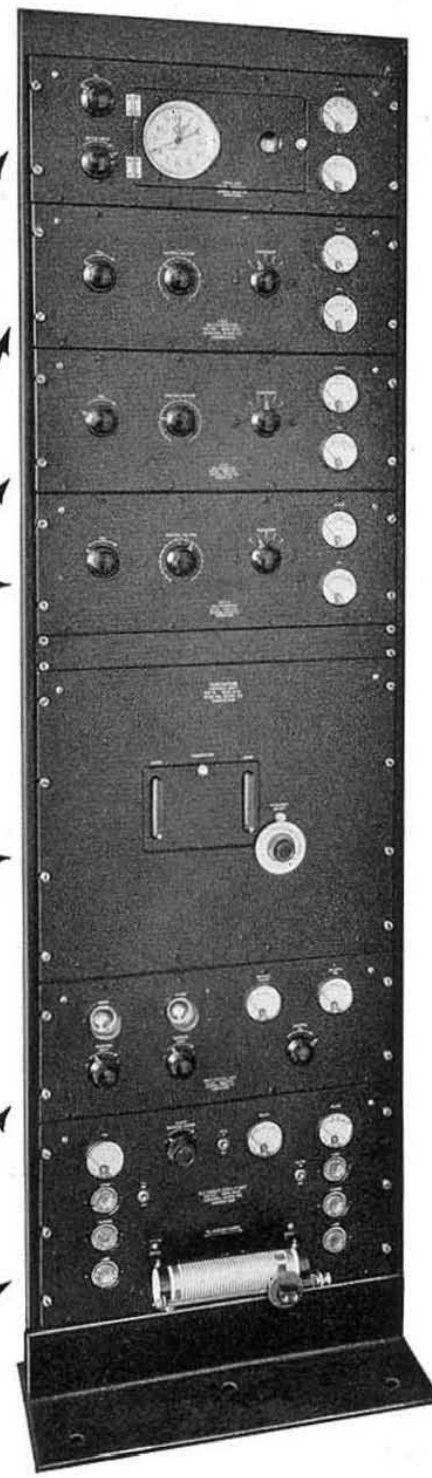
In the precise measurement of time and time intervals, developments have been more specialized, tending toward solutions of specific problems. Among these are measurements of the velocity of light, of the speed of rifle bullets, and the accurate transmission of radio time signals.

Laboratories and others interested in particular phases of frequency or time measurements are reminded that work on new methods and equipment is continually in progress and that we are prepared to develop and manufacture special-purpose equipment to order. Specific inquiries on all phases of frequency and time measurement are invited.

PRIMARY STANDARD OF FREQUENCY

The Class C-21-H Standard-Frequency Assembly is a complete primary standard of high precision. It is provided with a means for measuring the frequency of its crystal in terms of standard time without reference to any other standard of frequency. In addition it is arranged so that harmonic series of 1, 10, and 50 kilocycles are available to furnish calibrating points over the entire communication-frequency spectrum. From it can also be obtained one-second pulses and standard time.

The crystal oscillator in this assembly has a guaranteed accuracy of one part in a million but after the equipment has



Type 593-A Timing Unit

This unit contains a synchronous motor-driven clock (or counter) for comparing the frequency of the crystal with standard time. It consists of an input amplifier, a 1000-cycle synchronous motor-driven clock and an output amplifier for distributing a standard 1000-cycle signal to various parts of a laboratory. The clock carries a mechanism for generating one-second pulses and for comparing clock time with radio time signals to within 0.01 second.

Type 592-A Multivibrators

Two of these units are used as frequency dividers to reduce the 50-kilocycle crystal frequency to 1000-cycles for driving the timing unit. They also generate harmonic series of 1000 cycles and 10 kilocycles; a third unit generates 50-kilocycle harmonics. All of these frequencies are entirely controlled by the frequency of the crystal oscillator.

Type 590-A Piezo-Electric Oscillator, Type 576-A Quartz Bar, and Type 591-A Temperature-Control Unit

The temperature of the frequency determining elements of the assembly is held to within narrow limits by means of a two-stage temperature-control box. The inner box houses the 50-kilocycle quartz bar and keeps its temperature within 0.01°C. The outer box contains the other oscillator circuit elements and controls their temperature to within 0.1°C. The piezo-electric oscillator is designed for extreme frequency stability and its frequency is adjustable over a small range.

Type 594-A Heat-Control Panel

This panel contains the necessary controls for the crystal oscillator and the temperature box.

Type 595-A Power-Supply Unit

The rectifiers, filters, and controls for trickle charging the batteries are mounted in this unit. It contains a 6-volt, 5-ampere Tungar rectifier and a 180-volt rectifier for the plate battery.

Complete Description in Bulletin A

been installed and aged for some time an accuracy five times better can often be obtained. Each of the harmonic frequencies is known with the same accuracy so that measurements made anywhere over the entire range will have an accuracy far in excess of present-day requirements.

Originally developed for use in our own calibration work this assembly has since been installed by more than fifteen universities, communication companies, and government agencies in the United States and abroad.

Price: **$1860.00.**

SECONDARY STANDARD OF FREQUENCY

A good secondary standard of frequency is satisfactory for many uses where the reliability and extreme precision of a primary standard are not absolutely essential. It can be equipped with one or more multivibrators to yield a wide range of harmonic frequencies, and the reliability of its frequency can be of a fairly high order, especially if the standard is checked at frequent intervals against the standard-frequency transmissions of the United States Bureau of Standards or some other accurate source.

A suitable secondary standard is a Class C-10 Standard-Frequency Assembly which utilizes a temperature-controlled quartz crystal and a crystal oscillator operating at 100 kilocycles and is capable of maintaining its frequency to better than 20 parts in a million for long periods of time. The oscillator controls one multivibrator at a fundamental frequency of either 10 kilocycles or 100 kilocycles, as desired, so that harmonic series of both are obtainable, each known to better than 20 parts per million. The range is, thus, from 10 kilocycles to 6000 kilocycles or more, and each of the output frequencies can be utilized by the use of heterodyne methods.

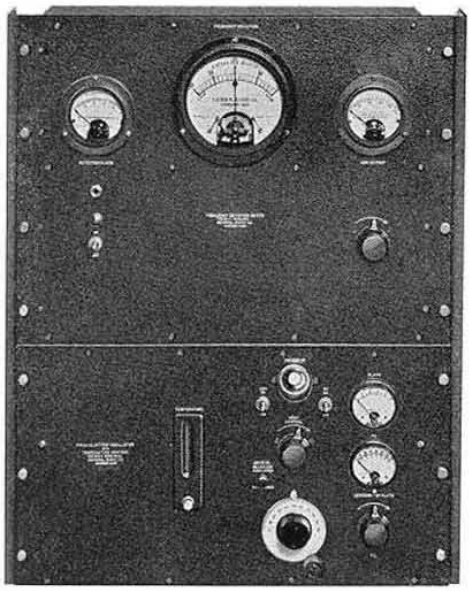
This standard is particularly recommended for the needs of the small college laboratory and of communication companies furnishing a limited class of service. Used in conjunction with either a TYPE 615-A or a TYPE 616-A Heterodyne Frequency Meter, measurements to better than 0.01 per cent can be made on transmitters and on received signals from below 100 kilocycles to 30,000 kilocycles.

The price of **$450.00** is for the crystal, the oscillator, and one multivibrator, but it does not include the TYPE 480-B Relay Rack, the blank panel, or the TYPE 616-AR Heterodyne Frequency Meter shown in the accompanying illustration.

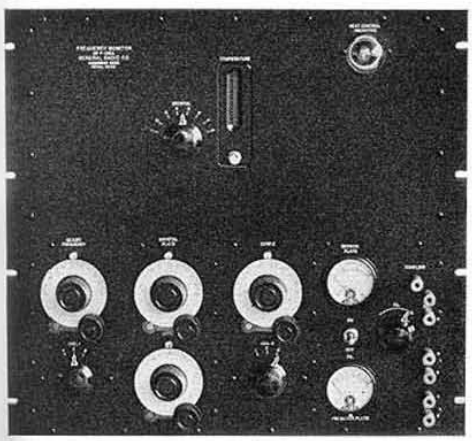
Complete Description in Bulletin A

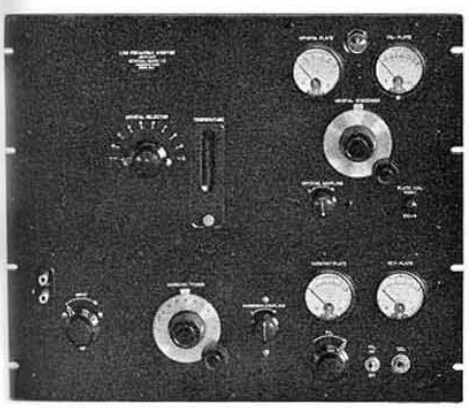
A Class C-10 Standard-Frequency Assembly with a TYPE 616-AR Heterodyne Frequency Meter (upper panel) makes a frequency-measuring equipment that is complete, except for the necessary radio receiver

FREQUENCY MONITORING EQUIPMENT



More than 150 U. S. broadcasting stations rely on this monitor to keep their transmitters within the 50-cycle tolerance





These two monitors are typical of those built for multiple-channel service. Any one of 8 or 10 different crystals can be selected at will

Frequency monitoring, while employing methods and equipment as used in frequency standardization and measurement, is specialized in that monitoring deals with the maintenance of station frequencies at prescribed values, or the routine measurement of the frequencies of groups of stations. The apparatus and methods consequently are modified to emphasize automatic or direct-reading features, or to shorten to a minimum the time required to make an observation.

For use in radio broadcasting and police radio stations, we offer a visual-type monitor consisting of the following units.

Item	*Price*
TYPE 575-D Piezo-Electric Oscillator	$215
TYPE 376-J Quartz Plate	85
TYPE 581-A Frequency-Deviation Meter	250
Total	**$550**

The use of this monitoring equipment will enable a station to maintain its frequency within a very few cycles of its assigned channel, complying with the 50-cycle monitoring tolerance required by the Federal Radio Commission. It is simple, easily installed, and shows both the magnitude and direction of a frequency drift. It has been approved by the Federal Radio Commission, Approval No. 1452.

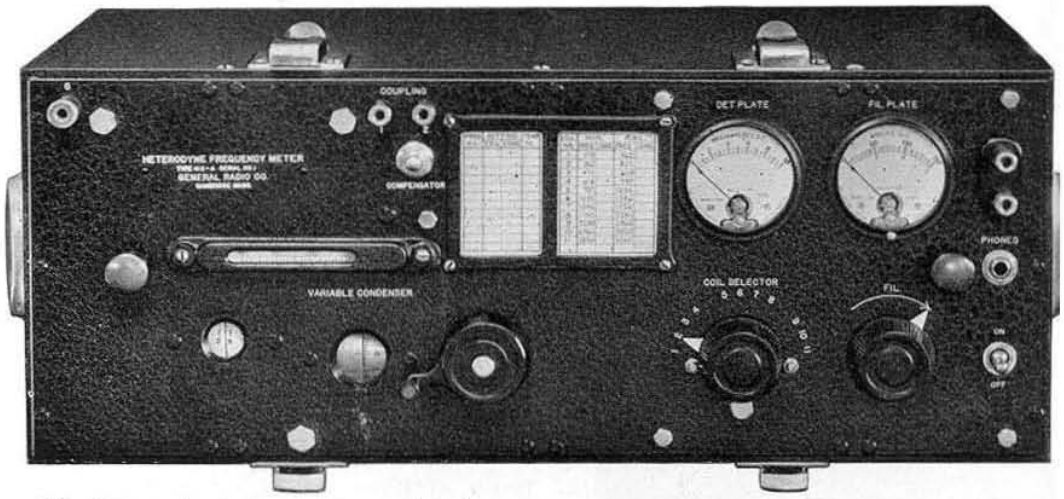
OTHER TYPES OF MONITORS

While we have built several other types of monitors, these have all been designed to meet the specific needs of the individual user. Photographs of two of these are shown on this page.

We are prepared to build equipment for monitoring all types of radio-communication channels. Inquiries concerning any special problems are solicited.

Complete Description in Bulletin A

TYPES 615-A and 616-A HETERODYNE FREQUENCY METERS



The heterodyne frequency meter is one of the most useful instruments in any frequency-measuring system. It has several advantages over the absorption type of wavemeter. By using heterodyne methods, settings can be made with much better precision, and measurements can be made at frequencies above and below the fundamental range through the use of harmonic methods. It can be used as a calibrated frequency-measuring instrument in the same way that a wavemeter is commonly used and it can also be used to interpolate between standard harmonic frequencies.

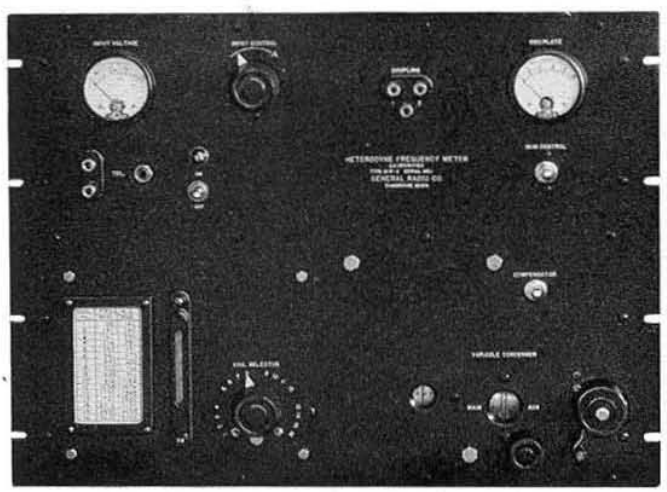
The TYPE 616-A Heterodyne Frequency Meter is a highly stable oscillating frequency meter using a new type of circuit. Its outstanding features are voltage stabilization, straight-line-frequency precision condenser and complete alternating-current operation. It includes a detector and audio amplifier for listening to heterodyne beats. It is designed for mounting a standard 19-inch (TYPE 480) relay rac Its fundamental frequency range is 1(kilocycles to 5000 kilocycles.

TYPE 615-A Heterodyne Frequency Meter

The TYPE 615-A Heterodyne Frequenc Meter is a portable battery-operated i strument similar in its operating chara teristics to the TYPE 616- Heterodyne Frequency Met described in the preceding par graph. A detector is include It is supplied in a covered al minum case with a carryi handle and has space for t necessary batteries. Its fund mental frequency range is fro 275 to 5000 kilocycles.

Prices: TYPE 615-A Heter dyne Frequency Mete **$375.00,** complete with ca brations and tubes.

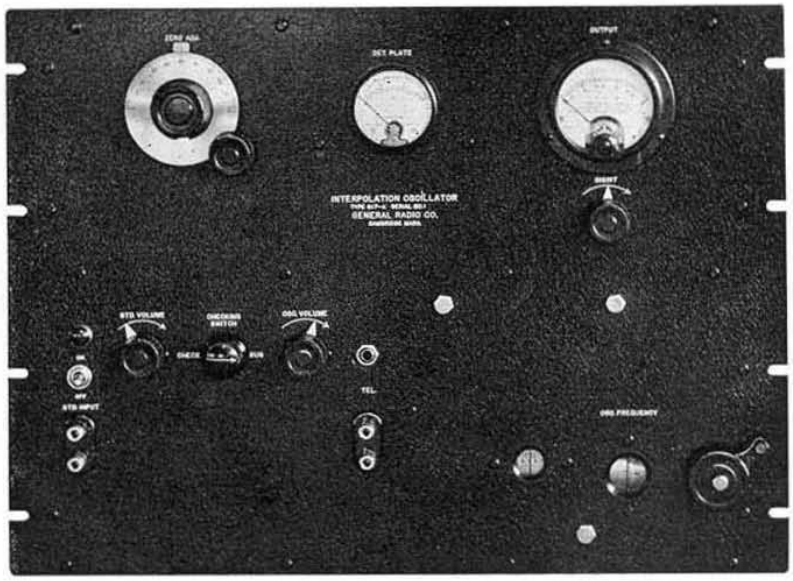
TYPE 616-AR Heterody Frequency Meter, **$500.0** complete with calibrations a tubes.



TYPE 616-AR Heterodyne Frequency Meter

Complete Description in Bulletin A

TYPE 617-A INTERPOLATION OSCILLATOR



This is a direct-reading beat-frequency oscillator for rapidly and accurately measuring the beat between a standard harmonic and a frequency under measurement. Oscillators of exceptional frequency stability are used. The frequency control is a straight-line-frequency precision condenser, calibrated directly in frequency, one cycle per scale division. Means are provided for introducing standard calibrating frequencies, either from a standard frequency assembly or some other reliable source, such as a 60-cycle line. A visual beat indicator is included.

It is designed for alternating-current operation and for mounting upon a standard 19-inch (TYPE 480) relay rack.

Price: **$500.00,** complete with tubes and calibration.

Complete Description in Bulletin A

TYPE 618-A HARMONIC OSCILLATOR

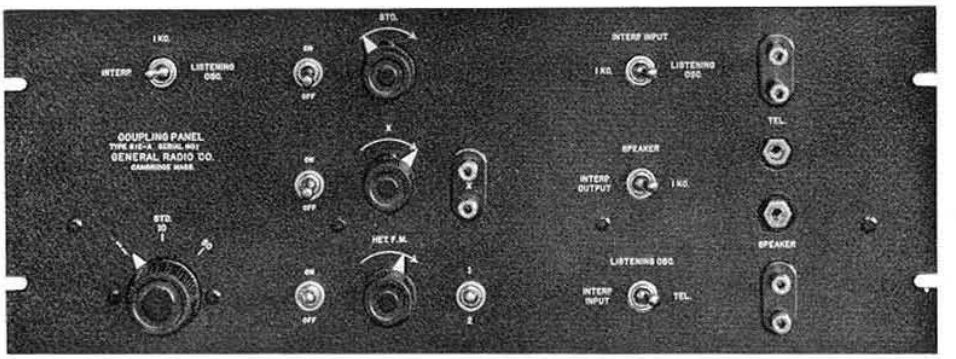
This is intended primarily to assist in utilizing transmissions of the United States Bureau of Standards or the signal from any radio transmitter whose frequency is accurately known. It consists of a 50-kilocycle oscillator, adjustable over a narrow range of frequency and a multivibrator operating at a fundamental frequency of either 10 or 50 kilocycles, as selected by a switch. When used with 5-megacycle transmissions the 100th harmonic of the 50-kilocycle fundamental is synchronized with the standard-frequency signal by adjusting the oscillator, and the multivibrator harmonics are then used for frequency measurement and calibration. The frequency of a broadcasting station can be checked in this manner.

Price: TYPE 618-AR Harmonic Oscillator for relay-rack mounting, **$120.00,** without tubes.

TYPE 618-AM Harmonic Oscillator, cabinet mounted, **$135.00,** without tubes.

Complete Description in Bulletin A

TYPE 612-A CONTROL PANEL



This panel carries the switches, volume controls, etc., which are necessary for the operation of a complete frequency measuring system. The outputs of the various units, heterodyne-frequency meter, interpolation oscillator, heterodyne detector, and frequency standard are brought t this panel and controlled from a singl position.

It is designed for relay-rack mounting

Price: **$65.00.**

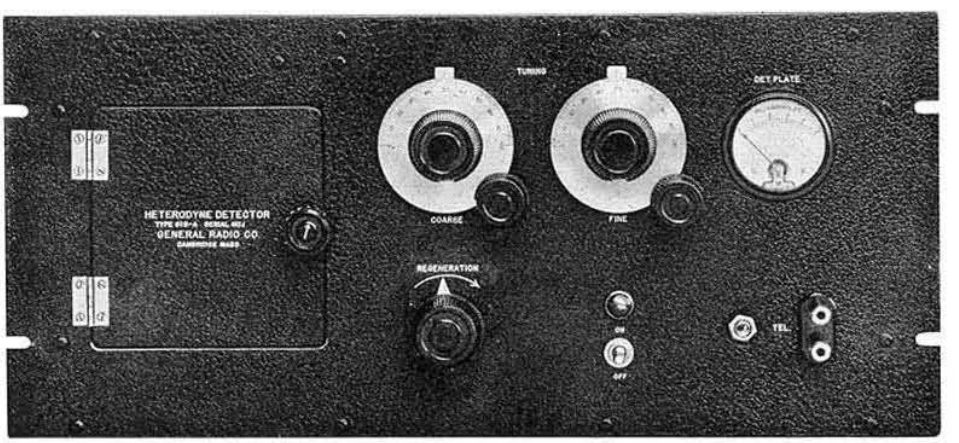
Complete Description in Bulletin A

TYPE 619-A HETERODYNE DETECTOR

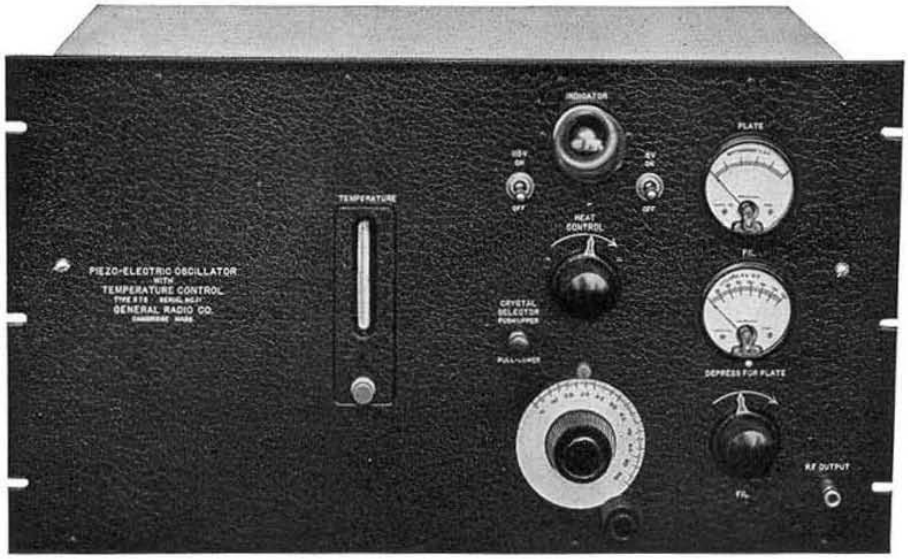
This instrument consists of a tuned regenerative detector and a two-stage audio amplifier covering a frequency range of from 90 to 6000 kilocycles. It is designed for use as a local receiver in a frequency-measuring system to produce beats between standard harmonic frequencies and frequencies under measurement. Plug-in coils are used and a rack for holding the coils when not in use is provided. It is designed for relay-rack mounting and is available in either a-c or battery operated models.

Prices: TYPE 619-AR, a-c operated, **$250.00**; TYPE 619-BR, battery operated, **$225.00.**

Complete Description in Bulletin A



TYPE 575-D PIEZO-ELECTRIC OSCILLATOR



This instrument is a temperature-controlled piezo-electric oscillator for use as a secondary frequency standard or for monitoring purposes. It has a greater accuracy and a better stability than any other secondary standard thus far available. The new oscillator circuit used is a modified form of the tuned-grid circuit using a screen-grid tube, and it is so designed that the frequency change due to wide variations in operating voltages and tubes is only a few parts in a million. The quartz plate is housed in a temperature-controlled chamber, which controls to within 0.1°C.

The use of this circuit permits a higher guarantee of accuracy than has previously been possible in a secondary standard and enables us to use it in our frequency monitor for broadcasting stations and in the Class C-10 Standard-Frequency Assembly.

This oscillator is intended to be used with TYPE 376-J and TYPE 376-K Quartz Plates. With TYPE 376-J the guaranteed accuracy is 0.002 per cent or 20 parts in one million; with TYPE 376-K, 0.003 per cent or 30 parts in one million.

Price: **$215.00,** for relay-rack mounting, complete with thermostat, thermometer, plug-in inductor, and heat-control indicator lamp, but without tube or crystal.

Complete Description in Bulletin A

TYPE 376 QUARTZ PLATES

These are piezo-electric quartz crystals for operation with General Radio piezo-electric oscillators as standards of frequency in laboratory measurements and in frequency monitoring installations. Since the high order of frequency stability required in such services is not compatible with high power output from the oscillator, the frequencies of all plates are guaranteed for operation at a low power level equivalent to that of a receiving tube with 135 volts on its plate. The type of oscillator in which the plate should be operated is also specified because this allows us to make a much closer accuracy guarantee than would otherwise be possible.

The frequencies of TYPE 376-H, TYPE 376-J, and TYPE 376-K are adjusted very closely to the ordered frequency, and they are guaranteed to be accurate to within a very few parts in a million. They are recommended for monitoring radio transmitters and as laboratory frequency standards. TYPE 376-H and TYPE 376-K are suitable for use in monitors for commercial radio telegraph channels. For monitoring a broadcast frequency a higher accuracy is required and the TYPE 376-J Quartz Plate is intended for this service.

TYPE 376-C and TYPE 376-D Quartz Plates are not adjusted so closely to the ordered frequency and for that reason they require less grinding and are lower in price. They are recommended for use in laboratories requiring an accurate standard, the frequency of which does not need to have a definite preassigned value. These plates operate at room temperature.

All plates are manufactured from high grade piezo-electric quartz, free from twinning. The plates are cut by modern optical manufacturing methods and the parallelism of the surfaces and their orientations with respect to the crystallographic axes are held to extremely small tolerances. The holders are designed for permanence of calibration and for a rapid transfer of heat from the surrounding space to the quartz.

SPECIFICATIONS

Frequency Range: All plates (except TYPE 376-J) can be made for any frequency in the range between 100 kc and 2000 kc; except that, between 200 kc and 400 kc, plates cannot be accommodated in the standard holder because of their dimensions, and special prices apply. TYPE 376-J is supplied only for frequencies which are multiples of 1 kc.

Accuracy of Adjustment: The frequency of the plate is adjusted, until it differs in our laboratory from the ordered frequency by an amount less than the amount given in the column headed "Adjusted Within" in the table.

Accuracy of Calibration: After the frequency of the plate has been adjusted as described in the

preceding paragraph, the frequency is accurately measured in terms of standard frequencies from a General Radio Class C-21-H Standard-Frequency Assembly and the result of this measurement is entered in the calibration certificate.

Certified Accuracy: The certificate mentioned in the preceding paragraph also states the limits to within which the frequency is guaranteed to be, as specified in the third column of the table, the one headed "Maximum Deviation from Certified Frequency." This column gives the maximum deviation of the crystal, from the certified frequency as measured by us, when the plate and oscillator are operated within the temperature and other operating limits specified by us.

Frequency Tolerance: To find the amount by which the actual frequency of the plate may differ from the frequency ordered, add the figures in the second and third columns ("Adjusted Within" and "Maximum Deviation"). For example, if a TYPE 376-D Quartz Plate is ordered, the user can rely on its frequency's being within 0.13% of the frequency which he specified when ordering and within 0.1% of the frequency entered in the certificate of calibration.

Oscillator: Contrary to the common assumption, the frequency and the frequency stability of a piezo-electric frequency standard depend upon the design and construction of the oscillator. Hence, the performance of all General Radio quartz plates is specified in a given type of oscillator.

TYPE 376-C and TYPE 376-D are calibrated in and intended for use with the TYPE 275 or TYPE 375 Piezo-Electric Oscillator which have no temperature control. These instruments are described in previous catalogs.

TYPE 376-H is ordinarily calibrated in the oscillator and temperature control box in which it is intended to be used, which should be of General Radio manufacture.

TYPE 376-J and TYPE 376-K quartz plates are sold for use only in a TYPE 575-D Piezo-Electric Oscillator. This oscillator uses a new type of circuit in which the crystal operates nearer its resonant frequency than in the conventional type of piezo-electric oscillator.

Mounting: The crystal holder consists of a bakelite base carrying a chromium plated brass cap with a means for adjusting, locking, and sealing the air gap. It is practically dust proof and is fitted with plugs for use in General Radio piezo-electric oscillators.

Dimensions: Base, (width) 2¾ x (depth) 2 x (height) 1¼ inches, over-all.

Net Weight: 1 pound.

Type	*Adjusted Within*	*Maximum Deviation from Certified Frequency*	*Temperature*	*Code Word*	*Price*
*376-C	5 % of frequency ordered	0.1 %	18°–32°C.	LAPEL	$45.00
*376-D	0.03 % of frequency ordered	0.1 %	18°–32°C.	LARVA	60.00
*376-H	0.001% of frequency ordered	0.009%	50° ±0.25°C.	LEVEL	85.00
*376-J	1 cps of frequency ordered	0.002%	50° ±0.1°C.	AGAPE	85.00
*376-K	0.001% of frequency ordered	0.002%	50° ±0.1°C.	AFOUL	85.00
Credit allowance for returned TYPE 376 Quartz Plates, Serial No. 2000 and higher					15.00

*Before ordering quartz plates, read carefully the above specifications. Our Engineering Sales Department will be glad to make suggestions regarding the type of quartz plate required for a specific purpose.

TYPE 547-A TEMPERATURE-CONTROL BOX

(NOT DESCRIBED IN BULLETIN A)

The increasing need for improved frequency stability in piezo-electric oscillators makes it necessary to control the temperature of the quartz plate. The TYPE 547-A Temperature-Control Box is particularly recommended for use in composite radio transmitters where the crystal operates at low power level, but it is by no means restricted to this use. A terminal plate carrying jacks for two TYPE 376 Quartz Plates (or any device, such as small resistors or condensers whose performance under controlled-temperature conditions is desired) is provided within the temperature-controlled space. Choice of the quartz plate which is in circuit is made by a switch mounted on the panel.

Within the cabinet are placed a balsa-wood insulating layer, distributed heaters (placed on all six faces of the interior assembly), an aluminum distributing layer, an asbestos attenuation layer, and a second aluminum distributing layer which forms the wall of the temperature-controlled space. A thermometer, graduated in $\frac{1}{2}$-degree C. divisions, reading from 40° to 60°C. and mounted behind a sl in the panel, indicates the air temperatu in the inner space. A rheostat is includ for heat regulation and a heat-contr indicator lamp for signaling the operati of the thermostats. Plugs and cords f connection of the heater circuits to t 115-volt alternating-current or dire current mains are provided.

The thermostat is of the adjustab mercury type, operating through a rel mounted on front panel to control t current through the heaters. The rel circuit is so arranged that failure of t 6-volt relay battery supply causes t heater circuits to remain open.

The unit will control the temperatu of the inner space to within ± 0.1° against changes in room temperature ± 11°C. (20°F.). If the amount of heat regulated by adjustment of the he control rheostat, to maintain the sa ratio of ON to OFF time in the operation the thermostat, somewhat better cont and a wider ambient temperature ra may be obtained.

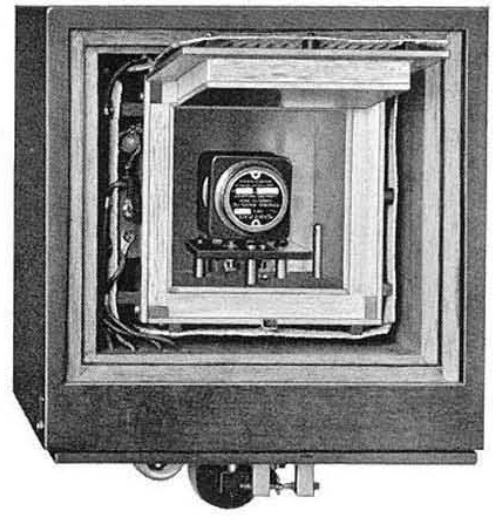
SPECIFICATIONS

Accuracy of Temperature Control: The unit will control the temperature of the inner space to within ±0.1°C. for changes in room temperature of ±11°C. (20°F.). Where the crystal is operated at a power level so high that it generates heat, the temperature can be held to within the same limits if the heat generated by the crystal remains constant.

Mounting: The instrument is mounted on a bakelite panel in a walnut cabinet.

Dimensions: Panel, (width) 12 x (height) 10 inches. Cabinet, (depth) 10 inches, over-all. The temperature-controlled inner chamber is a cube 4⅛ inches on each side. The effective depth is reduced to 3⅝ inches by the space occupied by the terminal plate.

Net **Weight:** 18 pounds.



Type		*Code Word*	*Price*
547-A	.....	BURLY	**$150.00**

TYPE 547-P2 THERMOSTAT AND TYPE 547-P3 THERMOMETER

This thermostat and thermometer are listed so that the users may replace them in case of breakage. They are for use in the TYPE 547-A Temperature-Control Box or in the TYPE 575-D Piezo-Electric Oscillator.

Type		*Code Word*	*Price*
547-P2	**Mercury-Type Thermostat**	LIBEL	**$20.00**
547-P3	**Thermometer, 40°–60°C., graduated in 0.5° steps**	LILAC	**4.00**

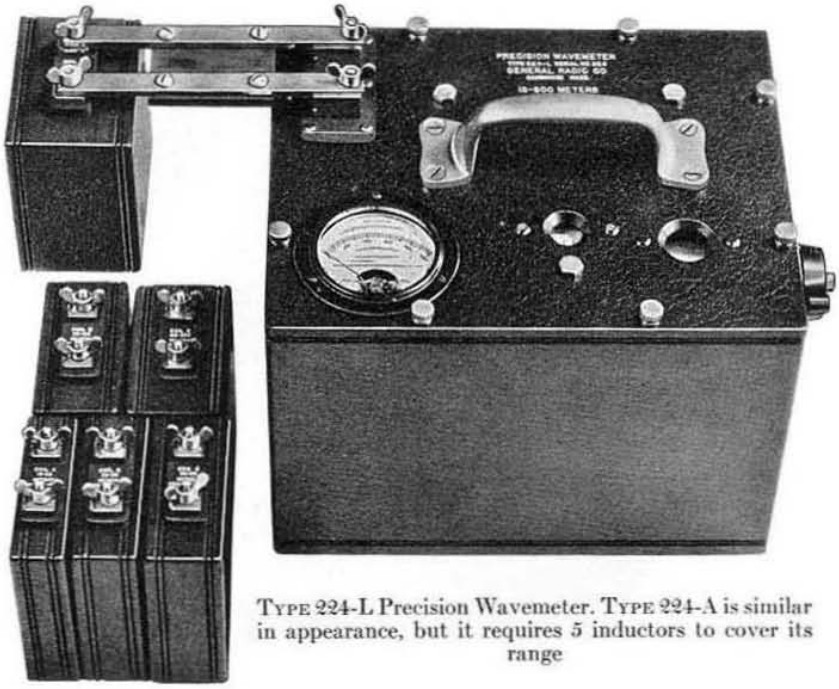
TYPE 591-P REPLACEMENTS

These are provided so that users may replace them in case of breakage. They are for use in the TYPE 591 Temperature-Control Unit, a component of the Class C-21-H primary standard of frequency.

Type		*Code Word*	*Price*
591-P1	**Outer Thermometer, 40°–60°C., graduated in 0.5° steps**	LOBBY	**$4.00**
591-P2	**Inner Thermometer, 46°–54°C., graduated in 0.1° steps**	LOCAL	**4.00**
591-P3	**Mercury-Type Thermostat (same as Type 547-P2)**	LIBEL	**20.00**

TYPE 224 PRECISION WAVEMETER

(NOT DESCRIBED IN BULLETIN A)



TYPE 224-L Precision Wavemeter. TYPE 224-A is similar in appearance, but it requires 5 inductors to cover its range

This wavemeter is an absorption-type instrument made in two ranges for the accurate measurement of frequency and wavelength. Its accuracy (0.25 per cent) is very good considering the extremely wide range of frequency it covers. Where fairly accurate measurements are to be made in a number of frequency bands, one of the TYPE 224 Precision Wavemeters is suggested. For the ultra-precise frequency measurements required in present-day commercial and laboratory service, w recommend the use of the heterodyne frequency meters and piezo-electric oscil lators described in preceding pages and i Bulletin A.

The condenser is of the precision worm drive type and the inductors are carefully designed for the ideal Maxwellian shape The resonance indicator is a thermo galvanometer.

SPECIFICATIONS

Frequency Range: This wavemeter is made in two sizes: TYPE 224-A, covering from 4290 kc to 12.5 kc (70 to 24,000 meters); and TYPE 224-L, from 20,000 kc to 500 kc (15 to 600 meters).

Condenser: The wavemeter uses a precision condenser similar to TYPE 222. It has semicircular plates giving a linear variation in capacitance with scale reading.

Inductors: TYPE 224-A is supplied with five and TYPE 224-L with six inductors to cover the ranges given in *Frequency Range*. Extra inductors can be supplied to extend the range of each instrument by small amounts but the attempt to greatly increas the range by this method is not recommended Inductors are mounted in individual walnut case with terminals. The connections between inducto and condenser are made by the rigid connecting stra shown in the photograph.

Calibration: Each inductor is calibrated at a number of points in terms of a Class C21-H Standard Frequency Assembly. The calibration for each in ductor is plotted on a chart which relates both frequency and wavelength to scale reading. The wavelength calibration is obtained from the fre

quency calibration by the use of 299.82 meters per second as a conversion factor.

The capacitance calibration for the condenser similar to that supplied with the TYPE 222 Precision Condenser (see page 31) is furnished.

Accuracy: The frequency calibration may be relied upon to within 0.25% of the true frequency for one year from the date of purchase. At the end of that period the instrument should be returned to our laboratory for checking and possible recalibration.

The capacitance calibration is accurate to within 1 $\mu\mu$f.

Resonance Indication: A thermogalvanometer is used as a resonance indicator. Reaction methods can also be used without altering the guaranteed accuracy of the calibration.

Mounting: A wooden storage case, fitted with lock and carrying handle, is furnished and this has partitions for holding the condenser unit, the inductors, and the calibration charts.

Dimensions: Carrying case, (length) 20 x (width) 12 x (depth) 11 inches, over-all.

Net Weight: 30 pounds including storage case.

Type	*Frequency*	*Wavelength*	*Code Word*	*Price*
224-A	4290–12.5 kc	70–24,000 meters	WAGER	$190.00
224-L	20,000– 500 kc	15–600 meters	UNDER	200.00

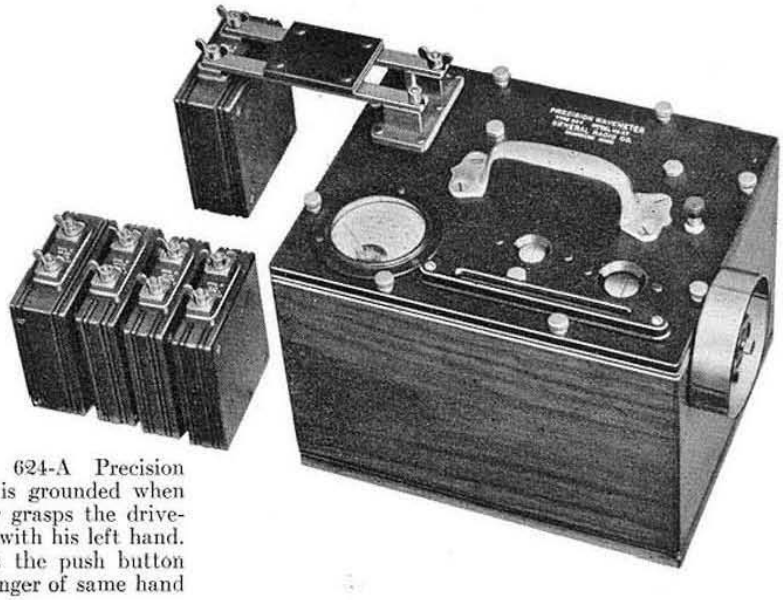
TYPE 624 PRECISION WAVEMETER

(NOT DESCRIBED IN BULLETIN A)

This instrument is a high-frequency wavemeter intended for use under service conditions where the greatest accuracy obtainable with commercial tuned-circuit wavemeters is required. It covers the range from 25,000 to 5670 kilocycles (12 to 53 meters).

Settings are made by the incremental capacitance method which allows settings to be made with high precision. Operation of a "push button" throws in or out of circuit a small condenser in parallel with the main tuning condenser. The main condenser is adjusted until operation of the push button causes no change in the deflection of the thermogalvanometer. With this method, a precision of setting of the order of one part in 20,000 can be obtained.

The condenser is of the precision worm-



The TYPE 624-A Precision Wavemeter is grounded when the operator grasps the drive-knob shield with his left hand. He operates the push button with little finger of same hand

drive type and has plates shaped to give a straight-line-frequency variation. The inductors combine low losses with extremely rugged construction.

A thermometer is mounted on the panel to indicate the temperature of the wavemeter when used. Data are provided fo correcting the calibration for the effect o temperature changes.

The guaranteed accuracy is 0.1 per cen for a period of one year from date o purchase.

SPECIFICATIONS

Frequency Range: This wavemeter covers a frequency range of from 25,000 kc to 5670 kc (12 to 53 meters).

Condenser: A precision condenser is used similar in construction to TYPE 222. The rotor plates are shaped to give a linear variation in frequency with scale reading.

Inductors: TYPE 624 Precision Wavemeter is supplied with 5 inductors to cover the range given above. Extra inductors can be supplied on special order to extend the range to 94 meters. The inductors are mounted in individual walnut cases with terminals. The connections between inductor and condenser are made by means of a rigid connecting strap similar to that used in the TYPE 224-A Precision Wavemeter.

Calibration: Each inductor is calibrated at a number of points in terms of a Class C21-H Standard Frequency Assembly. The calibration for each inductor is plotted on a chart of standard cross-section paper. Calibrations are supplied in frequency only. Wavelength values may be determined by use of a conversion factor, 299.82 meters per second. A capacitance calibration can be supplied if desired. See price list below.

Accuracy: The calibration may be relied upon to within 0.1% of the true frequency for one year from the date of purchase. At the end of that period the instrument should be returned to our laboratory for checking and possible recalibration. Since the cal bration is guaranteed to so close a tolerance, correction must be made for the effect of temperatur on the tuned circuit. For this purpose a thermomete is mounted on the instrument and an expression fo use in making this correction is furnished in th instruction book.

Incremental Capacitance: Scale settings ar made by the incremental capacitance method whic permits an extremely high order of precision. Opera tion of a push button throws in or out of circuit small condenser in parallel with the main tunin condenser. The main condenser is adjusted unt operation of the push button causes no change in th deflection of the thermogalvanometer. This mean that the incremental capacitance has spanned th resonance peak. With the push button open, th circuit is tuned to a frequency higher than resonanc while with the button depressed, the circuit is de tuned on the low side by an equal amount. This give a differential effect in reading the galvanometer an allows a precision of the order of one part in 20,000 The resonance indicator is a thermogalvanometer

Mounting: A wooden storage case fitted with loc and carrying handle is furnished and this has com partments for holding the condenser units, inductors and calibration chart.

Dimensions: Carrying case, (length) 20 x (width 12 x (depth) 11 inches.

Net Weight: 30 pounds including carrying case.

Type	*Frequency*	*Equivalent Wavelength*	*Code Word*	*Price*
*624-A	25,000–5670 kc	12–53 meters	AGATE	$275.00
	Mounted Capacitance Calibration Curve		CURVE	6.00

*Capacitance calibration supplied only when ordered. Use compound code word: AGATECURVE.

TYPE 624-P INDUCTORS

(NOT DESCRIBED IN BULLETIN A)

These are intended for use with the TYPE 624 Precision Wavemeter to extend its range to lower frequencies. Prices include calibration.

Type	*Frequency*	*Equivalent Wavelength*	*Code Word*	*Price*
*624-P7	5670–4270 kc	53–70 meters	ALIVE	$25.00
*624-P8	4270–3200 kc	70–94 meters	ALLAY	25.00

*Wavemeter with which inductors are to be used must be supplied with order so that calibration can be made.

TYPE 419-A RECTIFIER-TYPE WAVEMETER

(NOT DESCRIBED IN BULLETIN A)

The TYPE 419-A Rectifier-Type Wavemeter is a tuned-circuit instrument for general use in experimental work in the short-wave band between 1 and 15 meters. Provision is made for indicating resonance by means of a self-contained vacuum-tube rectifier which may be used in conjunction with either its micro-ammeter or a pair of telephone receivers. Any one of the numerous reaction methods may be used.

SPECIFICATIONS

Frequency Range: 300 Mc to 20 Mc or 1 meter to 15 meters by using the four plug-in inductors supplied with the instrument.

Calibration: Each inductor is individually calibrated with the greatest possible accuracy at several points in terms of the General Radio Company's primary standard of frequency. Each one is supplied with an individually mounted calibration curve which relates condenser scale divisions and frequency in megacycles per second. Each chart also carries an auxiliary curve which permits the rapid conversion of frequency into wavelength in meters.

Accuracy: The construction and calibration of this wavemeter are such that measurements, if carefully made, can be relied upon to within 1% of the indicated frequency.

Condenser: A unit similar in construction to the TYPE 568 Variable Air Condenser and having a straight-line-frequency variation is used. This is operated by a 100-division, TYPE 503-G Dial of the friction-drive type.

Inductors: Any one of the four plug-in inductors may be mounted in position at the side of the cabinet by means of a plug and jack arrangement.

Storage space is provided in the bottom of the cabinet for them when they are not in use. The nominal frequency range of each is shown in the following table. A sufficient amount of overlap is allowed on each inductor.

Inductor	*Frequency*	*Wavelength*
D	20– 40 Mc	15–7.5 meters
C	40– 75 Mc	7.5– 4 meters
B	75–150 Mc	4– 2 meters
A	150–300 Mc	2– 1 meter

Resonance Indicator: A 230-type tube with plate and grid connected together is used as a diode rectifier. This rectifier, in series with a high resistance for swamping out variations in its internal resistance when tubes are changed, is connected in parallel with the tuning condenser. Current is indicated on the 100-microampere galvanometer or, if desired, a pair of telephones may be inserted in the circuit for making aural observations on modulated oscillators.

Reaction methods may also be used with the same calibrations supplied with the instrument so long as the tube is in its socket.

Tubes: One 230-type tube, not furnished with the instrument, is required. The variation in inter electrode capacitance among different tubes of this type will not affect the calibration.

Power Supply: Filament current for the tube is taken from a 1.5-volt, No. 6 dry cell, mounting space for which is contained in the bottom of the cabinet. It is not supplied with the instrument.

Mounting: All equipment is carried on an aluminum panel finished in black crackle lacquer, which in turn is mounted on a polished walnut cabinet. Space is provided in the bottom for storing the dry cell, the four inductors, and the four calibration curve charts.

Accessories: The dry cell and the one tube are the only accessories required to put the wavemeter in operation after it is received.

Dimensions: (Length) 10 x (width) 7½ x (depth) 7 inches, over-all.

Net Weight: 7¾ pounds without tube or battery.

Type	*Frequency*	*Wavelength*	*Code Word*	*Price*
419-A	**300–20 Mc**	1–15 meters	CATER	**$100.00**

TYPE 574 WAVEMETER

(NOT DESCRIBED IN BULLETIN A)

This direct-reading tuned-circuit wavemeter is well adapted for general purpose work in commercial, experimental, and educational laboratories. It is unusually compact, and its wide frequency range and direct-reading feature make it useful for determining quickly the frequencies of transmitters, receivers, and oscillators.

Its precision is adequate for most routine frequency measurements. Even in high precision work the time-wasting and bothersome process of locating an unknown frequency on a precision wavemeter can often be simplified by first determining the approximate frequency with the TYPE 574 Wavemeter.

SPECIFICATIONS

Frequency Range: 166 kc to 70,000 kc (1800 meters to 4.3 meters), continuously, by using the five plug-in inductors supplied with the instrument.

Accuracy: The construction and calibration of this wavemeter are such that, if carefully made, measurements can be relied upon to within 1% of the indicated frequency.

Calibration: Each inductor is individually calibrated at five points in terms of the General Radio Company's primary standard of frequency, and intermediate points are secured by interpolation. The scales themselves are engraved on the inductors, thus making the instrument direct-reading. Coil A and Coil B are engraved in units of megacycles per second, others in kilocycles per second.

Inductor	*Frequency*	*Equivalent Wavelength*
E	166– 500 kc	1800– 600 meters
D	500– 1700 kc	600– 176 meters
C	1700– 6000 kc	176– 50 meters
B	6000–18,000 kc	50–16.6 meters
A	18,000–70,000 kc	16.6– 4.3 meters

Condenser: A special TYPE 334 Variable Air Condenser modified by a reduction gear is used to spread the calibration scale over approximately 345°. This facilitates precise settings. The condenser is driven by a slow-motion knob geared to the condenser shaft.

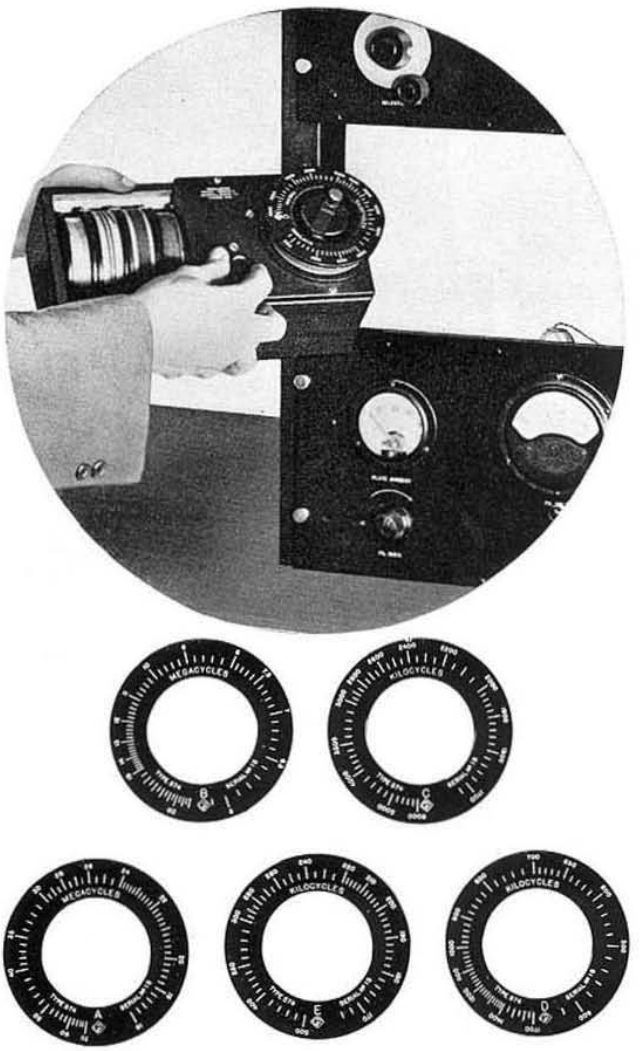
Inductors: Any one of the five plug-in inductors may be mounted in position by means of two pin-type plugs, while the four not in use are stored in a compartment. They are wound on moulded bakelite forms, 4 inches in diameter and 1 inch long. The nominal frequency range of each is shown in the accompanying table. A sufficient amount of overlap is provided on each inductor.

Resonance Indicator: Because of the necessity for light weight and compactness and because resonance between a tuned-circuit wavemeter and a vacuum-tube oscillator is most easily and precisely determined by any one of several reaction methods, neither resonance indicator nor high-frequency generator is included. Reaction methods are simple and require only plate or grid meters in the oscillator being measured or an auxiliary oscillating receiver.

Mounting: The condenser is mounted on a bakelite panel attached to the polished walnut case at one end of which is the storage compartment for spare inductors which are held in place by a spring clamp.

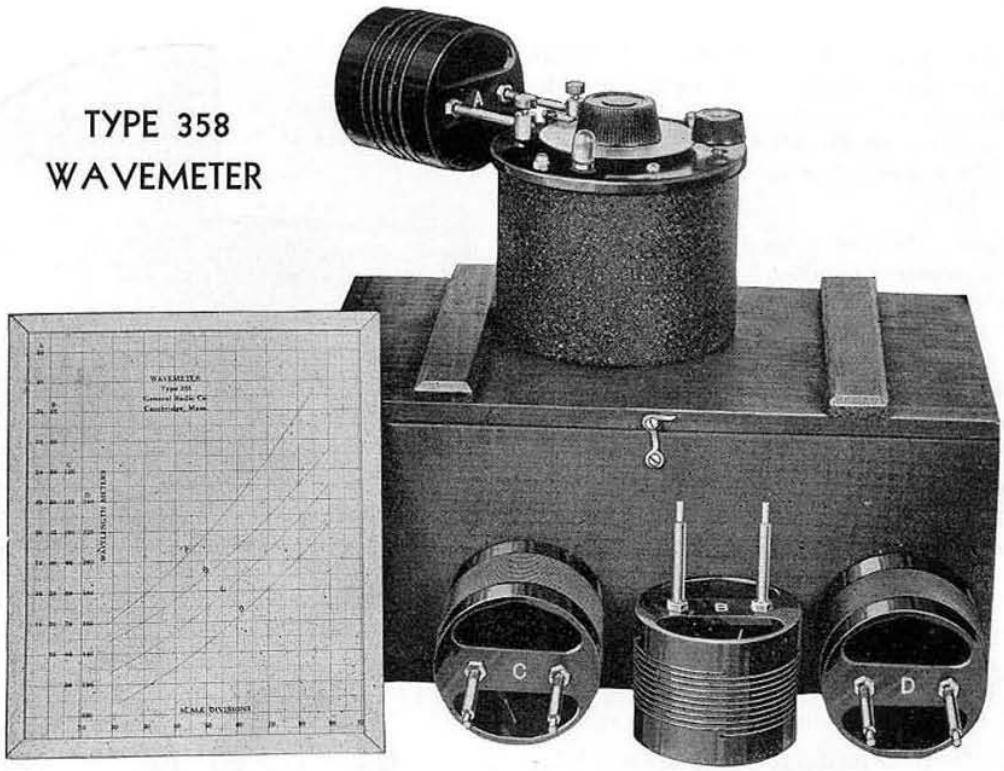
Dimensions: (Length) 11 x (width) 5 x (height) 5½ inches, over-all.

Net Weight: 4⅝ pounds.



Type	*Frequency*	*Equivalent Wavelength*	*Code Word*	*Price*
574	**166–70,000 kc**	1800–4.3 meters	CARRY	**$50.00**

TYPE 358 WAVEMETER



This is an inexpensive general-purpose device covering a wide frequency range. It is compact and is easily held in the hand while making measurements. In certain cases, the usefulness of the wavemeter may be increased through the addition of two inductors to extend the wavelength range. These inductors are available on special order and details will be supplied on request.

SPECIFICATIONS

Calibration: In wavelength; accuracy, 1%.

Condenser: TYPE 247 Condenser in shielded case.

Inductors: Four, on bakelite forms, fitted with pins to fit condenser terminals.

Resonance Indicator: Small flashlight bulb in special socket which closes circuit on removal of bulb.

Carrying Case: Space provided in wooden box for inductors, condenser, and calibration chart.

Dimensions: Carrying case, 11¾ x 7¼ x 5½ inches.

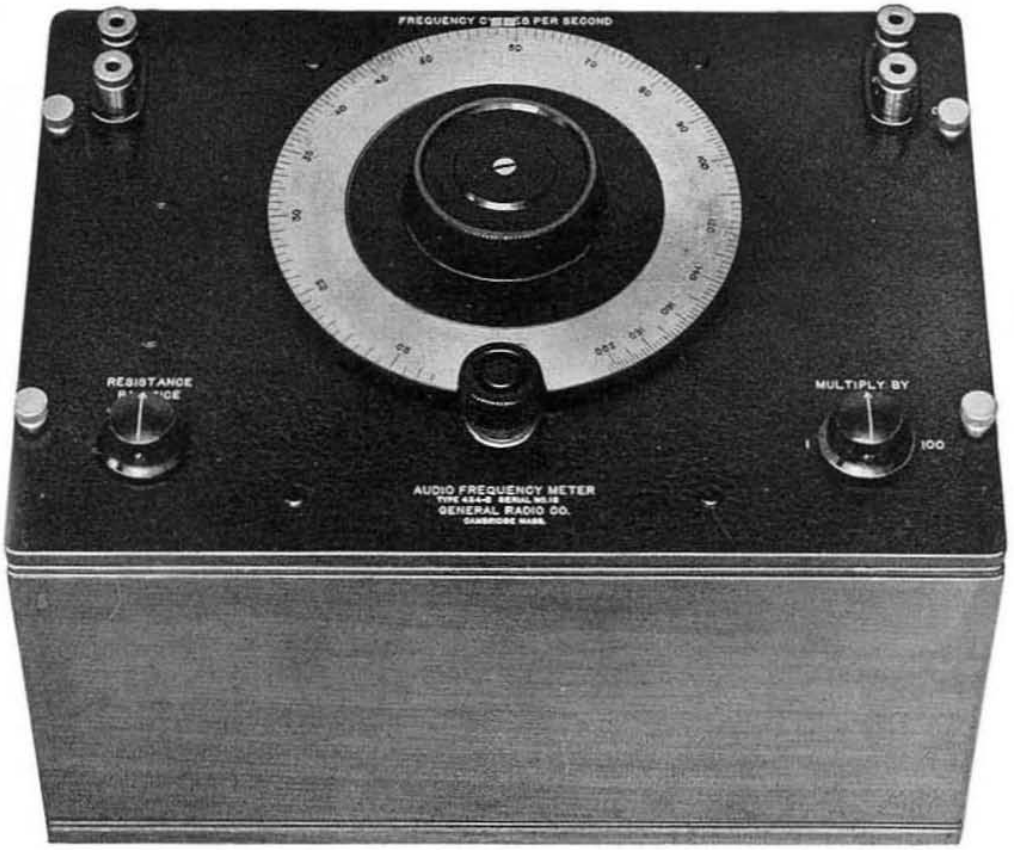
Net Weight: 4½ pounds.

Type	*Equivalent Frequency*	*Wavelength*		*Code Word*	*Price*
358	20,000–1364 kc	15–220 meters	.....	UPPER	$15.00

TYPE 434-B FREQUENCY METER

(NOT DESCRIBED IN BULLETIN A)

The TYPE 434-B Frequency Meter has been developed to provide a means for measuring, with an accuracy of 0.5 per cent, audio frequencies in the range from 20 to 20,000 cycles. It makes use of the Wien bridge, which contains only resistances and capacitances. This eliminates the magnetic pickup which exists in all frequency meters containing self- or mutual inductance.



The meter is direct-reading with an extremely long scale. The meter has three frequency ranges differing by ratios of 10:1, obtained by varying the condensers by ratios of 10:1. Thus the same scale is used for all three frequency ranges with decimal multiplying factors. The different frequencies are distributed along the scale logarithmically, *i.e.*, equal frequency ratios occupy equal scale lengths. This makes the fractional accuracy constant over the entire scale. This very desirable feature is obtained by a suitable shaping of the tapered resistors, which are the variable units in the meter. The inductors used in other types of frequency meters cannot be shaped to yield any desired frequency distribution.

The resistance balance of the bridge is approximately maintained for all scale settings. Exact balance is made by means of a suitable potentiometer. The setting of the frequency dial is not changed by lack of resistance balance, but merely dulled.

The null detector is usually a pair of high-resistance head telephones. They are sufficiently sensitive to enable the dial to be set to 5 per cent with 2 volts applied to the bridge within the frequency range 300–3000 cycles, if the waveform is pure. The dial may be set to 0.1 per cent by applying a higher voltage to the bridge or by using an amplifier such as the TYPE 514-A Amplifier between the bridge and the telephones. When the harmonic content of the supply is large, a low-pass filter, such as TYPE 330 Filter Sections, or a tuned circuit may be used for frequencies less than the natural frequency of the telephones (about 900 cycles). The TYPE 488-DM Alternating Current Voltmeter, preceded by the TYPE 514-A Amplifier and a TYPE 330 Filter Section, may also be used as a null detector.

SPECIFICATIONS

Frequency Range: 20–20,000 cycles in three ranges by means of a selector switch, 20–200 cycles, 200–2000 cycles, 2000–20,000 cycles.

Calibration: Each instrument is individually calibrated with more than sufficient accuracy in terms of the General Radio Company's primary standard of frequency. Each dial is then individually engraved.

Accuracy: The null point is narrow enough so that, with sufficient supply voltage or sufficient amplification on the null detector and with a fairly pure waveform, the dial may be set to 0.1%. The calibration on the dial may be relied upon to within 0.5% at all positions.

Drive: The 6-inch dial turns through an angle of 320° which gives a scale length of about 17 inches. It is driven by a slow-motion knob.

Impedances: Input, 3–10 kilohms; output, 1–4 kilohms, the smaller values corresponding to the higher frequencies.

Input Voltage: 110 volts, maximum.

Accessories: A null detector will be required t operate the instrument. This may be head telephones such as the Western Electric Type 1002-C or an amplifier-meter combination such as a TYPE 514-A Amplifier and a TYPE 488-DM Alternating Current Voltmeter or a TYPE 426-A or TYPE 626-A Thermonic Voltmeter, used in conjunction with TYPE 38 Filter Sections. Even with head telephones an amplifier and filter sections may prove useful.

Controls: Frequency dial, range selector switch resistance balance knob.

Mounting: Aluminum panel, ¼ inch thick finished in black crackle lacquer, mounted in copper lined walnut cabinet.

Dimensions: (Length) 12 x (width) 8¾ x (height 8¼ inches, over-all.

Net Weight: 15¼ pounds.

Type	*Frequency Range*		*Code Word*	*Price*
434-B	**20–20,000 cycles**	.....	COLOR	**$125.00**

TYPE 511 SYNCRO-CLOCKS

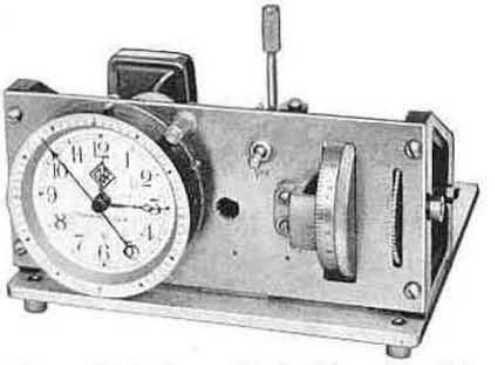
TYPE 511-B Syncro-Clock. Tone generators and other attachments can be mounted in the space at the right of the sub panel

The development of highly stable vacuum-tube oscillator circuits has made it possible for laboratories to secure electric and electro-mechanical systems which have practically constant frequency, angular velocity, or rotational period. For the measurement of these quantities, therefore, many of the devices used for determining frequency are useful.

For example, a synchronous-motor driven clock may be used as a source of precisely determined time intervals when driven by a standard-frequency oscillator and, conversely, it may be used for determining frequency when compared with a standard time interval. This dual purpose naturally offers a wide field of usefulness for such a device. Accurate timing is demanded not only by laboratories but in commercial practice.

The synchronous-motor-driven clock or Syncro-Clocks, described in this section may have, in addition to the clo

mechanism, a number of other accessories. The only one here listed is the "micro-dial" by means of which time intervals, as recorded by the Syncro-Clock, may be compared with time intervals determined by some other system. Among the others are seconds and tenth-seconds contactors for supplying accurately determined electrical impulses. On any one of the Syncro-Clock shafts may be mounted iron armature discs which, when rotated in the field of a magnet, may be made to generate electrical impulses. Since the frequency of these impulses is entirely dependent on the frequency of the standard-frequency source, a convenient means for securing low-frequency impulses is provided.



TYPE 511-C Syncro-Clock. The micro-dial is adjusted by the knurled wheel at the right

Clocks are normally supplied to keep true time when supplied with voltage of exactly 1000 cycles. They are available for panel mounting or mounted in a walnut case.

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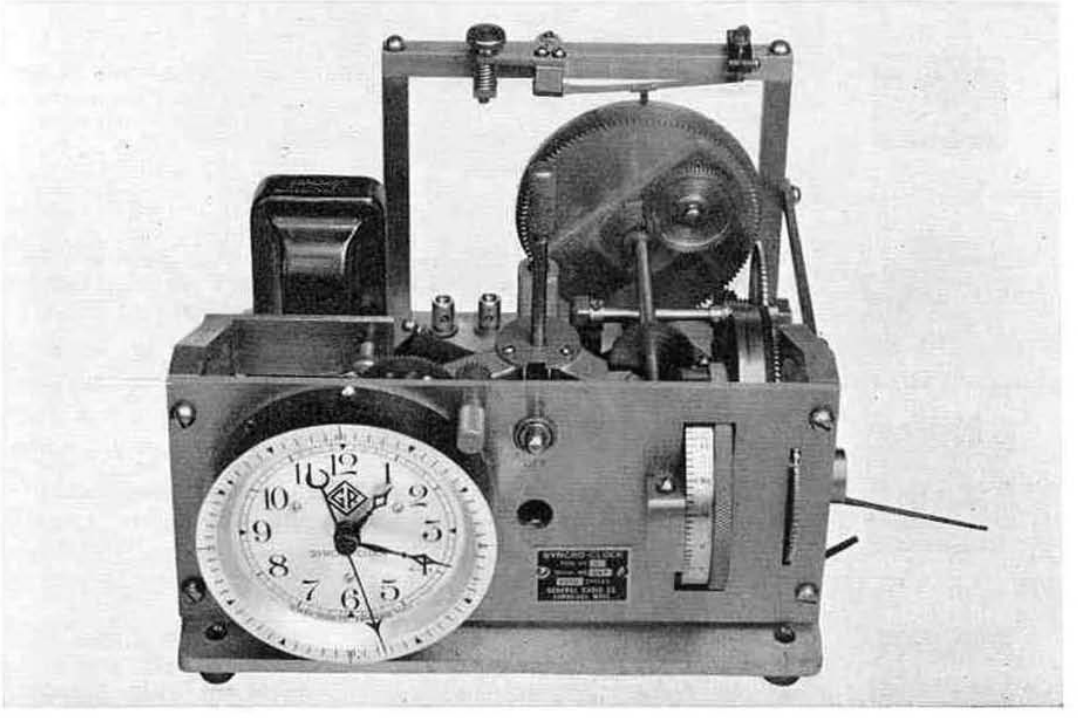
Type	*Description*	*Code Word*	*Price*
*511-A	**Panel mounting without micro-dial**	SYNCROFORD	**$160.00**
511-B	**Table mounting without micro-dial**	SYNCROFROG	**160.00**
*511-C	**Panel mounting with micro-dial**	SYNCROGOOD	**220.00**
511-D	**Table mounting with micro-dial**	SYNCROTOAD	**225.00**

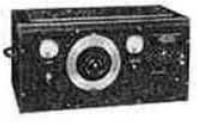
*Built to order, not carried in stock.



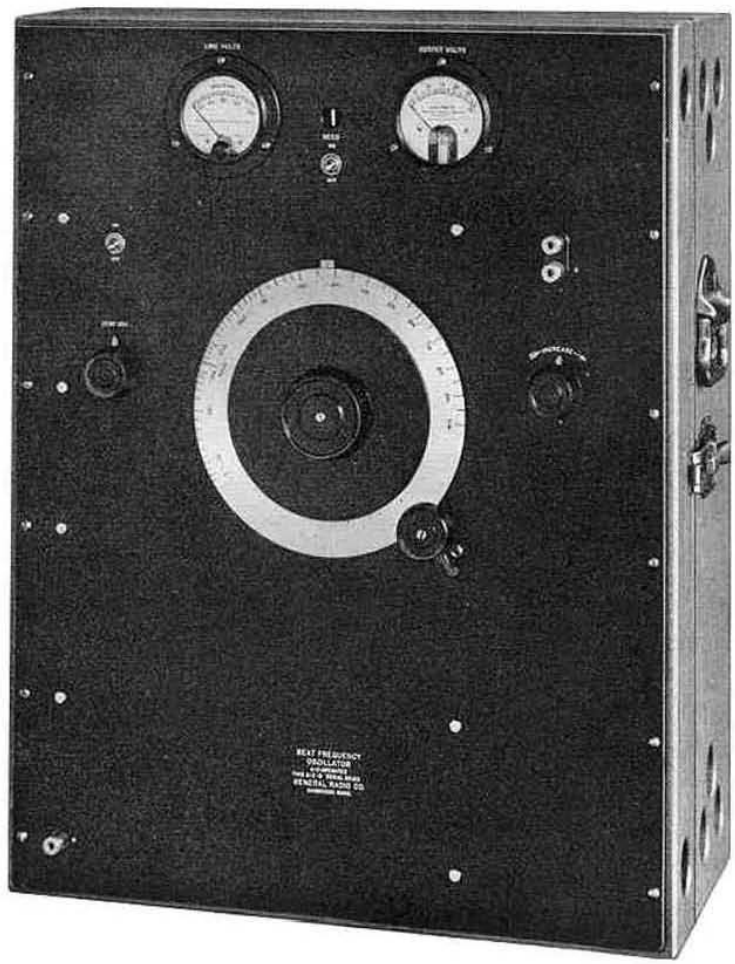
This special Syncro-Clock was built to transmit time signals in the standard NAA sequence. It operates from a Class C-21-H Standard-Frequency Assembly

OSCILLATORS

Oscillators are required for measurement with bridges and other apparatus and for observation of characteristics and behavior of apparatus over a range of frequencies. A number suitable for specific purposes and frequency ranges are described in the following section. Although all are designed for a maximum of frequency stability, none of them are intended for use as frequency standards; oscillators for that purpose are listed in the preceding section on frequency standards.

	Type	*Particular Applications*	*Identifying Features*
	**513-B**	Audio measurements requiring a continuously adjustable a-c operated oscillator.	Beat-frequency—A-c operated —5 to 10,000 cycles.
	**613-A**	Audio measurements requiring a continuously adjustable battery-operated oscillator.	Beat-frequency — Battery operated — 5 to 10,000 cycles.
	**377-B**	Audio- and carrier-frequency measurements requiring exceptional frequency stability and the best waveform.	Tuned-circuit oscillator — Battery operated — 20 to 70,000 cycles.
	**508-A**	Audio measurements where 10 selected frequencies are suitable.	Tuned-circuit — A-c operated — 10 selected frequencies between 200 and 4000 cycles.
	**241**	Bridge source — Measurements requiring an inexpensive low power source.	Reed-type electro-mechanical oscillator operating from 4½ volt battery.
	**213**	Bridge circuits, transmission line tests, etc., where a signal of fixed frequency and fair waveform is required.	Electro-mechanical oscillator stabilized by tuning fork, operating from 6-volt battery.
	**384**	Laboratory measurements requiring a low-power radio-frequency driver.	Tuned-circuit oscillator, with interchangeable plug-in inductors — Battery operated.

TYPE 513-B BEAT-FREQUENCY OSCILLATOR
A-C OPERATED



This is an alternating-current operated oscillator of the beat-frequency type covering the audio-frequency range between 5 cycles and 10,000 cycles.

The distinguishing characteristic of a beat-frequency oscillator is its ability to cover continuously a wide frequency range with one control and, at the same time, to maintain approximately constant output. This results from the use of two high-frequency oscillators, one of fixed and the other of adjustable frequency. The filtered difference frequency resulting from the detection of the combined outputs of the two oscillators is amplified to a useful power level. By means of such a circuit, the entire audio-frequency range may be covered by the rotation of a single dial. This feature renders the beat-frequency type of oscillator useful for the rapid study of all types of equipment.

The design of the instrument is such that the waveform and power output are adequate for general use, and when it is used in accordance with the operating instructions the reliability of the frequency calibration is excellent. Both oscillators operate near 100 kilocycles,

and the circuits are adjusted so that the difference frequency may be reduced to 1 cycle without their "pulling into step" with each other.

Filtering and circuit design have eliminated beats between harmonics of either oscillator and the fundamental frequency of the other.

SPECIFICATIONS

Frequency Range: Calibrated between 5 cycles and 10,000 cycles, it will actually deliver power at frequencies slightly lower and higher, respectively, than these.

Frequency Calibration: A tuned reed adjusted to have its resonant frequency near 100 cycles is provided as a reference standard of frequency. The main tuning control on the instrument is set to a line marked REED and then a compensating condenser is adjusted until the output frequency and the reed are in agreement as shown by maximum deflection of the reed. The REED mark is correctly placed to within one cycle.

Each instrument is individually calibrated in terms of the General Radio Company's primary standard of frequency and the dial of the main tuning control is engraved at suitable intervals over the entire range. The dial is 8 inches in diameter and has a spread of 270° so that the scale is spread out over almost 18 inches.

For one year from the date of purchase, the calibration can be relied upon to within 2% when the oscillator has been adjusted to the reed frequency at the REED point.

Frequency Stability: In order to reduce the frequency drift, due to temperature changes, coils and condensers of the tuned circuits have been placed in balsa-wood boxes to reduce temperature changes. The output frequency may drift 5 cycles to 15 cycles in the first two hours due to internal heating, but this effect is slight thereafter in the absence of a marked change in room temperature. A 15-volt change in the supply voltage causes 2 or 3 cycles shift in the output frequency. If the accuracy of the work justifies such a precaution, the oscillator frequency may, at any time, be checked against the tuned reed.

Output: The open circuit voltage varies between 15 and 21 volts over the entire range and is at least 20 volts with a ±1 volt variation above 80 cycles. The output control is an 18,000-ohm voltage divider. A 0-30-volt rectifier type voltmeter is permanently connected across the OUTPUT terminals.

The maximum power output at 1000 cycles is: 30 mw for a load impedance of 3500 ohms; 25 mw for a load impedance of 10,000 ohms.

Internal Output Impedance: 3500 ohms at maximum output.

Waveform: Harmonics (chiefly second) amount to 5% to 10% of the fundamental amplitude above 100 cycles depending upon the load impedance. Above 100 cycles and with a 10,000-ohm load the harmonic content is about 5%. Below 100 cycles it increases, reaching 20% at 10 cycles.

The amplitude of the "power supply ripple" is approximately 0.25%. Carrier-frequency voltages from both oscillators have been eliminated by suitable filters.

Controls: On the panel are mounted, in addition to the main frequency control dial, an ON-OFF switch for the power supply, an ON-OFF switch for the tuned reed, an auxiliary frequency-adjusting knob, and the output voltage control.

Variations in output with line voltage are appreciable and, for that reason, a line voltage rheostat is included so that large fluctuations may be compensated for.

Meters: On the panel are mounted a line voltmeter and a 0-30-volt oxide-rectifier voltmeter connected directly across the OUTPUT terminals.

Tubes: One (RCA or equivalent) 280-type tube is used as a rectifier and five 227-type tubes are used as oscillators and amplifiers.

Power Supply: 100-120 volt, 50-60 cycle line. The total drain is about 50 watts.

Terminals: The power supply connects to a standard receptacle inside the cabinet. A ground terminal and the OUTPUT terminals are mounted on the panel.

Mounting: All apparatus is mounted on the engraved panel which is finished in black crackle lacquer. The panel is mounted in a heavy oak case with brass carrying handles and lock. It may be bolted to the wall, hinges allowing the cabinet to swing out for replacing tubes, etc.

Accessories: The instrument is supplied without tubes but with a 7-foot cord for making connection to the power supply.

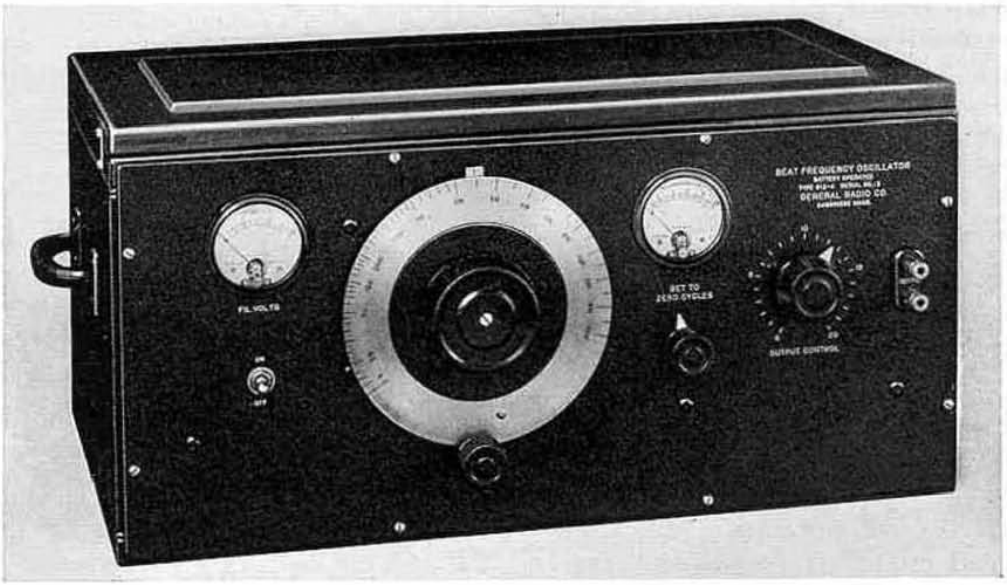
Dimensions: Panel, (width) 19 x (height) 24½ inches. Over-all cabinet size, including handles, (width) 20½ x (height) 25 x (depth) 11 inches.

Screw holes in the panel are the standard spacing for mounting the instrument in a TYPE 480 (standard 19-inch) Relay Rack.

Net Weight: 71½ pounds.

Type		*Code Word*	*Price*
513-B	.....	NATTY	**$450.00**

TYPE 613-A BEAT-FREQUENCY OSCILLATOR
BATTERY OPERATED



This is a battery-operated instrument which possesses the desirable features of good waveform, frequency stability, and open scale which characterize the TYPE 513-B Beat-Frequency Oscillator previously described.

This oscillator is adjusted to the calibrated conditions by setting to zero beat by means of a plate-current meter. The dial of each instrument is individually calibrated and engraved.

The output has been carefully filtered so that spurious high frequencies are not present.

SPECIFICATIONS

Frequency Range: Calibrated between 5 cycles and 10,000 cycles, it will actually deliver power at frequencies slightly lower and higher, respectively, than these.

Frequency Calibration: A reference calibration is secured by setting the two component oscillators to zero beat, using the plate-current meter as an indicator. The main tuning control is set to a line marked "0" and then the compensating condenser is adjusted until the plate current meter ceases to vibrate, thus indicating zero beat.

Each instrument is individually calibrated in terms of the General Radio Company's standard of frequency and the dial of the main tuning control is then engraved. The dial is 6 inches in diameter and has a spread of 270° so that the scale is spread out over almost 14 inches.

For one year from the date of purchase, the calibration can be relied upon to within 2% after the oscillator has been checked at the zero beat point.

Frequency Stability: The radio-frequency oscillators are stable and under uniform temperature conditions the beat frequency will stay within a few cycles over a period of several hours. Changes in ambient temperature will cause slight changes in frequency due to the temperature coefficient of the tuned circuits. When a drift in frequency is observed it can be corrected by resetting the zero beat adjustment.

Output: The open-circuit output voltage does not depart from a 13-volt average by more than 20% over the entire frequency range.

Internal Output Impedance: 5000 ohms.

Waveform: On open circuit the total harmonic content is less than 2% of the fundamental above 100 cycles. With a 5000-ohm load it is less than 5% above 100 cycles; below 100 cycles it increases rapidly as the frequency is reduced, reaching 10% at 20 cycles.

Controls: In addition to the main tuning control and the auxiliary control for adjusting to the zero reference frequency, there is the output voltage divider and an ON-OFF switch.

Meters: A filament voltmeter and a detector plate-current meter are mounted on the panel.

Tubes: Three 230-type and one 231-type (RCA or equivalent) tubes are required. None are supplied with the instrument.

Power Supply: Space for mounting three 45-volt plate batteries and two No. 6 dry cells for filament supply is provided inside the cabinet.

Terminals: Two binding posts on the panel are provided for making connections to the oscillator.

Mounting: The instrument is mounted on an aluminum panel finished in black crackle lacquer and contained in a polished walnut cabinet with carrying handles.

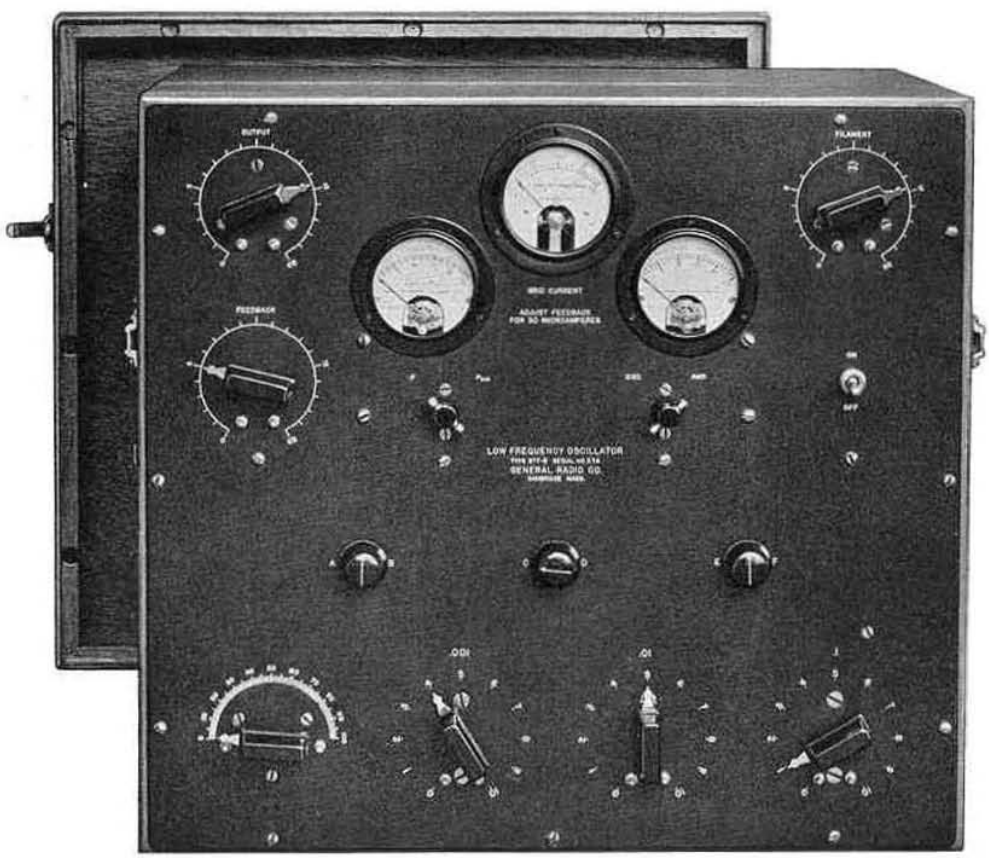
Dimensions: Panel, (width) 19 x (height) 8¾ inches. Cabinet, (width) 22 x (height) 12¼ x (depth) 9 inches, over-all.

Net Weight: 33¼ pounds without batteries.

Type		*Code Word*	*Price*
613-A	.....	NAVAL	**$210.00**

TYPE 377-B LOW-FREQUENCY OSCILLATOR

In the communication laboratory a general purpose oscillator is an extremely useful instrument. An oscillator for general use must meet more rigid specifications than any other type because of the wide range of uses to which it is put. The TYPE 377-B Low-Frequency Oscillator is designed to meet the demand for an instrument of this sort. Its frequency range extends from the low audio to low radio



frequencies. Frequency stability and low harmonic content are other important characteristics. Among its uses are bridge measurements of all kinds, studies of the response curves of transformers and loudspeakers, the study of filter characteristics, and the study of cable and other dielectric behavior. Since the frequency goes to 70 kilocycles, power level and attenuation measurements on lines and networks can be made at carrier as well as audio frequencies.

This type of oscillator is useful in general scientific work as well as in the more specialized problems of electrical communication and is recommended for general use in college and industrial laboratories.

SPECIFICATIONS

Frequency Range: Any frequency between 25 cycles and 70,000 cycles can be obtained. The range can be extended downward to 10 cycles for a small additional charge.

Power Output: 50 milliwatts with one amplifier tube; 100 milliwatts with two amplifier tubes. It is adjustable by means of voltage divider. The internal output impedance with the voltage divider set for maximum output is approximately 3000 ohms.

Waveform: The maximum harmonic content is about 3% of fundamental amplitude. Most of it is introduced by the amplifier.

This may be reduced to about 1% for loads of 8000 ohms or more by reducing the signal level applied to the amplifier. The method of doing this involves changing biasing resistors and is described in the instructions accompanying the instrument.

Calibration: A calibration for 50 points accurate to within 1% is made in terms of the General Radio primary standard of frequency for each instrument. The corresponding settings of the condensers and the inductor switches are entered on two charts. One is mounted inside the back cover, the other in an aluminum chart holder.

Frequency Stability: Changes in tubes and operating voltages have a minor effect on the frequency, a change of 25% in plate voltage, for example, producing about 0.1% change in frequency. Changing tubes causes about the same amount of shift. This is unusually good performance for a power oscillator of so wide a frequency range.

Controls: All controls are located on the panel. They are: inductor selector switches, condenser switches, variable condenser, feed-back adjustment, output power adjustment, and filament rheostat.

Meters: Meters are provided for reading oscillator grid current as an index to correct feed-back adjustment, filament and plate voltage, and oscillator and amplifier plate current.

Mounting: All parts are mounted on an engraved bakelite panel in a heavy oak case with carrying handles and a cover. The case may be bolted to the wall, hinges allowing the cabinet to swing out for replacing tubes, etc.

Terminals: All battery and output terminals are inside the case, which has holes in its side for the connecting wires.

Tubes: Two or three 112-A-type (RCA or equivalent) tubes are used, one as an oscillator and either one or two as amplifiers. Tubes are not supplied with the instrument.

Power Supply: 135 volts, 16 ma (plate) and 6 volts, 0.75 a (filament) are required to operate 3 tubes in addition to the grid-biasing battery mounted inside the case. Only the latter is included in the price of the instrument.

Dimensions: Cabinet with cover, (width) 19⅛ x (height) 18 x (depth) 10½ inches, over-all.

Net Weight: 57 pounds.

Type		*Code Word*	*Price*
377-B	.....	OMEGA	$350.00
	Alteration to extend range downward to 10 cycles	EXTRA	35.00

Use the compound code word OMEGAEXTRA when ordering an oscillator with the alteration.

TYPE 508-A OSCILLATOR

Operated entirely from the 110-volt alternating-current mains, the TYPE 508-A Oscillator delivers 10 frequencies between 200 cycles and 4000 cycles. This illustration shows TYPE 508-AM Oscillator

This is an alternating-current operated instrument of medium power, yielding 10 frequencies separated by approximately equal percentage intervals to cover the more commonly used portion of the audio range. It is intended for use in bridge measurements and in measurements on electrical communication apparatus and systems where it is necessary that measurements be made at a number of different frequencies.

In many measurements considerable amounts of power are required; the TYPE 508-A Oscillator, therefore, operates at a high power level. It is entirely alternating-current operated, as in this way the power required is obtained at a minimum expense, and the necessity for maintaining an external power-supply system is avoided.

Both frequency stability and waveform are extremely good for an oscillator delivering a high power output. There is no direct current in the output circuit.

It is normally supplied, mounted in a cabinet, but a model adapted for mounting in a standard 19-inch relay rack is available.

SPECIFICATIONS

Frequency Range: The 10 frequencies available are 200, 300, 400, 600, 800, 1000, 1600, 2000, 3000, and 4000 cycles. Selection is made by a single 10-point switch. Frequencies between these values can be secured by the use of an external condenser which can be plugged into the jack terminals on the panel at the left. For frequencies between 250 cycles and 4000 cycles a TYPE 219-G Decade Condenser with a TYPE 335-Z Variable Air Condenser is suitable. Between 200 cycles and 250 cycles an additional 0.5 μf condenser is required. These condensers are not supplied with the instrument.

Frequency Calibration: Each instrument is adjusted in our laboratory to within 5% of the frequencies engraved on the panel.

Frequency Stability: Any frequency of this oscillator can be relied upon to remain constant to within 1% over a period of several hours in spite of changes in load or line voltage.

Output: Approximately 0.5 watt into a load of 2000 ohms. This maximum power output varies between approximately 0.3 watt and 0.8 watt as the frequency is changed. A high-impedance voltage divider for adjusting the power output is included.

Internal Output Impedance: 2000 ohms at maximum output.

Waveform: On open circuit, the total harmonic content of the output wave is less than 8% of the fundamental amplitude. This increases as the load

impedance is reduced, approaching a maximum of 11% when the output terminals are short-circuited. The maximum open-circuit hum voltage across the terminals is 0.5 volt.

Controls: An ON-OFF switch for the power supply is the only control except for the frequency selector and the VOLUME CONTROL voltage divider.

Tubes: One 245-type tube and one 280-type rectifier tube (RCA or equivalent) are required. Neither is included in the price of the instrument.

Power Supply: 100 to 120-volt, 50 to 60-cycle line. The power drain is about 40 watts.

Terminals: The power supply connects to a standard receptacle inside the cabinet. The terminals for connecting the output and for attaching an external condenser (see "Frequency Range") are mounted on the panel.

Mounting: All apparatus is mounted on a metal shelf secured to the aluminum front panel. The circuit is entirely enclosed in a metallic shield to prevent pickup to associated apparatus. As normally supplied, the shielded oscillator unit is mounted in a hand-rubbed walnut cabinet. This is known as TYPE 508-AM.

The TYPE 508-AR Oscillator fits a standard 19-inch relay rack

When a model mounted in a standard 19-inch relay rack is required, the unit can be removed from the cabinet and provided with panel extension plates to secure the standard width. An oscillator so modified is known as TYPE 508-AR.

Accessories: Instrument is supplied without tubes, but with a 7-foot cord for making connection to the power supply.

Dimensions: For TYPE 508-AM: Panel, (width) 15 x (height) 8¾ inches. Cabinet, (width) 18 x (height) 10 x (depth) 12¼ inches, over-all.

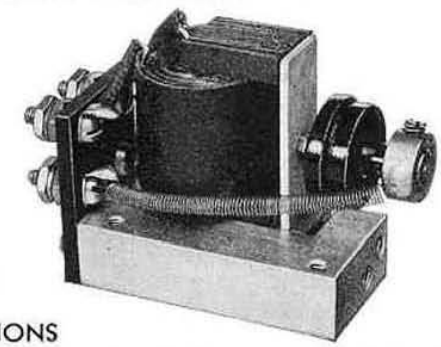
For TYPE 508-AR: (Width) 19 x (height) 8¾ x (depth behind panel) 10 inches, over-all.

Net Weight: 33¾ pounds for TYPE 508-AM and 30¼ pounds for TYPE 508-AR.

Type	*Description*	*Code Word*	*Price*
508-AM	**Cabinet mounting**	ARROW	**$120.00**
508-AR	**For relay-rack mounting**	ARSON	**105.00**

TYPE 241 MICROPHONE HUMMER

This is an electro-mechanical oscillator in which the frequency is determined by a tuned reed. It is intended for use as a low-power, alternating-current source for bridge and other measurements where the purity of waveform, frequency stability, and other features of the TYPE 213 Audio Oscillator are not essential.



SPECIFICATIONS

Frequency: Approximately 1000 cycles.

Output: About 20 milliwatts, maximum.

Internal Output Impedance: Two models are available: TYPE 241-A has an internal impedance of 250 ohms; TYPE 241-B, 4.5 ohms.

Power Supply: This oscillator is intended to operate from a 4½-volt battery of the type used as a grid-bias battery in vacuum-tube circuits.

Mounting: Supplied unmounted as shown in the illustration with two No. 25 holes for attaching to a base board.

Dimensions: (Length) 2⅞ x (height) ⅜ x (width) 1 1/16 inches, over-all.

Net Weight: 1 pound.

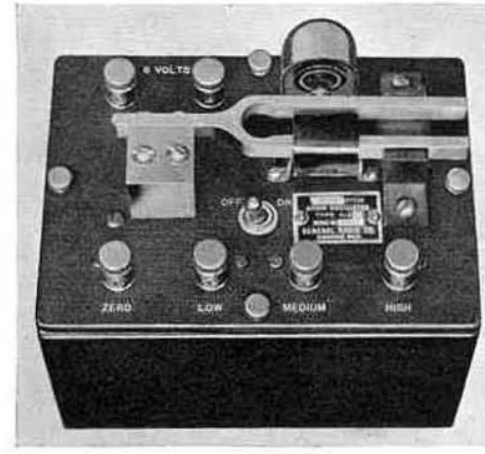
Type	*Impedance*	*Code Word*	*Price*
241-A	**250 ohms**	APHIS	**$10.00**
241-B	**4.5 ohms**	APISH	**10.00**

TYPE 213 AUDIO OSCILLATOR

The TYPE 213 Audio Oscillator is a battery-operated, electro-mechanical oscillator in which the frequency is stabilized by a tuning fork. It is intended for delivering small amounts of power in bridge measurements and telephone line tests. The 400-cycle model when used with a TYPE 530 Band-Pass Filter is recommended for use in broadcasting stations where a test signal of good waveform is required for measuring modulation percentage, distortion factor, and speech-amplifier gain.

Because of its reliability this oscillator has been used in police radio systems and airplane beacon transmitters to furnish a test signal.

The frequency is determined by the frequency of the tuning fork which drives a microphone button. The advantages of this oscillator are simplicity, reliable operation, and rugged construction.



SPECIFICATIONS

Frequency: Two models, one operating at 1000 cycles and one at 400 cycles, are carried in stock, but special instruments can be constructed for any 100-cycle multiple between 400 cycles and 1500 cycles. Designs are on file; prices on request.

Calibration: The actual frequency will be less than the rated value by about 0.5% due to the loading of the fork by the microphone button.

Frequency Stability: The maximum change in frequency with load is about 0.1%. This and variations introduced by temperature are entirely negligible for practically all purposes for which this oscillator is likely to be used.

Output: A maximum of 50 milliwatts can be obtained.

Internal Output Impedance: The power output is delivered through a transformer-filter. Three taps are provided permitting the use of loads from 20 to 10,000 ohms.

Waveform: The harmonic content varies with the load impedance. With normal resistive loads it will vary from about 3 to 8%.

Tubes: This is an electro-mechanical oscillator and requires no tubes of any kind.

Power Supply: Normally obtained from a 6-volt d-c source such as a storage battery or dry cells. Drain approximately 125 ma.

Terminals: Two binding posts for the power supply and three binding posts for the output circuit are mounted on the panel.

Mounting: All parts are mounted on a bakelite panel in a polished walnut cabinet.

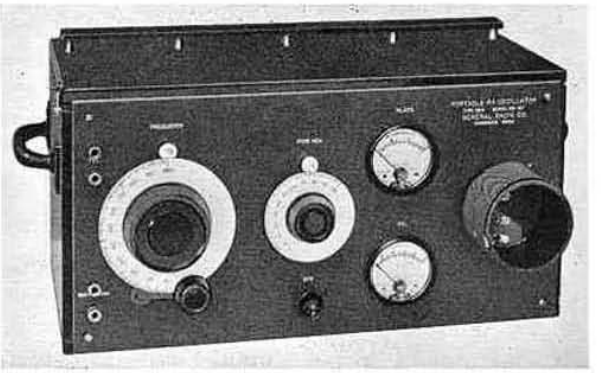
Dimensions: Panel, (width) 6⅛ x (length) 4¾ inches. The over-all height of the instrument depends upon the frequency, being 5 inches for frequencies between 1000 and 1500 cycles and 6⅛ inches between 400 and 900 cycles.

Net Weight: Approximately 5½ pounds.

Type	*Frequency*	*Code Word*	*Price*
*213-B	1000 cycles	ANGEL	$34.00
*213-C	400 cycles	AMUSE	42.00

*Specify frequency as well as type number when ordering. Prices for other frequencies will be supplied on request.

TYPE 384 PORTABLE RADIO-FREQUENCY OSCILLATOR



This oscillator is a low-power radio-frequency driver for laboratory use. It has a wide frequency range and is easily portable. A pair of terminals is provided for introducing a modulating frequency, and another pair for telephones when it is desired to use the oscillator as a heterodyne detector.

SPECIFICATIONS

Frequency Range: 10 kc to 20,000 kc depending on the inductor used. A list of the TYPE 384 Inductors, together with the frequency range covered by each, is given below. None are included in price of instrument.

Power Output: No definite figure can be given for the power output which varies considerably over the frequency range. The fact that a 199-type tube is used should give a rough idea of the power output.

Waveform: Harmonics of considerable magnitude are present in the output, an advantage when it is used as a general-purpose instrument.

Calibration: No calibrations can be supplied. The instrument is intended to be a general-purpose laboratory oscillator, not a frequency standard.

Tubes: One of the 199-type (not included in the price) is required.

Power Supply: Battery space is provided inside cabinet.

Mounting: Bakelite panel mounted in a walnut cabinet with a battery compartment, a rack for holding spare inductors, and carrying handles.

Dimensions: Panel, (length) 18 x (width) 9⅛ inches. Cabinet, (depth) 9⅛ inches, over-all.

Net Weight: 13 pounds.

Type	*Code Word*	*Price*
384	ODIUM	$90.00

TYPE 384 INDUCTORS

These are intended for use with the TYPE 384 Portable Radio-Frequency Oscillator, as specified in the description of this instrument. See the illustration accompanying the TYPE 384 Portable Radio-Frequency Oscillator.

Type	*Frequency Range*	*Code Word*	*Price*
384-A	20,000-10,000 kc	HAZEL	$3.00
384-B	10,000- 3750 kc	HEAVY	3.00
384-C	4290- 1500 kc	HELOT	3.00
384-D	1579- 522 kc	HERON	3.00
384-E	531- 176 kc	HILLY	4.00
384-F	176- 68 kc	HINNY	4.00
384-G	68- 25 kc	HOARY	5.00
384-H	25- 10 kc	HOLLY	8.50
*384-D8	1500- 500 kc	HOBBY	4.50

*This has a figure-8 winding, designed to have a minimum external field.

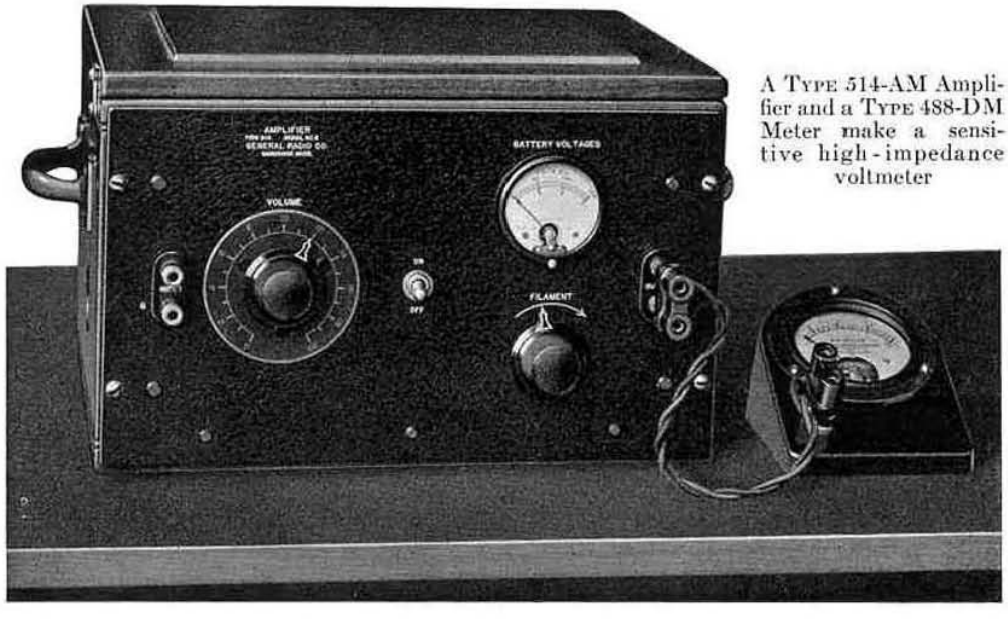
AMPLIFIERS

TYPE 514-A AMPLIFIER

As methods for making electrical measurements at various frequencies increase in accuracy, there has arisen a demand for an amplifier somewhat different in performance from those generally available. For work in connection with precision measurements, such an amplifier must be capable of operating on signals of extremely low intensity and should cover a wide range of frequencies with fairly uniform efficiency. It will be recognized that these operating characteristics are essential where an amplifier is to be used in determining the null point in bridge measurements and in similar work. It is also necessary that the amplification be stable in order that the amplifier may be used for comparison methods. These same requirements must also be met when the amplifier is to be used with photo-electric cells and with microphones.

The TYPE 514-A Amplifier, designed to meet these operating requirements, employs a three-stage resistance-capacitance-coupled circuit operated entirely by dry batteries. The input impedance may be varied to meet external circuit conditions and may have values sufficiently high to permit the amplifier to be used for observations of voltage across high impedances. The output is designed to work into load impedances of 20,000 ohms. It is, therefore, suitable for use with headphones or with a copper-oxide-rectifier voltmeter. When used with the latter instrument it functions admirably as a high-impedance high-sensitivity voltmeter. By means of a volume control having a numbered scale, it is possible to adjust the sensitivity to some predetermined calibration.

A multi-contact plug receptacle is mounted in such a way that external circuits, such as condenser transmitters, photo-electric cells, and similar devices, together with their associated amplifying tubes, may be connected to the amplifier by means of a single cable. Where such auxiliary equipment is used, the entire power supply may be obtained from the batteries associated with the TYPE 514-A Amplifier through connections to the multi-contact receptacle by means of a TYPE 514-P1 7-Contact Plug Unit.



A TYPE 514-AM Amplifier and a TYPE 488-DM Meter make a sensitive high-impedance voltmeter

SPECIFICATIONS

Frequency Range: The gain of this amplifier is practically constant over the frequency band between 50 cycles and 50 kc although the actual upper limits are determined to a large extent by the tube and value of load resistance used. More specific data are available on request.

Amplification: With a 230-type tube and an external load of 20,000 ohms the voltage amplification is in excess of 200 to 1. With a 231-type tube and an external load of 5000 ohms the voltage amplification is in excess of 50 to 1. Amplification is adjustable by means of a potentiometer in the grid circuit of the second tube.

Internal Output Circuit: With a 230-type tube 12 volts may be obtained across an external load of 20,000 ohms. With a 231-type tube 15 volts may be obtained across an external load of 5000 ohms.

Input Impedance: One megohm. Interchangeable coupling units may be used to give other values as required. Complete information is given in the instruction book accompanying the instrument.

Tubes: Three 230-type tubes, or two 230-type and one 231-type tubes, are required. Tubes are not included in the price of the amplifier.

Power Supply: Two 1.5-volt No. 6 dry cells, three 45-volt block batteries, and one 4.5-volt or one 22.5-volt block battery with tap at 4.5 volts are required for filament-, plate-, and grid-circuit supplies, respectively. The filament-current drain is 180 ma at 2 volts; 250 ma at 2 volts, if the 231-type tube be used. The total plate current is 2.4 ma at 135 volts; or 3.4 ma, if the 231-type tube be used. Batteries are not included in the price of the amplifier.

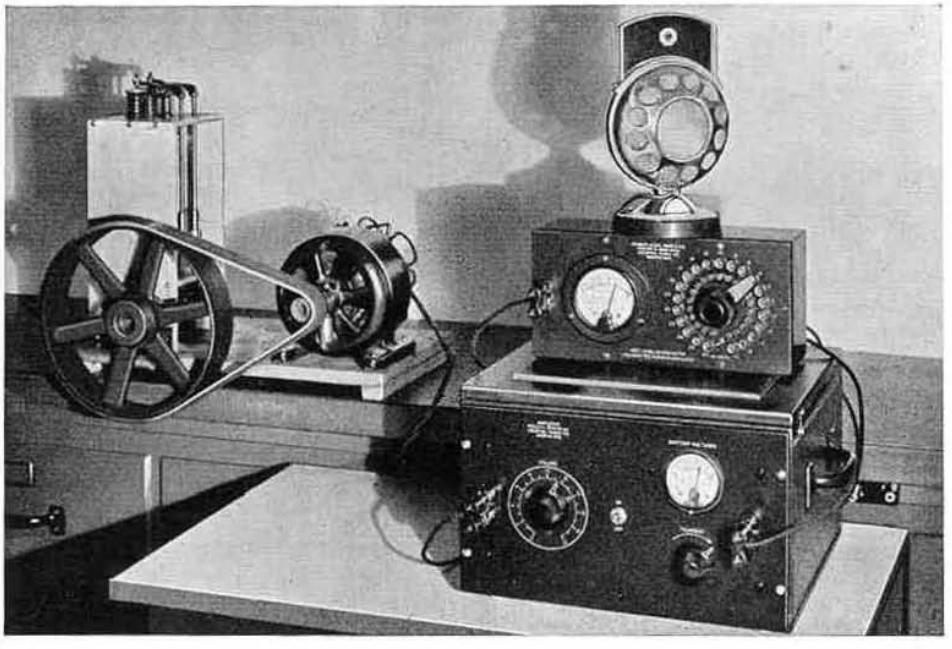
Mounting: The apparatus is mounted on a metal shelf secured to an aluminum front panel and is entirely enclosed in a metal shield to prevent pickup from associated apparatus.

The unit may be furnished mounted in a walnut cabinet having space for batteries (TYPE 514-AM) or it can be supplied fitted with panel extensions for mounting in a standard 19-inch (TYPE 480) relay rack. The rack mounting model is known as TYPE 514-AR.

Dimensions: Panel size, (width) 12 x (height) 7 inches. Cabinet size for TYPE 514-AM, (width) 15 x (height) 8¼ x (depth) 12¼ inches, over-all. Size for TYPE 514-AR, (width) 19 x (height) 7 x (depth) 6 inches, over-all.

Net Weight: TYPE 514-AM, 15¾ pounds; TYPE 514-AR, 10½ pounds. The necessary batteries weigh approximately 14½ pounds.

Type	*Description*	*Code Word*	*Price*
514-AM	**Cabinet mounting**	ARGUS	**$76.00**
514-AR	**For relay-rack mounting**	ARMOR	**65.00**
514-P1	**7-Contact Plug Unit**	ARRAY	**1.00**



A TYPE 514-AM Amplifier, TYPE 586-CM Power-Level Indicator, and a microphone can be used to measure the increase in noise level caused by machinery

BRIDGES AND ACCESSORIES

The simplicity and accuracy of bridge methods have led to their general adoptio for the measurement of resistance, inductance, capacitance, and vacuum-tube parame ters. General Radio makes bridges for all of these needs.

IMPEDANCE BRIDGES

	Type	*Particular Applications*	*Identifying Features*
	**293**	Resistance, inductance, and capacitance measurement for direct-current, audio- and carrier-frequencies	All terminals are available s that any bridge circuit can b set up
	**216**	Precision measurement of capacitance and power factor between 200 and 10,000 cycles	Equal ratio arms, shieldin self-contained decade resisto
	**383**	Measurement of capacitance of vacuum tubes and condensers up to 600 $\mu\mu$f at 1000 cycles	Portable unit, self-contain except for null indicator
	**240**	Measurement of large capacitances (1000 $\mu\mu$f to 11.1 μf) at 1000 cycles	Portable unit, completely se contained

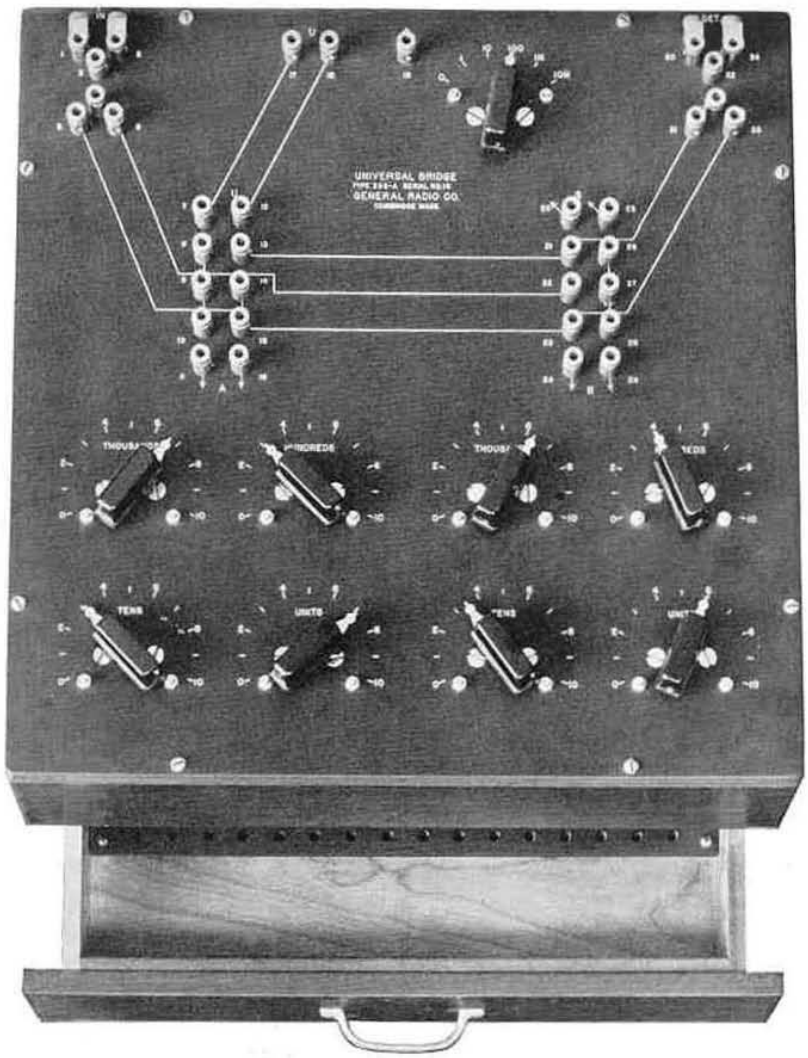
VACUUM-TUBE BRIDGE

	Type	*Particular Applications*	*Identifying Features*
	**561**	Measurement of all interelectrode parameters for all tubes	A-c filament supply (fro 110-volt mains) for all tub included. Sockets for 4-, 5-, and 7-prong bases

BRIDGE ACCESSORIES

	Type	*Particular Applications*	*Identifying Features*
	**210**	Audio-frequency bridge measurements of all kinds	Both arms adjustable, 7 step
	**229**	A galvanometer shunt having shunt ratio independent of galvanometer resistance	Five values of shunt ratio i each size

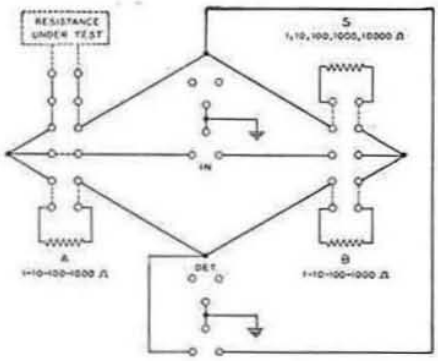
TYPE 293-A UNIVERSAL BRIDGE



The TYPE 293-A Universal Bridge is designed to present a fundamental circuit which may be connected to produce a wide variety of standard direct- and alternating-current bridges. The instrument consists of three resistance arms and a terminal board by means of which the various circuits can be set up with plugs and jacks. The bridge arrangement permits the measurement of inductance, capacitance, and resistance over a wide frequency range (0–50,000 cycles). It can also be set up as a frequency meter. The instrument has, therefore, a much wider general usefulness in a college or measurement laboratory than the usual form of permanently connected bridge circuit.

The resistance arms of the bridge consist of two similar arms, each having a total resistance of 11,110 ohms in four decade dials (1, 10, 100, and 1000 ohms), and a third arm having resistances of 1, 10, 100, 1000, and 10,000 ohms.

The bridge elements are shown diagrammatically in the accompanying drawing, which illustrates the points in the circuits where terminals are located. The bridge circuit is shown connected for the



Schematic diagram of a TYPE 293-A Universal Bridge set up for measuring resistance

standard Wheatstone bridge. The dotted lines are connections made by means of the plug connectors on the terminal board. The plugs are arranged in two groups, each group terminating elements of one side of the bridge. The plug arrangement permits the connection of additional elements in series with any of the bridge arms. The input and output (power and null detector) circuits can be brought out directly or through transformers. Jacks are provided to fit transformers which can be supplied for the bridge.

When used for resistance measurements no additional standard is required, the *S* arm of the bridge being used as a standard. For inductance and capacitance measurements, an external standard is required. The bridge does not include a null detector or power supply.

A particularly useful feature of the bridge is its high accuracy with very high ratios. Tests on the bridge arranged in the standard Wheatstone bridge circuit have shown that it is possible to use ratios as high as 1000 : 1 with excellent accuracy in making resistance measurements. When substitution methods are used, extremely high accuracy of comparison is possible. This can be of the order of one part in 10,000 with the bridge as normally supplied. Using the TYPE 293-P3 Slide-Wire Resistor, an extra significant figure may be obtained. This unit may be used to extend the decade arms from 1 ohm to approximately zero resistance.

The absolute accuracy of the measurement, of course, depends upon that of the standard. Inductances as high as 1000 henrys can be measured with a 1-henry standard. Capacity unbalance of the order of 0.01 micromicrofarad can be observed. The shielding and arrangement of the bridge are such that accurate results can be obtained at frequencies as high as 50,000 cycles when properly constructed input and output transformers are used. Impedances of the order of 10 ohms to 1000 ohms can be measured at this frequency.

SPECIFICATIONS

Bridge Arms: The *A* and *B* arms each consist of four decade resistors covering a range of 1 ohm to 11,110 ohms in 1-ohm steps. The *S* arm is a resistor containing a 1, 10, 100, 1000, and 10,000 ohm unit. The characteristics are similar to those of the TYPE 602 Decade-Resistance Box.

Accuracy: All resistors are adjusted to within 0.1% of the specified value except the 1-ohm units which are adjusted to within 0.25%.

The absolute accuracy of measurement, of course, will depend upon the accuracy of the standard.

Frequency Range: The bridge can be used at all frequencies from direct current up to 50,000 cycles.

Shielding: The cabinet is copper lined and the *A*, *B*, and *S* arms are shielded from each other. The panel is shielded over the *A* and *B* arms.

Accessories: To facilitate making the connections required by this flexible bridge, there are supplied with each instrument 10 double plugs, 2 double shielded connector cords, and 2 single connector cords.

For suggestions as to the choice of suitable standards, sources of power, and null indicators consult the section on bridge accessories, page 91.

Shielded input and output transformers and the TYPE 293-P3 Slide-Wire Resistor are described in the following section.

Dimensions: Panel, (width) 15½ x (depth) 16⅜ inches. Cabinet, (height) 8⅜ inches, over-all.

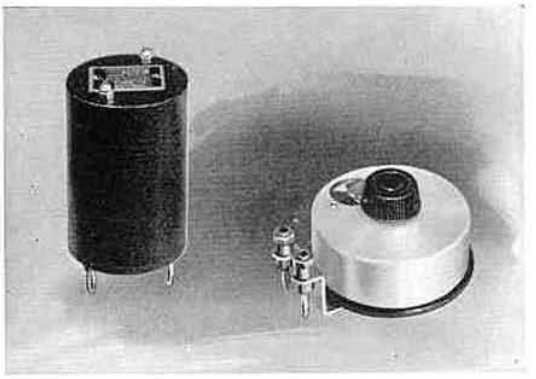
Net Weight: 22¼ pounds.

Type		*Code Word*	*Price*
293-A	.....	BACON	**$140.00**

TYPE 293-P ACCESSORIES

In using the TYPE 293-A Bridge for alternating-current measurements, shielded input and output transformers are desirable. The following transformers are available and are satisfactory for measurements in the audio-frequency range. Both transformers can be used with either coil as input or output and are grounded in either position when plugged into the bridge.

When the impedance under measurement is low, it is desirable to extend the range of the bridge arms downward. This may be done by the use of one or two TYPE 293-P3 Slide-Wire Resistors. The TYPE 293-P3 Slide-Wire Resistor is a shielded resistor calibrated directly and having a range of 0–1.3 ohm. The slide-wire calibration is accurate to 0.02 ohm at any setting. The unit is arranged for plug mounting on the bridge terminal board.



Type	*Turns Ratio*	*Inductance High Side*	*Frequency Range*	*Circuit Impedance*		*Net Weight*	*Code Word*	*Price*
				High Side	*Low Side*			
293-P1	3:1	2.5 h	50–5000 cycles	2700	300	2 lb.	BADGE	**$12.00**
293-P2	2.55:1	2.5 h	50–5000 cycles	25,000	4000	2 lb.	BAFFY	**12.00**
293-P3	Slide-Wire Resistor.....					8 oz.	BAGGY	**20.00**

TYPE 216 CAPACITY BRIDGE

The precise measurement of small values of capacitance and power factor requires a bridge circuit that is carefully and thoroughly shielded. The TYPE 216 Capacity Bridge is suited for precision measurements of this type at audio frequencies.

This bridge is an equal-arm shielded bridge designed primarily for the measurement of small capacitances over a range of audio frequencies from 200 to 10,000 cycles. The ratio arms are 5000 ohms each. A third resistance variable up to 11,110 ohms by 1-ohm steps may be connected into either of the other two arms, thus providing the resistance adjustment necessary for a complete balance.

This bridge is not self-contained, in the sense that the power source, null indicator, and standards of capacitance must be provided and connected externally.

The ratio arms are made equal within 0.05 per cent. Errors due to capacitances to ground of the various arms of the bridge, the power source, and the null indicator are minimized by the symmetry of the bridge and by the use of shielded input and output transformers which are themselves symmetrical with respect to their cores and shields, thus making them astatic to external fields. These transformers are completely shielded from the rest of the bridge, as is also the added resistance. Such precautions enable capacitances placed in adjacent arms to be compared with a maximum error of 0.2 per cent or one micromicrofarad, whichever is the larger.

Using a substitution method in which two capacitances are used alternately in the same arm of the bridge, so that errors

TYPE 216 Capacity Bridge

in the adjustment of the ratio arms and those due to ground capacitances do not enter directly, the two capacitances may be compared with an error of 0.05 per cent or 0.05 micromicrofarad, whichever is the larger. With a power source of 100 volts at a frequency of 1 kilocycle and using a 2-stage amplifier and telephones as a null indicator, the capacitance balance can be adjusted to one part in a million.

The equivalent series resistance of a condenser may be determined with this bridge, using a substitution method and a TYPE 222-M Precision Condenser as the standard capacitance. Expressing this resistance as the power factor of the condenser, its error is about 2 per cent or 0.00005, whichever is the larger.

The TYPE 222-M Precision Condenser (1000 micromicrofarads) is usually used as the standard capacitance for this bridge. Its range may be extended to both large and small capacitances by the use of the extra resistors provided, which allow the ratio arms to differ from unity by 0.1, 1, and 10 per cent.

This bridge may also be used for the comparison of inductances and as the basis for the Anderson, Heaviside, Wien, and resonance bridges. Its use for these bridges is somewhat limited to the comparison of large reactances by the size (5000 ohms) of its ratio arms.

SPECIFICATIONS

Ratio Arms: 5000 ohms. 3 additional resistors of 5, 50, and 500 ohms, allowing the ratio of these arms to differ from unity by 0.1, 1, and 10%.

Standard Resistor: 4-decade resistance 1–11,110 ohms, variable by 1-ohm steps. Can be connected in either arm by means of switch mounted on side of cabinet.

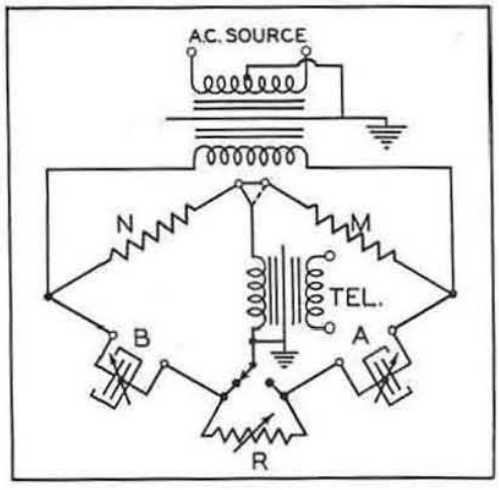
Accuracy of Adjustment: 0.1%. Ratio arms are equal to 0.05%.

Type of Winding: Unifilar for ratio arms. Ayrton-Perry for standard resistance, which has characteristics identical with those given for TYPE 602 Decade-Resistance Boxes (page 7).

Transformers: Input: shielded, astatic, ratio 1 to 2.5, step-up, working between 1600 and 10,000 ohms. Output: shielded, astatic, ratio 2.8 to 1, step-down, working between 200,000 and 25,000 ohms.

Range: Capacitance 1 $\mu\mu$f to 10 μf. Frequency, 200 to 10,000 cycles per second.

Shielding: Copper lining in cabinet, separate compartments for transformers, ratio arms, and standard resistance.



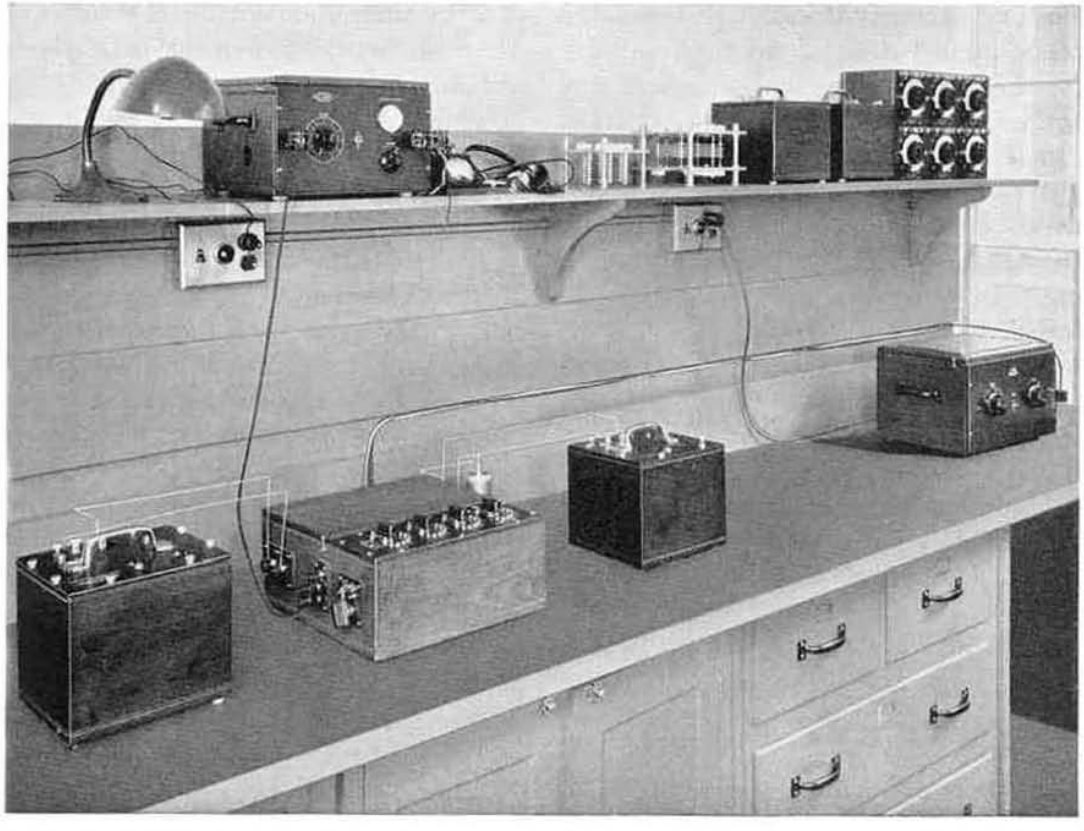
Mounting: Resistances mounted on bakelite and enclosed in a hand-rubbed walnut cabinet with hinged cover. All terminals mounted on hard rubber inserts in sides of cabinet. All exposed metal parts (except contact faces) nickel plated.

Accessories Required: Power source, null indicator, standards of capacitance, and balancing condenser. See list of bridge accessories (page 91).

Dimensions: Top, 14 x 15 inches; depth, 7 inches.

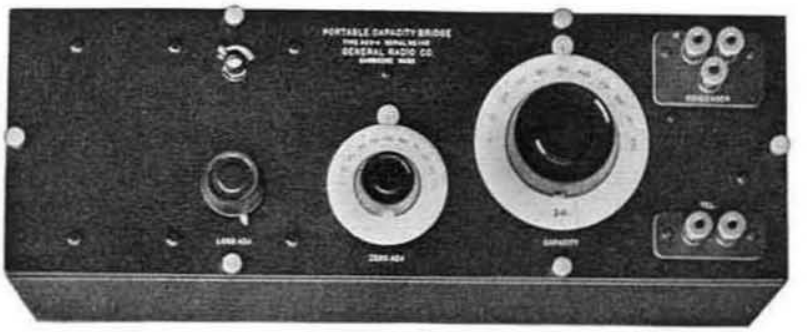
Net Weight: 19¼ pounds.

Type		*Code Word*	*Price*
216	.....	CIVIC	**$175.00**



A TYPE 216 Capacity Bridge and auxiliary apparatus for the measurement of dielectric constant and power factor of liquids. *Left to right on the bench:* Balancing condenser, TYPE 216 Capacity Bridge, test cell, TYPE 222-M Precision Condenser (calibrated variable). The power source is a TYPE 508-AM Oscillator at the extreme right of the bench, and on the shelf is a TYPE 514-AM Amplifier used with either the meter or telephone receivers as a null indicator

TYPE 383 PORTABLE CAPACITY BRIDGE



TYPE 383-A Portable Capacity Bridge

This bridge is an equal-arm, partially shielded bridge designed for the measurement of small capacitances at a frequency of 1000 cycles. The TYPE 383-A Portable Capacity Bridge has a maximum range of 30 micromicrofarads suitable for the measurement of the inter-electrode capacitances of vacuum tubes. The TYPE 383-B Portable Capacity Bridge has a maximum range of 600 micromicrofarads, suitable for the measurement and comparison of the tuning condensers of radio receivers.

The power source and standard of capacitance are supplied with these bridges, which are portable and self-contained. Only the null indicator, a head telephone, must be provided and connected externally.

The power source, a microphone hummer, is connected to the bridge through a shielded, symmetrical input transformer. A substitution method of measuring the unknown condenser is employed, in which the bridge is initially balanced with the standard condenser set at zero (actually its maximum) by adjusting a parallel vernier condenser. The unknown condenser is then connected and the standard adjusted to rebalance the bridge. This method minimizes any error due to inequality of the ratio arms and ground capacitances.

The three inter-electrode capacitances of a vacuum tube are delta-connected. The ordinary measurement of any one includes the capacitance of the other two in series. A direct measurement of any one may be made by connecting the third terminal of the delta to the common junction of the ratio arms. This places one of the two extra capacitances across one of the ratio arms, leaving the desired capacitance across the standard condenser only. Two convenient socket adapters are provided as accessories which make this connection by the mere act of plugging one into the terminals on the bridge panel. Its own capacitance is eliminated by including it in the circuit during the initial balancing of the bridge.

SPECIFICATIONS

Capacitance Range: This bridge is made in two ranges: TYPE 383-A, 0 to 30 $\mu\mu$f and TYPE 383-B, 0 to 600 $\mu\mu$f.

Power-Factor Range: The method of securing the resistance balance in this bridge prevents a satisfactory capacitance balance from being obtained for condensers with very large losses. All air condensers and vacuum tubes ordinarily encountered can be measured without difficulty. This limit on power factor is inversely proportional to the capacitance under test, being 4% power factor at 30 $\mu\mu$f for TYPE 383-A and 2% at 600 $\mu\mu$f for TYPE 383-B.

Accuracy: The bridge is accurate to within 5% of full-scale for TYPE 383-A and to within 2% of full-scale for TYPE 383-B.

It can be balanced to within 0.2% for TYPE 383-A and to within 1% of full-scale for TYPE 383-B.

Transformers: Input: shielded, astatic, ratio 1 to 8.7 step-up, working between 1300 and 100,000 ohms. Output: TYPE 285-D ratio 2.7 to 1 step-down, working between 150,000 and 20,000 ohms.

Power Source: TYPE 241-A Microphone Hummer, frequency 1000 cycles, 4.5-volt dry battery supplied.

Accessories: A null indicator (see page 91 for suggestions) is the only bridge accessory that is not furnished with the bridge.

Two socket adapters for UX- and UY-base tubes are supplied with the TYPE 383-A Bridge.

Mounting: Unit mounted on aluminum panel and enclosed in hand-rubbed walnut cabinet. All terminals mounted on hard rubber plates. All exposed metal parts nickel plated.

Dimensions: Panel, (length) 18 x (width) 6⅛ inches. Cabinet, (depth) 6½ inches, over-all.

Net Weight: 14¾ pounds, both types.

Type	*Range*	*Code Word*	*Price*
383-A	**0 to 30 μμf**	BRUIN	**$80.00**
383-B	**0 to 600 μμf**	BUGLE	**80.00**

TYPE 240 CAPACITY METER

This bridge is a variable ratio-arm, unshielded bridge, designed for the measurement of large capacitances at a single frequency of about 1000 cycles per second. Its range is from 0.001 to 11.1 microfarads with an accuracy of 0.3 per cent of the maximum reading of its three dials, or, to three units on its smallest dial; minimum reading, 10 micromicrofarads.

This bridge is portable and completely self-contained. The power source, a microphone hummer, is connected directly to the bridge between the junction of the ratio arms and the junction of the condensers. The standard capacitance is a fixed mica condenser. The added resistance providing the resistance balance is a TYPE 214 Rheostat, calibrated directly in power factor up to 4 per cent. The power-factor setting may be in error by 0.5 per cent (power factor expressed in per cent, not fractional error expressed in per cent). The reading of the power-factor dial must be considered merely as an indication of high or low losses.

SPECIFICATIONS

Range: Capacitance, 1000 μμf to 11.1 μf. Power factor, 0 to 4%.

Accuracy: Capacitance measurements are accurate to within 0.3% of maximum reading. Power factor measurements are accurate to within 0.5% power factor.

Power Source: TYPE 241-A Microphone Hummer, frequency 1000 cycles, 4.5-volt dry battery supplied.

Null Indicator: Murdock head telephone, approximately 10,000 ohms impedance at 1000 cycles.

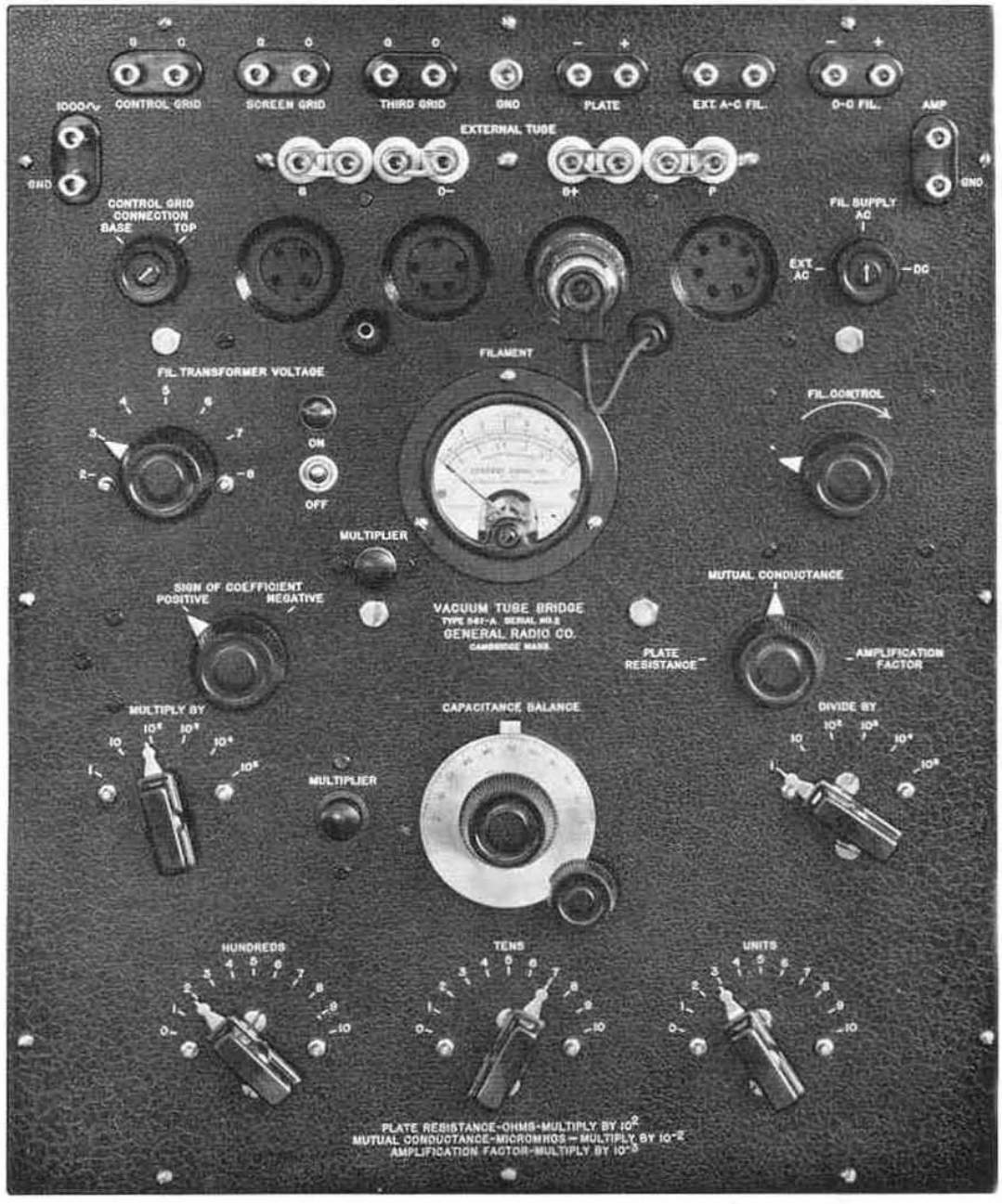
Mounting: Resistances are mounted on hard rubber panel and enclosed in hand-rubbed walnut cabinet with hinged cover and leather handle.

Dimensions: Top, 7 x 14½ inches; depth, 6 inches.

Net Weight: 10⅞ pounds.

Type	*Range*	*Code Word*	*Price*
240	**1000 μμf to 11.1 μf**	CYNIC	**$85.00**

TYPE 561-A VACUUM-TUBE BRIDGE



Panel view of a Type 561-A Vacuum-Tube Bridge with a 57-type tube in position for measurement

An important group of measurements ordinarily taken by means of bridge methods is that of the dynamic characteristics of vacuum tubes. These parameters, amplification constant, mutual conductance, and plate resistance, change under the influence of electrode potentials, and the manner in which these changes take place determines the usefulness of the tube for many applications. A knowledge

of the behavior of these parameters is of particular importance in the case of the new multiple-element tubes where automatic volume control, silent tuning, and similar devices depend for their effectiveness on tube characteristics. Both the tube and set manufacturers require a simple and accurate means of obtaining data as to these characteristics.

The characteristics of new tubes introduced within the last few years cover so wide a range of values that an entirely new approach to the problem has had to be worked out to produce an instrument that would measure all of them. The TYPE 561-A Vacuum-Tube Bridge is properly speaking not a bridge circuit at all but an adaptation of gain measurements in which a decade attenuator is made to read the amplification factor and, by a suitable combination of circuits, mutual conductance and plate resistance as well. These three parameters are measured independently, *i.e.*, none of the balances depends in any way on any other so that independent cross checks can be obtained from the circuit equations.

The bridge embodies new measuring circuits and a more satisfactory method of balancing out the effects of the tube interelectrode capacitances than has heretofore been available. Not only is the accuracy of measurement considerably improved, but all three of the usual parameters may be independently measured over very wide limits.

The procedure in making measurements is simple and straightforward, and is exactly the same for the three coefficients: amplification factor, plate resistance, and transconductance. A three-position switch is turned to whichever quantity is desired, multiplier switches are set at the appropriate value for the tube being tested, and balance is obtained by adjusting a three-decade attenuator and a variable condenser. At balance the decades read directly, to three significant figures, the quantity being measured.

Negative values of the tube coefficients may be measured as readily as positive values, except in regions where dynatron oscillations cannot be prevented.

The measuring circuits and the tube-control circuits may be separated by opening link connectors on the top of the panel. This not only facilitates the testing of tubes associated with other control apparatus, but also makes it possible by changing the cross connections in a very simple manner to measure grid-circuit parameters, or parameters referred to any pair of electrodes.

A double-range alternating-current and direct-current filament voltmeter and a source of alternating-current heater power are included. No external filament connections need be made for alternating-current tubes, except to the 110-volt line.

Four-, five-, six-, and seven-prong sockets are built into the instrument, and a switch is provided for switching the control-grid connection from the base to the cap. Practically all standard receiving tubes, therefore, can be very conveniently measured. Tubes having special base connections such as pentode output tubes not employing a separately heated cathode can be tested by means of the adapter supplied with the bridge or connected externally.

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.

By means of a novel method of balancing out tube capacitances, their effect upon the measured coefficients is rendered negligible. For instance, the plate resistance of a tube having a high value of plate-to-filament capacitance can be measured without any error due to this capacitance.

SPECIFICATIONS

Range: Amplification factor (μ); 0.001 to 10,000.

Dynamic internal plate resistance (r_p); 50 ohms to 20 megohms.

Mutual conductance (S_m); 0.02 to 20,000 micromhos (volts per micro-ampere).

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.

Range of Tubes Covered: All standard four-, five-, six-, and seven-prong receiving tubes can be measured on this instrument without the use of adapters, except that five- or six-prong tubes not having separate heaters require the use of a single adapter furnished with the bridge. A switch is provided for switching the control-grid connection from the base to the cap.

Tubes having special bases can be tested by means of an adapter or connected externally.

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 milliamperes and maximum plate voltage is 1500 volts.

Filament Supply Circuits: A double-range rectifier-type alternating-current and direct-current filament voltmeter and a source of alternating-current heater power are contained in the instrument. No external filament connections need be made for alternating-current tubes, unless voltage greater than 8 volts or current greater than 3.5 amperes is required. The filament rheostat for direct-current filament supply has a capacity of 750 milliamperes.

When measuring alternating-current heated tubes, the bridge requires connection to a source of 115-volt 60-cycle alternating current.

Electrode Voltage Supply: Batteries or suitable power supplies are necessary for providing the various voltages required by the tube under test.

Power Supply: A source of 1000 cycles is required. The TYPE 213-B Audio Oscillator is suitable for this purpose.

Null Indicator: A suitable null indicator is required. The TYPE 514-A Amplifier used in conjunction with a sensitive pair of telephones is recommended for this purpose.

Constructional Features: The lower half of the front panel of the instrument contains the special bridge circuit used in measuring the coefficients. The upper half of the panel contains tube sockets, alternating-current filament supply, filament voltmeter, rheostats, terminals for various voltages, and terminals for direct connection of an external tube to the bridge circuit. This arrangement provides the greatest flexibility for general use.

Mounting: The instrument is mounted on a black crackle lacquered aluminum panel and is furnished in a polished walnut cabinet. A leatherette dust cover is supplied to cover the instrument when not in use.

Dimensions: (Length) 18⅜ inches x (width) 15¾ inches x (height) 11 inches.

Net Weight: 45 pounds.

Type		*Code Word*	*Price*
561-A	.....	BEIGE	**$345.00**

BRIDGE ACCESSORIES

All bridges require for their operation a power source, a null indicator, and comparison standards. Other accessories are transformers for matching the impedance of the power source and null indicator to the bridge, amplifiers, filters, Wagner ground, galvanometer shunt, and separate ratio arms. These accessories are listed in this section with a brief discussion of their relative merits and a reference to the section where they are fully described.

POWER SOURCES

The TYPE 213 Audio Oscillators are satisfactory as single-frequency power sources. They may be obtained for any 100-cycle multiple in the range from 400 to 1500 cycles. The TYPE 241 Microphone Hummer has a higher harmonic content in its output and is less stable in frequency. It is, however, satisfactory for routine bridge measurements and is used in TYPE 383 Portable Capacity Bridges and the TYPE 240 Capacity Meter.

The TYPE 377-B Low-Frequency Oscillator is satisfactory as a variable-frequency power source. TYPE 613-A Beat-Frequency Oscillator has a smaller power and is less stable in frequency, but it is easier to set at a given frequency. The TYPE 513-B Beat-Frequency Oscillator will be found especially convenient because it is operated entirely from the commercial 110-volt alternating-current power supply. Where the frequency does not need to be continuously adjustable, the use of the TYPE 508-A Oscillator is suggested. It has good waveform and is alternating-current operated.

Instrument	*Frequency*	*Page*	*Price*
TYPE 213-B Audio Oscillator	1000 cycles	76	$34.00
TYPE 213-C Audio Oscillator	400 cycles	76	42.00
TYPE 241 Microphone Hummer	1000 cycles	75	10.00
TYPE 377-B Low-Frequency Oscillator	25–70,000 cycles	72	350.00
TYPE 508-A Oscillator	200, 300, 400, 600, 800, 1000, 1600, 2000, 3000 and 4000 cycles	74	120.00
TYPE 513-B Beat-Frequency Oscillator	5–10,000 cycles	69	450.00
TYPE 613-A Beat-Frequency Oscillator	5–10,000 cycles	71	210.00

STANDARDS AND BALANCING REACTANCES

The TYPE 602 Decade-Resistance Boxes, TYPE 133 Standard Resistances, TYPE 500 Resistors, TYPE 106 Standard Inductances, and TYPE 222 Precision Condensers may be used as primary standards. The other reactances listed below may be calibrated in terms of these standards or used as balancing reactances in substitution methods.

Instrument	*Page*	*Price*
TYPE 602 Decade-Resistance Box	8	$25.00–$70.00
TYPE 133 Standard Resistance	13	6.00– 15.00
TYPE 500 Resistor	12	2.00
TYPE 106 Standard Inductances	44	25.00– 36.00
TYPE 107 Variometers	43	30.00– 40.00
TYPE 219 Decade Condensers	41	32.00– 50.00
TYPE 222 Precision Condensers	30	85.00–100.00
TYPE 246 Condensers	33	38.00– 54.00

NULL INDICATORS

Head telephones are the most satisfactory null indicators, both because of their great sensitivity and because of the ability of the human ear to discriminate between a fundamental tone, its harmonics, and noise. They are highly selective, with a resonant frequency around 1 kc. This prevents their use below 200–400 cycles. Below these frequencies and down to 50 cycles, the TYPE 338-G Vibration Galvanometer provides a tuned null indicator. The TYPE 426-A and TYPE 626-A Thermionic Voltmeters may be used over the whole range of audio frequencies and up to perhaps 1500 kc, but are much less sensitive than either of the other null indicators and are not selective. The TYPE 626-A Vacuum-Tube Voltmeter operates in the same way as the TYPE 426-A but it is alternating-current operated.

Oxide rectifier voltmeters may be used as null detectors over the entire audio-frequency range. The TYPE 483-C (20,000 ohm) Output Meter is particularly recommended.

An amplifier is generally needed to increase the sensitivity when using any form of visual null indicator, and the use of an amplifier is advised for precise measurements even when using telephones. The TYPE 514-AM Amplifier has been designed for this purpose. It gives a sensitivity with the TYPE 483-C Output Meter that is about equivalent to that obtainable with telephones without an amplifier.

Instrument	*Range*	*Page*	*Price*
Western Electric Head Telephones (W. E. Type Number 1002-C)	200 cycles– 10,000 cycles		$12.00
TYPE 338-G Vibration Galvanometer	50 cycles– 1000 cycles	113	175.00
TYPE 426-A Thermionic Voltmeter	10 cycles– 1500 kc	129	160.00
TYPE 626-A Vacuum-Tube Voltmeter	10 cycles– 1500 kc	128	100.00
TYPE 483-C Output Meter	10 cycles– 10,000 cycles	131	54.00
TYPE 514-AM Amplifier	50 cycles– 50,000 cycles	78	76.00

TRANSFORMERS AND FILTER SECTIONS

The TYPE 359 and TYPE 666 Variable-Ratio Transformers are specially designed for matching the power source and null detector to a bridge. The TYPE 166 Telephone Transformer is a less expensive transformer of narrower range in both ratio and frequency. TYPE 585 Transformers are fixed-ratio transformers, designed primarily as tube-coupling transformers, but suitable for use with many bridges.

TYPE 330 Filter Sections may be connected between the bridge and null detector to suppress harmonics and ground noise. The combination of high- and low-pass sections of suitable cut-off frequencies provides a band-pass filter. The TYPE 534 Band-Pass Filter is a single unit for filtering in either the generator or the null indicator. It is made for 400-cycle and for 1000-cycle operation.

Instrument	*Page*	*Price*
TYPE 359 Variable-Ratio Transformers	144	$20.00
TYPE 166 Telephone Transformer	144	7.00
TYPE 666 Variable-Ratio Transformer	144	12.50
TYPE 585 Transformers	144	7.00–12.00
TYPE 330 Filter Sections	126	12.00
TYPE 534 Band-Pass Filter	125	18.00–24.00

WAGNER GROUNDS

Since a Wagner ground of the resistance type is merely a fixed resistance with a variable tap, the TYPES 471, 314, 371, 214, 410, and 301 Potentiometers may be used as Wagner grounds. By removing the connection between the two sections of any of the TYPES 334 or 335 Condensers having balanced sections, these condensers become satisfactory Wagner grounds of the capacitance type.

Instrument	*Page*	*Price*
TYPE 471 Rheostat and Potentiometer	22	$6.00
TYPE 314 Rheostat and Potentiometer	23	4.00
TYPE 371 Rheostat and Potentiometer	24	4.00–5.00
TYPE 214 Rheostat and Potentiometer	25	1.50
TYPE 410 Rheostat and Potentiometer	26	1.00
TYPE 301 Rheostat and Potentiometer	26	1.00
TYPE 334 Condensers	37	2.50–10.00
TYPE 335 Condenser	37	6.00

TYPE 210 RATIO-ARM BOX

The nucleus of a bridge is the ratio arms. This box provides a set of ratio arms giving ratios from unity to 1000 by factor steps of about three.

SPECIFICATIONS

Resistances: Each arm, 1, 3, 10, 30, 100, 300, 1000 ohms.

Accuracy of Adjustment: 0.1%.

Type of Winding: Ayrton-Perry, manganin wire, having characteristics identical with those listed under TYPE 602 Decade-Resistance Boxes.

Switches: TYPE 202, 7-points.

Finish: Resistances and terminals mounted on bakelite panel and enclosed in hand-rubbed walnut cabinet. All exposed metal parts (except contact faces) nickel plated.

Dimensions: Panel, 5 x 7½ inches; depth, 4 inches.

Net Weight: 2⅜ pounds.

Type	*Code Word*	*Price*
210	RABID	**$28.00**

TYPE 229 GALVANOMETER SHUNT

This galvanometer shunt is of the Ayrton-Mather "Universal" type, which provides an amount of shunting (ratio of galvanometer current at any setting to that at maximum setting) which is independent of the resistance of the galvanometer. For other reasons, however, the shunt must be matched to the galvanometer. The total resistance of the shunt must be large compared to that of the galvanometer, so that the sensitivity of the galvanometer is not appreciably reduced when the shunt is connected and set at unity. This total shunt resistance should be approximately the external critical damping resistance of the galvanometer. Most galvanometers are so designed that both these conditions may be fulfilled. This instrument can also be used as a voltage divider.

SPECIFICATIONS

Total Resistance: See price list.

Shunt Ratios: 0.000; 0.001; 0.01; 0.1; 1.0.

Accuracy of Adjustment: 0.1%.

Type of Winding: Unifilar, manganin wire for all resistances except the 9000-ohm unit of TYPE 229-H which is of "fish-line" type with nichrome wire.

Switch: TYPE 202, 5-points.

Finish: Resistances and terminals mounted on bakelite panel and enclosed in hand-rubbed walnut cabinet. All exposed metal parts (except contact faces) nickel plated.

Dimensions: Panel, 3½ x 5½ inches; depth, 3½ inches.

Net Weight: 1 pound.

Type	*Resistance*	*Code Word*	*Price*
229-L	**1000 ohms**	GAVOT	**$15.00**
229-H	**10,000 ohms**	GIANT	**18.00**

STANDARD-SIGNAL GENERATORS

General Radio introduced the first commercially practicable standard-signal generator or "microvolter" to the radio industry in the summer of 1928. Since then, the leading manufacturers of America and Europe have designed and tested their products with General Radio standard-signal generators.

Improvements have been made from time to time as the results of research showed us how the accuracies could be bettered and the usefulness of the instrument enhanced. Broadcast engineers have, for example, found that field-intensity surveys, made with the standard-signal generator, pay big dividends in showing the way to a more profitable coverage of their radio audience. Power companies concerned with inductive interference and co-ordination problems have used it to measure radio interference quantitatively.

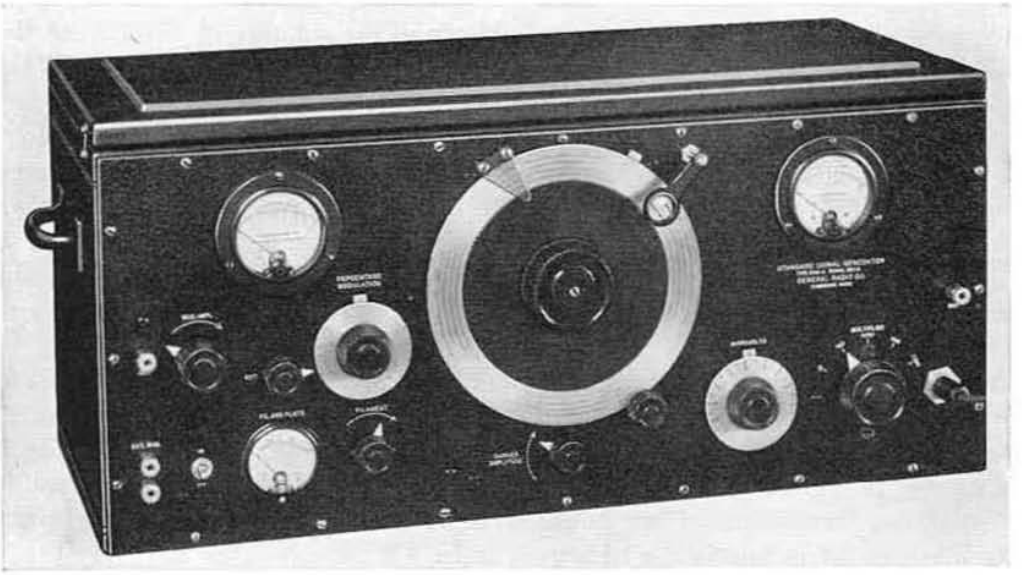
Improvements have had to do with the bettering of attenuators, reducing leakage, and perfecting the modulating system. Design problems encountered in doing this have sometimes seemed insurmountable to the engineer faced with the necessity for making one instrument do many jobs, for keeping down the number of tubes and battery drain, for working at low power levels to prevent leakage, and for avoiding, if possible, the use of multistage tuning controls.

Modulation difficulties never dreamed of by the broadcast engineer are met when it becomes necessary to design for a minimum of frequency modulation and fly-wheel effect, for a high percentage modulation without distortion, and for maximum power output, all at power levels that can be effectively shielded.

Three new types of signal generator have been designed within the last year. All types of laboratories will find one of these types to meet their testing requirements satisfactorily. These are described in the following pages.

	Type	*Particular Applications*	*Identifying Features*
	**603**	High precision, sensitivity, selectivity, and fidelity measurements on radio receivers and field-intensity measurements	Wide frequency range and high precision —Low leakage even at 25 Mc
	**601**	Sensitivity measurements on radio receivers, especially on the production line and airway maintenance service — Also field intensity tests	Moderate precision, portability and low cost —Wide frequency range
	**600**	Checking on receivers in the U. S. broadcast band when high speed and precision are essential	Five-channel frequency selector — step-by-step attenuator — Excellent modulation characteristics
	**418**	Dummy antenna for standard IRE tests on radio receivers	Reactive type for U. S. broadcast band, resistive type for higher frequencies

TYPE 603-A STANDARD-SIGNAL GENERATOR



The development of radio receivers for operation at high frequencies has had its corollary in a demand for a satisfactory standard-signal generator to go to very high frequencies. A careful study of the problem has indicated that generators similar in general construction to those now employed can be used with suitable design modification at frequencies as high as 25 megacycles. It is believed that work at higher frequencies will require a rather different design of signal generator and attenuator system from that now used.

The General Radio Company has had under development for the last year a new standard-signal generator designed to meet the need for dependable behavior at high frequencies. The TYPE 603-A Standard-Signal Generator is the result of this development.

This instrument may be used over a frequency range extending from 100 kilocycles to 25 megacycles. Over this range its performance is well within the limits of accuracy which we have become accustomed to expect from standard-signal generators in the broadcast-frequency range. It is capable of modulation up to 90 per cent at broadcast and higher frequencies. Internal modulation at 400 cycles is provided and provision is made for external modulation as well.

The new standard-signal generator will be used for the usual fidelity, sensitivity, and selectivity tests on receivers throughout the very wide frequency range for which it is adapted. It is also suitable for field-strength measurements throughout this wide range, since it is semi-portable and can easily be transferred in an automobile.

The new standard-signal generator has a number of interesting design features. The shield has been so modified without increase of leakage that it is not necessary to remove any screws in order to change coils. Immediate access to the coil compartment is obtained by raising the lid on the cabinet. Space for the extension coils is also provided inside of the cabinet. Leakage around the lid is avoided by a refrigerator-door type of construction in the shielding.

An interesting new type of attenuator and shield has been evolved. The usual resistance type of attenuator has been

used with a modified construction as made necessary by the much higher frequencies involved. The attenuator is enclosed in a sectionized shield which makes possible very large attenuations even at frequencies at 25 megacycles without serious errors.

The controls are shown on the front of the panel. Those at the right govern the radio-frequency circuit, those at the left the modulation circuit. The carrier frequency is controlled by a large dial with slow-motion adjustment. This dial carries an accurately engraved scale of 600 divisions, spread around 270° of its circumference. The use of this dial in conjunction with a coil spread of approximately 2 to 1 in frequency makes possible a direct use of the main frequency scale for use in selectivity and band-width determination. Calibration charts are provided and they are of such size as to be read to the same accuracy as the dial scale.

Two additional convenience features will be noted on this dial: The magnifying glass over the main index greatly assists in setting and reading the scale. The secondary index, together with the space on the dial rim for extra scales, permits calibration of the instrument at special points to suit the user's requirements.

The carrier-frequency output voltage is controlled by the three adjustments in the lower right section of the panel. The carrier amplitude is adjusted, by means of the middle control, to a reference line on the right-hand meter. Maintaining this adjustment constant, the output is adjusted by means of the slide wire labeled MICROVOLTS and the multiplier. Continuous variation from one volt to ½ microvolt is provided. The output is taken off from the shielded plug terminals in the lower right edge of the cabinet.

The modulation-control system is shown at the left. The meter indicates the modulation voltage and is set by means of the modulation amplitude control to a reference line. With the per cent modulation dial set at the desired modulation percentage, external modulation may be connected at the terminals indicated and controlled in the same manner.

SPECIFICATIONS

Carrier-Frequency Range: Inductors are available for a range of 100 kc to 25,000 kc.

Modulation: An internal (plug-in type) modulator provides a frequency of 400 cycles. Units for other frequencies can be provided. Modulation characteristics change somewhat over the wide operating range of the instrument. Modulation up to 90% may be obtained under most conditions of operation without exceeding 10% harmonic. Provision is made for external modulation. The input impedance at the external modulation terminals is approximately 5000 ohms and a power of about 60 milliwatts will modulate the instrument to 30% throughout its range. The TYPE 513-B (a-c operated) or the TYPE 613-A (battery-operated) Beat-Frequency Oscillator or the TYPE 377-B Low-Frequency Oscillator are suitable sources of modulation voltage. One stage of amplification, using a power tube, is required for high modulation percentages when using these oscillators. Low modulations are measured by means of a voltmeter in the audio-frequency circuit. High modulation percentages are read on the output meter, using the change in carrier amplitude as a measure of modulation percentage.

Frequency Calibration: Calibration curves are available, accurate to 0.5%. The dial spread and chart interval are such that frequency intervals for selectivity curves may be read directly from the main dial which is provided with a magnifying glass. In the broadcast range intervals of 200 cycles may be set. The dial has 600 divisions.

Output System: The input circuit to the attenuator is adjusted to standard value, using a reference line on the radio-frequency current meter. A non-reactive rheostat is used for this adjustment. The attenuator consists of a slide wire at the input end followed by a step-by-step multiplier. This arrangement permits the use of a sturdy slide-wire construction. The output is continuously adjustable. The output impedance is 10 ohms up to the 10,000 microvolt setting, 37.5 ohms at 10,000, and 120 at 100,000.

Output-Voltage Range: The output voltage is continuously adjustable from 0.5 microvolt to 1 volt.

Output Voltage Accuracy: At broadcast and lower frequencies the error is that involved in meter calibration and adjustment of the cards. This aggregates 3% at 1 microvolt output. There is no frequency error at these frequencies. At 10 megacycles the error at 1 microvolt becomes 10% and at 15 megacycles it is 12%. At 25 megacycles it is 20%.

Frequency Modulation: Frequency modulation is a function of frequency and of the inductor used. In the broadcast band it will not exceed 200 cycles total swing at any point and is less than 50 cycles at the standard test frequencies for 30% modulation. If the TYPE 603-P11 Inductor is used frequency modulation will be about 500 cycles at 1500 kc.

Stray Fields: There is no detectable stray field at a distance of 5 inches from the instrument, even at 25 Mc.

Construction Features: The radio-frequency oscillator is isolated in a shielded compartment. The attenuator is divided into several sections, shielded from each other.

A refrigerator-door type of shielding has been worked out for the shielding about the lid which makes a tight shield without screws. Coils can be changed by simply lifting the cover.

Accessories: The instrument is supplied with calibrated TYPE 603-P5 and TYPE 603-P6 Inductors covering the broadcast band, with a TYPE 418-B and TYPE 418-C Dummy Antenna but without tubes or batteries.

Terminals: The output voltage is brought out through a shielded plug and test lead. Terminals are also provided on the panel for the external modulation source.

Tubes: Two tubes (one 230-type and one 231-type of standard characteristics) are required and are not included in the price of the instrument.

Power Supply: Four 45-volt blocks for plate battery and 3 volts for filament are required. Space is provided in the cabinet for two 6-inch dry cells and four 45-volt blocks of the Burgess 5308 size. Batteries are not included in the price.

Mounting: The instrument is enclosed in a walnut cabinet with black-lacquered aluminum panel.

Dimensions: Cabinet, (height) 12¼ x (depth) 11¾ x (length) 29 inches, over-all.

Net Weight: 63 pounds.

Type	*Frequency Range*	*Output Range*	*Code Word*	*Price*
***603-A**	**100 kc–25,000 kc**	**0.5 microvolts to 1 volt**	EXACT	**$600.00**

*Price includes 2 calibrated inductors for broadcast band (420 kc to 1900 kc).

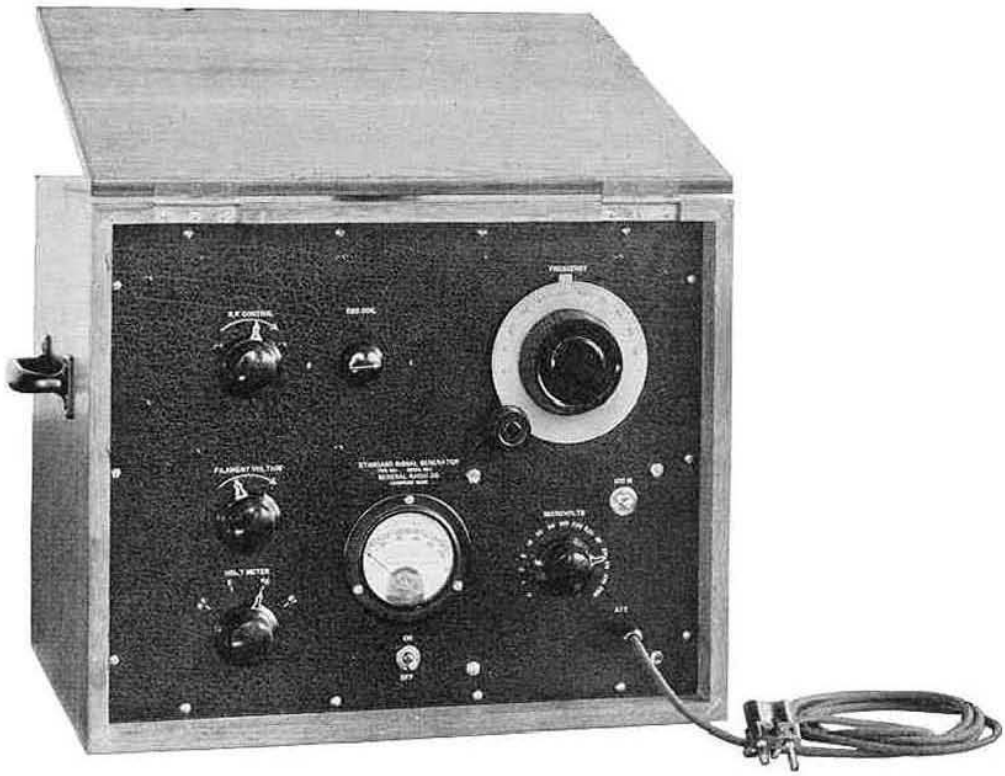
TYPE 603-P INDUCTORS

These are intended for use with the TYPE 603-A Standard-Signal Generator. We particularly recommend that, if calibrated inductors are required, they be ordered with the standard-signal generator with which they are to be used. The TYPE 603-P Inductors are stocked without calibration, but a calibration curve can be made to order. The calibration is accurate to plus or minus 0.5 per cent.

Type	*Frequency Range*	*Code Word*	*Price*
***603-P1**	**15–25 Mc**	SIGPARTANT	**$15.00**
***603-P2**	**10–15 Mc**	SIGPARTBIB	**15.00**
***603-P3**	**4.4–10 Mc**	SIGPARTBOY	**10.00**
***603-P4**	**1.9–4.4 Mc**	SIGPARTCAT	**10.00**
***603-P5**	**850–1900 kc**	SIGPARTCUP	**10.00**
***603-P6**	**420–850 kc**	SIGPARTDOG	**10.00**
***603-P7**	**210–420 kc**	SIGPARTEYE	**12.00**
***603-P8**	**100–210 kc**	SIGPARTFLY	**12.00**
***603-P11**	**550–1500 kc**	SIGPARTGAS	**10.00**
Frequency Calibration (per Inductor).....		CURVE	**5.00**

*Frequency calibration supplied only when ordered. Use compound code words, SIGPARTANTCURVE, SIGPARTBIBCURVE, etc.

TYPE 601-A STANDARD-SIGNAL GENERATOR



This instrument is designed to provide a generator of radio frequencies for use in the frequency range from 100 kilocycles to 6000 kilocycles to be easily portable, and to deliver either a modulated or unmodulated signal having an amplitude adjustable from one to 150,000 microvolts.

Since it is often desirable to cover two frequency bands in one instrument without the time delay and inconvenience usually involved in changing inductors, the TYPE 601-A Standard-Signal Generator is provided with internal mountings for two inductors and a convenient switch for transferring from one to the other. Any two inductor combinations may be used; for example, the intermediate-frequency and broadcast bands (150–200 kilocycles and 550–1500 kilocycles), or the broadcast and aircraft bands (550–1500 kilocycles and 1400–4000 kilocycles). All inductors are mounted on plug bases and are easily removable, if other combinations are required.

The inductors are toroidal in form, which reduces their external field to a negligible amount, and the whole unit is carefully shielded so that it may be used to test the most sensitive unshielded receivers.

The TYPE 601-A Standard-Signal Generator may be used for making accurate sensitivity tests on all types of receivers, either regenerative or non-regenerative, operating within its frequency range. It may be used for lining and adjustment tests for superheterodyne intermediate frequency amplifiers. Because of its relatively low price, simplicity of operation and ruggedness, it is quite suitable for production testing work of radio receivers. The particular value of the TYPE 601-A Standard-Signal Generator is for portable work, such as the periodical testing of receivers already installed on police cars, ships, airplanes, and other places where receivers are apt to get severe usage which may gradually put them out of adjustment.

SPECIFICATIONS

Carrier-Frequency Range: 100 kc to 6000 kc covered by the use of the six TYPE 601-P Inductors, any two of which may be plugged into the instrument and selected by means of a switch. These may be supplied either with or without calibrations. None are included in the price of this instrument.

Frequency Calibration: See description of TYPE 601-P Inductors.

Modulation: Internal 400 cycle vacuum-tube oscillator, with good waveform adjusted to give 30% modulation, is provided. Circuit may be adjusted for 50% modulation on special order at no additional charge. External modulation sources cannot be used.

Output System: Input to the attenuator is read by vacuum-tube voltmeter which is calibrated at two points to provide a multiplying factor of 1 or 1.5 for the attenuator reading. The attenuator which has a resistive ladder structure is calibrated directly in microvolts. The resistance units are wound on very small, thin mica cards having essentially no reactance. The internal resistance of the output circuit is constant at 10 ohms, except at the 10M, 20M, and 100M points, where it is 20, 40, and 200 ohms respectively.

The attenuator is tapped near the high potential end and a separate "high output" terminal brought out on the panel above the attenuator control knob.

Output Voltage Range: The attenuator is calibrated in the following steps which correspond to a meter setting of 1: 0-1-2-5-10-20-50-100-200-500-1M-2M-5M-10M-20M.

The voltmeter multiplying factor of 1.5 makes available microvolt readings between these points from 1.5 to 30,000 microvolts. The "high output tap" gives an output of 100,000 or 150,000 microvolts depending upon the voltmeter reading. The output of the attenuator when set at zero is never as large as one-tenth of the one-microvolt output.

Output Voltage Accuracy: Output voltage calibration for outputs below 10 microvolts and through the frequency range from 100 kc–1500 kc is good to within about 10% between adjacent attenuator ratios. For the same output voltage range and through its frequency range from 1500 kc–6000 kc about 20% between adjacent attenuator ratios. At output above 10 microvolts the errors are less than 5% and 10% respectively for the above-mentioned frequency ranges. The accuracy of comparison, that is, the ability of the instrument to repeat readings when no tubes have been changed, is about 1%. The accuracy of comparison is the figure of merit which must be considered when receivers are to be tested against a nominal output voltage or a standard receiver. The absolute value of output voltage depends upon adjustment of vacuum tube voltmeter.

Frequency Modulation: Varies with the inductor and frequency adjustment. It is less at frequencies above 1500 kc. For 30% modulation it is always less than 0.03% at more than half scale on tuning condenser; at highest frequency on any inductor not more than 0.1%. For 50% modulation, figures are proportionally higher.

Stray Fields: The use of toroidal inductors and careful shielding reduces stray fields to a negligible amount.

Construction Features: Radio-frequency circuits in separately shielded compartment on metal shelf. Entire assembly mounted in copper-lined oak cabinet. Attenuator divided into three shielded sections, to reduce stray effects.

Connection to the set under test is made by means of the flexible shielded lead provided, which connects to the output of the signal generator through a specially constructed plug and submounted jack. This construction eliminates binding posts and provides a completely shielded path from the receiver to the attenuator output. All high-frequency wiring which is not double shielded is run in concentric shielded cable.

All low frequency, battery, and meter circuits are connected through choke and bypass condenser filters, eliminating practically all of the radio frequencies in these units. All of the low-frequency circuits and batteries are enclosed in the copper-lined cabinet for additional protection against leakage.

Controls: Carrier amplitude control, filament rheostat, voltmeter selector switch, inductor selector switch, frequency control, and attenuator.

Terminals: The attenuator output and the "high output" terminals are plugs located behind the panel to which connections are made by means of a shielded plug and test lead. The latter is fitted with terminals for making connections to a dummy antenna or directly to a circuit under test.

Meter: A meter, connected to a multi-point switch, is provided to read filament and plate voltages as well as radio-frequency output amplitude.

Tubes: Three 230-type tubes, not included in the price of the instrument, are required.

Power Supply: From dry batteries placed inside shielded cabinet. For plate, block batteries, 45 and 67.5 volts, 2 ma. For filament, two No. 6 dry cells, 180 ma. Only a 4.5-volt C battery is supplied.

Accessories: A shielded plug and test lead, but no dummy antenna, are furnished as regular equipment. A TYPE 418-B or TYPE 418-C Dummy Antenna must be ordered separately.

Mounting: Aluminum panel, ¼ inch, finished in black crackle lacquer, mounted in natural finish oak cabinet, with five-ply veneer hinged oak cover and carrying handles. Panel is slightly recessed into the cabinet for protection.

Dimensions: Panel, (width) 15 x (height) 12 inches. Over-all, (width) 16 x (height) 13½ x (depth) 12½ inches.

Net Weight: 50½ pounds with batteries, 40 pounds without batteries.

Type	*Frequency Range*	*Output Range*	*Code Word*	*Price*
601-A	**100–6000 kc***	**1–150,000 microvolts**	JUROR	**$210.00**

*Inductors must be ordered separately.

TYPE 601-P INDUCTORS

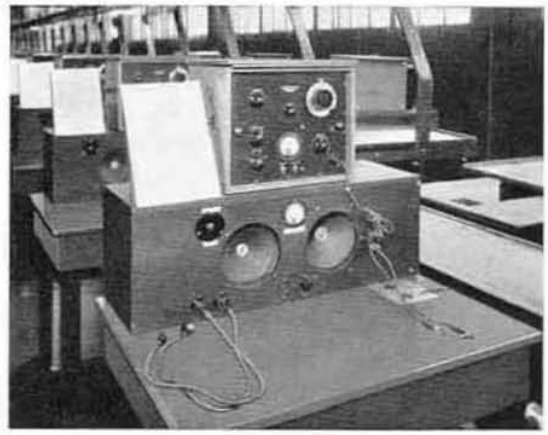
These are intended for use with the TYPE 601-A Standard-Signal Generator. No inductors are supplied with the instrument and we particularly recommend that, if calibrated inductors are required, they be ordered with the standard-signal generator, since they must be calibrated in the generator with which they are to be used. The TYPE 601-P Inductors are carried in stock without calibrations, but a continuous calibration curve can be supplied on order.

The curve gives data accurate to within ±1 per cent.

Type	*Frequency Range*	*Code Word*	*Price*
***601-P1**	**2500–6000 kc**	STANSIGTOP	**$7.00**
***601-P2**	**1400–4000 kc**	STANSIGBIB	**7.00**
***601-P3**	**550–1500 kc**	STANSIGHUM	**7.00**
***601-P4**	**200– 550 kc**	STANSIGSUN	**7.00**
***†601-P5**	**150– 200 kc**	STANSIGSIN	**9.00**
***601-P6**	**100– 200 kc**	STANSIGGAS	**12.00**
	Frequency Calibration Curve (per inductor)	CURVE	**5.00**

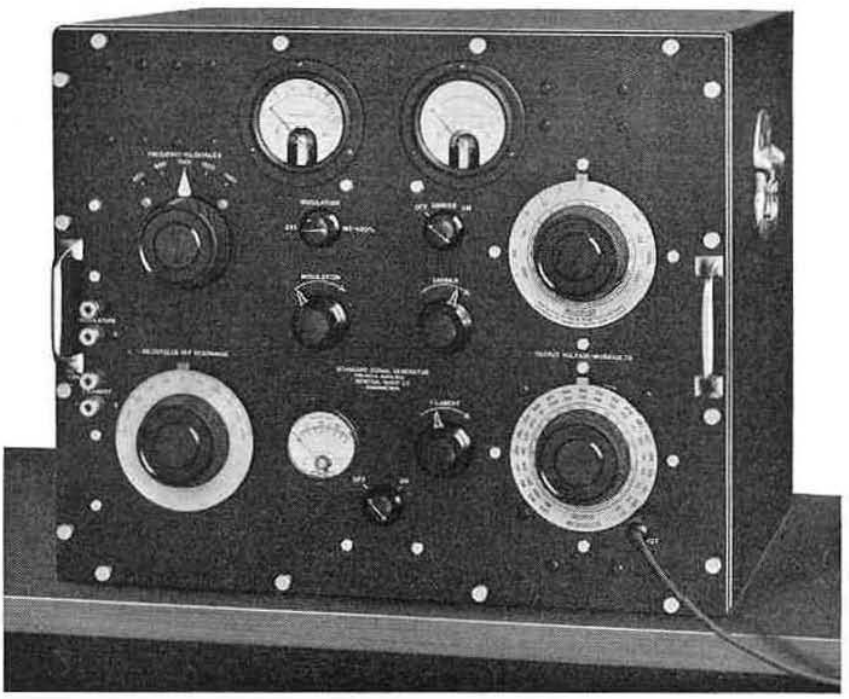
*Frequency calibrations supplied only when ordered. When ordering calibrated inductors by telegraph, use compound code words, *e.g.*, STANSIGTOPCURVE, etc.

†Has a fixed shunt capacitance in order to spread out the calibration through the superheterodyne intermediate-frequency range.



A battery of TYPE 601-A Standard-Signal Generators used for final inspection test on Kolster assembly line

TYPE 600-A STANDARD-SIGNAL GENERATOR



This instrument is designed primarily for measurements on radio broadcast receivers. Particular attention has been given to the mechanical arrangement in order to facilitate routine observations of the fundamental performance characteristics. The choice of frequencies and ranges covered have been chosen to agree with the recommendations of the Institute of Radio Engineers and of the Standardization Committee of the Radio Manufacturers' Association.

Any one of five frequencies may be selected by a frequency-control switch. At three of these frequencies there is connected into the circuit a condenser having straight-line frequency plates and covering a frequency band of ±50 kilocycles. This arrangement facilitates the taking of selectivity curves.

In order to provide for the measurement of very sensitive receivers, special precautions have been taken against stray electrical and magnetic fields. In addition to the usual electrostatic shielding, the oscillating circuit has been enclosed in a heavy aluminum casting which makes stray magnetic fields entirely negligible. The output voltage is controlled by an attenuator adjustable in increments of 6 per cent and covering the range from 0.1 to 316,000 microvolts.

On the attenuator controls there is marked a supplementary scale which gives the output level directly in decibels above a zero level of one microvolt. This latter scale will be found most convenient for routine measurements in the development laboratory and on the production line.

The use of a special type of oscillating circuit minimizes frequency modulation and permits linear amplitude modulation up to 100 per cent. A direct-reading modulation meter is included on the panel. The calibration of this meter is independent of the oscillator battery voltage, and an internal 400-cycle audio oscillator is

provided. In addition, a switch permits the use of an external modulation of other frequencies, if desired, for taking fidelity characteristics.

So effective is the shielding system that absolutely no error due to interference could be found when measuring a receiver capable of detecting 0.03 microvolts.

SPECIFICATIONS

Carrier-Frequency Range: For sensitivity and fidelity tests five channels are available: 600, 800, 1000, 1200, and 1400 kc. Selectivity tests can be made at 600, 1000, and 1400 kc, a control calibrated directly in kilocycles enabling ±50-kc deviations to be obtained.

Frequency Calibration: Accurate to 0.5% as shipped. Trimmers permit adjusting each channel frequency more closely, if desired. Variations in battery voltages have a negligible effect on frequency. The calibration of the "off channel" dial is accurate to within ±5%.

Modulation: An internal 400-cycle vacuum-tube oscillator provides linear amplitude modulation up to 100%. Its total harmonic content is less than 3% of the fundamental voltage.

Modulating voltages for fidelity tests must come from an external source, which for 100% modulation should be able to deliver 15 volts across 5000 ohms. The TYPE 513-B Beat-Frequency Oscillator or the TYPE 377-B Low-Frequency Oscillator is recommended. The following maximum values of percentage modulation are possible for the corresponding modulating frequencies: 400 cycles, 100%; 1 kc, 95%; 6 kc, 50%; 10 kc, 30%.

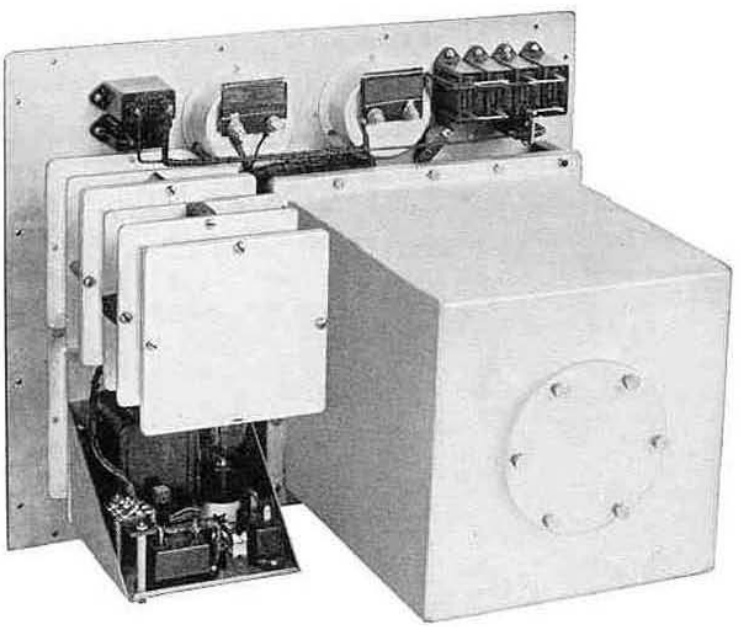
A direct-reading modulation meter, whose reading is independent of battery voltage, indicates percentage modulation for both internal and external modulation.

Output System: By means of a vacuum-tube voltmeter, a constant voltage is maintained across the input to a two-stage resistance attenuator consisting of a 120-db 10-ohm ladder network, adjustable in 10-db steps, followed by a 10-db 10-ohm T-type network, adjustable in 0.5-db steps. The attenuator scales are direct-reading in microvolts and in decibels referred to one microvolt as zero level. The internal output resistance is 10 ohms at all settings, which, with the dummy antenna furnished, makes the resistance zero as far as the receiver under test is concerned.

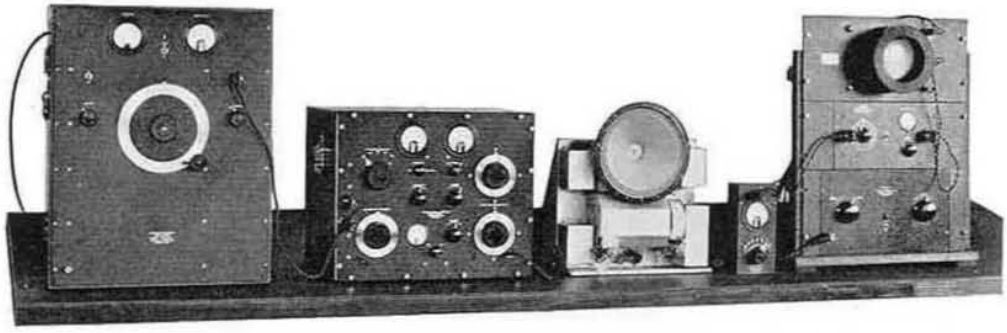
Output-Voltage Range: 0.1 to 316,000 microvolts or —20 db to +110 db referred to one microvolt as zero level.

Output Voltage Accuracy: The calibration of the attenuator has an absolute accuracy of better than 10% at all settings; adjacent attenuator ratios, to within ±0.5%. The input to the attenuator can be held to within ±3% provided the vacuum-tube voltmeter is adjusted for the particular tubes used. Otherwise it will be correct to ±10%.

Frequency Modulation: Less than 150 cycles (total swing) up to 50% modulation.



Interior view of a TYPE 600-A Standard-Signal Generator



A laboratory set-up for testing an experimental chassis with a TYPE 600-A Standard-Signal Generator

Stray Fields: All external points on the panel (meters, binding posts, etc.) are equipotential to within one microvolt. Magnetic field is less than two microvolts per meter at all external points.

Construction Features: The carrier-frequency oscillator is completely enclosed in an aluminum casting; a small covered hand hole in this facilitates changing tubes. Leads to the attenuator are doubly shielded concentric conductors. The 120-db attenuator is built in three sections, each housed in an aluminum casting and operated by an insulated shaft. In addition to the inner shields, the outer cabinet is completely shielded, electro-magnetically.

Controls: Channel selector, ±50-kc tuning control for selectivity tests, internal-external modulation switch, modulation voltage amplitude control, carrier on-off switch, carrier amplitude control, filament rheostat and switch, and two-dial attenuator.

Meters: Filament-plate voltmeter, percentage modulation meter, and micro-ammeter for vacuum-tube voltmeter

Terminals: The output voltage is brought out through a detachable plug and shielded test lead with terminals for connecting to the dummy antenna. Terminals are also provided on the panel for the filament battery and for the external modulation source.

Tubes: Two 112-A-type and two 227-type tubes, included in the price of the instrument, are required.

Power Supply: For plate, self-contained block batteries, 180 volts, 12 milliamperes. Space provided inside cabinet of instrument. For filament, external storage battery, 6 volts, 1.8 amperes, leads provided. Batteries are not included in the price of the instrument.

Accessories: A TYPE 418-B Dummy Antenna, output test lead filament-supply cable, and tubes are furnished as regular equipment.

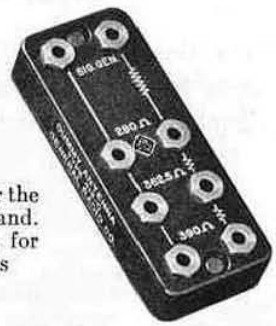
Mounting: Aluminum panel finished in black crackle lacquer, mounted in hand-rubbed walnut cabinet.

Dimensions: Panel, (width) 19 x (height) 15¾ x (thickness) ¼ inches. Over-all, including handles, (width) 20 x (height) 15¾ x (depth) 15⅜ inches.

Net Weight: 85 pounds with plate batteries, 75 pounds without batteries.

Type	*Frequency Range*	*Output Range*	*Code Word*	*Price*
600-A	**600, 800, 1000, 1200, 1400 kc**	**0.1 to 316,000 microvolts**	ASKEW	**$885.00**

TYPE 418 DUMMY ANTENNA



Left: TYPE 418-B, for the U. S. broadcast band. *Right:* TYPE 418-C, for higher frequencies

Tests on radio receivers with the standard-signal generator require the use of a dummy antenna connected between the generator and the receiver under test. The two dummy antennas listed below are made in accordance with the specifications of the Institute of Radio Engineers.

TYPE 418-B is for work in the broadcast range (550 kc to 1500 kc) and consists of a resistor, inductor, and condenser connected in series. The effective height is taken as 4 meters.

Tentative standard specifications of the I. R. E. for a dummy antenna operating at frequencies above 1500 kc call for a non-reactive resistor having a total resistance of 400 ohms. The TYPE 418-C Dummy Antenna has been designed to meet this specification and is intended primarily for use with the TYPE 603-A Standard-Signal Generator. It consists of a series resistor adjustable by taps so that the total resistance of the standard-signal generator and dummy antenna can always be kept at 400 ohms.

SPECIFICATIONS

Resistance: TYPE 418-B has a resistance of 15 ohms at broadcast frequencies which, with the 10-ohm internal output impedance of General Radio standard generators, makes up the 25 ohms called for by the I.R.E. specifications.

Three output connections are provided on TYPE 418-C: one at 280 ohms for use with the 100,000 multiplier setting, one of 362.5 ohms for the 10,000 multiplier setting, and one of 390 ohms for all other multiplier settings of the TYPE 603-A Standard-Signal Generator. The 390-ohm connection may be used with other standard-signal generators having an internal output impedance of 10 ohms.

Inductance: TYPE 418-B, 20 μh; TYPE 418-C, none.

Capacitance: TYPE 418-B, 200 $\mu\mu$f; TYPE 418-C, none.

Mounting: TYPE 418-B is mounted in the moulded bakelite case shown in the accompanying illustration and is fitted with input and output binding posts arranged to accommodate a TYPE 274-M Plug.

TYPE 418-C is mounted in the moulded base shown in the illustration. Connections to it are made by means of a TYPE 274-M Plug.

Dimensions: TYPE 418-B, (length) 2⅛ x (width) 1⅜ x (height) 2 inches, over-all.

TYPE 418-C, (length) 3¾ x (width) 1½ x (height) ¾ inches, over-all.

Net Weight: 5 ounces.

Type	*Code Word*	*Price*
418-B	EPHOD	**$6.00**
418-C	DEUCE	**5.50**

OSCILLOGRAPHS, MODULATION AND DISTORTION MEASUREMENTS, AND FILTERS

This section describes our line of oscillographs and accessories together with instruments for the measurement of modulation percentage and distortion factor. A variety of electric wave filters is also described.

	Type	*Particular Applications*	*Identifying Features*
	**General Radio Cathode-Ray Oscillograph**	Observation and recording of transient or recurrent high-frequency phenomena	Brilliant image—complete alternating-current operation
	**506**	Linear time axis for cathode-ray oscillograph—Used for observation and recording of recurrent waveforms in true amplitude-time relationship	Accurately linear — complete alternating-current operation—Frequency controlled by voltage under observation
	**338**	Observation of low-speed recurrent phenomena—Can be used as a chronograph with TYPE 408	Low cost—Moving elements rugged and easily replaced
	**408**	High-speed recording of transient phenomena with the cathode-ray or string oscillographs	Hand- or motor-drive—Compactness and unusual high speed
	**457**	Measurement of percentage modulation distortion in broadcast transmitters	Direct-reading—high precision—No direct connection to transmitter
	**536**	Quantitative measurement of harmonic distortion in amplifiers, radio transmitters, etc.	Direct reading—Accurate—Speedy operation
530 534 FILTERS	**330**	For eliminating harmonics in bridge circuits, etc., and for separating one band of frequencies from another	High-pass, low-pass, and band-pass sections are available

GENERAL RADIO CATHODE-RAY OSCILLOGRAPH

The cathode-ray oscillograph has justly become a popular and widely used laboratory instrument because of its adaptability to a great number of uses.

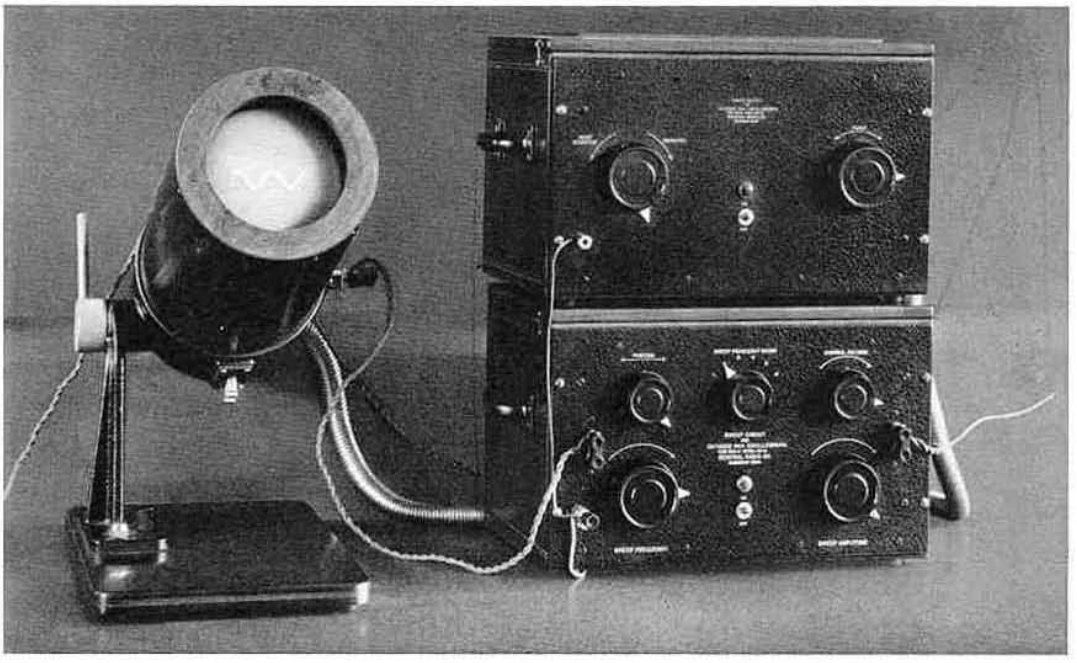
Because the "moving element" in this type of oscillograph is a beam of electrons, the cathode-ray oscillograph is inherently well suited for use where high frequencies and wide frequency ranges are involved. Since the beam may be deflected simultaneously in two directions, two-dimensional patterns may be formed upon the fluorescent screen. When the beam is deflected horizontally with a constant velocity (by means of a sweep circuit, for example), complicated waveforms may be directly observed.

A few examples of the many uses of the cathode-ray oscillograph are: frequency comparison by means of Lissajou's figures, direct visual observation of recurrent waveforms and transients, and high-speed photographic recording of complex electrical phenomena.

A great advantage of the new General Radio cathode-ray oscillograph tube is the way in which the spot is focused. Instead of focusing by a magnetic field or a change in filament current, an additional focusing electrode has been inserted in the tube and focusing is accomplished by varying the potential applied to it.

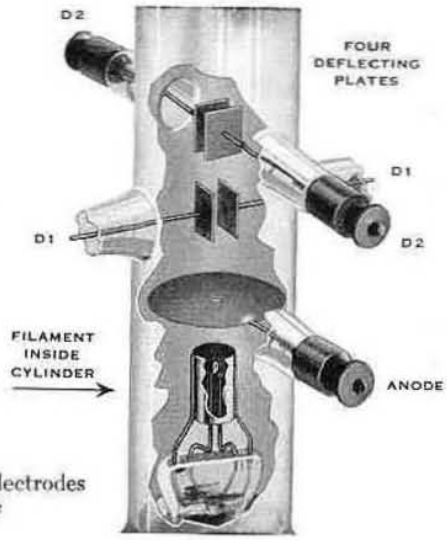
Due to the design of the tube and to the kind of fluorescent material used on the screen, the patterns obtained with the TYPE 478-A Cathode-Ray Oscillograph Tube are unusually bright and easily visible in daylight. Photographs may be taken of the patterns as they appear on the fluorescent screen.

The General Radio Cathode-Ray Oscillograph is a completely self-contained and alternating-current operated unit. Terminals are provided for application of de-



Brilliancy is an important feature of the General Radio Cathode-Ray Oscillograph. This photograph (unretouched except in the background) was taken in a brightly lighted room using the TYPE 506-A Bedell Sweep Circuit and the oscillograph to show the waveform of an oscillator

The tube used in the General Radio Cathode-Ray Oscillograph



Arrangement of electrodes in the tube

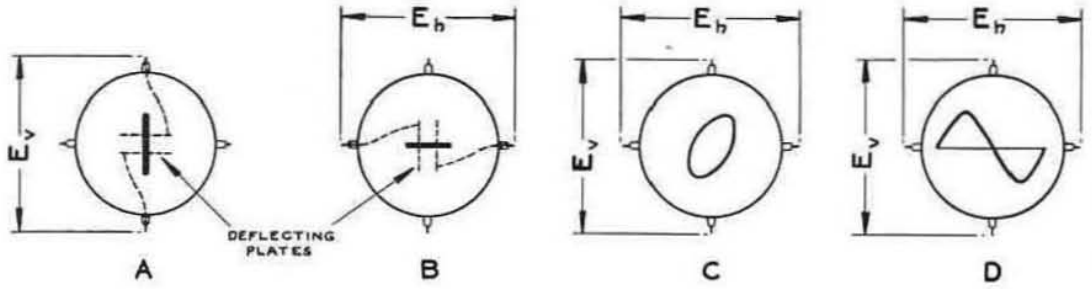
flecting voltages to horizontal and vertical deflecting plates and for insertion of an alternating voltage in series with the direct plate for modulating the cathode-ray beam.

Controls are provided for separate adjustment of brilliancy or sensitivity and focus.

The complete General Radio Cathode-Ray Oscillograph consists of three units, the TYPE 478-A Cathode-Ray Oscillograph Tube, the TYPE 497-A Tube Mounting, and the TYPE 496-B Power-Supply Unit.

The operating principle of the cathode-ray oscillograph tube is simple. Electrons emitted by the oxide-coated filament are drawn toward the high-potential anode, thus acquiring a velocity sufficient to pass through a hole in it and strike a fluorescent screen on which a spot of light appears. A negatively charged cylinder around the filament serves to concentrate the electrons into a small beam.

Between the anode and the fluorescent screen, the electron beam passes between the plates of two very small condensers, so arranged that an electric field between one pair causes a deflection of the beam (and the spot) in a direction perpendicular to the deflection caused by a field between the other pair. These are the deflecting



Fundamental cathode-ray oscillograph patterns. Alternating voltages may be applied to the vertical or horizontal deflecting plates as in A and B. Pattern C results when E_v and E_h are applied simultaneously the frequencies f_v and f_h being the same. If E_h is derived from a General Radio sweep circuit and E_v is derived from an alternating voltage, the wave shape of E_v appears in Pattern D. The true wave shape of E_v can also be obtained from Pattern A with a moving film camera or a rotating mirror

The General Radio Cathode-Ray Oscillograph for table mounting. At the left is the TYPE 496-BM Power-Supply Unit; at the right, the TYPE 497-A Tube Mounting containing the tube

plates across which the voltages to be observed are impressed. When alternating voltages are applied, the spot traces figures like those represented in the accompanying sketches. These are the fundamental patterns upon which more complicated uses of the cathode-ray oscillograph are based.

SPECIFICATIONS

Brilliance: Patterns are brilliant and easily visible even in broad daylight.

Photographs may be taken of single transits of the spot across the screen at velocities up to 400 inches per second with an *f*4.5 lens, a plate as fast as the Eastman Hyper-press and controls set for maximum brilliancy. This lens and plate would, for instance, record one transit of a spot moving fast enough to complete a 2-inch (diameter) circle in 1/60th of a second. A faster lens or plate would increase the permissible velocity correspondingly. Photographs at much greater velocities may be obtained by allowing the spot to repeat the pattern several times.

Diameter of Screen: 5 inches.

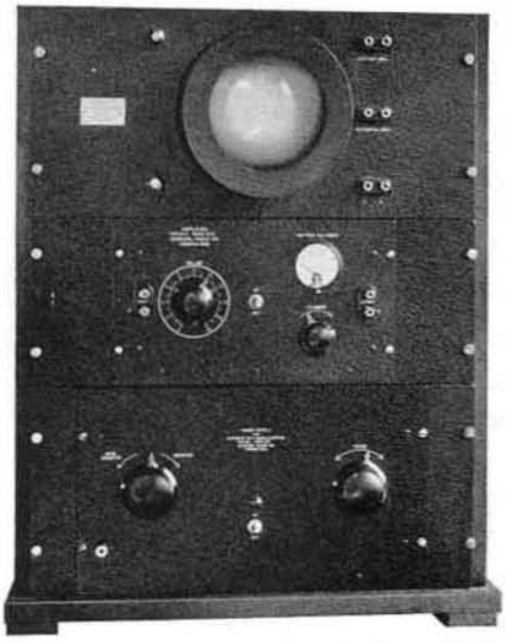
Voltage Sensitivity: Over the normal range of anode voltages, 500–2500 volts, the voltage sensitivity is a linear function of anode voltage. Sensitivity is about one volt per millimeter with SENSITIVITY control set at maximum and about 5 volts per millimeter with SENSITIVITY control set at minimum. Increasing the sensitivity reduces the brilliance, and vice versa.

Impedance of Deflecting System: The capacitance of either pair of deflecting plates is less than 1.5 $\mu\mu$f. When the oscillograph tube is installed in the TYPE 497-A Tube Mounting, the net capacitance of each pair of plates and its associated terminals and wiring is about 15 $\mu\mu$f. The resistance between the deflecting condenser plates due to the gas content depends on the voltage applied and varies between 10^6 and 10^7 ohms.

Magnetic Deflection: If desired, magnetic deflection may be used with the General Radio Cathode-Ray Oscillograph.

Power-Supply Unit: The TYPE 496-B Power-Supply Unit supplies all voltages needed for the operation of the cathode-ray oscillograph (500–2000 volts for plate, 50–400 volts for focusing electrode, and adjustable filament voltage). This unit is regularly supplied in a polished walnut cabinet (TYPE 496-BM), but can be furnished for relay-rack mounting on order.

Tube Mounting: The TYPE 497-A Tube Mounting is a universal mounting for holding the tube in any desired position and for making connections between the tube and the TYPE 496-B Power-Supply Unit. It has a number of features which facilitate the use of the oscillograph, make for convenience in operating, and prolong the life of the tube by minimizing the danger of accidental burnout or breakage. Terminals are provided for connecting the voltages to be analyzed. A suitable panel for adapting the instrument to rack mounting can be built to order.



The cathode-ray oscillograph can also be supplied for mounting in a 19-inch relay rack. The photograph shows, in addition, a TYPE 514-AR Amplifier for use with the oscillograph

Cable: All power-supply wiring between the tube and the power-supply unit is carried in a 5-foot flexible shielded cable, on one end of which is the tube socket and on the other the special plug base, which fits the corresponding jack plate in the power-supply unit. This cable is supplied as regular equipment.

Terminals: Binding posts are mounted at the top and side of the tube mounting, to which the voltages to be analyzed may be connected by means of standard TYPE 274-M Plugs. Adjustable links are provided for short-circuiting either or both pairs of deflecting plates and for using them either with or without grounded terminals.

For some purposes it is often desirable to introduce an alternating voltage in series with the power supply to the anode. To facilitate this, two terminals are provided at the bottom of the unit. These are normally short-circuited, and at ground potential.

Tube Life: Each TYPE 478-A Cathode-Ray Oscillograph Tube is guaranteed for three months from the date of our shipping it or for fifty hours of operation, whichever shall come first. Adjustments under this guarantee will be made on the basis of a new tube at half price. When the cathode-ray oscillograph tube is operated carefully, its normal life will generally exceed greatly the guarantee.

The guarantee is void if the tube is abused, handled carelessly, operated at voltages greater than those recommended in the instruction book, or used in any other than a General Radio Power-Supply Unit.

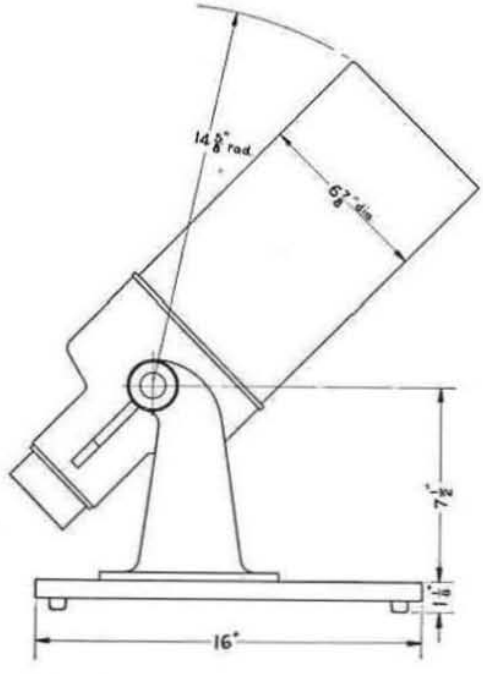
Rectifier Tubes Required: One 280-type and one 866-type are required for the power-supply unit. Neither is supplied with the unit.

Power Consumption: The power-supply unit requires connection to a source of 105–115 volts, 50–60 cycle alternating current. Power consumption is approximately 40 watts.

Power-Supply Cord: A 7-foot cord, fitted with attachment plugs for making connections to the power supply, is furnished.

Dimensions: TYPE 497-A Tube Mounting (see accompanying sketch); TYPE 496-BM Power-Supply Unit: Panel, 15 x 8¾ inches. Over-all cabinet size, exclusive of carrying handles, width 15¼, height 9⅝, depth 9½ inches.

Net Weight: TYPE 478-A Cathode-Ray Oscillograph Tube: 1 pound; TYPE 497-A Tube Mounting: 17½ pounds; TYPE 496-BM Power-Supply Unit: 30 pounds; Total: 48½ pounds.



Dimensions for the TYPE 497-A Tube Mounting

	Description	*Code Word*	*Price*
General Radio Cathode-Ray Oscillograph	Table Mounting	COMET	**$280.00**

COMPONENT PARTS FOR CATHODE-RAY OSCILLOGRAPH

The three units are also sold separately. Cathode-ray oscillograph tubes are guaranteed, however, only when used with the TYPE 496-B Power-Supply Unit.

Type	*Description*	*Code Word*	*Price*
478-A	Cathode-Ray Oscillograph Tube	APPLY	$95.00
497-A	Tube Mounting	ARBOR	75.00
496-BM	Power-Supply Unit	ARGON	110.00

TYPE 506-A BEDELL SWEEP CIRCUIT

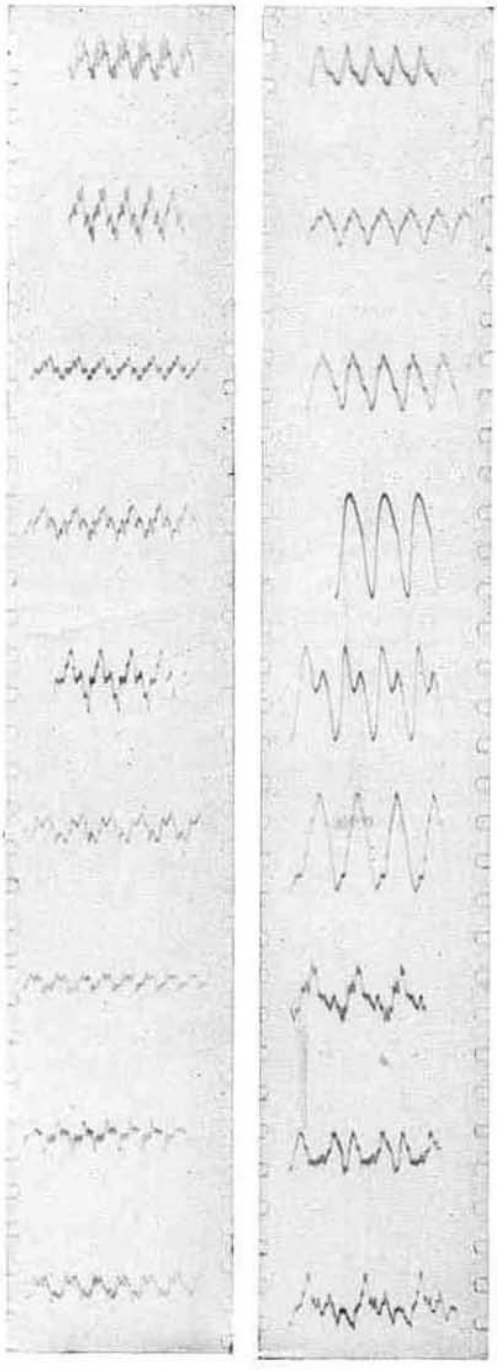
This instrument supplies a linear time axis for the cathode-ray oscillograph so that waveforms may be observed upon the fluorescent screen in their true amplitude-time relationship. It performs the same function as the conventional rotating mirror or moving film camera, but it has the advantage that it is entirely electrical in operation and has no moving parts. A further advantage of the sweep circuit is its frequency stabilization, by means of which stationary patterns are formed on the oscillograph screen.

The sweep circuit is entirely self-contained and alternating-current operated. It is regularly supplied in a walnut cabinet identical in size and shape with that of the TYPE 496-BM Power-Supply Unit. It can also be supplied for relay-rack mounting on special order.

This sweep circuit supplies a linear time axis for the cathode-ray oscillograph. Linearity, wide frequency range, and a-c operation are its principal features

SPECIFICATIONS

Sweep Frequency: Can have any value between about 10 cycles and 8000 cycles, but to secure a stationary pattern it is controlled or "stabilized" by the voltage under observation at the same or a submultiple (½, ⅓, ¼, etc.) frequency. When the sweep frequency is equal to the "observed frequency" the pattern shows one complete cycle; for a frequency ratio of ½, the pattern shows two complete cycles, etc. Hence, with a 3-cycle pattern, for example, frequencies as high as 24,000 cycles can be observed.



Oscillograms of sustained notes from a B♭ clarinet (*left*) and a C-melody saxophone (*right*) using the TYPE 506-A Sweep Circuit. Exposure: 0.1 second for each of the 18 records

Length of Sweep: This depends upon the amplitude of the sweep voltage. It is sufficient (approximately 300 volts) to sweep the entire width of the oscillograph screen at sweep frequencies up to 2000 cycles, falling off to about ½ of this at 8000 cycles. These data are for the oscillograph operated at minimum sensitivity (maximum brilliance). A control for adjusting the length of sweep is provided.

Frequency Stabilization: Since the control circuit presents a high impedance (approximately 200,000 ohms) and is protected by a filter and shielded transformer against interference from within the sweep circuit, control voltage is usually obtained from the vertical deflection terminals of the oscillograph. Approximately 3 volts, r.m.s., are necessary for control of sweep frequencies up to 4000 cycles and approximately 10 volts, r.m.s., up to 8000 cycles. A potentiometer is provided so that the amount of control voltage may be adjusted for best results.

Controls: Controls are provided on the sweep circuit for varying each of the following characteristics: frequency of sweep, length of sweep, amount of control voltage applied to discharge tube, horizontal position of pattern on fluorescent screen.

Shielding: The instrument is completely shielded to minimize interference and to stabilize the operating temperature of the mercury-vapor discharge tube.

Tubes: One General Radio TYPE 506-P1 Mercury Vapor Discharge Tube, supplied with the sweep circuit, and one each of the following RCA (or equivalent) tubes are required: 281-type, 224-A or 224-type, and 227-type. The latter are not included in the price of the instrument.

Power Supply: The instrument is entirely operated from 105–115-volt, 60-cycle power mains.

Power Consumption: 35 watts.

Mounting: The instrument is constructed on an aluminum panel finished in black crackle lacquer and mounted in a polished walnut cabinet. A model to mount on a 19-inch relay rack can be built to order, details on request.

Accessories: A 7-foot cord, fitted with attachment plugs for making connections to the power mains, and a TYPE 506-P1 Mercury-Vapor Discharge Tube are furnished.

Dimensions: Panel, 15 x 8¾ inches. Over-all cabinet size, exclusive of carrying handles, width 15¼, height 9⅝, depth 9½ inches.
Net Weight: 35 pounds.

Type	*Description*	*Code Word*	*Price*
506-AM	**Cabinet mounting**	ADIEU	**$170.00**

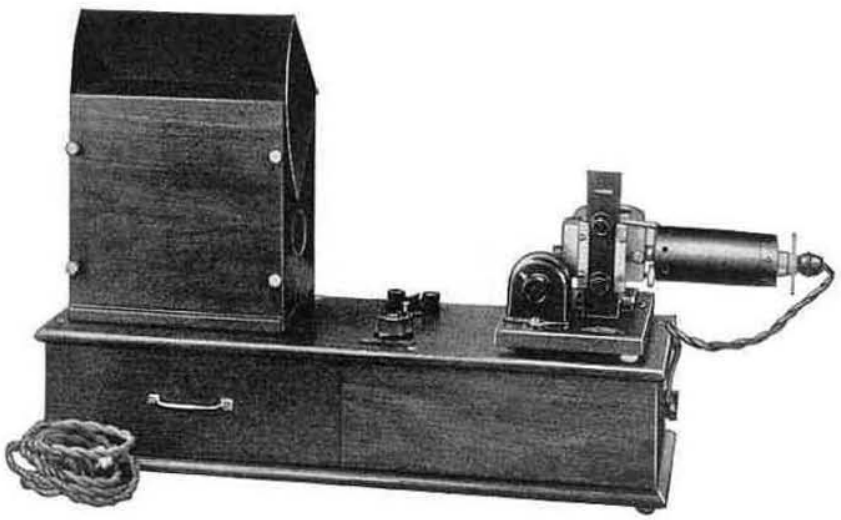
TYPE 506-P1 MERCURY-VAPOR DISCHARGE TUBE

One of these tubes is supplied with each TYPE 506-A Sweep Circuit. It is listed here for replacement purposes.
Net Weight: 4 ounces.

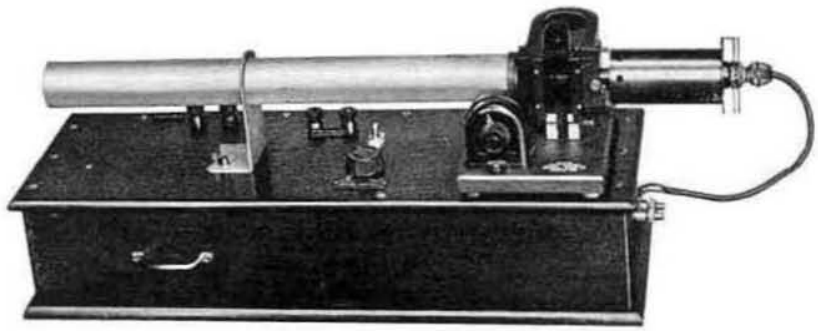
Type	*Code Word*	*Price*
506-P1	ACORN	**$10.00**

TYPE 338-L STRING OSCILLOGRAPH AND TYPE 338-G STRING GALVANOMETER

In many lines of work and experimentation with alternating currents, the need is frequently felt for a simple, sensitive, portable, and inexpensive oscillograph, with which one may view with ease either sustained waveforms or transient currents and voltages existing at any point in an electric circuit or network. To meet these requirements, the General Radio Company has designed a compact and moderately priced instrument. The instrument is especially valuable as a chronograph.



TYPE 338-L String Oscillograph. The rotating mirror and screen are housed in the box at the left



TYPE 338-G String Galvanometer

A timing line may be provided by means of a two-element suspension, or by means of a TYPE 407 Synchronous Shutter.

The vibrating element of the oscillograph is a fine tungsten wire fixed in a magnetic field supplied by permanent magnets. The current under observation passes through this string and is deflected by the interaction of its own field with that supplied by the permanent magnet. The string, being suspended in the beam of a powerful incandescent lamp, casts a shadow upon a suitable screen, thus furnishing a means of observing the amount of deflection.

Equipped with a lens system and a fixed screen, the instrument is useful as a vibration galvanometer, since the string may be tuned to give a good degree of sensitivity at any desired frequency over a considerable range.

If, instead of a fixed screen, the shadow of the string is cast upon a rotating mirror, the speed of which is adjustable, the wave of either current or voltage can be traced out. For many kinds of work, the portability, ruggedness, and low cost of this oscillograph make it especially desirable. The strings are inexpensive and easily replaced, an advantage when the oscillograph is to be used by students in laboratory classes.

The TYPE 338-L String Oscillograph consists of three parts, the galvanometer unit, the viewing box which contains the rotating mirror, and a walnut cabinet base upon which the two are mounted. The latter carries all the necessary controls. An eddy-current type of motor (non-synchronous) drives the octagonal rotating mirror. Its speed may be adjusted so as to synchronize with any desired impressed frequency to produce a stationary image of any recurrent waveform. The observed waveform consists of a shadow line projected upon an illuminated field.

The TYPE 338-G String Galvanometer omits the rotating mirror box and substitutes for it a projection tube 1¾ inches in diameter, terminating in a circular translucent screen. A vibration galvanometer is obtained which is very useful as a null-balance indicator for bridge measurements at 60 cycles or other low frequencies where telephone receivers are insufficiently sensitive, or at higher frequencies where a visual detector is desired.

SPECIFICATIONS

Rotating Mirror and Optical System: A single straight tungsten wire is vibrated in the focal plane of an easily adjusted and focused optical system. The shadow image of this wire, after reflection from the rotating mirror which provides the time axis, is focused directly upon the observing screen. Ponderous and troublesome mirrors are thus avoided. The translucent screen, arranged in the arc of a circle, is approximately 6 inches long by 2½ inches wide, and is printed with rectangular co-ordinates

for convenient reference. Stable speed range of mirror equivalent to scale length of from 30 to 250 inches per second.

Galvanometer and String: The galvanometer unit is sensitized by two permanent magnets which eliminate the need for direct-current excitation. The characteristics of the strings are described below under TYPE 338 Accessories. Two TYPE 338-P1 Single String-Holders are supplied.

Frequency Range: Optimum, 0 to 200 or 300 cycles. Usable, 0 to 3000 cycles.

Light Source: Transformer operated from 110-volt, 60-cycle power supply, delivers 8 volts for lighting standard automobile headlight lamp.

Mounting: Galvanometer and lamp housing, viewing box containing rotating mirror, and all controls mounted on cabinet base. Whitewood carrying case (30 x 18 x 11 inches) supplied.

Power Supply: 110 volts, 60 cycles. About 40 watts required.

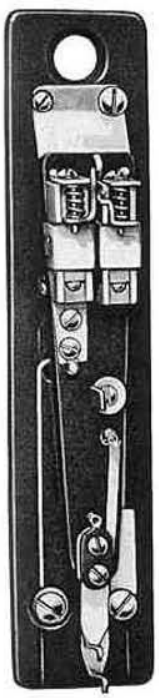
Dimensions: Table space required, 24 x 8 inches. Over-all height, 14 inches.

Net Weight: 28¼ pounds without carrying case; 56 pounds with carrying case.

Type	*Description*	*Code Word*	*Price*
338-L	**String Oscillograph**	OFFER	**$250.00**
338-G	**String Galvanometer**	OFTEN	**175.00**

TYPE 338-P ACCESSORIES AND REPLACEMENTS

These consist of the single and double string-holders, replacement strings, a transformer, and a rheostat. The two latter are especially useful for adapting the impedance of the string to the impedance of the circuit under measurement.

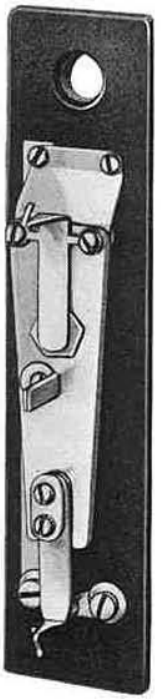


TYPE 338-P2 Double String-Holder

The TYPE 338-P1 Single String-Holder contains one string mounted upon a metal rocker arm which in turn is attached to a bakelite strip. Provision is made for damping the vibration of the string, if desired, by means of a drop of oil.

It is quite simple to replace broken strings in this unit by means of a small soldering iron. For this purpose, the TYPE 338-P3 String Replacement, which is stretched in a convenient mounting frame of coarse copper wire, may be ordered, or if desired, the string-holder may be returned to the factory for repair.

The TYPE 338-P2 Double String-Holder is designed to carry two electrically independent tungsten filaments, giving thus two simultaneous waveforms upon the observing screen. The use of two independent strings offers a wide range of application. It is somewhat more difficult to replace strings in this TYPE 338-P2 Double String-Holder, and it is recommended that holders be returned to the factory for restringing when necessary.



TYPE 338-P1 Single String-Holder

SPECIFICATIONS

Material: Tungsten wire, 0.0004 inch diameter.

Length: 3½ inches.

Resistance: 45 ohms.

Maximum Current: Direct current, 200 milliamperes; alternating current, 300 milliamperes.

Sensitivity: With the string undamped and tuned to the fundamental of the applied alternating-current frequency, the following amounts of power are required to produce a waveform having an amplitude of one millimeter on the screen.

At 60 cycles	0.001 microwatt
At 250 cycles	0.025 microwatt
At 500 cycles	0.144 microwatt
At 1000 cycles	1.8 microwatts

The direct-current sensitivity of the same string when tuned to various frequencies is seen from the following data which gives the potential required to produce a steady deflection of one millimeter on the screen.

At 60 cycles	5 millivolts
At 250 cycles	65 millivolts
At 500 cycles	300 millivolts
At 1000 cycles	1300 millivolts

Type	*Description*	*Code Word*	*Price*
338-P1	**Single String-Holder**	OCCUR	$10.00
338-P2	**Double String-Holder**	OLIVE	35.00
338-P3	**Single Replacement String in Mounting Frame**	AGREE	1.00
585-N	**Transformer,** see page 141	.....	.....
340	**Rheostat,** see page 27	.....	.....
	Restringing TYPE 338-P1 (including string)	.....	1.25
	Restringing TYPE 338-P2 (including strings)	.....	3.00

TYPE 408-A CAMERA

The usefulness of many instruments used in the laboratory for the observation of waveforms is greatly increased by a suitable high-speed continuous-film camera. It not only furnishes a permanent record but in addition supplies a time axis for the recording of transient phenomena. The TYPE 408-A Camera with its accessories is suitable for photography with any oscillograph, but it is adapted for use with the TYPE 338-L String Oscillograph or the General Radio Cathode-Ray Oscillograph.

The camera as listed is driven by hand and film speeds up to 30 inches per second can be obtained. A motor-drive attachment is available by means of which film speeds up to 8 feet per second. This corresponds to a wavelength of approximately 1/10th of an inch for a 1000-cycle trace.

For use with the TYPE 338-L String Oscillograph the camera requires no lens since one is already mounted on the TYPE 409-A Camera Shelf. The adjustable slit supplied with the camera can be removed, if desired, and replaced with a lens so that the camera becomes available for photography with the General Radio Cathode-Ray Oscillograph.

The camera with a TYPE 407-A Synchronous Shutter and a TYPE 409-A Camera Shelf mounted on the string oscillograph

SPECIFICATIONS

Film Feed Mechanism: The camera consists of a rectangular aluminum casting with two separate compartments. One is the magazine for unexposed film, the other is for exposed film. They are designed to hold 100-foot reels so that exposures of any length up to that amount may be obtained. A resettable counter measures the amount that has been exposed. The film passes from the first magazine over a driving sprocket and thence through a light-tight slot into the second magazine. While on the sprocket it is momentarily exposed through a horizontal transverse slit mounted on the face of the camera.

Optical System: The slit through which the film is exposed is 15/16 inch in length, *i.e.*, the useful width of 35 mm film. The amount of the opening is adjustable. This slit is used when the camera operates with the TYPE 338-L String Oscillograph.

When the camera is to be used with the cathode-ray oscillograph a TYPE 408-P3 Lens Assembly is required.

Film Data: The use of 100-foot reels of Eastman No. 697, 35 mm recording paper is recommended, all performance data for the camera being based on the use of this paper. It is much easier to handle than ordinary film and when developed with Eastman X-ray Developer produces a contrasty and very satisfactory record. Paper and developing powder can be obtained from the General Radio Company (see the description below), if it is not available from local stocks of the Eastman Kodak Company.

Records less than 100 feet long can be unloaded in the darkroom with no loss of film, or in daylight with the loss of only a few inches, if care is used.

Drive: The TYPE 408-A Camera is equipped with a hand crank. The drive shaft runs in ball bearings and provision is made for attaching a TYPE 408-P5 Motor-Drive Assembly.

Finish: The aluminum camera case is finished in black crackle lacquer. All other exposed parts are finished in either black or white nickel plate.

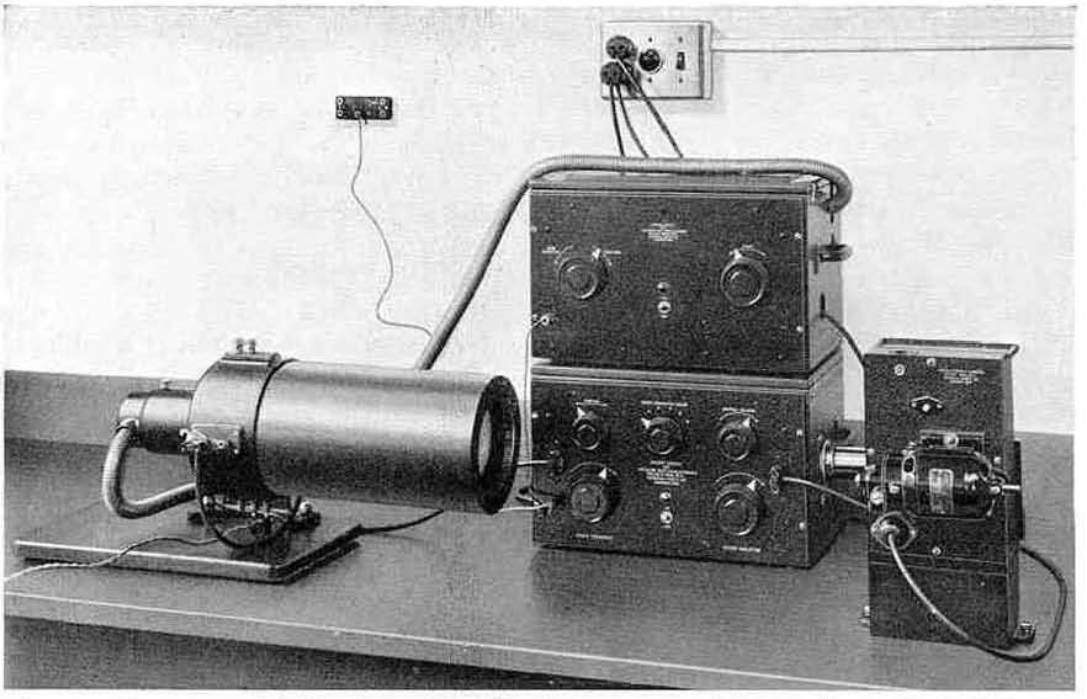
Accessories: The camera is supplied with one blank reel but with no recording paper. Recording paper, developing powder, lens assembly, and motor-drive attachment are described on page 118.

Mounting: The camera is supplied without the wooden base shown in the accompanying illustration. This base is supplied with the TYPE 408-P3 Lens Assembly. There are two tapped holes in the base of the camera for mounting it on this or any other suitable mounting base.

Dimensions: (Height) 9 x (depth) 6 x (width) 4½ inches, including the drive handle.

Net Weight: 10 pounds.

Type	*Description*	*Code Word*	*Price*
408-A	**Hand-Driven Camera**	ANGER	**$175.00**



A motor-driven camera (with lens) set up for making high-speed records with the General Radio Cathode-Ray Oscillograph. The sweep circuit (lower cabinet) is not connected

TYPE 408-P3 LENS ASSEMBLY

The TYPE 408-A Camera is provided with a slit aperture only. When it is to be used with the General Radio Cathode-Ray Oscillograph a fast (wide aperture) lens is required. The TYPE 408-P3 Lens Assembly incorporates an *f*2.5 lens in a suitable mounting for attaching it to the front face of the TYPE 408-A Camera.

This also includes the camera-mounting base shown in the illustration.

SPECIFICATIONS

Lens Speed: *f*2.5. **Net Weight:** 13 ounces.

Type	*Description*	*Code Word*	*Price*
408-P3	**Lens Assembly**	OSCILOLENZ	**$65.00**

TYPE 408-P5 MOTOR-DRIVE ASSEMBLY

This attachment consists of a small high-speed universal motor operating from a 110-volt power supply, either alternating current or direct current. It fits the TYPE 408-A Camera as shown in the accompanying illustration and with it film speeds up to 8 feet per second can be obtained. It is particularly useful when high-frequency transients are to be recorded by means of the camera and the General Radio Cathode-Ray Oscillograph. It weighs 10 pounds.

Type	*Description*	*Code Word*	*Price*
408-P5	**Motor-Drive Assembly**	OSCILODRIV	**$50.00**

TYPE 408-P2 DEVELOPING POWDER AND TYPE 408-P4 RECORDING PAPER

We recommend the use of Eastman No. 697 recording paper in the TYPE 408-A Oscillograph Camera and maintain a small stock made up with perforated leaders on 100-foot reels. It can also be obtained from the Eastman Kodak Company through any of the latter's own retail stores, but we understand that it is made up to order only. A user who has need of a sufficient quantity may be able to persuade his local dealer to carry a stock.

The use of Eastman X-ray developing powders is recommended. We carry these in stock in cartons of six pairs of packages, "12-ounce size."

Type	*Description*	*Weight*	*Code Word*	*Price*
408-P1	**100-ft. reel of Eastman No. 697 paper**	16 oz.	OSCILOFILM	**$3.25**
408-P2	**Carton of X-ray developing powders**	16 oz.	OSCILODOPE	**1.00**

TYPE 409 CAMERA SHELF

The camera shelf supports the TYPE 408-A Camera on the base of the TYPE 338-L String Oscillograph and keeps the optical system in alignment.

The shelf is made of aluminum and is properly drilled for aligning the several parts. It is easily attached to the oscillograph equipment under the galvanometer. As part of the shelf, a two-position mirror and mounting are supplied. This operates like the view finder in a graflex camera, a turn of the wrist serving to throw the string image from the rotating mirror box into the camera and vice versa. Simultaneous visual observations and photographic records are not possible, but one may closely follow the other.

Another part of the shelf equipment consists of a mounting carrying a cylindrical lens having a horizontal axis. This lens is for the same purpose as that in the rotating mirror box; that is to say, it condenses a pencil of rays into a narrow horizontal beam focused along the slit, thereby increasing the intensity of illumination many fold.

The illustrations show the arrangement of the condensing lens. Only a corner of the mirror is visible between viewing box and synchronous shutter.

SPECIFICATIONS

Finish: The shelf is finished in black crackle lacquer.

Net Weight: 5¼ pounds.

Dimensions: 15 x 15 inches, over-all.

Type	*Code Word*	*Price*
409	ANNOY	$30.00

TYPE 407 SYNCHRONOUS SHUTTER

By means of this device narrow transverse time lines can be marked upon the oscillogram. These timing lines are spaced at intervals of 1/50th of a second, with additional identifying marks at every 0.1-second and at every 1-second interval.

The TYPE 338-L String Oscillograph makes an accurate chronograph when used with this unit.

The synchronous shutter is a manually-started synchronous motor, operating from the 60-cycle power supply. The shutter consists of a wheel of five spokes, mounted on the shaft. It is mercury-damped, and the accuracy of timing is therefore substantially equal to the accuracy with which the frequency of the power supply is maintained at 60 cycles. The unit is mounted on the camera shelf, where the shutter wheel will intercept the light from the oscillograph, thereby making a white trace on the moving film or paper.

SPECIFICATIONS

Shutter: The unit is supplied with a five-spoke wheel, but if timing lines, spaced at 0.01-second intervals, are desired, the user may order a ten-spoke shutter, the TYPE 407-P1 Shutter Wheel, as additional equipment.

Power Supply: 105 to 115 volts, 60 cycles. A short, permanently attached cable is provided for making connections to the power-supply terminals on the TYPE 338-L String Oscillograph.

Finish: The unit is finished in black crackle lacquer.

Accessories: Two machine screws for attaching the unit to holes in the TYPE 409 Camera Shelf are provided.

Dimensions: 4 x 3½ x 6 inches.

Net Weight: 5½ pounds.

Type	*Code Word*	*Price*
407	AMISS	$60.00

TYPE 407-P1 SHUTTER WHEEL

A ten-spoke shutter wheel is available for users who wish timing lines at intervals of 0.01 second. It is easily attached to the drive shaft of the synchronous motor.

Type	*Description*	*Weight*	*Code Word*	*Price*
407-P1	**Shutter Wheel (10 spokes)**	7 oz.	ASPEN	**$10.00**

TYPE 457-A MODULATION METER

Proper operation of a broadcast transmitter requires more knowledge about the performance of the modulation system than the operating engineer has been able to obtain readily. Measurements of the percentage of modulation and the adjustment of the transmitter for the maximum amount of undistorted modulation have been difficult, involving as they have a well-developed, experimental technique and relatively complex equipment. The advantages of a simple and accurate modulation meter will be apparent to every broadcast engineer.

The TYPE 457-A Modulation Meter is a direct-reading instrument for the accurate measurement of percentage modulation. It has a number of important uses. Determinations can be made while a program is in progress so that it may be used by the monitoring operator to indicate when the maximum allowable percentage modulation is being exceeded. This modulation meter is no more difficult to operate than a power-level indicator.

The maximum allowable percentage of modulation for any given adjustment of the transmitter can be determined by increasing the audio-frequency input voltage until further increases no longer produce proportional increases in percentage modulation. Greater values of percentage modulation indicate that the transmitter is being overloaded with resulting distortion. Since the percentage modulation can be measured on the negative peaks of the audio-frequency wave as well as on the positive peaks, lack of symmetry in the modulation or shifts in the average value of the carrier voltage during modulation can be detected and steps taken to correct the maladjustment.

About 75 volts of modulated carrier voltage may conveniently be introduced into the modulation meter from a pickup inductor coupled to the output circuit of

the transmitter. The power required to operate it (approximately 0.5 watt) is negligible even in low-power transmitters.

The instrument consists essentially of a linear rectifier for obtaining a wave identical in form with the envelope of the modulated radio-frequency wave and a means, including a vacuum-tube peak voltmeter, for examining the maximum and minimum values of the rectified wave. The circuit is arranged so that, after a preliminary adjustment of the radio-frequency voltage applied to the rectifier, percentage modulation for either positive or negative peaks is given directly by a dial reading.

SPECIFICATIONS

Accuracy: In ordinary use the error is less than 5% in modulation at audio frequencies up to about 3000 cycles. The inherent error of the instrument is considerably less than this, and, if sufficient care is used in setting it up and in taking observations, the error may be reduced to below 2% in modulation. For example, when the modulation meter reads 75% modulation, the true value will be between 73% and 77%.

The accuracy is greater at high modulation percentages than at low and is greater at low modulation frequencies than at high.

Range: The above values of accuracy may be expected for carrier frequencies in the range between 400 kc and 4000 kc (750 meters-75 meters, approximately). The instrument can be modified to permit its use on carrier frequencies as high as 15,000 kc (20 meters), information about which will be supplied on request.

Tubes: Two UY-227 tubes or equivalent are required.

Power Supply: Two Burgess No. 5308 block batteries or equivalent 90-volt battery are required to deliver about 2 ma. A battery compartment is provided inside the cabinet. Filament-heater power is supplied from the 105–115 volt, 50–60 cycle line.

Terminals: A receptacle for plugging in the 110-volt supply is provided on the right-hand side of the cabinet. Battery connections are made to flexible leads. On the front panel and on terminal plates at the back, duplicate pairs of binding posts are provided for the radio-frequency input and for the output of the linear rectifier, so that it can be used with other analyzing equipment if desired.

Shielding: A shield of nickel-plated brass protects the circuit from stray electric fields.

Mounting: All parts are mounted on an aluminum panel finished in black crackle lacquer. The instrument can be supplied mounted in a polished walnut cabinet or with panel extensions suitable for mounting it in a standard 19-inch (TYPE 480) relay rack.

The cabinet mounting model is known as TYPE 457-AM; the rack mounting model is known as TYPE 457-AR.

Accessories: The instrument is supplied with a 7-foot cord for making connections to the 110-volt line but without tubes, battery, or pickup inductor.

Dimensions: Panel size, (length) 15 x (height) 7 inches. Cabinet size for TYPE 457-AM, (length) 18⅛ x (height) 7¾ x (depth) 10⅞ inches, over-all, including handles. Panel size for TYPE 457-AR, (length) 19 x (height) 7 x (depth) 10 inches, over-all.

Net Weight: 25 pounds for TYPE 457-AM; 19 pounds for TYPE 457-AR.

Type	*Description*	*Code Word*	*Price*
457-AM	**Cabinet Mounting**	MANGE	**$125.00**
457-AR	**Relay-Rack Mounting**	MANGY	**110.00**

TYPE 536-A DISTORTION-FACTOR METER

The TYPE 536-A Distortion-Factor Meter measures the total harmonic content of the alternating-current wave under test and gives directly the ratio between the square root of the sum of the squares of the amplitude of all harmonics and the amplitude of the fundamental. This is the distortion factor, an excellent measure of the objectionableness of the distortion introduced by amplifiers, lines, or other circuit elements.

Most of the methods of measuring harmonic distortion that have been employed either have been laborious, or have involved elaborate equipment. The TYPE 536-A Distortion-Factor Meter has been developed to enable distortion measurements to be made accurately and rapidly. This instrument has a further important advantage over earlier apparatus in that its input impedance is very high. It may, therefore, be connected almost anywhere without causing appreciable disturbance of the circuit under test.

In order that these ends might be achieved, two important simplifications of the problem have been made at the outset. Only a single fundamental frequency is employed, and only the total harmonic distortion is measured.

The first of these limitations is not serious because harmonic production is essentially an amplitude phenomenon. Frequency usually enters into the problem only secondarily. For this reason a study at a single frequency of the harmonic production in a given piece of apparatus under various operating conditions yields valuable information. The technique of measurement is simplified to such an extent that the required data may be very rapidly obtained.

The measurement of total harmonic content is for most purposes preferable to the measurement of the several components separately. We obtain in this way a single quantity as a measure of the impurity of the voltage source. The "Distortion Factor" measured by the instrument is

$$D = \frac{\sqrt{E_2^2 + E_3^2 + E_4^2 + \dots}}{E_1}$$

This is the ratio to the fundamental of the effective value of the combined harmonics. This quantity is an excellent measure of

the objectionableness of the distortion present in the transmission of speech or music. For example, a second harmonic of 5 per cent with a third harmonic of 5 per cent is seen to give a smaller distortion factor than a single harmonic of 10 per cent, and is correspondingly less objectionable.

The present general use of the pentode output tube makes a dependable means of studying the output capabilities of an amplifier especially desirable. Output measurements without some indication of the distortion present are of doubtful significance. The use of the TYPE 536-A Distortion-Factor Meter in conjunction with the TYPE 483 Output Meter in making these measurements gives truly reliable data for the comparison of various types of amplifiers.

If a suitable linear rectifier is available for demodulation, the TYPE 536-A Distortion-Factor Meter provides a means of measuring the impurity of the modulated output of a radio-telephone transmitter. Such a high-quality linear rectifier is contained in the TYPE 457-A Modulation Meter, and terminals are provided for connection to the distortion-factor meter. The use of these two instruments in conjunction, therefore, makes possible the direct determination of modulated distortion.

The principal elements of the instrument are an excellent high-pass filter and a calibrated resistance network by means of which the filter output is compared with the input voltage. A dial is rotated until the same indication is obtained for two positions of a switch. The distortion factor is then given directly by the dial reading. Two ranges are provided giving 3 per cent and 30 per cent, respectively, at the maximum dial setting. The characteristics of the filter are such that the fundamental is attenuated about 75 decibels more than the harmonics. Power-supply hum voltages are likewise suppressed. All harmonics up to the fifteenth are transmitted equally within 0.4 decibel. The filter is so designed that no appreciable harmonic distortion is produced by the inductors, even when large input voltages are applied. A resistance pad is provided ahead of the filter so that the calibration is not altered by the impedance out of which the instrument works.

SPECIFICATIONS

Range and Sensitivity: With the recommended auxiliary equipment, 10 volts across the input terminals makes possible the measurement of distortion factors as low as 0.02. If larger distortion factors are to be measured, the input voltage may be reduced in the same proportion. Similarly, if larger input voltages are available, proportionately smaller distortion factors may be measured.

For special uses, the range and sensitivity may be very greatly extended by employing more amplification. If desired, two TYPE 514-A Amplifiers may be used in tandem for special work.

Frequency Range: 380–420 cycles.

Input Impedance: About 175,000 ohms.

Accuracy: When the TYPE 488-HM Alternating-Current Galvanometer is used as indicator, the error is less than 5% for distortion factors as low as 0.005. If necessary, greater accuracy can be obtained by substituting an instrument of the thermocouple type, as this indicates more accurately the effective value of a composite voltage. Inasmuch as the thermocouple instrument is less sensitive, more sluggish, and has a much smaller overload capacity, the TYPE 488-HM Alternating-Current Galvanometer is usually to be preferred.

Auxiliary Equipment: The distortion-factor meter must be used with a suitable amplifier and indicating instrument. The TYPE 514-A Amplifier and TYPE 488-HM Alternating-Current Galvanometer are recommended for general use. The amplifier must have a flat characteristic, variable gain, and an input impedance greater than half a megohm. The indicating instrument should be sensitive and have a square-law characteristic in order to indicate the effective value of the combined harmonics.

Where a 400-cycle voltage is applied to the apparatus under test, it must usually be filtered to obtain sufficient purity. The extent to which this is

necessary depends, of course, on the magnitudes of the distortion factors to be measured.

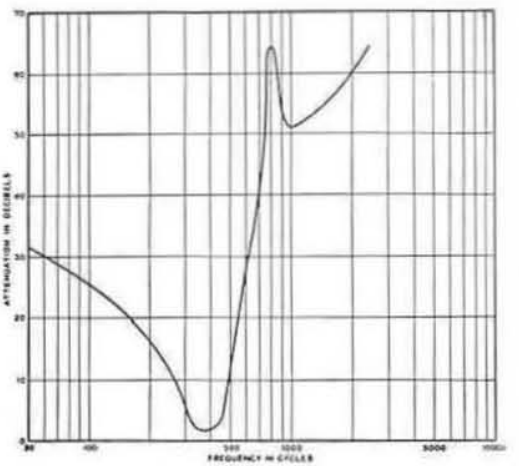
One or more TYPE 330-A or TYPE 330-C Filter Sections may be employed if extreme purity is not required. A special band-pass filter TYPE 530-A and TYPE 530-C has been developed for use with the TYPE 536-A Distortion-Factor Meter. This filter is described below.

Dimensions: Panel, (length) 12 x (height) 7 inches. Cabinet, (length) 15 x (height) 8¼ x (depth) 12¼ inches, over-all.

Net Weight: 30 pounds.

Type	*Code Word*	*Price*
536-A	DRAFT	**$140.00**

TYPE 530 BAND-PASS FILTER



This filter is designed primarily for use with the TYPE 536-A Distortion-Factor Meter to purify the voltage applied to apparatus under test. It is useful in any other cases where an extremely pure 400-cycle voltage is desired. The use of one of these filters reduces the harmonic content by at least 50 decibels. They may be used with a fundamental frequency of from 375 to 425 cycles. Sufficient attenuation is provided at the low-frequency end to remove any power-supply hum voltage which may be present. The two types differ only in characteristic impedance. These filters are not carried in stock but are supplied on order.

SPECIFICATIONS

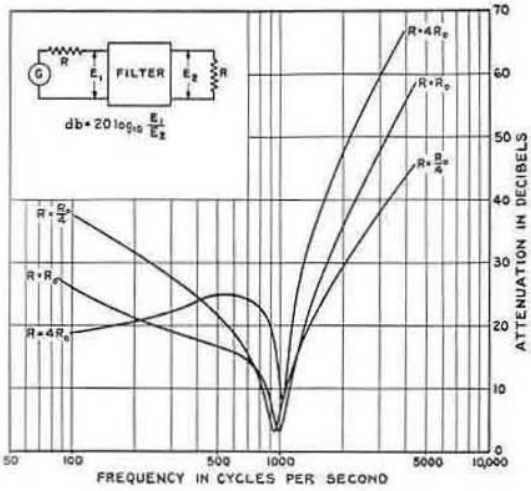
Mounting: All are mounted in Model D cases, dimensions for which are given on page 140.

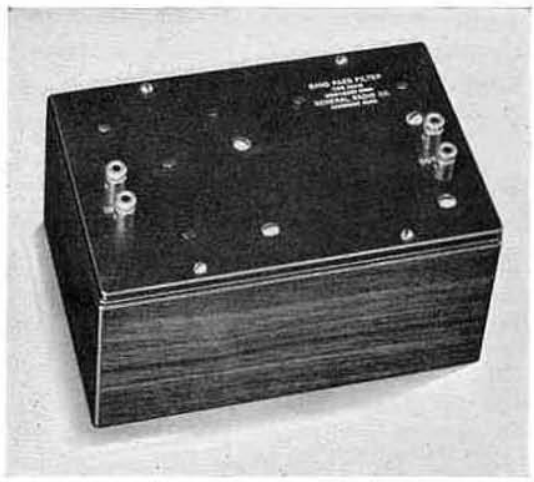
Net Weight: 8 pounds.

Type	*Impedance*	*Pass Band*	*Code Word*	*Price*
***530-A**	**600 ohms**	375–425 cycles	FOCAL	**$37.50**
***530-C**	**6000 ohms**	375–425 cycles	FURRY	**37.50**

*Built to order—not carried in stock.

TYPE 534 BAND-PASS FILTER





This filter contains in a single unit an entire band-pass filter.

This filter is designed primarily for use in connection with bridge measurements in order to suppress harmonics, and also any hum which may be present in the generator. It may be used either in the generator output or in the detector input.

The transmission characteristic is similar to that of a simple resonant circuit, except that it offers appreciably higher discrimination to frequencies outside the transmitted region. The minimum transmission loss is approximately 3 decibels. Discrimination against the second harmonic is normally 33 decibels. For the 400-cycle filter the discrimination against low-frequency hum is in excess of 16 decibels, for the 1000-cycle filter it is in excess of 25 decibels.

SPECIFICATIONS

Attenuation Characteristic: See accompanying curve.

Impedance: The filters listed are designed on the basis of generator and load impedances of 2000 ohms. Formulae are available for computing filters for other impedances.

It should be noted that the discrimination of the filter and its minimum transmission point are dependent upon the terminal impedances. At the second harmonic, for example, the discrimination is increased 12 db when working between four times normal terminal impedances, and decreased 6 db when working between one-quarter normal terminal impedances. Discrimination against low-frequency hum may vary as much as 22 db as the generator and load impedances are varied between four times the nominal value and one-quarter the nominal value. Over this same range the minimum attenuation point may vary approximately 10% in frequency and 5 db in attenuation.

Calibration: Filters are adjusted by selecting condensers of the series resonant circuit so that the minimum attenuation point is within 1% of the value shown in the nameplate.

Mounting: The filter is attached to a bakelite panel and enclosed in a walnut cabinet.

Dimensions: (Length) 7¾ x (width) 5 x (height) 3⅝ inches, over-all.

Net Weight: 4 pounds.

Type	*Frequency*	*Code Word*	*Price*
*534-A	400 cycles	EXCEL	$24.00
534-B	1000 cycles	EXERT	18.00

*Not carried in stock—delivery two weeks.

TYPE 330 FILTER SECTION

This series of simple high-pass and low-pass filter sections includes high-pass T-type sections, and the low-pass filters π-type sections. These individual sections are built into shielded metal cans including laminated iron-core inductor, with two condensers. Any number of similar or different sections may, of course, be joined in series to produce a multisection filter. The accompanying curves give an idea of their transmission characteristics. The important influence of the terminating impedance on sharpness of cut-off should be noted.

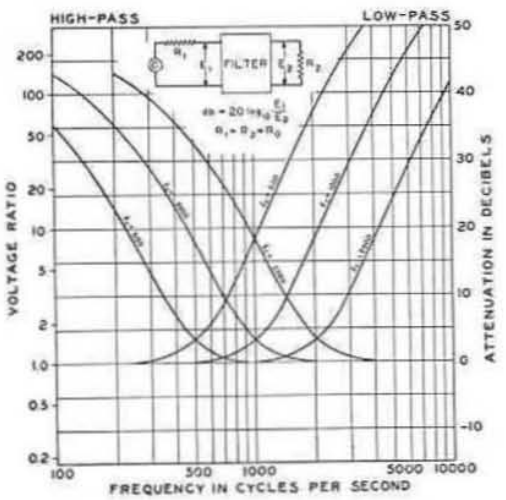
A group of filters with convenient values of impedances and cut-off frequency is listed below. The General Radio Company specializes in equipment of this sort, and similar sections having any desired electrical constants may be obtained on special order. The theoretical cut-off frequency f_o and the iterative impedance should be specified when ordering such special sections. Low-pass and high-pass sections may be combined to make band-pass and band-elimination filters.

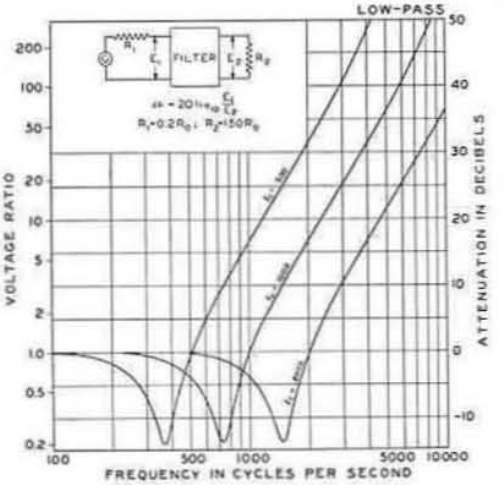
SPECIFICATIONS

Mounting: All are mounted in Model C cases, dimensions for which are given on page 143.

Net Weight: Approximately 3⅜ pounds for all sizes.

Type	f_o	*Impedance*		*Code Word*	*Price*
330-A	500 cycles	600 ohms	Low Pass	FILTERGOAT	$12.00
330-C	500 cycles	6000 ohms	Low Pass	FILTERSHOE	12.00
330-E	1000 cycles	600 ohms	Low Pass	FILTERTOAD	12.00
330-G	1000 cycles	6000 ohms	Low Pass	FILTERSIGN	12.00
330-J	2000 cycles	600 ohms	Low Pass	FILTERHEAD	12.00
330-L	2000 cycles	6000 ohms	Low Pass	FILTERBELL	12.00
330-B	500 cycles	600 ohms	High Pass	FILTERGIRL	12.00
330-D	500 cycles	6000 ohms	High Pass	FILTERSEAT	12.00
330-F	1000 cycles	600 ohms	High Pass	FILTERMUSH	12.00
330-H	1000 cycles	6000 ohms	High Pass	FILTERPIPE	12.00
330-K	2000 cycles	600 ohms	High Pass	FILTERFOOT	12.00
330-M	2000 cycles	6000 ohms	High Pass	FILTERWALK	12.00





METERS

The meters described in this section include vacuum-tube voltmeters, oxide-rectifier voltmeters and thermocouples, together with various special combinations for special needs. By their use voltages in the audio- and radio-frequency spectrums can be measured.

	Type	*Practical Applications*	*Identifying Features*
	626	Voltage measurements at audio and radio frequencies where the meter must have a high impedance	0-3 volts — Complete alternating-current operation
	426	Voltage measurements at audio and radio frequencies where the meter must have a high impedance	0-3 volts — Operated from batteries
	483	Output voltage and power measurements at audio frequencies for one impedance	Constant impedance over all voltage ranges
	583	Output power measurements at audio frequencies for a wide variety of different impedances	Direct-reading in milliwatts — Wide range in power and impedance
	586	Monitoring and signal-level measurements on broadcast and recording audio channels	No batteries, tubes, or other replacement parts required
	492 493	Oxide rectifiers: Audio-frequency voltage measurements — Thermocouples: Current measurements at audio, carrier, and radio frequencies	Compact, convenient mounting—Thermocouples, both contact- and separate-heater types mounted in vacuo
	488 588 298	Experimental laboratory measurements where a mounted meter is a convenience — Meter mounting fits navy-type meters	Meter mounting made of moulded bakelite — Can be fitted with jacks to connect couples, rectifiers, shunts, etc.

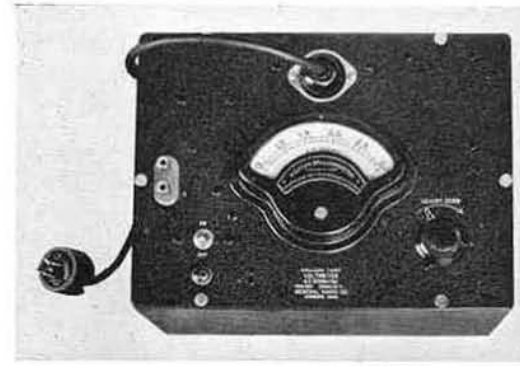
TYPE 626-A VACUUM-TUBE VOLTMETER

ALTERNATING-CURRENT OPERATED

The wide applicability of the thermionic type of alternating-current voltmeter introduced the need for such an instrument designed to be operated wholly by 60 cycles, 110-volt alternating current.

The TYPE 626-A Voltmeter is a direct-reading, serviceable, moderately precise instrument of the compensated, depressed-zero type. The filaments of the tubes used are run at subnormal voltages so that their normal life is considerably increased. A rugged d'Arsonval type of meter having a full-scale deflection of 300 microamperes is the indicating device.

The design of the circuits and the type of tubes used result in a minimum wandering of the zero point from aging, the chief source of error being fluctuations in the line voltage (see below). A rheostat is provided on the panel for adjusting the instrument so that all values of line voltage between 100 and 120 volts may be used. Sudden erratic changes in line voltage are not in general detrimental, owing to the large thermal capacity of the cathode of the thermionic tube.



SPECIFICATIONS

Range: 0 to 3 volts, root-mean-square.

Power Supply: Alternating current, 50–60 cycles, 100–120 volts. The instrument draws a current of approximately 0.15 amperes from the power supply. A pilot lamp and "on-off" switch are mounted on the panel.

Tubes: One 227-type for the thermionic voltmeter, one 171-type for the rectifier unit, and one 874-type ballast tube for stabilizing the plate voltage are required. These are supplied with the instrument. In the event of failure of the voltmeter tube, the instrument should be returned to us for recalibration.

Calibration: Each instrument is individually calibrated and is accurate to within 1% of full-scale value.

Line-Voltage Error: A drop of one volt in the power supply will reduce the reading of the meter at any given point on the scale by 0.015 volts (0.5% of full-scale). This error is linear. The meter is adjusted for different values of line voltage by a control rheostat which restores the needle to zero.

Frequency Error: Below 1500 kc, this error is negligible. At 3000 kc, the frequency error is less than 2%, and at 4000 kc, it is less than 4%.

Waveform Error: The instrument is calibrated in terms of r.m.s. values of a pure sinusoidal wave. Since most thermionic voltmeters read average rather than r.m.s. values, any departure from a sinusoidal wave due to the presence of harmonics will introduce an appreciable error.

Input Impedance: 10 megohms. No external direct-current path is required.

Ground: It is desirable to ground the low potential input terminal.

Mounting: Aluminum panel, polished walnut case.

Accessories: A six-foot attachment cord and the three tubes are supplied with the instrument.

Dimensions: (Length) 11 x (width) 8½ x (height) 8¾ inches, over-all.

Net Weight: 14½ pounds.

Type	*Range*		*Code Word*	*Price*
626-A	**0–3 volts, r.m.s.**	.....	ETHIC	**$100.00**

TYPE 426-A THERMIONIC VOLTMETER

The vacuum tube lends itself particularly well to use as a voltmeter where no current may be taken by the instrument. In the TYPE 426-A Thermionic Voltmeter all external circuits have been eliminated.

The plate-to-filament resistance of the three-element tube is used as one arm of a bridge circuit. Changes in the grid potential caused by the measured voltage cause changes in the value of this resistance, which unbalance the bridge. The amount of unbalance is indicated by a hand-calibrated micro-ammeter, thereby measuring the potential impressed.

SPECIFICATIONS

Range: 0 to 3 volts, root-mean-square.

Power Supply: 22.5-volt battery which supplies filament, grid, and plate potentials. Space is provided in instrument case to accommodate two 22.5-volt batteries connected in parallel. External battery recommended, however, and connections are provided.

Calibration: The meter is calibrated against root-mean-square values of a sinusoidal wave.

Accuracy of Calibration: Within 1% up to 1000 hours, at which time the instrument should be returned to the factory for a new tube and calibration. See price list.

Frequency Error: Less than 2% of full scale at 20 kc; less than 3% at 300 kc. Although calibration is not accurate to this order of magnitude at broadcast and higher radio frequencies, the instrument may be used for making voltage comparisons in that range.

Waveform Error: Very slight when due to third harmonic. Appreciable when due to second harmonic. Second harmonic error can be almost wholly corrected by reversing the leads to the meter and averaging the two readings obtained.

Adjustment: With voltmeter terminals short-circuited, the meter pointer is set at zero by means of a rheostat mounted in the case.

Scale: Individually calibrated. Mirror back for anti-parallax readings with the knife edge pointer.

Dimensions: (Length) 10¼ x (width) 9 x (depth) 7¾ inches, over-all.

Net Weight: 11 pounds.

Type	*Range*	*Code Word*	*Price*
426-A	**0–3 volts, r.m.s.**	SERUM	**$160.00**
	Recalibration, including replacement tube		**20.00**

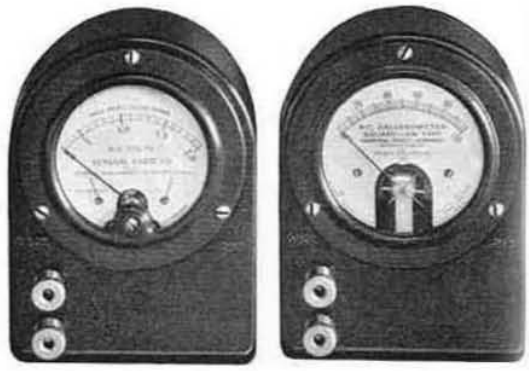
TYPE 488-BM and TYPE 488-DM ALTERNATING-CURRENT METERS

OXIDE-RECTIFIER TYPE

These instruments are designed for the measurement of alternating-current voltages at frequencies from 10 to 20,000 cycles per second. The indicating element consists of four small copper-oxide units arranged in the form of a bridge for obtaining full-wave rectification. The alternating-current voltage applied to the input terminals of this type of structure results in a direct current through a

d'Arsonval galvanometer proportional to the root-mean-square value of the alternating voltage.

A change of impedance with applied voltage is a characteristic of all copper-oxide rectifiers, and hence it is desirable that some means be provided for maintaining the input impedance to this type of instrument at a constant value. In the types listed below, the proper choice of resistances external to the indicating element has provided a satisfactory means for meeting this problem.



Left: Both TYPE 488-BM and TYPE 488-DM have this 2-volt scale. *Right:* TYPE 488-HM

SPECIFICATIONS

Voltage Range: 0 to 2 volts.

Impedance Range: Impedances of 4000 and 20,000 ohms are available.

Impedance Characteristic: Same as for TYPE 483 Output Meter, see opposite page.

Accuracy of Calibration: Same as for TYPE 483 Output Meter, see opposite page.

Length of Scale: 2½ inches.

Mounting: Each meter is supplied mounted in a TYPE 298-A Meter Mounting.

Dimensions: Diameter, 3½ inches; depth, 2¼ inches, over-all. Mounting hole diameter, $2\frac{27}{32}$ inches.

Net Weight: 12 ounces.

Type	*Range*	*Impedance*	*Code Word*	*Price*
488-BM	0–2 volts, r.m.s.	4000 ohms	OURMETGOAT	$20.00
488-DM	0–2 volts, r.m.s.	20,000 ohms	OURMETSHOE	35.00

TYPE 488-HM SQUARE-LAW GALVANOMETER

The usual rectifier-type voltmeter has a nearly linear characteristic and is subject to some waveform error. By carefully redesigning the rectifier circuit it has been found possible to produce a meter practically free from this defect. The TYPE 488-HM Alternating-Current Galvanometer was developed for use with the TYPE 536-A Distortion-Factor Meter to replace the less rugged thermocouple instrument usually employed for such work. Since it is used for a comparison instrument no calibration is required.

SPECIFICATIONS

Range: 0 to approximately 600 millivolts full scale.

Resistance: Approximately 700 ohms.

Scale: The 2.5-inch scale is divided into fifty equal divisions marked 0-100.

Calibration: The meter is adjusted so that full-scale deflection is obtained at approximately 600 millivolts.

Waveform Error: The approach to a square-law characteristic is sufficiently close so that even when two equal voltages of different frequencies are simultaneously applied the waveform error is less than 3%. This means that the effective value of the composite voltage causing a certain deflection will be within 3% of the single frequency voltage causing the same deflection.

Frequency Characteristic: The meter will give the same deflection to within 2% for alternating-current voltages up to 2000 cycles, to within 5% up to 5000 cycles, and within 10% up to 10,000 cycles.

Adjustment: A screw is provided under the glass face for making the zero adjustment. The glass may be removed by unscrewing the bezel.

Mounting: The meter is supplied mounted in a TYPE 298-A Meter Mounting.

Dimensions: Flange diameter, 3½ inches; back-of-panel depth, 2¼ inches, over-all; body diameter, $2\frac{27}{32}$ inches.

Net Weight: 12 ounces.

Type	*Range*	*Code Word*	*Price*
488-HM	0–600 millivolts, square law	OURMETHEAD	$30.00

TYPE 483 OUTPUT METER

The general acceptance of the constant-impedance copper-oxide rectifier type of output meter, introduced by the General Radio Company about three years ago, for the measurement of the performance of radio receivers and for many other experimental uses, has been such that it is desirable to extend the line in order that they may be available for use in connection with the various types of receivers now available. The extremely high sensitivity of the latest models greatly increases their field of usefulness to the engineer.

Three impedance values have been selected as the most generally used. For other impedances, the use of impedance-matching transformers is suggested. The General Radio Company will be glad to quote on suitable transformers upon request.

With each of the various types of receivers, it is desirable that the output meter have sufficient sensitivity to permit measurements of hum voltage. By incorporating the latest improvements in methods of meter construction, it has been possible to obtain a full-scale sensitivity of 2 volts even at a characteristic impedance of 20,000 ohms. This sensitivity has been obtained without loss of mechanical ruggedness.

In order to increase the utility of these output meters, seven multiplying steps have been provided. In this way the total range has been increased and the interval between steps has been decreased.

SPECIFICATIONS

Impedance Range: Three values of impedance are available: 4000, 8000, and 20,000 ohms.

Impedance Characteristic: When the multiplier is set at "1" the impedance of the instrument is that due to the meter alone and hence varies somewhat with the applied voltage. The impedance of the 8000-ohm instrument, for instance, increases approximately 50% at ¼ full-scale voltage; the 20,000-ohm instrument increases approximately 30% at approximately ¼ full-scale voltage. With increase in multiplying setting the impedance approaches a pure resistance of the rated value. This is accurately adjusted to within ±2%.

Sensitivity: All have a full-scale sensitivity of 2 volts. See price list.

Accuracy of Calibration: With the multiplier at one, the accuracy of calibration depends entirely on the properties of the copper-oxide voltmeter. These are such that the instrument is accurate to within 4% of its full-scale reading at frequencies up to 2000 cycles. The error increases at higher frequencies at the rate of about ½ of 1% for each 1000 cycles up to about 30,000 cycles. The errors are in the negative direction, that is, the meter readings are low.

At a multiplier setting of two, there is an additional error in the indicated voltage due to the variation in meter impedance with voltage. For the 4000- and 8000-ohm meters, this error is 5% at one volt and 10% at 0.5 volt. For the 20,000-ohm meter this error is 3% at one volt and 6% at 0.5 volt. The network

error at a multiplier setting of two is greater than at any other setting and decreases rapidly as the multiplier ratio is increased.

Scale Length: 2½ inches.

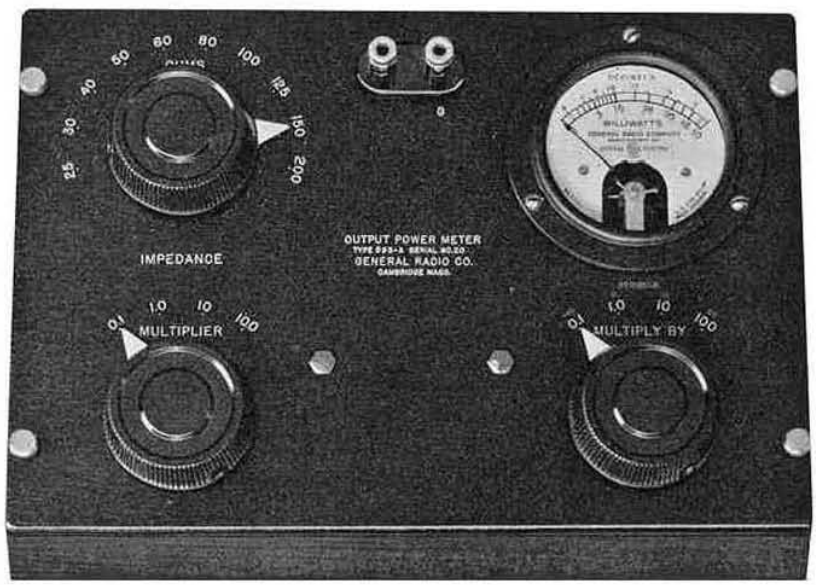
Mounting: The copper-oxide-rectifier voltmeter and the multiplier switch are mounted on a bakelite panel which, in turn, is mounted in a polished walnut case.

Dimensions: (Length) 9 x (width) 4¼ x (height) 4¾ inches, over-all.

Net Weight: 3 pounds.

Type	*Impedance*	*Voltage Range*	*Power Range*	*Power for Half-Scale Deflection*	*Code Word*	*Price*
483-A	4000 ohms	0–200 volts	0–10 watts	0.25 mw	AVAST	$42.00
483-B	8000 ohms	0–200 volts	0– 5 watts	0.125 mw	AVERT	50.00
483-C	20,000 ohms	0–200 volts	0– 2 watts	0.05 mw	AVOID	54.00

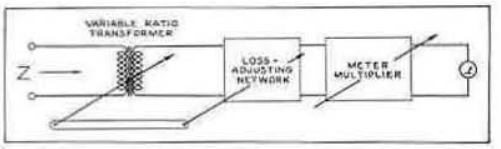
TYPE 583-A OUTPUT POWER METER



The direct measurement of power at the levels usually encountered in audio-frequency communication circuits has previously been an impossibility. In the past, the usual method of making such measurements has been to measure the current or voltage in a given load resistance and then to calculate the power by formula. This instrument reads power directly. Adjustments are provided for an impedance range from 2.5 to 20,000 ohms and for a power range from 0.1 to 5000 milliwatts.

Fundamentally, the instrument consists of a multi-tapped transformer which couples the circuit under test to a very sensitive copper-oxide rectifier-type meter. The transformer has a tapped primary and secondary, variable by means of switches on the panel. As these switches are adjusted, besides varying the impedance, they introduce proper amounts of compensating resistance to keep the loss in the transformer constant at all impedance settings and to provide the exact stated impedance at the input binding posts.

This arrangement is, in effect, an ideal impedance-matching transformer (between the input and the meter) followed by a fixed and known amount of attenuation.



Schematic diagram for the TYPE 583-A Output Power Meter

Under this condition, all of the power from the input is transferred to the meter circuit. The meter scale is calibrated directly in power, taking into account the correction for inherent electrical power loss in the system.

A multiplier is included to increase the power range of the meter by a maximum of 1000 to 1 in appropriate steps. An auxiliary scale calibrated in decibels is also provided.

Many uses for such an instrument are possible. For instance:

(*a*) The power that an audio-frequency generator will deliver to a load of a given impedance can be found immediately with no calculations.

(*b*) The effect of power delivered as influenced by load impedance can be measured.

(*c*) An important application is in the measurement of radio receivers. It will serve for the standard selectivity, sensitivity, band-width, and fidelity tests. The auxiliary decibel scale will be recognized as being most convenient for this. Speaker impedances change with frequency. Once the rate of this variation is determined, the actual power delivered by the set into the speaker at different frequencies can be found by adjusting the power meter to the appropriate values for each frequency.

(*d*) The characteristic impedance of telephone lines, phonograph pickups, vacuum-tube oscillators, etc., can be determined by adjustment of the impedance of the power meter until a maximum reading is obtained. This occurs when the impedance of the meter is equivalent to the impedance of the power source under measurement.

Care has been taken to obtain the widest frequency range possible and the limits given in the specifications are liberal, representing worst conditions. Over certain impedance ranges, the characteristics are somewhat improved. The frequency response curve, in all cases, is flat, with dropping response at the extreme ends. No peaks are present.

Although ample accuracy is available for nearly all measurements, certain limitations must be set; for instance, the measurement of a good audio-frequency transformer whose characteristics approach that of the meter itself should not be attempted.

SPECIFICATIONS

Power Range: 0.1 to 5000 milliwatts.

Meter: Calibrated from 1 to 50 milliwatts with auxiliary scale reading from 0 db to 17 db with 1 milliwatt as reference level.

Multiplier: Multiplies meter power scale by factors of 0.1, 1.0, 10, and 100. Also adds —10, 0, +10, and +20 db to auxiliary decibel scale.

Frequency Characteristic: Accuracy varies with frequency and impedance setting. Maximum error in full-scale power reading does not exceed 0.3 db between 150 and 2500 cycles, nor does it exceed 1.5 db at 20 and 10,000 cycles. The average error is 0.3 db at 30 and 5000 cycles; and 0.6 db at 20 and 10,000 cycles.

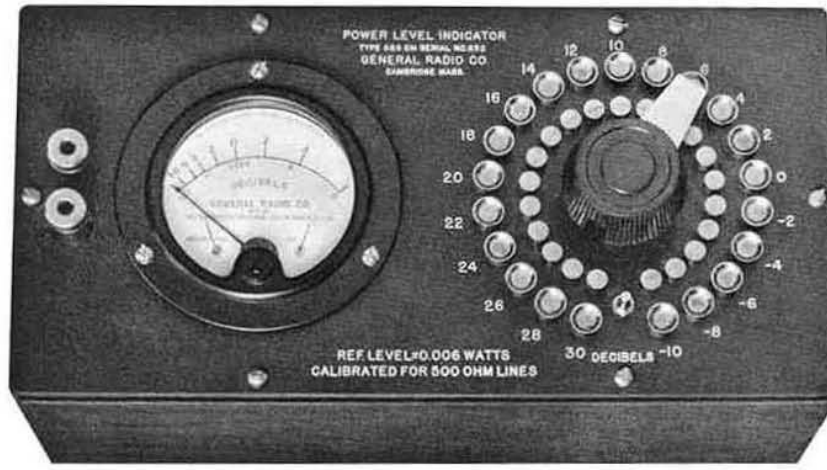
Maximum error in impedance does not exceed 7% between 150 and 3000 cycles, nor does it exceed 50% at 20 and 10,000 cycles. The average error is 8% at 30 and 5000 cycles; and 20% at 20 and 10,000 cycles.

Size: (Length) 10 x (width) 7 x (height) 6 inches, over-all.

Net Weight: 8¼ pounds.

Type		*Code Word*	*Price*
583-A	.....	ABUSE	$95.00

TYPE 586 POWER-LEVEL INDICATOR



A cabinet-mounted power-level indicator. The scales on the instrument shown are used on TYPE 586-CR as well as TYPE 586-CM

The importance of maintaining a careful check upon the signal amplitude at various points in voice-transmission circuits is well recognized by acoustic engineers. Too low a level means interference from background noises; too high a level means overloading of amplifiers and reproducers, and the introduction of crosstalk into nearby channels.

The TYPE 586 Power-Level Indicator has many advantages for work of this kind. It is portable, compact, rugged, accurate, low in price, and requires no batteries or replacements.

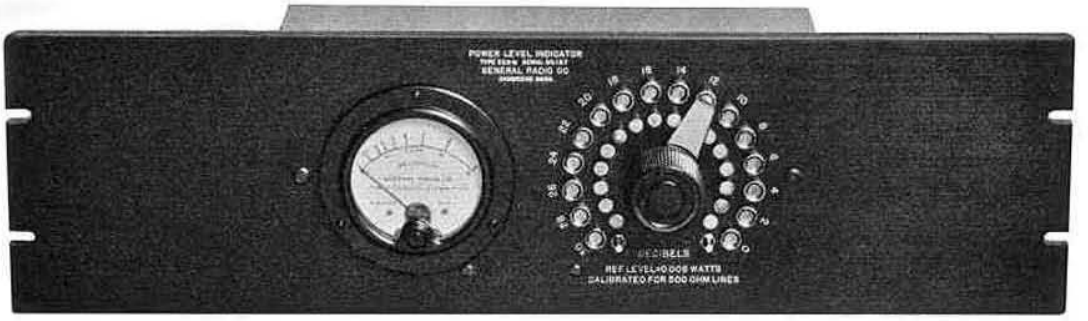
This instrument always presents a purely resistive load to the line, thus eliminating all possibility of changing the frequency characteristics of the line.

The moving element, slightly damped to prevent any undue overthrow on sudden surges, is particularly rugged and will withstand the hard usage attendant upon maintaining a continuous check on the rapidly changing power level of voice circuits.

Between the input terminals and the indicating voltmeter is inserted an adjustable L-type attenuation network which serves as a multiplier for increasing the range while maintaining the input impedance constant regardless of setting. The power level in decibels is obtained by taking the sum of the reading of the multiplier switch and the meter reading.

The TYPE 586 Power-Level Indicator is made in two ranges, each of which can be supplied mounted in a cabinet or with a wide panel for mounting in a 19-inch relay rack. TYPE 586-A and TYPE 586-B have sufficient sensitivity for the usual voice levels encountered in telephone operating practice; TYPE 586-CM and TYPE 586-CR have the maximum sensitivity without sacrifice of ruggedness or dependability.

Units of this sort can be used in exactly the same way as the older vacuum-tube operated types of volume indicators, and have the obvious advantages of requiring no batteries or tubes, being lighter in weight and having equal or better accuracy.



A power-level indicator for relay-rack mounting. The scales on the instrument shown are used on TYPE 586-A as well as TYPE 586-B

SPECIFICATIONS

Power Level Range: TYPE 586-A and TYPE 586-B cover the range between —10 db and +36 db; TYPE 586-CM and TYPE 586-CR cover the range between —20 db and +36 db. Both of these power-level ratings are for a zero level of 6 milliwatts in a 500-ohm line.

Internal Input Impedance: 5000 ohms. Note that this is the internal resistance of the instrument and has exactly the same significance as the "resistance" of a voltmeter. This high resistance means that the loss introduced by bridging the power-level indicator across a line is very small.

Scale Reading: For TYPE 586-A and TYPE 586-B: Zero level at mid-scale. This corresponds to 6 milliwatts or 1.73 volts when connected across a 500-ohm line. It is graduated in steps of 2 db to cover the range from —10 db to +6 db. The network is adjustable in steps of 2 db.

For TYPE 586-CM and TYPE 586-CR: —10-db level at mid-scale. This corresponds to 0.6 milliwatt or 0.548 volt when connected across a 500-ohm line. Actual meter sensitivity varies from —20 db to —4 db, but for convenience it is calibrated in 2-db steps from —10 db to +6 db. The remainder of the range is covered by multiplier.

Indicating Element: Copper-oxide-rectifier voltmeter calibrated to read power level in decibels.

Accuracy: Slight variation in oxide-rectifier impedance with current passing through introduces a small error. The effect is greatest at the —10-db mark on meter where the reading may be 0.5 db low. The average error is from 0.1 db to 0.2 db and is entirely negligible. No appreciable frequency error up to 10,000 cycles per second. These specifications apply to all models.

Distortion: Due to the highly resistive impedance characteristics and the absence of iron, no detectable distortion is introduced into the monitored circuits by these power-level indicators.

Uses: Monitoring the power level of a voice circuit. Power and voltage measurements. Amplifier gain and circuit loss determinations. Equalization measurements on voice circuits.

Correction Term: When used across loads or lines of other than 500-ohms impedance, the correct power level may be obtained by adding to or subtracting from the instrument indications a constant correction term taken from a chart furnished with each instrument.

Mounting: TYPE 586-A and TYPE 586-CM are mounted on a bakelite panel in a polished walnut cabinet. TYPE 586-B and TYPE 586-CR are intended for mounting on a standard 19-inch, TYPE 480, relay rack.

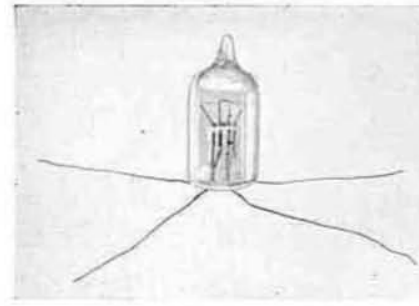
Dimensions: For TYPE 586-A and TYPE 586-CM: (Length) 10 x (height) 5 x (depth) 5 inches, over-all. For TYPE 586-B and TYPE 586-CR: (Length) 19 x (height) 5 x (back of panel depth) 3¼ inches, over-all. Panel thickness, ¼ inch.

Net Weight: 2⅞ pounds for cabinet models, 4 pounds for rack-mounting models.

Type	*Power-Level Range*	*Mounting*	*Code Word*	*Price*
586-A	**—10 db to +36 db**	**Cabinet Model**	HABIT	**$60.00**
586-B	**—10 db to +36 db**	**Relay-Rack Model**	HANDY	**64.00**
586-CM	**—20 db to +36 db**	**Cabinet Model**	HONEY	**75.00**
586-CR	**—20 db to +36 db**	**Relay-Rack Model**	HONOR	**80.00**
586-P1	**Meter only for Types 586-A and 586-B**		POWLEVGOAT	**20.00**
586-P4	**Meter only for Types 586-CM and 586-CR**		POWLEVSHOE	**30.00**

TYPE 493 VACUUM THERMOCOUPLES

TYPE 493 Thermocouples are mounted in a bakelite case with plugs to fit a TYPE 274-RJ Mounting Base



Both the contact and separate-heater couples are sealed into an evacuated glass bulb

In the thermocouple, the heat caused by the flow of current through a wire is applied to a junction of dissimilar metals. Such a junction sets up a direct-current voltage which actuates a direct-current indicating meter. This type of instrument is a true integrating ammeter since the direct-current-meter reading is a function of the average squared current in the heater.

A thermocouple is, therefore, independent of waveform. Frequency errors can occur only at frequencies so high that the very small shunting effect of stray capacitances in the couple mounting become significant (beyond 20 Mc).

The high accuracy and extensive frequency range inherent in measurements made with the thermocouple have made this unit very popular in many types of audio- and radio-frequency measurements.

Two types of couples are described in specifications on page 137. One is the so-called contact type, in which the heating element through which the alternating current flows is in direct contact with the junction. The other couple is of the separate-heater type, in which the heating element is separated from the junction by a small glass bead which completely insulates the alternating current from the direct-current part of the unit. This has many advantages in certain types of high-frequency measurements. The couple may be used with fewer precautions against stray capacitances to ground and generally at somewhat higher frequencies.

Structurally, the contact type is somewhat simpler than the separate-heater type and is, consequently, less expensive.

The thermo-junctions used in these couples are mounted in an evacuated glass bulb. The vacuum serves to prevent conduction of heat from the couple and also reduces the effect of external temperature variations. The glass bulb is surrounded by felt and mounted in a bakelite container fitted with plugs for plugging into a TYPE 274-RJ Mounting Base.

The evacuation is done with the glass heated to a high temperature, thus removing occluded gases from the elements, assuring a high vacuum and a resultant high stability of calibration.

The design of both the contact and separate-heater types permits a considerable overload before burnout.

In earlier models the contact type was more sensitive than the separate-heater type. Due to the recent improvement in the design of the separate-heater type, its sensitivity is now equivalent to the contact type.

The TYPE 588-AM Direct-Current Meter, described on page 138, is especially designed for use with these couples.

These couples are suitable for use on either alternating or direct current and may, of course, be calibrated on direct current.

SPECIFICATIONS

Type of Couple: The type number "493" is used to designate all thermocouples described here. A single letter following the type number, *e.g.*, TYPE 493-A, indicates a thermocouple of the contact type; a double letter, *e.g.*, TYPE 493-HA, indicates a separate-heater thermocouple.

Couple Resistance: Heaters are adjusted to within ±10% of the values given in the following table. The actual value is engraved on the nameplate of the couple case to within 0.01 ohm for TYPES 493-A, 493-B, 493-C, 493-HA, 493-HB, and 493-HC; to within 0.1 ohm for TYPES 493-E and 493-HE; and to within 1.0 ohm for TYPES 493-H, 493-K, 493-HH, and 493-HK.

Electrical Sensitivity: The price list indicates the current required to produce 10 millivolts on open circuit. This value is held to within ±10% for all couples.

Thermal Sensitivity: 26 microvolts per degree Fahrenheit.

Overload: All heaters will withstand a continuous overload of at least 50% of rated current to give 10 millivolts open circuit.

Coefficient of Resistance: Couple elements, 0.00013 per degree Fahrenheit; heater, 0.00009 per degree Fahrenheit.

Meter: The TYPE 588-AM Direct-Current Meter, described on page 138, is recommended for use with these couples.

Dimensions: Size of case, exclusive of plugs, 2⅛ x 1⅝ x ¾ inches.

Net Weight: 4 ounces.

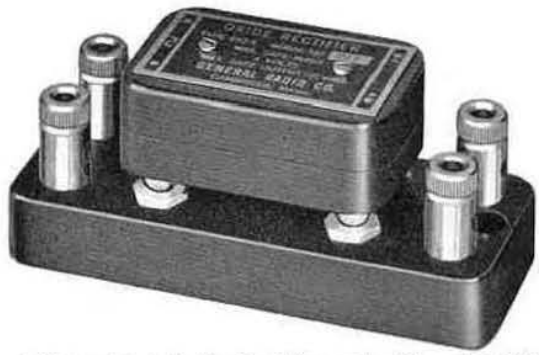
Type	*Heater Resistance*		*Current to Give 10 Millivolts Open Circuit*	*Code Word*	*Price*
493-A	**0.5 ohm**	**Contact type**	275 ma	FUNNY	**$12.00**
493-C	**2 ohms**	**Contact type**	100 ma	FOCUS	**12.00**
493-E	**10 ohms**	**Contact type**	25 ma	FOLLY	**12.00**
493-H	**100 ohms**	**Contact type**	7 ma	FORAY	**12.00**
493-K	**450 ohms**	**Contact type**	4.5 ma	FORUM	**12.00**
493-HA	**0.5 ohm**	**Separate-heater type**	275 ma	EAGER	**15.00**
493-HC	**2 ohms**	**Separate-heater type**	100 ma	EDICT	**15.00**
493-HE	**10 ohms**	**Separate-heater type**	25 ma	EARLY	**15.00**
493-HH	**100 ohms**	**Separate-heater type**	7 ma	EASEL	**15.00**
493-HK	**450 ohms**	**Separate-heater type**	4.5 ma	EDIFY	**15.00**

TYPE 492-A OXIDE RECTIFIER

The TYPE 492-A Oxide Rectifier is provided for use with relays and direct-current indicating instruments on alternating-current service. The unit is at present offered primarily for experimental use and the following specifications are indicative rather than positive.

Junctions of certain forms of copper-oxide have a characteristic of uni-lateral conductivity to electric current. In the TYPE 492-A units four copper-oxide rectifiers are arranged in the form of a bridge providing full-wave rectification of applied alternating current.

It must be realized that the copper-oxide type of rectifier is subject to changes in both sensitivity and frequency characteristics with output load. The sensitivity also varies with impressed voltage. The values given below approximate those obtained under usual conditions of voltage and load.



A TYPE 492-A Oxide Rectifier and a TYPE 274-RJ Mounting Base

As used in meter circuits, fixed resistors are inserted in series or shunt with the rectifiers to reduce the apparent variations due to the copper-oxide rectifiers. The TYPE 500 or TYPE 510 Resistors are recommended for this purpose.

SPECIFICATIONS

Frequency Error: The rectifier may be used without appreciable frequency error at frequencies below 5000 cycles per second.

Temperature Error: Temperature errors of about 5% may be expected between normal extreme temperatures. Maximum sensitivity is obtained with a load of 5000 to 7000 ohms. This value should be used when the instrument is operating a relay. If a 1-milliampere meter of 400 or 500-ohms resistance is used, full-scale deflection will be obtained at about 2 volts across the rectifier input.

The maximum current output from the rectifier should not exceed 15 ma, nor should the impressed voltage exceed 3 volts.

Obviously, the apparent change of impedance with resistance can be greatly reduced by proper use of series and shunt resistance on the input side.

Dimensions: Size of case, exclusive of plugs, 2⅛ x 1⅜ x ¾ inches.

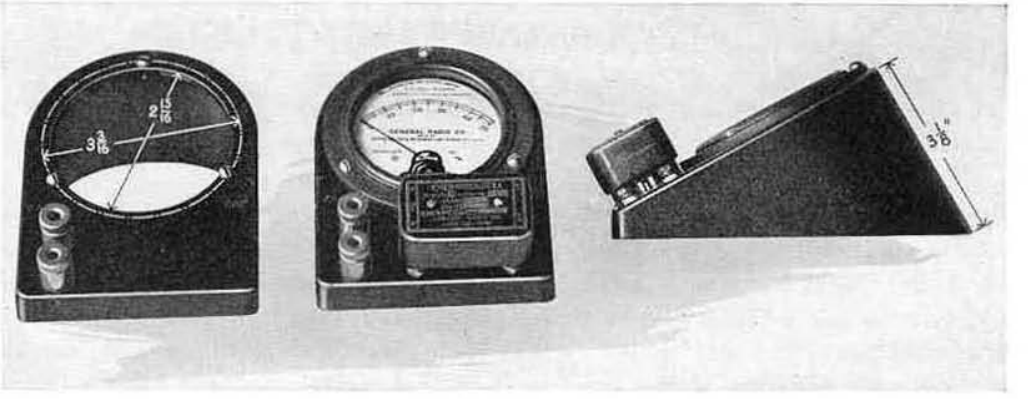
Net Weight: 4 ounces.

Type	*Code Word*	*Price*
492-A	FLORA	**$7.00**

TYPE 588-AM DIRECT-CURRENT METER

This is a direct-current galvanometer having full-scale sensitivity of 500 microamperes and a resistance of 10.0 ohms (5 millivolts) which adapts it for use in conjunction with Type 493 Thermocouples. Since each thermocouple must be individually calibrated, the scale is laid out with 50 equal divisions marked from 0 to 50, thus making easy the preparation and reading of calibration curves. The meter is supplied with the TYPE 298-B Meter Mounting which has jacks for plugging in the thermocouple.

This meter may also be used with the TYPE 492-A Oxide Rectifier, described above.



Left: A TYPE 298-A Meter Mounting showing dimensions. *Center and right:* A TYPE 588-AM Direct-Current Meter showing how a TYPE 493 Thermocouple or a TYPE 492-A Oxide Rectifier can be plugged in

SPECIFICATIONS

Range: 0 to 500 microamperes full scale.

Resistance: Approximately 10 ohms.

Scale: The 2½-inch scale is divided into 50 equal divisions marked 0 to 50.

Calibration: Full-scale deflection is adjusted to within 2% of the specified value of 500 microamperes. Other points are not calibrated but deflection is approximately proportional to current over the entire range.

Adjustment: A screw is provided in the glass face for making the zero adjustment.

Dimensions: See accompanying photograph.

Net Weight: 1¾ pounds.

Type	*Range*	*Code Word*	*Price*
588-AM	**0–500 microamperes**	OURMETMUSH	**$21.00**

TYPE 298 METER MOUNTINGS

During the last few years, the General Radio Company has made extensive use of flush-type meters mounted in the standard 3½-inch navy-type bakelite case. These have been developed for use in power-level indicators, in output meters, and as galvanometers associated with rectifier elements and with thermocouples.

To meet the growing demand for individual meters used apart from complete instruments, the General Radio Company has developed the TYPE 298 Meter Mounting. This is a moulded bakelite case supporting the meter at an angle of approximately 30° from the horizontal. Two of our TYPE 138-V Jack-Top Binding Posts are mounted at the lower left-hand corner. In the TYPE 298-B model, four TYPE 274-J Jacks are mounted in accordance with standard spacing. These jacks, therefore, permit the use of the TYPE 492 Rectifiers or of the TYPE 493 Thermocouples with the meter. It is also possible to use multipliers or attenuation networks mounted in the same kind of bakelite cases.

This unit fits all navy-type meters having short studs. Dimensions are given in the accompanying photograph.

SPECIFICATIONS

Dimensions: (Height) 2½ inches x (width) 3¾ inches x (length) 6 inches.

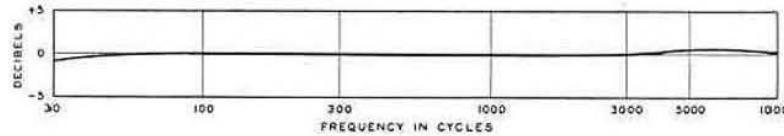
Net Weight: 1 pound.

Type		*Code Word*	*Price*
298-A	**Without Jacks**	FABLE	**$2.00**
298-B	**With Jacks**	FACET	**2.25**

AUDIO-FREQUENCY TRANSFORMERS

The following pages present the General Radio Company's line of audio-frequency transformers, including models for input, interstage, output, and impedance-matching use.

All of these transformers have cores made of the best grade of silicon steel, which results in unusually good frequency characteristics and high overload point. Due to the high saturation point it is not necessary, under normal operating conditions, to use parallel plate feed. The accompanying curve shows the frequency characteristic of the new General Radio TYPE 541-J Transformer, which may be considered as representative of the line.



The transformers are practically unaffected by mechanical shock and heavy direct current through the windings will not magnetize the cores permanently. This means that the transformers will retain their characteristics for years of use. These are important factors which should be considered in choosing transformers for high-quality audio-frequency transmission and amplifier systems.

Detailed specifications for each group of transformers are preceded by charts which summarize important uses of each for ready reference. They will help the designer of audio-frequency equipment to select the correct transformer for a particular purpose. Under each of the various uses to which the transformers may be applied are listed the correct transformers for the purpose, together with schematic diagrams and information concerning the voltage ratios, impedances, etc. It will be noted that several transformers have tapped windings allowing use in either balanced or unbalanced circuits, which is of great value in laboratory or experimental work.

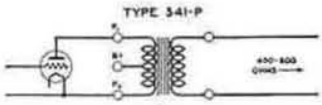
SPECIAL TRANSFORMERS

Special transformers can be built to meet requirements not covered by the stock models shown in the charts. Prices will be quoted on request.

General Radio transformers are mounted in the three sizes of cases shown in the samples above. *Left to right:* Model B, Model C, and Model D. See page 143 for dimensions

VACUUM-TUBE OUTPUT TRANSFORMERS

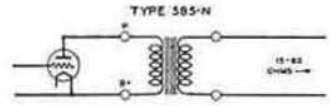
TUBE-TO-LINE, TUBE-TO-SPEAKER, ETC.



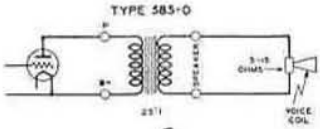
A

A Single tube to line.

B Single tube to string oscillograph vibrator. (For use with TYPE 338 String Oscillograph.)



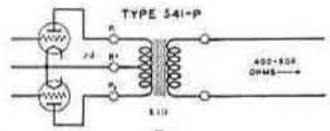
B



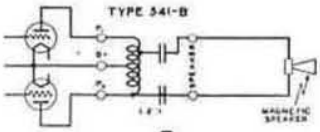
C

C Single power output tube to dynamic (low-impedance) speaker.

D Balanced (push-pull) stage to line.



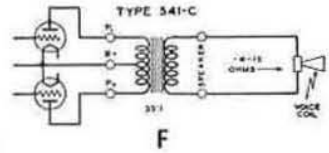
D



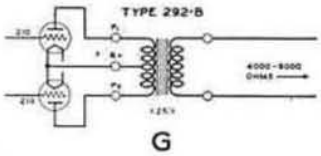
E

E Balanced (push-pull) output stage to magnetic (high impedance) speaker.

F Balanced (push-pull) output stage to one or more dynamic (low-impedance) speakers.



F



G

G Output of Class B stage using two 210-type tubes to modulate 50-watt (or smaller) transmitter.

SPECIFICATIONS

Voltage Ratio: Consult the preceding charts where the voltage ratio applying to the particular use is given beneath the graphical symbol for the transformer core.

Frequency Range: The following table shows the frequency range in cycles per second over which the voltage ratio lies within ±2 db of its value over the flat portion of the characteristic.

Impedance Range: The values given in the table are for the internal output impedance of the circuit out of which the transformer operates within a voltage ratio of 2 db over the frequency range.

Primary Winding: The value of primary inductance in henrys is given in the table for the rated maximum direct current listed in the adjacent column. The d-c resistance of the primary is also stated.

Mounting: All transformers are mounted in the standard drawn-steel, wax-filled cases shown on page 140. All use Model B cases except TYPE 541-B which is mounted in a Model C case.

Dimensions: See the dimensioned drawing on page 143.

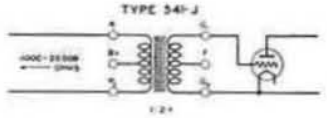
Net Weight: Approximately 2½ pounds for all except TYPE 541-B which weighs 3 pounds.

	Range		*Primary**			*Code*	
Type	*Frequency*	*Impedance*	*Inductance*	*Max. D-C*	*Resistance*	*Word*	*Price*
292-B	20–6000	6000–10,000	150 h	30 ma	460 ohms	TUDOR	**$10.00**
541-B	30–10,000	2500–15,000	60 h	50 ma	750 ohms	TORSO	**10.00**
541-C	30–10,000	2500–15,000	76 h	50 ma	750 ohms	TAPER	**6.00**
541-P	30–11,000	5000–25,000	100 h	25 ma	750 ohms	ABIDE	**12.00**
585-N	60–5000	5000–15,000	40 h	10 ma	500 ohms	OBESE	**8.00**
585-O	60–6000	2000–6000	20 h	55 ma	464 ohms	TITLE	**7.00**

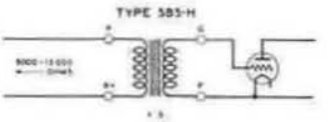
* Data are for whole of split or tapped windings.

VACUUM-TUBE INPUT TRANSFORMERS

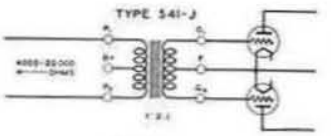
TUBE-TO-TUBE, MICROPHONE-TO-TUBE, LINE-TO-TUBE, ETC.



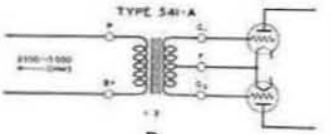
A High-impedance amplifier input, for operation from a pick-up, detector tube, amplifier tube, etc.



A

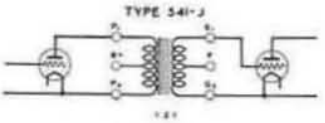


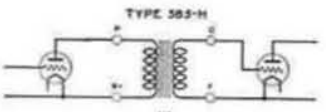
High-impedance input to balanced (push-pull) stage. **B**



B

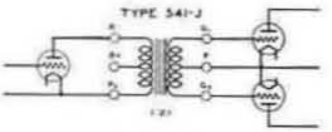
C Amplifier interstage for operation from triode (such as 199, 201-A, 112-A, 226, 227, 230, 237, 56, etc.) into amplifier or power output tube.

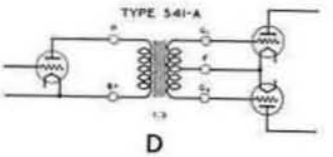




C

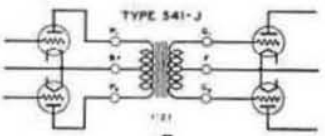
Input to balanced (push-pull) amplifier or power output stage from triode (such as 199, 201-A, 226, 227, 230, 237, 56, etc.). **D**





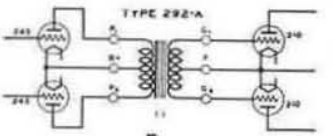
D

E Balanced (push-pull) interstage. Push-pull triodes into push-pull amplifier or power output stage.

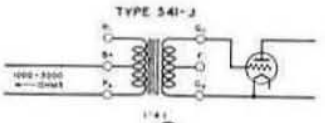


E

Input to Class B stage using two 210-type tubes. Two 245-type tubes as drivers. **F**



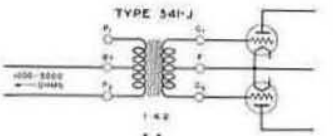
F



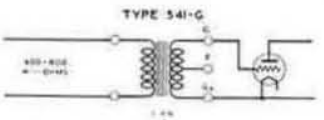
G Medium-impedance input.

G

Medium-impedance input to balanced (push-pull) stage. **H**



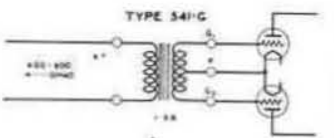
H



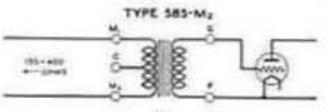
I Line to tube.

I

Line to balanced (push-pull) stage. **J**



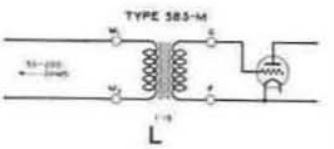
J



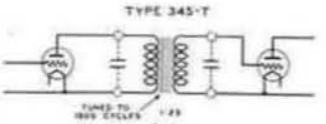
K Single or double button microphone, medium impedance line, etc., to tube.

K

Single button microphone, 100- or 200-ohm line, etc., to tube. **L**



L



M Tuned for maximum selective response at 1000 cycles. For use in heterodyne reception of code signals. It works out of a standard triode.

M

SPECIFICATIONS

Voltage Ratio: Consult the preceding charts where the voltage ratio applying to the particular use is given beneath the graphical symbol for the transformer core.

Frequency Range: The following table shows the frequency range in cycles per second over which the voltage ratio lies within ±2 db of its value over the flat portion of the characteristic.

Impedance Range: The values given in the table are for the internal output impedance of the circuit out of which the transformer operates within a voltage ratio of 2 db over the frequency range.

Primary Winding: The value of primary inductance in henrys is given in the table for the rated maximum direct current listed in the adjacent column. The d-c resistance of the primary is also stated.

Mounting: All transformers except TYPE 345-T are mounted in the standard drawn-steel, wax-filled cases shown on page 140. All use Model B cases.

TYPE 345-T is mounted in a special small-size square case.

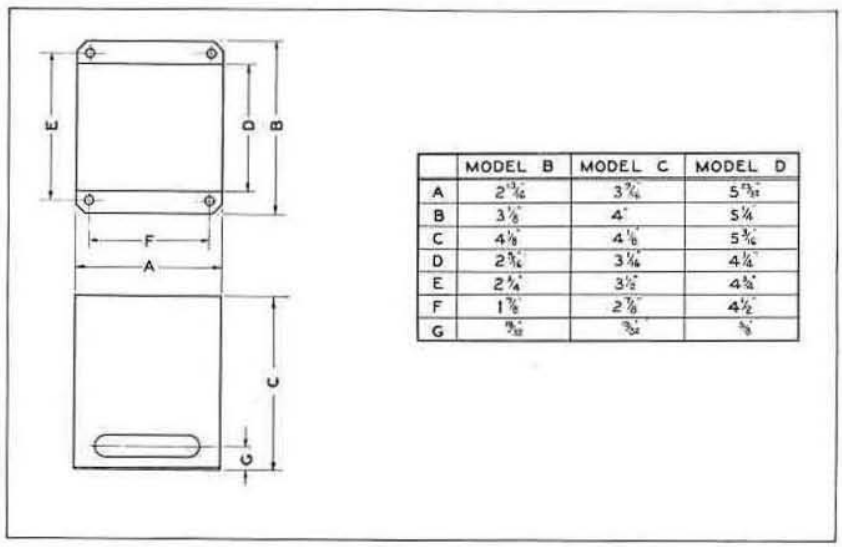
Dimensions: See the dimensioned drawing below for all except TYPE 345-T which is $2\frac{5}{8}$ x $1\frac{15}{16}$ x $2\frac{11}{16}$ inches.

Net Weight: $2\frac{1}{2}$ pounds, approximately, for all except TYPE 345-T which weighs $1\frac{1}{2}$ pounds.

	Range		*Primary**			*Code*	
Type	*Frequency*	*Impedance*	*Inductance*	*Max. D-C*	*Resistance*	*Word*	*Price*
292-A	20–11,000	2500–4500	70 h	36 ma	620 ohms	TUNIC	**$7.00**
†**345-T**	1000	.....	.....	10 ma	8 ohms	ABBOT	**5.00**
541-A	40–9000	2500–15,000	45 h	10 ma	1750 ohms	TALLY	**6.00**
541-G	30–11,000	400–600	8 h	50 ma	80 ohms	ABEAM	**12.00**
541-J	30–10,000	4000–20,000	150 h	15 ma	2300 ohms	ABHOR	**7.50**
585-H	40–8000	5000–15,000	50 h	12 ma	2000 ohms	TIPSY	**6.00**
585-M	40–5000	50–200	0.65 h	100 ma	20 ohms	TARDY	**10.00**
585-M2	40–10,000	150–400	2.4 h	100 ma	32 ohms	TARRY	**10.00**

* Data are for whole of split or tapped windings.

† TYPE 345-T is intended to work out of a triode like a 230-, 27-, or 56-type tube. At 500 cycles and 2000 cycles its response is down approximately 15 db from the value at 1000 cycles.



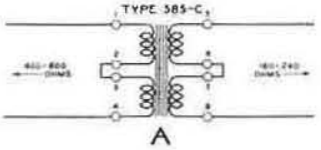
	MODEL B	MODEL C	MODEL D
A	$2\frac{13}{16}$"	$3\frac{3}{4}$"	$5\frac{53}{64}$"
B	$3\frac{1}{8}$"	4"	$5\frac{1}{4}$"
C	$4\frac{1}{8}$"	$4\frac{1}{8}$"	$5\frac{3}{4}$"
D	$2\frac{5}{8}$"	$3\frac{1}{4}$"	$4\frac{1}{4}$"
E	$2\frac{1}{4}$"	$3\frac{1}{2}$"	$4\frac{3}{4}$"
F	$1\frac{7}{8}$"	$2\frac{7}{8}$"	$4\frac{1}{2}$"
G	$\frac{9}{32}$"	$\frac{3}{32}$"	$\frac{5}{8}$"

Dimensions for standard General Radio transformer-mounting cases. Photographs are shown on page 140

IMPEDANCE-MATCHING TRANSFORMERS

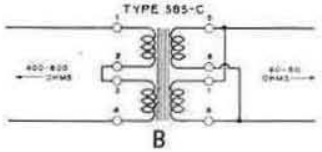
In a great many circuits it is necessary to couple two elements of different impedances together in such a way that there is no impedance mismatch at the junction. This impedance adjustment is necessary in order to minimize reflection loss at the junction and in order to provide correct terminating impedances for calibrated networks.

For impedance matching or circuit isolation in extremely high quality voice and music transmission circuits TYPE 585-C and TYPE 585-R Transformers are recommended. On the other hand, where it is desirable to have the impedance ratio variable over a wide range by means of a switch or plug arrangement at some sacrifice in frequency characteristics, the TYPE 359 and TYPE 666-A Variable Ratio Transformers are recommended. For use in connection with bridges and similar equipment where a flat frequency characteristic is not necessary, the TYPE 166 Transformer may be used.



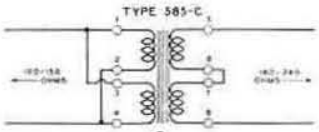
A

A High quality impedance matching. Approximately 500 ohms to 200 ohms (balanced or unbalanced).



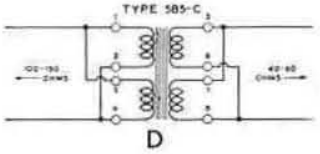
B

B High quality impedance matching. Approximately 500 ohms to 50 ohms (balanced or unbalanced).



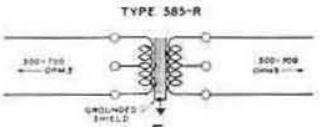
C

C High quality impedance matching. Approximately 125 ohms to 200 ohms (balanced or unbalanced).



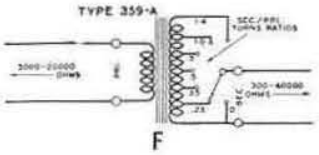
D

D High quality impedance matching. Approximately 125 ohms to 50 ohms.

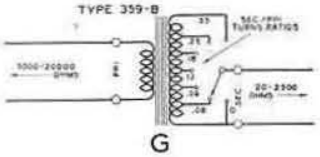


E

E High quality circuit isolation. For use between balanced and unbalanced circuits of 500 to 700 ohms. Electro-static shield between the windings.

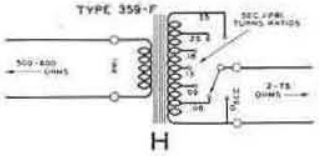


F



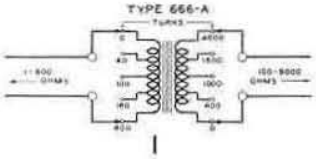
G

F, G, H Variable-ratio impedance-matching transformer. Ratio varied by switch mounted on transformer case.



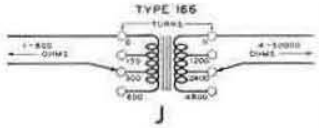
H

I Variable-ratio impedance-matching transformer. Ratio varied by plug and jack arrangement.



I

J Multi-ratio impedance-matching transformer for use in connection with bridges, etc. Binding posts are provided for the various taps.



J

SPECIFICATIONS

Voltage Ratio: Consult the preceding charts where the voltage ratio or the turns ratio for each transformer is given.

TYPE 359 Transformers have a tapped secondary and a switch for quickly changing the turns ratio.

The TYPE 666 Variable Transformer has plug taps on both primary and secondary. Taps are brought out to binding posts on the terminal plate of the TYPE 166 Transformer. See the accompanying illustration.

Frequency Range: The following table shows the frequency range in cycles per second over which the voltage ratio lies within ±2 db of its value over the flat portion of the characteristic.

Impedance Range: The values given in the table are for the internal output impedance of the circuit out of which the transformer operates within a voltage ratio of 2 db over the frequency range.

Primary Winding: The value of primary inductance in henrys is given in the table for the rated maximum direct current listed in the adjacent column. The d-c resistance of the primary is also stated.

Mounting: All TYPE 585 and TYPE 359 Transformers are mounted in the standard drawn-steel cases shown on page 140. TYPE 585 Transformers use Model B cases; TYPE 359 Transformers, Model C cases.

The method of mounting the TYPE 666-A and TYPE 166 Transformers is shown in the illustration.

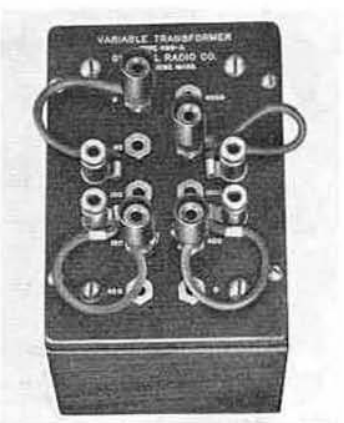
Dimensions: For TYPE 585 and TYPE 359, see the dimensional drawing on page 143.

Net Weight: TYPE 585: 2½ pounds, approximately. TYPE 359: 3½ pounds, approximately. TYPE 666-A: 3½ pounds. TYPE 166: 2 pounds.

	Range		*Primary**			*Code*	
Type	*Frequency*	*Impedance*	*Inductance*	*Max. D-C*	*Resistance*	*Word*	*Price*
166	150–5000	.....	.....	.....	.....	TOPIC	**$5.00**
359-A	40–4000	5000–20,000	10.3 h	15 ma	700 ohms	PILOT	**20.00**
359-B	30–5000	5000–20,000	10.3 h	15 ma	700 ohms	PIOUS	**20.00**
359-F	30–4000	500–600	0.7 h	40 ma	28 ohms	POLAR	**20.00**
585-C	30–10,000	100–150 / 400–600	6 h	10 ma	49 ohms	ABODE	**7.50**
585-R	40–11,000	500–700	2.5 h	15 ma	22 ohms	ABOMA	**7.50**
666-A	90–9000	1–800	.....	.....	.....	ABOON	**12.50**

*Data are for whole of split or tapped windings.

TYPE 359-A



TYPE 666-A

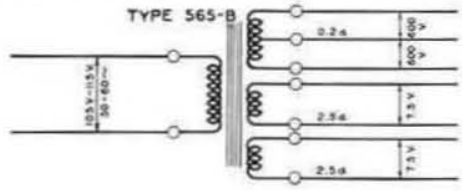
TYPE 166

POWER TRANSFORMERS, FILTERS, AND ACCESSORIES

Power transformers, rectifier filters, center-tap resistors, radio-frequency chokes, and voltage dividers for the adjustment of output voltages are listed below.

TYPE 565-B TRANSFORMER

This is designed for use in full-wave rectification systems, using two 281-type tubes to supply plate current to 210-type, 250-type, and similar tubes. Filament windings are provided for operation of the rectifier and amplifier tubes. It has a power rating of 200 watts and is mounted in a Model D case. It should be operated from 105–115 volt, 50–60 cycle alternating current lines.



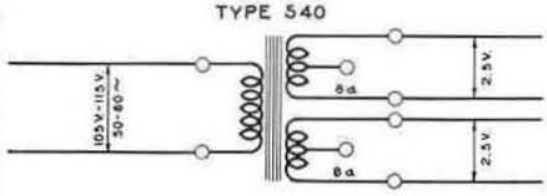
Type	Secondary I Volts	Secondary I Amp.	Secondaries II and III Volts	Secondaries II and III Amp.	Power	Weight	Code Word	Price
565-B	600–0–600	0.2*	7.5	2.5	200 watts	14¼ lb.	TACIT	$13.50

* For center tapped winding as used with full-wave rectifier.

TYPE 540 FILAMENT TRANSFORMER

The heater-filament voltage for the alternating-current 227-type and 245-type tubes is standardized at 2.5 volts. This transformer is designed to supply sufficient filament power for any number up to ten of these tubes in parallel. Two center tapped filament windings are provided.

It has a power rating of 70 watts and is designed for operation on 105- to 115-volt, 50- to 60-cycle lines. It is mounted in a Model C case.

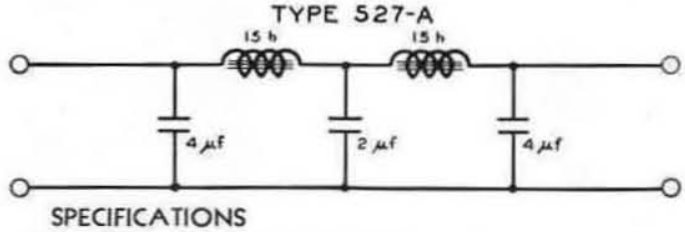


Type	Secondaries I and II Volts	Secondaries I and II Amp.		Power	Weight	Code Word	Price
540	2.5	8*	.....	70 watts	5 lb.	TRIAD	$10.00

* Each secondary. Total for transformer 16 amperes.

TYPE 527-A RECTIFIER FILTER

This is a two-section π-type filter, suitable for use as a smoothing filter in a high-voltage, high-power rectifier. All ratings are conservative, assuring efficient performance.



SPECIFICATIONS

Inductors per Section: 15 henrys, 175 ohms, 100 ma.

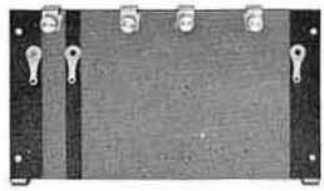
Condensers: 1000 volts, 4-2-4 μf.

Dimensions: Model D case. See table, pages 140 and 143.

Net Weight: 9½ pounds.

Type	Inductor L Inductance	Inductor L Max. Current	Inductor L Resistance	Condenser C Capacitance	Condenser C Max. Voltage	Code Word	Price
527-A	15 h	100 ma	175 ohms	4-2-4 μf	1000 volts	FATTY	$17.50

TYPE 379



TYPE 446

TYPE 437

TYPE 439

TYPE 379 RADIO-FREQUENCY CHOKES

The TYPE 379 Radio-Frequency Chokes are available in two models, one of low inductance to carry a heavy current, and one of high inductance to carry a lower current. The specifications below give the details of the two models. The windings are sectionalized and the effective capacity does not exceed 4 micromicrofarads.

SPECIFICATIONS

Dimensions: 2 x 1¾ x 1¾ inches. **Net Weight:** 6 ounces.

Type	*In-ductance*	*Allowable Current*		*Frequency Range*	*D-C Resistance*	*Weight*	*Code Word*	*Price*
		Intermit.	*Continuous*					
379-T	**8 mh**	**300 ma**	**140 ma**	1500–15,000 kc	35 ohms	6 ounces	JIMMY	**$1.25**
379-R	**60 mh**	**90 ma**	**65 ma**	400–2000 kc	140 ohms	6 ounces	JEWEL	**1.25**

TYPE 446 VOLTAGE DIVIDER

The output of a plate-power supply for experimental work must be adjustable to meet a wide variety of tube conditions. The TYPE 446 Voltage Divider provides three adjustable voltages in the plate-supply sections, and one grid-bias voltage. Extra sliders may be purchased.

SPECIFICATIONS

Resistance: Plate Section, 15,000 ohms; Grid Section, 1500 ohms. **Dimensions:** 7½ x 4⅝ x 1¼ inches. **Net Weight:** 5 ounces.

Type	*Total Resistance*	*Maximum Current*	*Code Word*	*Price*
446	**15,000–0–1500 ohms**	20 milliamperes	VISTA	**$2.75**
446-P1	**Extra Slider**	.....	.....	**.10**

TYPE 437 and TYPE 439 CENTER-TAP RESISTANCE UNITS

The TYPE 437 and TYPE 439 Center-Tap Resistance Units, designed for mounting directly on the filament terminals of the tube socket, offer a convenient means of connection to the mid-potential point of the filament. The position of the tap on the TYPE 437 Center-Tap Resistance Unit is adjustable, permitting the balancing out of hum by this means.

Type	*Center Tap*	*Total Resistance*	*Maximum Current*	*Weight*	*Code Word*	*Price*
437	**Adjustable**	60 ohms	200 milliamperes	1 ounce	PERIL	**$0.50**
439	**Fixed**	60 ohms	200 milliamperes	1 ounce	PASTY	**.35**

SWITCHES, DIALS, AND OTHER ACCESSORIES

Carefully designed and well-made accessories are essential in all kinds of experimental work around the laboratory. The items described in the following pages include switches, dials, binding posts, relay racks, and a variety of plug-and-jack combinations built up from the well-known General Radio plugs and jacks.

TYPE 202 SWITCH

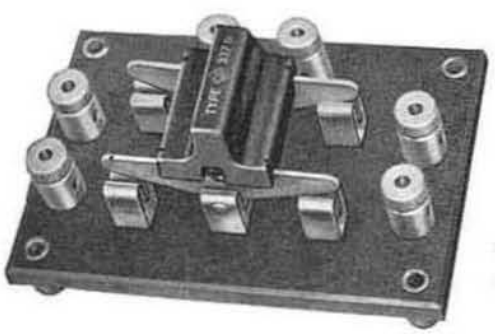
This switch, shown approximately one-half size in the accompanying photograph, has four phosphor-bronze blades which make a wiping contact with the bushing as well as with the switch contacts. TYPES 138-B or 138-C Switch Contacts are recommended for use with this switch. The knob is of moulded bakelite.

SPECIFICATIONS

Radius: 1⅜ inches. **Over-all Axial Length:** 2 inches.

Type	*Panel Thickness*	*Weight*	*Code Word*	*Price*
202-A	⅛ to ¼ inch	3 ounces	SWITCHTOAD	**$0.75**
202-B	¼ to ⅜ inch	3 ounces	SWITCHGOOD	**.75**

TYPE 337 SWITCH



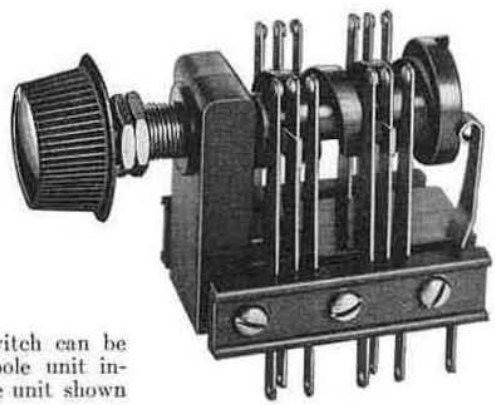
These switches are most convenient for quick change-over circuits. Their rugged construction guarantees long life; and the switches have large contact area for low resistance and high current-carrying capacity.

TYPE 337-A, 2-pole double throw switch

Type	*Description*	*Weight*	*Panel Size*	*Code Word*	*Price*
337-A	**2-Pole Double Throw**	½ lb.	4 in. x 2¾ in.	SWITCHFROG	**$3.00**
337-B	**4-Pole Double Throw**	1 lb.	6¾ in. x 5 in.	SWITCHGOAT	**7.00**
337-C	**6-Pole Double Throw**	1½ lb.	6¾ in. x 6¾ in.	SWITCHBIRD	**10.00**

TYPE 339 SWITCH

This switch consists of a moulded bakelite bracket, which carries the bushing for the switch shaft. The moving poles of the switch are controlled by the worm, one-quarter of a turn of which will make the contacts close. The fixed poles can be bent to make contact in center position also, making a wide number of circuit combinations possible.



The TYPE 339 Switch can be supplied as a 2-pole unit instead of the 4-pole unit shown

SPECIFICATIONS

Mounting: Entire assembly supported from single 3/8-inch panel hole. Panel thicknesses up to 3/8 inch may be used.

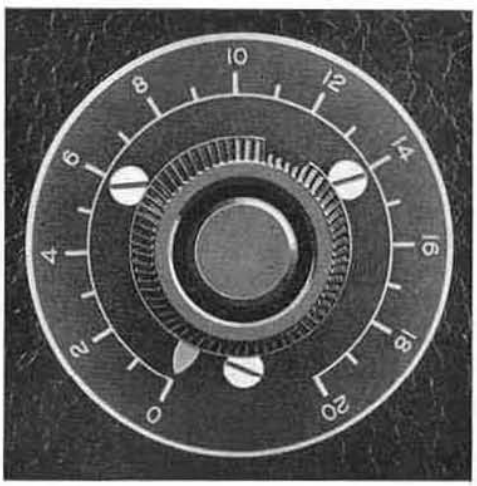
Electrical Capacity: Insulated for 250 volts. Contacts will safely break 2 amperes.

Net Weight: 6 ounces.

Type	*Description*	*Dimensions*	*Code Word*	*Price*
339-A	**4-Pole Double Throw**	2 1/2 x 1 5/8 x 2 3/8 inches	PUPPY	**$2.50**
339-B	**2-Pole Double Throw**	1 7/8 x 1 5/8 x 2 3/8 inches	PUTTY	**2.00**

TYPE 318-A DIAL PLATE

The TYPE 318-A Dial Plate is a photo-etched metal scale with raised nickel-silver markings on a flat black background. It carries twenty divisions equally spaced around an arc of 303°, one inch in radius, and it is intended for use with General Radio TYPE 214 and TYPE 371 Rheostats and Potentiometers. The same three machine screws which hold the rheostat or potentiometer to the panel will hold the TYPE 318-A Dial Plate in position. The accompanying illustration shows the dial plate and a TYPE 214 Rheostat mounted on a panel.

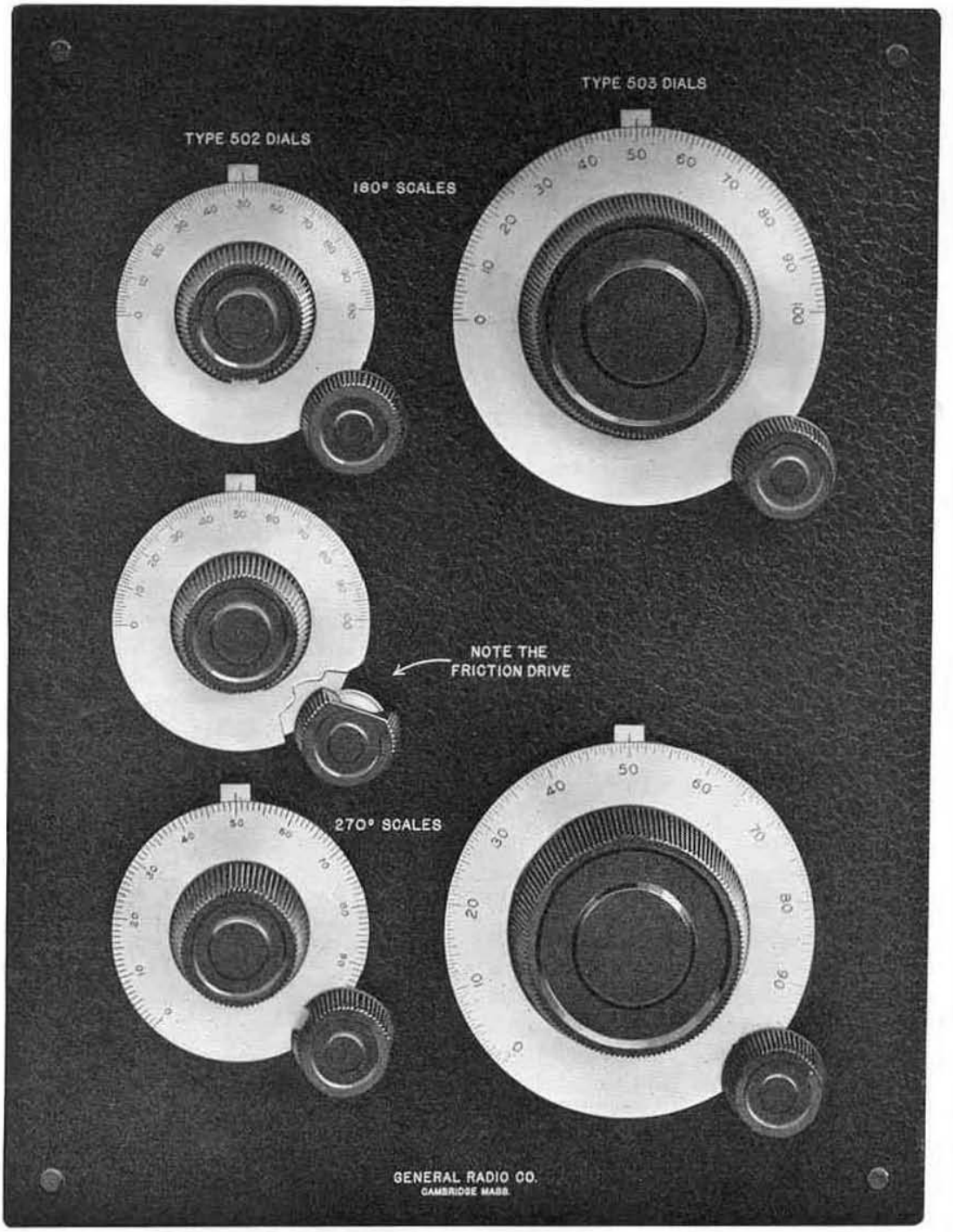


SPECIFICATIONS

Dimensions: Diameter, 3 inches.

Net Weight: 1 ounce.

Type		*Code Word*	*Price*
318-A	.....	DEVIL	**$0.35**



TYPE 502 and TYPE 503 (friction-drive) Dials. The dial in the center of the panel at the left has been cut away to show the friction-drive device

TYPE 310 and TYPE 317 DIALS

These dials meet the most rigid requirements for an inexpensive dial by means of which settings may be duplicated with precision. Fine markings facilitate accurate settings, and, since indicator and dial are both in the same plane, there is no parallax.

Markings are etched in permanent black on the dull polished surface of the 1/32-inch nickel-silver dial plate. Individual graduations equally spaced around an arc of 180° or 270° as specified in the following data table.

The indicator rides the edge of the dial even if the shaft be slightly out of true. An indicator, a machine screw and nut for fastening it, and a drilling template are packed with each dial.

	Dial			*Shaft*				
Type	*Diameter*	*Arc*	*Divisions*	*Diameter*	*Length*	*Weight*	*Code Word*	*Price*
310-A	2¾ in.	180°	100	¼ in.	½–¾ in.	2 oz.	DIZZY	$0.80
310-F	2¾ in.	180°	100	⅜ in.	½–¾ in.	2 oz.	DEMUR	.80
310-G	2¾ in.	270°	100	⅜ in.	½–¾ in.	2 oz.	DITTY	.80
317-A	4 in.	180°	100	¼ in.	⅝–⅞ in.	4 oz.	DONOR	1.50
317-B	4 in.	270°	200	¼ in.	⅝–⅞ in.	4 oz.	DOWDY	1.50
317-F	4 in.	180°	100	⅜ in.	⅝–⅞ in.	4 oz.	DOWEL	1.50
317-G	4 in.	270°	200	⅜ in.	⅝–⅞ in.	4 oz.	DRAMA	1.50

TYPES 502 and 503 DIALS

These new dials have etched divisions filled with black on a polished nickel surface. The markings are distinct and easily readable, making close setting possible. The vernier or slow-motion control is simple and smooth in operation.

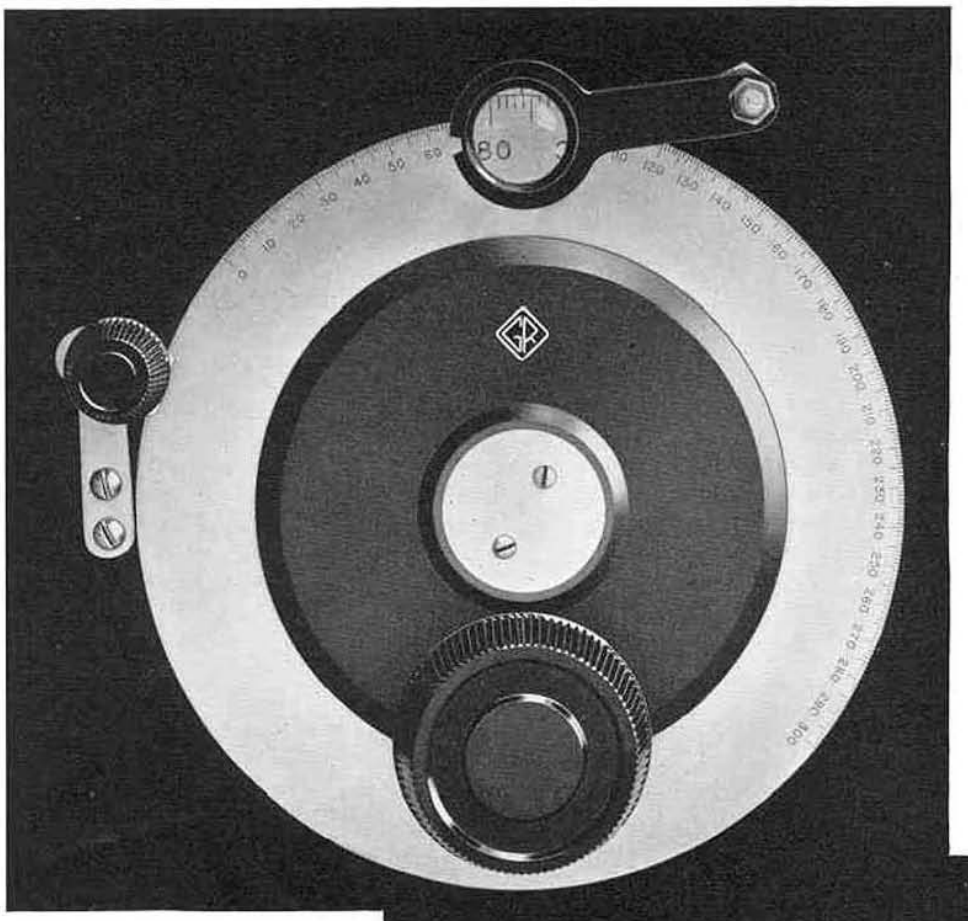
It was originally designed for use on our line of laboratory measuring instruments, but we are offering it for general use in the belief that its ruggedness and simplicity will appeal to laboratory workers and amateurs. It is easy to mount, a center punch and a 7/16-inch drill being the only tools required. It is so designed that it in no way interferes with the mounting of the dial. Adjustments on the friction drive can be made without disturbing the calibration of the instrument to which the dial is attached.

Beneath the face of the dial is mounted a disc of slightly smaller diameter which is gripped by a friction wheel attached to the slow-motion drive knob. The friction-drive shaft is carried in a bushing inserted in the panel. The shaft hole in the bushing is slightly eccentric with respect to the center of the hole holding the bushing, thus affording a simple means of adjusting the amount of friction between the friction wheel and the disc behind the dial.

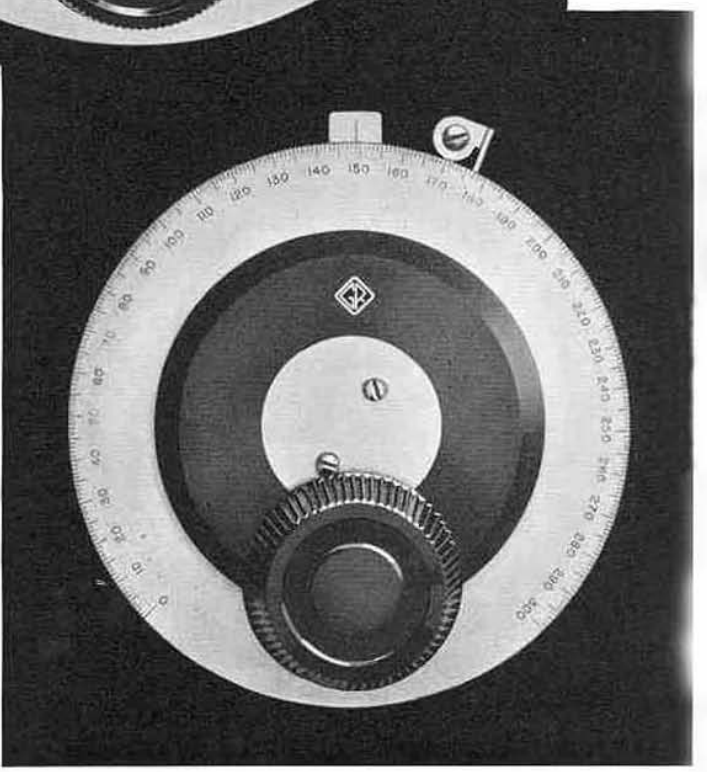
The TYPE 502 and TYPE 503 Dials are supplied complete with friction drive, indicator, indicator fastening screw and nut, and drilling template.

	Dial		*Shaft*	*Dial*	*Reduction*		*Code*	
Type	*Diameter*	*Arc*	*Diameter*	*Type*	*Ratio*	*Weight*	*Word*	*Price*
502-A	2¾ in.	180°	¼ in.	310-A	1:3.3	3 oz.	DRUID	$1.50
502-F	2¾ in.	180°	⅜ in.	310-F	1:3.3	3 oz.	DYING	1.50
502-G	2¾ in.	270°	⅜ in.	310-G	1:3.3	3 oz.	DAILY	1.50
503-A	4 in.	180°	¼ in.	317-A	1:5	6 oz.	DRYAD	2.00
503-F	4 in.	180°	⅜ in.	317-F	1:5	6 oz.	DUCAT	2.00
503-G	4 in.	270°	⅜ in.	317-G	1:5	6 oz.	DUMMY	2.00

Friction drive licensed under U. S. Patents 1,713,146 and 1,744,675



Above: TYPE 706-A (6-inch) Precision Dial showing a TYPE 519-A Dial Lens and a TYPE 520-A Dial Lock in place



Right: TYPE 704-B (4-inch) Precision Dial. It, too, can be used with a TYPE 519-A Dial Lens and a TYPE 520-A Dial Lock if desired

TYPES 704 and 706 PRECISION DIALS

These are for use wherever the dial setting must be determined with a high degree of accuracy. The scales are engraved by a new process, which results in highly precise spacing of the graduations.

The slow motion is of the friction-drive type and operates in such a manner that the scale turns in the same direction as the control knob. The control knob projects from a stationary bakelite plate around which the large scale revolves.

The TYPE 704 and TYPE 706 Precision Dials are unusually easy to mount, requiring the drilling of only one extra hole in the panel. The only tools required are a center punch and a 7/16-inch drill. Adjustments can be made on the friction drive without removing the dial from the shaft.

Each dial is supplied complete with indicator, drilling template, and an adapter, allowing installation on either a 1/4-inch or a 3/8-inch shaft.

Type	*Dial Diameter*	*Dial Arc*	*Scale Divisions*	*Diameter of Knob*	*Reduction Ratio*	*Weight*	*Code Word*	*Price*
704-A	**4 in.**	**180°**	**200**	1½ in.	1:6	10 oz.	DABBY	**$7.50**
704-B	**4 in.**	**270°**	**300**	1½ in.	1:6	10 oz.	DAIRY	**7.50**
706-A	**6 in.**	**180°**	**300**	2 in.	1:8	18 oz.	DASHY	**8.00**
706-B	**6 in.**	**270°**	**450**	2 in.	1:8	18 oz.	DATUM	**8.00**

Friction drive licensed under U. S. Patents 1,713,146 and 1,744,675

TYPE 519-A DIAL LENS

This consists of a small lens with an adjustable holder for mounting on a panel over a dial indicator. It makes possible the reading of the TYPE 704 and TYPE 706 Dials with an unusually high degree of precision. The arm can be swung out of the way when not in use. A 3/8-inch hole is required in the panel.

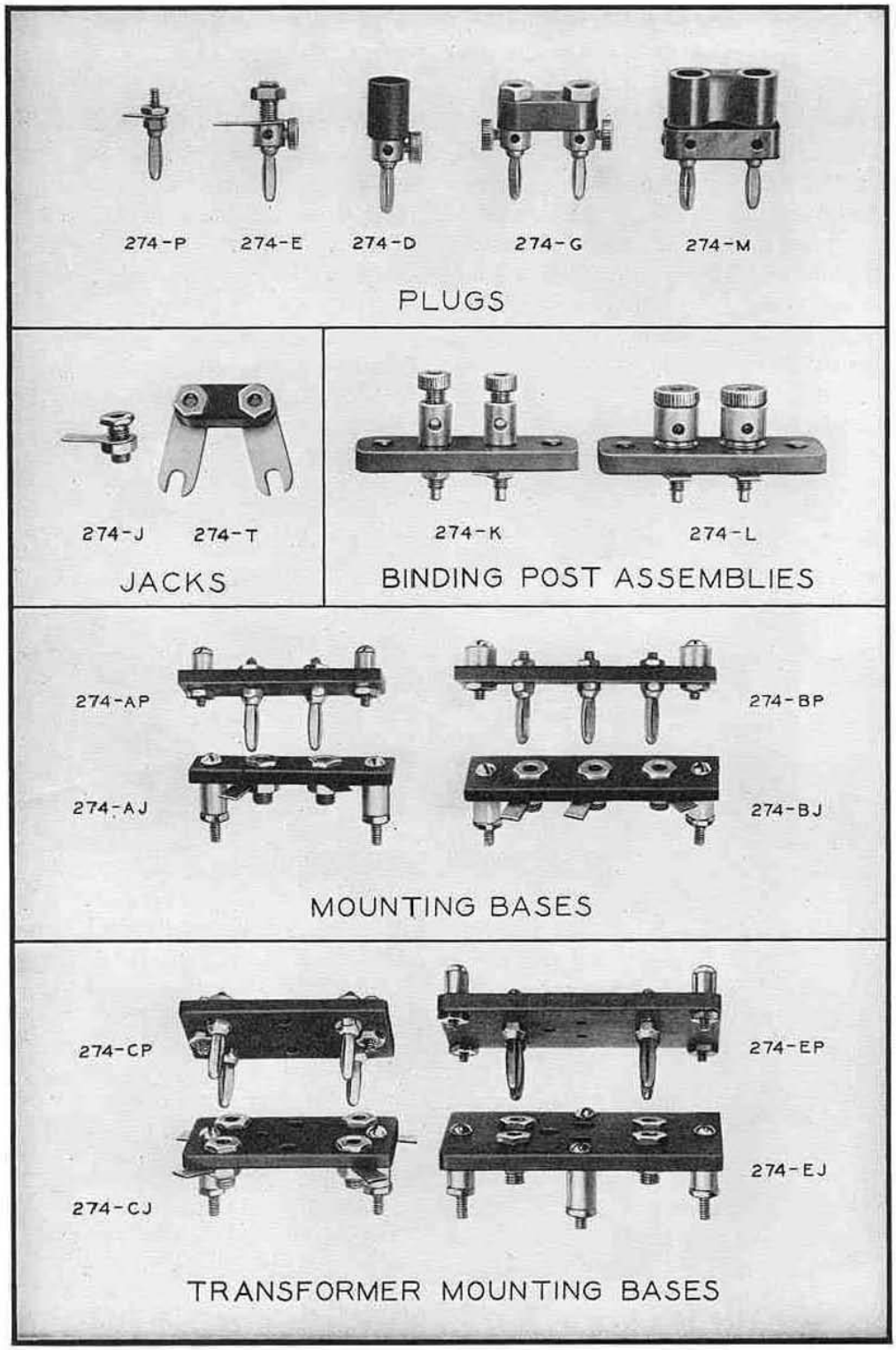
Type	*Code Word*	*Price*
519-A	ABASH	**$1.50**

TYPE 520-A DIAL LOCK

This makes it possible to lock any General Radio dial firmly in position when desired. It holds the dial tightly, preventing it from turning, but exerts no appreciable force on the shaft on which the dial is mounted.

The TYPE 520 Dial Lock requires two holes (No. 28 drill) for mounting.

Type	*Code Word*	*Price*
520-A	ABATE	**$0.75**



TYPE 274 Plugs, Jacks, and Mounting Bases (illustration ½ size). The transformer mounting plug bases, TYPES 274-CP, 274-EP, and 274-HP (not illustrated) are fitted with locating pins

TYPE 274 PLUGS, JACKS, AND MOUNTING BASES

All of the devices listed in this section are built up from various combinations and modifications of the TYPE 274-P Plug and the TYPE 274-J Jack.

PLUGS

Type	*Description*	*Code Word*	*Price*
274-P	Single Plug (Basic Unit)	STANPARCAT	$0.06
274-E	Single Plug with Jack Shank	STANPARDOG	.20
274-D	Single Insulated Plug with Jack Shank	STANPAREYE	.25
274-G	Open-Type Double Plug with Jack Shanks	STANPARPIG	.50
274-M	Insulated Double Plug with Jack Shanks	STANPARBUG	.40

JACKS

Type	*Description*	*Code Word*	*Price*
274-J	Single Jack (Basic Unit)	STANPARTOP	$0.05
274-T	Double Adjustable Jack	STANPARTIP	.50

MOUNTING BASES

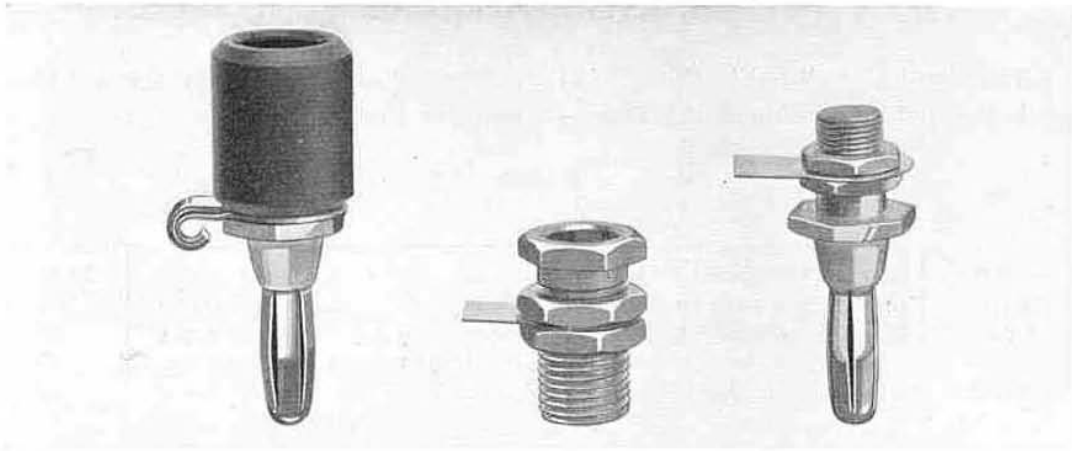
Type	*Description*	*Code Word*	*Price*
274-AP	2-Gang Plug Base	STANPARBIB	$0.50
274-AJ	2-Gang Jack Base	STANPARHUM	.50
274-BP	3-Gang Plug Base	STANPARSUN	.60
274-BJ	3-Gang Jack Base	STANPARSIN	.60
*274-CP	4-Gang Plug Base	STANPARSUM	.60
*274-CJ	4-Gang Jack Base	STANPARGIN	.60
*274-EP	4-Gang Transformer Mounting Plug Base	STANPARGAS	.75
*274-EJ	4-Gang Transformer Mounting Jack Base	STANPARFAD	.75
†274-HP	6-Gang Transformer Mounting Plug Base	STANPARBED	.90
†274-HJ	6-Gang Transformer Mounting Jack Base	STANPARNOT	.90
‡274-RJ	4-Gang Transformer Mounting Jack Base	STANPARPUP	1.00
274-Q	Locating Pin	STANPARCAD	.05

*Drilled to accommodate two more TYPES 274-P Plugs and 274-J Jacks for converting 4-gang bases into 6-gang bases.
†Identical with TYPES 274-EP and 274-EJ 4-gang bases except that the 6-gang bases are fitted with 6 plugs and jacks.
‡See page 138.

BINDING POST ASSEMBLIES

Type	*Description*	*Code Word*	*Price*
274-K	With Type 138-V Binding Posts	STANPARBAG	$0.65
274-L	With Type 138-X Binding Posts	STANPARTAG	.65

TYPE 674 PLUGS AND JACKS



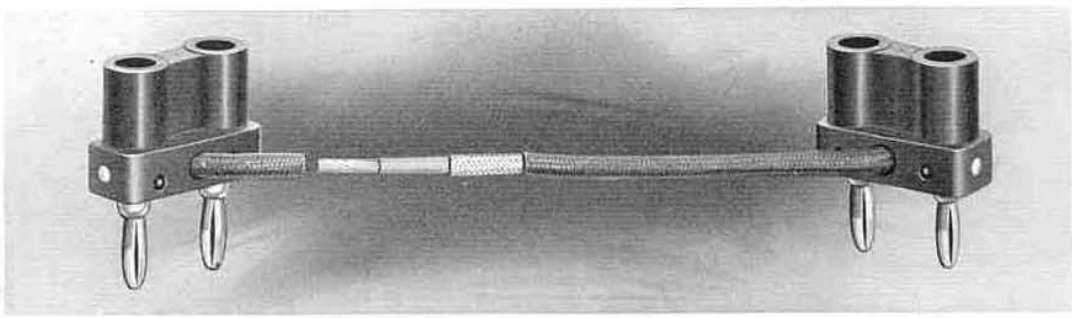
TYPE 674-D TYPE 674-J TYPE 674-P

Similar in general design and appearance to the TYPE 274 Plugs and Jacks, these new units are larger in size and have much greater contact area. They are for use where heavy currents are to be carried, or low contact resistance is imperative.

Made in three models shown (6/7 size). Current-carrying capacity, 50 amperes.

Type	*Description*	*Code Word*	*Price*
674-P	Single Plug (Basic Unit)	STANPARAPE	$0.35
674-J	Single Jack (Basic Unit)	STANPARAYE	.25
674-D	Single Insulated Plug with Jack Shank	STANPARARK	.50

TYPE 274-NC SHIELDED CONDUCTOR



A TYPE 274-NC Shielded Conductor with a section cut away to show the arrangement of conductors and insulation

In most high-frequency laboratory and experimental set-ups good shielding is required for the longer leads. The TYPE 274-NC Shielded Conductor consists of a central conductor made up of 41 strands of No. 34 tinned copper wire, twisted. This is covered with cotton and rubber insulation, over which is a tightly woven copper shield and black cotton insulation.

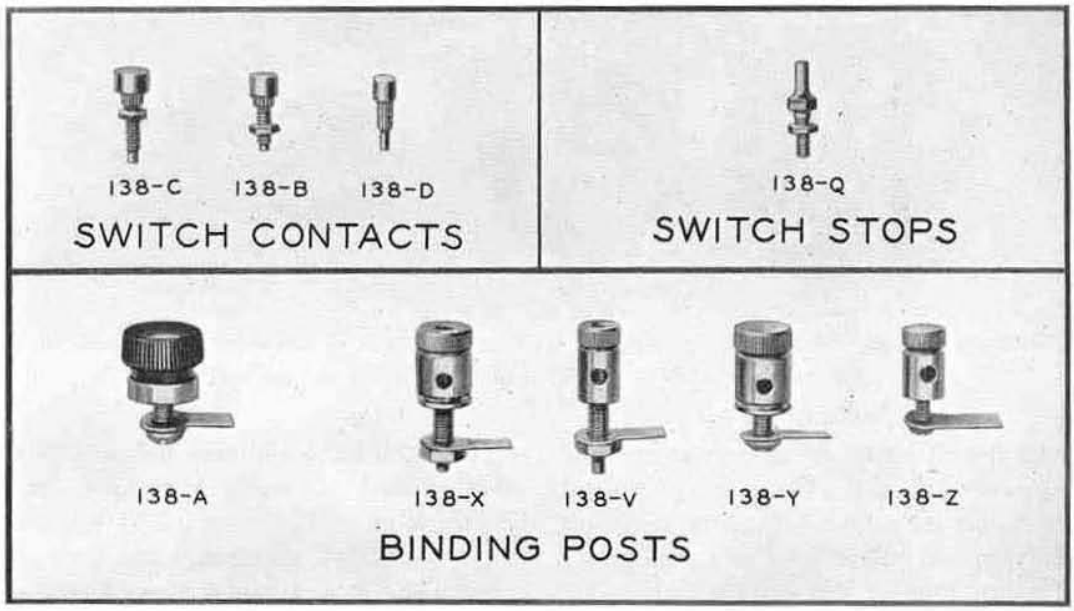
Each end is terminated in a TYPE 274-M Plug for convenience. A white spot denotes the inner or high-potential cable.

SPECIFICATIONS

Length: 3 feet.
Capacitance: 100 $\mu\mu$f per foot.
Impedance: About 30 ohms.
Outside Diameter: 3/16 inch.

Type	*Code Word*	*Price*
274-NC	STANPARZOO	$1.50

TYPE 138 BINDING POSTS, SWITCH CONTACTS, AND SWITCH STOPS



BINDING POSTS

Type	*Material*	*Diameter*	*Height*	*Maximum Panel Thickness*	*Thread*	*Code Word*	*Price*
138-A	Bakelite and N. P. Brass	3/4 in.	5/8 in.	3/8 in.	10–32	STANPARCUP	$0.18
*138-V	Nickel-Plated Brass	3/8 in.	11/16 in.	3/8 in.	10–32	STANPARANT	.20
*138-X	Nickel-Plated Brass	1/2 in.	11/16 in.	3/8 in.	10–32	STANPARBOY	.20
138-Y	Nickel-Plated Brass	1/2 in.	3/4 in.	1/4 in.	10–32	STANPARMIK	.14
138-Z	Nickel-Plated Brass	3/8 in.	5/8 in.	1/4 in.	6–32	STANPARHIT	.07

*See also TYPES 274-K and 274-L Binding Post Assemblies, page 155.

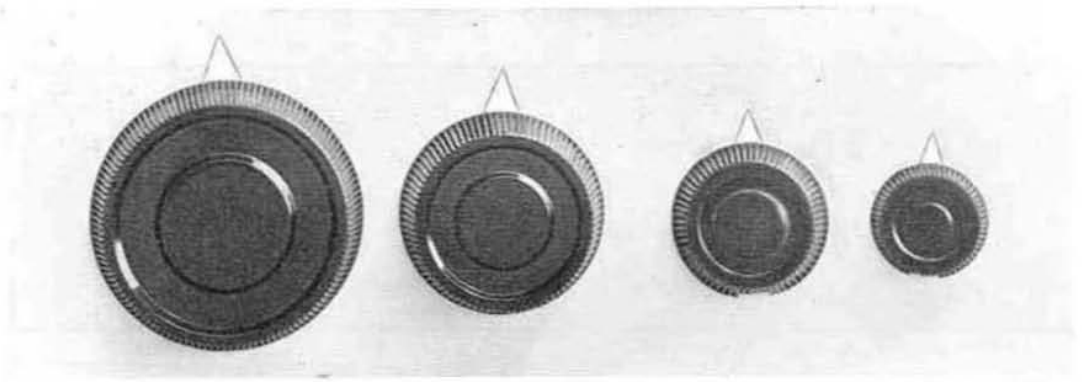
SWITCH CONTACTS

Type	*Material*	*Diameter*	*Height*	*Maximum Panel Thickness*	*Thread*	*Code Word*	*Price*
138-B	Nickel-Plated Bronze	1/4 in.	0.190 in.	5/16 in.	6–32	CONTACTANT	$0.04
138-C	Nickel-Plated Bronze	5/16 in.	0.190 in.	7/16 in.	6–32	CONTACTBUG	.04
138-D	Nickel-Plated Bronze	3/16 in.	0.195 in.	7/16 in.	.....	CONTACTCAT	.03

SWITCH STOPS

Type	*Material*	*Diameter*	*Height*	*Maximum Panel Thickness*	*Thread*	*Code Word*	*Price*
138-Q	Nickel-Plated Brass	1/8 in.	7/8 in.	5/16 in.	6–32	STANPARBUL	$0.04

TYPE 537 KNOBS



TYPES 537-D and 537-L — TYPES 537-C and 537-K — TYPES 537-B and 537-J — TYPE 537-A
All TYPE 537 Knobs have white celluloid pointers which may be removed if desired (illustration ½ size)

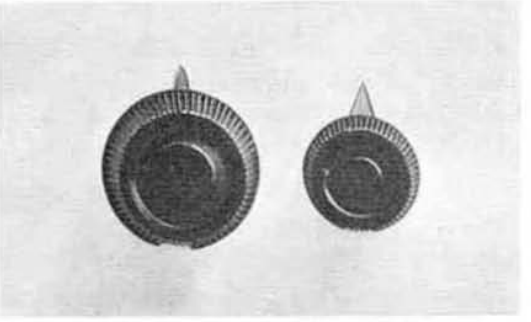
In order that experimenters assembling their own apparatus from our component parts may have knobs to correspond with the standard knobs used on the majority of our equipment, the standard knobs are listed below. These comprise the new and uniform series that are being used on our laboratory instruments as well as the component parts.

The knob is of moulded bakelite with metal inserts to carry the shaft. The pointer is of insulating material, so that the entire knob is electrically dead, and is a flat white color to show clearly against almost any background. The pointer may be easily removed if not required.

Type	*Diameter*	*Shaft*	*Net Weight*	*Code Word*	*Price*
537-A	**1⅛ inches**	**¼ inch**	1 ounce	STANNOBAPE	**$0.20**
537-B	**1½ inches**	**¼ inch**	1 ounce	STANNOBBIB	**.30**
537-C	**2 inches**	**¼ inch**	1½ ounces	STANNOBCUP	**.40**
537-D	**2⅝ inches**	**¼ inch**	2 ounces	STANNOBDYE	**.50**
537-J	**1½ inches**	**⅜ inch**	1 ounce	STANNOBJOB	**.30**
537-K	**2 inches**	**⅜ inch**	1½ ounces	STANNOBKIT	**.40**
537-L	**2⅝ inches**	**⅜ inch**	2 ounces	STANNOBLAP	**.50**

TYPE 137 KNOBS

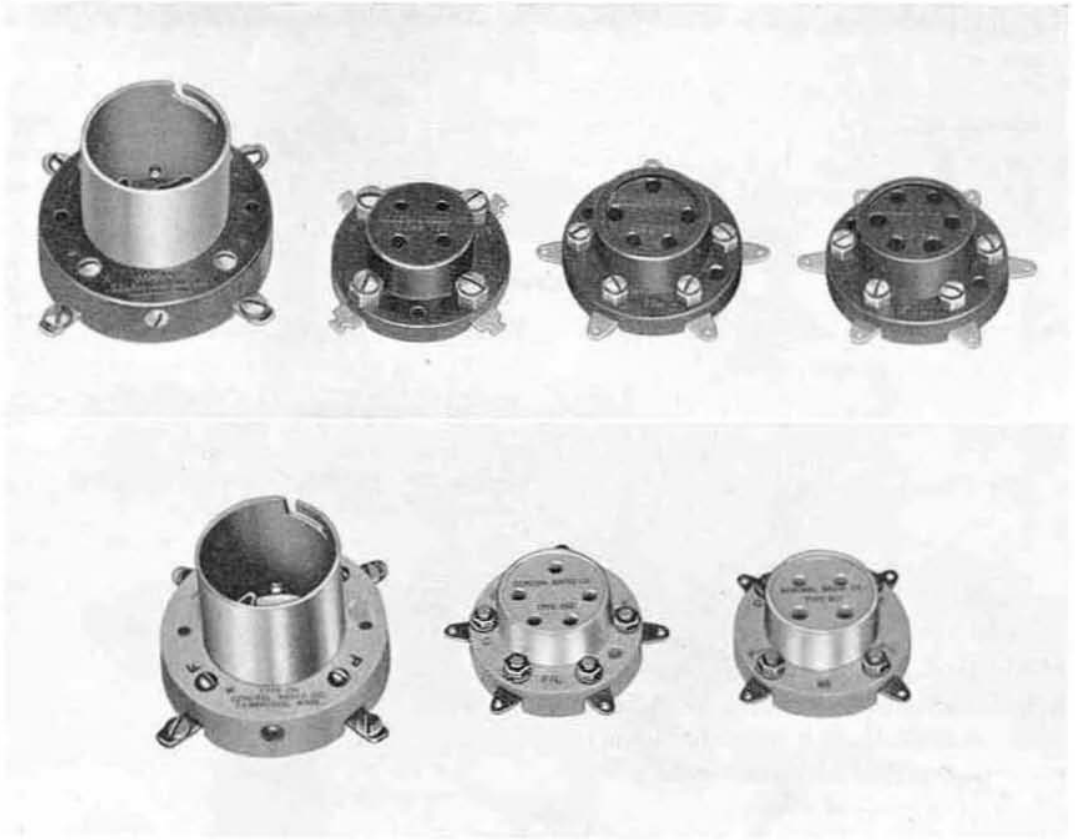
These are shown in the illustration at the right of the page. They are made of moulded bakelite with brass inserts for ¼-inch shafts. Each is supplied with a setscrew and a polished metal pointer.



TYPE 137-D TYPE 137-J
Both have metal pointers (illustration ½ size)

Type	*Diameter*	*Shaft*	*Net Weight*	*Code Word*	*Price*
137-D (with pointer)	**1½ inches**	**¼ inch**	2 ounces	STANNOBANT	**$0.30**
137-J (with pointer)	**1⅛ inches**	**¼ inch**	1 ounce	STANNOBDOG	**.20**

GENERAL RADIO VACUUM-TUBE SOCKETS



Above: TYPE 156 TYPE 349 TYPE 438 TYPE 444
Below: TYPE 656 TYPE 657 TYPE 658

These sockets are designed for long and hard usage. The contacts are spring tempered and will make firm connection with the tube prongs after long periods of operation. Connection to the sockets may be made by either the screw terminals or large-size soldering lugs provided.

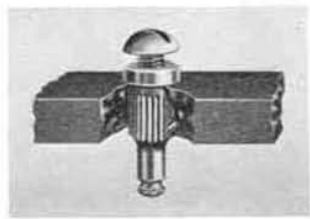
Sockets are available with bakelite and with glazed isolantite bases. For most work the bakelite bases are preferred because of their lower price, but where low high-frequency losses and high surface resistivity are desirable, isolantite bases are recommended. The latter is a desirable feature in sockets that are to be used with photo-electric cells and their associated amplifiers.

The net weight of all sockets is 2 ounces, except TYPE 156 and TYPE 656 which weigh 4 ounces.

Type	*Base Material*	*Type of Tube*	*Diameter*	*Height*	*Code Word*	*Price*
156	**Bakelite**	**UV, UX, West. Elec. E Tube**	2 7/16 inches	1 5/16 inches	SOBER	**$0.75**
349	**Bakelite**	**UX—Small 4-prong**	1 7/8 inches	3/4 inch	SEDAN	**.35**
438	**Bakelite**	**UY—Small 5-prong**	1 7/8 inches	3/4 inch	STUDY	**.35**
444	**Bakelite**	**Small 6-prong**	1 7/8 inches	3/4 inch	NOVEL	**.50**
656	**Isolantite**	**UV, UX, West. Elec. E Tube**	2 7/16 inches	1 27/32 inches	SOLID	**1.50**
657	**Isolantite**	**UX—4-prong**	1 7/8 inches	15/16 inch	AMAZE	**1.50**
658	**Isolantite**	**UY—5-prong**	1 7/8 inches	15/16 inch	AMONG	**1.50**

TYPE 738-A INSERT TERMINAL

A most convenient new terminal for use where only limited space is available. Shank is tinned for soldering. The other end is threaded for a 6–32 machine screw under which any type of soldering lug may be attached. It is mounted by driving it into a drilled hole as shown in illustration.



SPECIFICATIONS

Maximum Panel Thickness: 3/8 inch.

Mounting Hole: 0.187 inch (No. 10 drill).

Over-all Height (less screw): 9/16 inch.

Type	*Code Word*	*Price*
738-A	UNIPARTAPE	**$0.04**

TYPE 260 PORCELAIN INSULATOR

This lead-in or stand-off insulator is equipped with a threaded brass rod at its upper end, so that it may be used for supporting wiring of instruments as well as lead-in or ground wires.

SPECIFICATIONS

Over-all Height: 2 1/8 inches.

Diameter at Base: 2 1/8 inches.

Type	*Code Word*	*Price*
260	CONIC	**$0.20**

TYPE 480 RELAY RACK

This rack is intended for mounting standard 19-inch panels whose heights are integral multiples of 1¾ inches. Racks of this type have been in use in telephone plants for many years, and they are fast becoming standard practice in laboratories for mounting apparatus.

Two sizes are available. TYPE 480-A is the large rack having mounting space for the equivalent of 36, 1¾-inch panels. TYPE 480-B is suitable for use on the laboratory bench and provides space for mounting the equivalent of 25, 1¾-inch unit panels.

SPECIFICATIONS

Construction: Steel frame with welded joints. Both models have provision for bolting them to the floor or table, but they are stable enough to stand without fastening for all ordinary service.

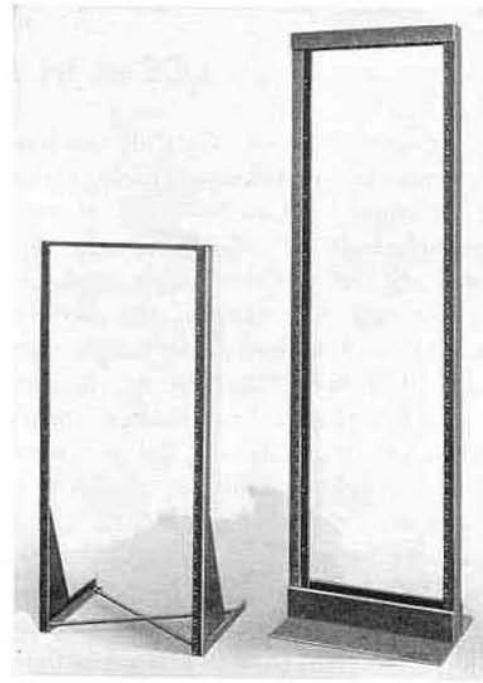
Drilling: Standard drilling for 19-inch relay-rack panels is employed. Holes are tapped and cleaned for a 10–32 panel-mounting screw.

Accessories: Panel-mounting screws, panel-protecting washers, and bridle rings for cabled wiring are supplied.

Dimensions: TYPE 480-A: Frame, (height) 69⅛ x (width) 20 x (depth) 3 inches, over-all. Base, (width) 20 x (depth) 15 inches. Panel mounting space, 63 inches or 36 "unit racks."

TYPE 480-B: Frame, (height) 44 x (width) 20 x (depth) 1½ inches, over-all. Base, (width) 20 x (depth) 15 inches. Panel-mounting space, 43¾ inches or 25 "unit racks."

Net Weight: TYPE 480-A, 100 pounds. TYPE 480-B, 20 pounds.



Left: TYPE 480-B; *right,* TYPE 480-A

Type	*Panel Space*	*Code Word*	*Price*
480-A	**63 inches or 36 "Rack Units"**	NEEDY	**$40.00**
480-B	**43¾ inches or 25 "Rack Units"**	NEGRO	**15.00**

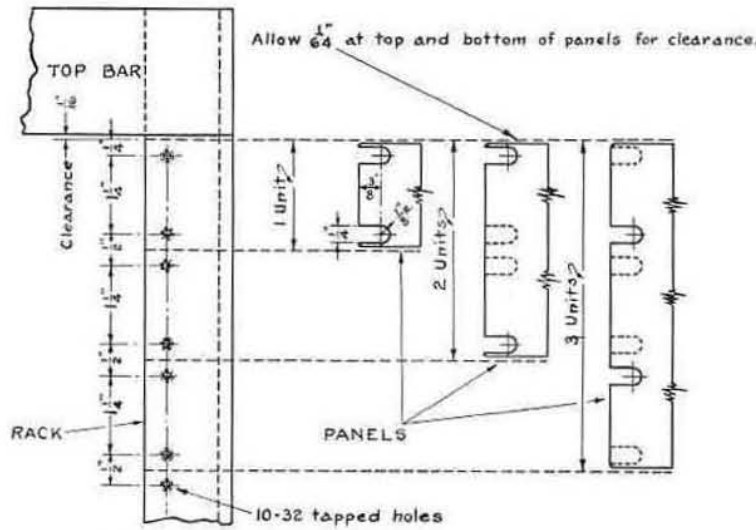
NOTES ON LAYING OUT RELAY-RACK PANELS

1. Make panel height a multiple of 1¾ inches less 1/32 inch for clearances.

2. Both top and bottom edges of a properly mounted panel will, neglecting clearances, always fall half way between a pair of holes spaced ½ inch apart on the rack.

3. It is seldom necessary to cut all the possible mounting-screw slots in a panel, but it can be done if desired.

4. Any panel laid out to fit the rack will also fit, if the panel is turned end-for-end or back-for-front.



Note: Clearance between vertical supports on rack 17½ inches.

APPENDIX

LOSSES IN AIR CONDENSERS

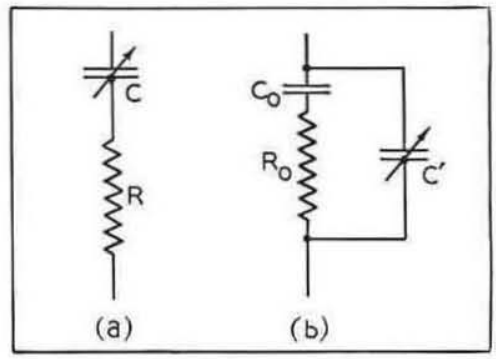
The energy losses in an air condenser are due to losses in the solid dielectric used in the supports.* Low losses are, of course, desirable but they cannot be reduced indefinitely without sacrificing mechanical rigidity and the ability of the condenser to hold a calibration. Fortunately, practically all of the laboratory measurements in which the loss of the condenser must be known can be arranged so that it is merely necessary to know how they change as the condenser capacitance is varied.

The higher-grade laboratory condensers manufactured by the General Radio Company are designed so that the small amount of solid dielectric used is placed in an electric field that is unvarying with respect to rotor position. Hence the losses are constant with setting. It is then possible to assume that the condenser behaves as a loss-free variable condenser in parallel with a fixed condenser having all the losses. This means that when using one of these condensers to measure the loss in some other condenser the loss introduced by the standard condenser, since it does not change with rotor setting, can be eliminated from the measurement by the choice of a suitable method.

This quality of having constant losses with changes in rotor setting is approximately true for all General Radio condensers and this leads us to our choice of the quantity $R\omega C^2$ as the figure of merit for expressing the energy loss in an air condenser. It turns out that $R\omega C^2$ is constant for all values of ω and C. $R\omega C^2$ is therefore preferred to power factor $R\omega C$ as a figure of merit for the condenser.

The equivalent series resistance R of an air condenser may be calculated for any frequency when the figure of merit $R\omega C^2$ is known. Thus for a figure of merit of 0.06×10^{-12} the resistance of a condenser of 1000 $\mu\mu$f capacitance at a frequency of 1000 cycles is 10 ohms.

The choice of $R\omega C^2$ as the figure of merit is based upon the following considerations: Any air condenser C having an equivalent series resistance R may be represented by a condenser C_o due to the solid dielectric circuits and supports and having all the losses, R_o, in parallel with a loss-free condenser C' (see the accompanying diagram).



By working out the energy relations in (*a*) and in (*b*) on the assumption that all the losses are very small, it is found that

$$R = \frac{R_o \omega C_o^2}{\omega(C'+C_o)^2} = \frac{R_o \omega C_o^2}{\omega C^2},$$

and

$$R\omega C^2 = R_o \omega C_o^2.$$

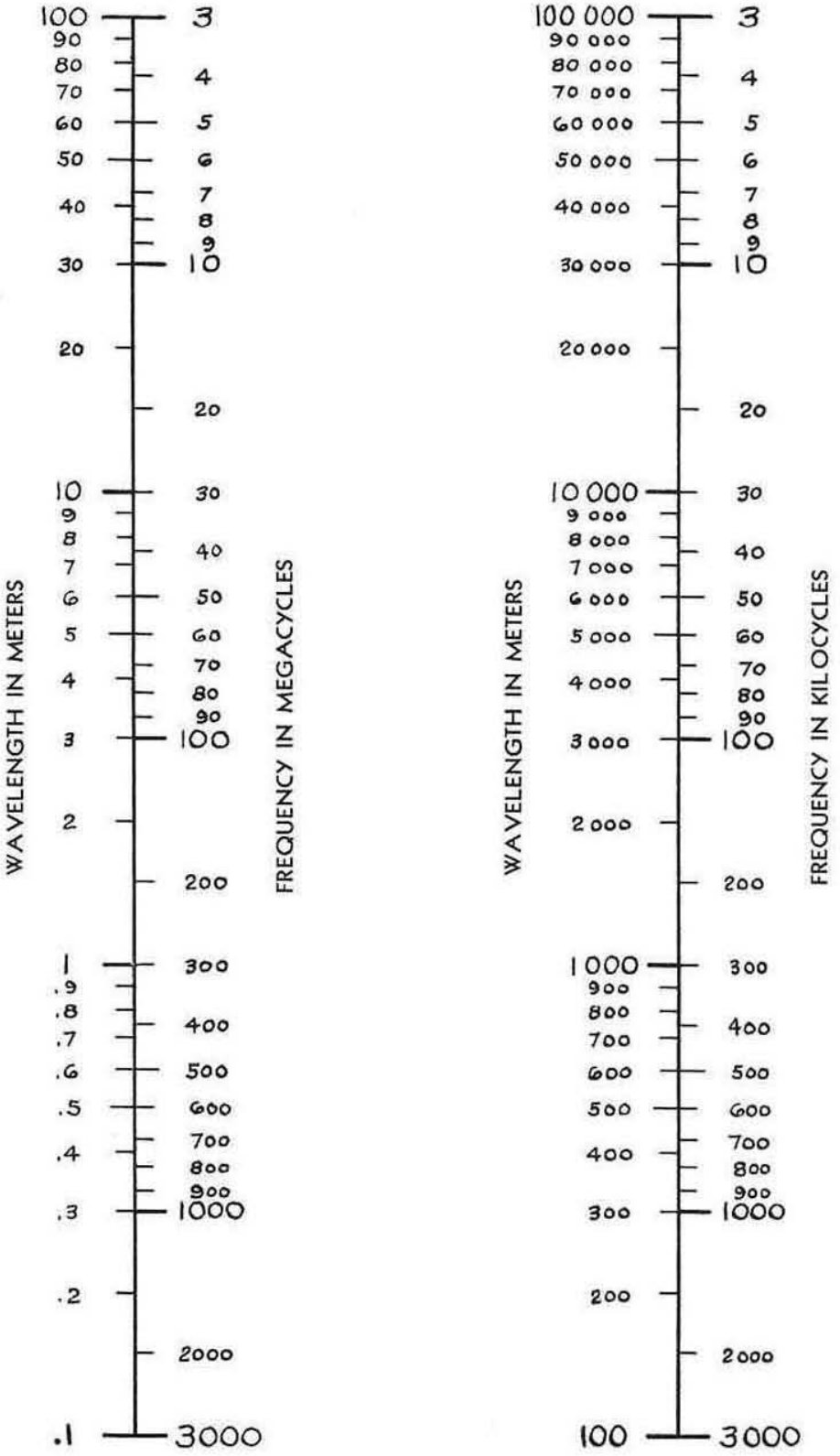
If the energy losses in the condenser are constant with setting, then C_o is a fixed condenser with an isolantite or hard-rubber dielectric, depending upon the actual construction of the condenser C. For different frequencies the power factor of this solid dielectric is essentially constant, hence the quantity $R\omega C^2$ is constant for all ordinary values of ω and C, and is a characteristic of the condenser.

The same reasoning is approximately true when, because the losses change with rotor setting, C_o is not a fixed condenser.

*Except at high voltages where there are ionization losses in the air dielectric and at high frequencies (above 5 Mc, perhaps) where eddy-current losses in the metal plates and the effects of resonance in the condenser begin to appear.

FREQUENCY-WAVELENGTH CONVERSION CHART

Note that both the frequency and the wavelength scales are logarithmic and that the frequency scale is in different units in the left-hand and right-hand sections.



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* in 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 the same or equal 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,

$$N_{db} = 20 \log_{10} \frac{E_1}{E_2} + 10 \log_{10} \frac{Z_2}{Z_1} + 10 \log_{10} \frac{k_2}{k_1} \qquad (4)$$

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. 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 the same or equal 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,

$$N_{nep} = \log_e \frac{E_1}{E_2} + \frac{1}{2} \log_e \frac{Z_2}{Z_1} + \frac{1}{2} \log_e \frac{k_2}{k_1} \qquad (8)$$

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 × 10 × 10 = 288.4

Power ratio: 9.2 db →

8.318 × 100 × 100 = 83180

Number of decibels negative (−): Add +20 decibels successively to the given number of decibels until the sum falls within the range of Table I. *For the voltage ratio,* divide the value from the left-hand voltage-ratio column by 10 for each time you added 20 db. *For the power ratio,* divide the value from the left-hand power-ratio column by 100 for each time you added 20 db.

Example—*Given:* −49.2 db

−49.2 db + 20 db + 20 db = −9.2 db

Voltage ratio: −9.2 db →

.3467 × 1/10 × 1/10 = .003467

Power ratio: −9.2 db →

.1202 × 1/100 × 1/100 = .00001202

TABLE II: VOLTAGE RATIOS TO DECIBELS

For ratios smaller than those in table—Multiply the given ratio by 10 successively until the product can be found in the table. From the number of decibels thus found, subtract +20 decibels for each time you multiplied by 10.

Example—*Given:* Voltage ratio = .0131

.0131 × 10 = .131 × 10 = 1.31

From Table II, 1.31 →

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. From the number of decibels thus found, add + 20 db for each time you divided by 10.

Example—*Given:* Voltage ratio = 712

712 × 1/10 = 71.2 × 1/10 = 7.12

From Table II, 7.12 →

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+				→ −db+				
Voltage Ratio	*Power Ratio*	*db*	*Voltage Ratio*	*Power Ratio*	*Voltage Ratio*	*Power Ratio*	*db*	*Voltage Ratio*	*Power Ratio*
1.0000	**1.0000**	**0**	**1.000**	**1.000**	**.5623**	**.3162**	**5.0**	**1.778**	**3.162**
.9886	.9772	.1	1.012	1.023	.5559	.3090	5.1	1.799	3.236
.9772	.9550	.2	1.023	1.047	.5495	.3020	5.2	1.820	3.311
.9661	.9333	.3	1.035	1.072	.5433	.2951	5.3	1.841	3.388
.9550	.9120	.4	1.047	1.096	.5370	.2884	5.4	1.862	3.467
.9441	.8913	.5	1.059	1.122	.5309	.2818	5.5	1.884	3.548
.9333	.8710	.6	1.072	1.148	.5248	.2754	5.6	1.905	3.631
.9226	.8511	.7	1.084	1.175	.5188	.2692	5.7	1.928	3.715
.9120	.8318	.8	1.096	1.202	.5129	.2630	5.8	1.950	3.802
.9016	.8128	.9	1.109	1.230	.5070	.2570	5.9	1.972	3.890
.8913	**.7943**	**1.0**	**1.122**	**1.259**	**.5012**	**.2512**	**6.0**	**1.995**	**3.981**
.8810	.7762	1.1	1.135	1.288	.4955	.2455	6.1	2.018	4.074
.8710	.7586	1.2	1.148	1.318	.4898	.2399	6.2	2.042	4.169
.8610	.7413	1.3	1.161	1.349	.4842	.2344	6.3	2.065	4.266
.8511	.7244	1.4	1.175	1.380	.4786	.2291	6.4	2.089	4.365
.8414	.7079	1.5	1.189	1.413	.4732	.2239	6.5	2.113	4.467
.8318	.6918	1.6	1.202	1.445	.4677	.2188	6.6	2.138	4.571
.8222	.6761	1.7	1.216	1.479	.4624	.2138	6.7	2.163	4.677
.8128	.6607	1.8	1.230	1.514	.4571	.2089	6.8	2.188	4.786
.8035	.6457	1.9	1.245	1.549	.4519	.2042	6.9	2.213	4.898
.7943	**.6310**	**2.0**	**1.259**	**1.585**	**.4467**	**.1995**	**7.0**	**2.239**	**5.012**
.7852	.6166	2.1	1.274	1.622	.4416	.1950	7.1	2.265	5.129
.7762	.6026	2.2	1.288	1.660	.4365	.1905	7.2	2.291	5.248
.7674	.5888	2.3	1.303	1.698	.4315	.1862	7.3	2.317	5.370
.7586	.5754	2.4	1.318	1.738	.4266	.1820	7.4	2.344	5.495
.7499	.5623	2.5	1.334	1.778	.4217	.1778	7.5	2.371	5.623
.7413	.5495	2.6	1.349	1.820	.4169	.1738	7.6	2.399	5.754
.7328	.5370	2.7	1.365	1.862	.4121	.1698	7.7	2.427	5.888
.7244	.5248	2.8	1.380	1.905	.4074	.1660	7.8	2.455	6.026
.7161	.5129	2.9	1.396	1.950	.4027	.1622	7.9	2.483	6.166
.7079	**.5012**	**3.0**	**1.413**	**1.995**	**.3981**	**.1585**	**8.0**	**2.512**	**6.310**
.6998	.4898	3.1	1.429	2.042	.3936	.1549	8.1	2.541	6.457
.6918	.4786	3.2	1.445	2.089	.3890	.1514	8.2	2.570	6.607
.6839	.4677	3.3	1.462	2.138	.3846	.1479	8.3	2.600	6.761
.6761	.4571	3.4	1.479	2.188	.3802	.1445	8.4	2.630	6.918
.6683	.4467	3.5	1.496	2.239	.3758	.1413	8.5	2.661	7.079
.6607	.4365	3.6	1.514	2.291	.3715	.1380	8.6	2.692	7.244
.6531	.4266	3.7	1.531	2.344	.3673	.1349	8.7	2.723	7.413
.6457	.4169	3.8	1.549	2.399	.3631	.1318	8.8	2.754	7.586
.6383	.4074	3.9	1.567	2.455	.3589	.1288	8.9	2.786	7.762
.6310	**.3981**	**4.0**	**1.585**	**2.512**	**.3548**	**.1259**	**9.0**	**2.818**	**7.943**
.6237	.3890	4.1	1.603	2.570	.3508	.1230	9.1	2.851	8.128
.6166	.3802	4.2	1.622	2.630	.3467	.1202	9.2	2.884	8.318
.6095	.3715	4.3	1.641	2.692	.3428	.1175	9.3	2.917	8.511
.6026	.3631	4.4	1.660	2.754	.3388	.1148	9.4	2.951	8.710
.5957	.3548	4.5	1.679	2.818	.3350	.1122	9.5	2.985	8.913
.5888	.3467	4.6	1.698	2.884	.3311	.1096	9.6	3.020	9.120
.5821	.3388	4.7	1.718	2.951	.3273	.1072	9.7	3.055	9.333
.5754	.3311	4.8	1.738	3.020	.3236	.1047	9.8	3.090	9.550
.5689	.3236	4.9	1.758	3.090	.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 165

TABLE II

GIVEN: { Voltage / Current } Ratios 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 × ½ = 5.328 db

Voltage Ratio	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
1.0	**.000**	**.086**	**.172**	**.257**	**.341**	**.424**	**.506**	**.588**	**.668**	**.749**
1.1	.828	.906	.984	1.062	1.138	1.214	1.289	1.364	1.438	1.511
1.2	1.584	1.656	1.727	1.798	1.868	1.938	2.007	2.076	2.144	2.212
1.3	2.279	2.345	2.411	2.477	2.542	2.607	2.671	2.734	2.798	2.860
1.4	2.923	2.984	3.046	3.107	3.167	3.227	3.287	3.346	3.405	3.464
1.5	3.522	3.580	3.637	3.694	3.750	3.807	3.862	3.918	3.973	4.028
1.6	4.082	4.137	4.190	4.244	4.297	4.350	4.402	4.454	4.506	4.558
1.7	4.609	4.660	4.711	4.761	4.811	4.861	4.910	4.959	5.008	5.057
1.8	5.105	5.154	5.201	5.249	5.296	5.343	5.390	5.437	5.483	5.529
1.9	5.575	5.621	5.666	5.711	5.756	5.801	5.845	5.889	5.933	5.977
2.0	**6.021**	**6.064**	**6.107**	**6.150**	**6.193**	**6.235**	**6.277**	**6.319**	**6.361**	**6.403**
2.1	6.444	6.486	6.527	6.568	6.608	6.649	6.689	6.729	6.769	6.809
2.2	6.848	6.888	6.927	6.966	7.008	7.044	7.082	7.121	7.159	7.197
2.3	7.235	7.272	7.310	7.347	7.384	7.421	7.458	7.495	7.532	7.568
2.4	7.604	7.640	7.676	7.712	7.748	7.783	7.819	7.854	7.889	7.924
2.5	7.959	7.993	8.028	8.062	8.097	8.131	8.165	8.199	8.232	8.266
2.6	8.299	8.333	8.366	8.399	8.432	8.465	8.498	8.530	8.563	8.595
2.7	8.627	8.659	8.691	8.723	8.755	8.787	8.818	8.850	8.881	8.912
2.8	8.943	8.974	9.005	9.036	9.066	9.097	9.127	9.158	9.188	9.218
2.9	9.248	9.278	9.308	9.337	9.367	9.396	9.426	9.455	9.484	9.513
3.0	**9.542**	**9.571**	**9.600**	**9.629**	**9.657**	**9.686**	**9.714**	**9.743**	**9.771**	**9.799**
3.1	9.827	9.855	9.883	9.911	9.939	9.966	9.994	10.021	10.049	10.076
3.2	10.103	10.130	10.157	10.184	10.211	10.238	10.264	10.291	10.317	10.344
3.3	10.370	10.397	10.423	10.449	10.475	10.501	10.527	10.553	10.578	10.604
3.4	10.630	10.655	10.681	10.706	10.731	10.756	10.782	10.807	10.832	10.857
3.5	10.881	10.906	10.931	10.955	10.980	11.005	11.029	11.053	11.078	11.102
3.6	11.126	11.150	11.174	11.198	11.222	11.246	11.270	11.293	11.317	11.341
3.7	11.364	11.387	11.411	11.434	11.457	11.481	11.504	11.527	11.550	11.573
3.8	11.596	11.618	11.641	11.664	11.687	11.709	11.732	11.754	11.777	11.799
3.9	11.821	11.844	11.866	11.888	11.910	11.932	11.954	11.976	11.998	12.019
4.0	**12.041**	**12.063**	**12.085**	**12.106**	**12.128**	**12.149**	**12.171**	**12.192**	**12.213**	**12.234**
4.1	12.256	12.277	12.298	12.319	12.340	12.361	12.382	12.403	12.424	12.444
4.2	12.465	12.486	12.506	12.527	12.547	12.568	12.588	12.609	12.629	12.649
4.3	12.669	12.690	12.710	12.730	12.750	12.770	12.790	12.810	12.829	12.849
4.4	12.869	12.889	12.908	12.928	12.948	12.967	12.987	13.006	13.026	13.045
4.5	13.064	13.084	13.103	13.122	13.141	13.160	13.179	13.198	13.217	13.236
4.6	13.255	13.274	13.293	13.312	13.330	13.349	13.368	13.386	13.405	13.423
4.7	13.442	13.460	13.479	13.497	13.516	13.534	13.552	13.570	13.589	13.607
4.8	13.625	13.643	13.661	13.679	13.697	13.715	13.733	13.751	13.768	13.786
4.9	13.804	13.822	13.839	13.857	13.875	13.892	13.910	13.927	13.945	13.962
5.0	**13.979**	**13.997**	**14.014**	**14.031**	**14.049**	**14.066**	**14.083**	**14.100**	**14.117**	**14.134**
5.1	14.151	14.168	14.185	14.202	14.219	14.236	14.253	14.270	14.287	14.303
5.2	14.320	14.337	14.353	14.370	14.387	14.403	14.420	14.436	14.453	14.469
5.3	14.486	14.502	14.518	14.535	14.551	14.567	14.583	14.599	14.616	14.632
5.4	14.648	14.664	14.680	14.696	14.712	14.728	14.744	14.760	14.776	14.791
5.5	14.807	14.823	14.839	14.855	14.870	14.886	14.902	14.917	14.933	14.948
5.6	14.964	14.979	14.995	15.010	15.026	15.041	15.056	15.072	15.087	15.102
5.7	15.117	15.133	15.148	15.163	15.178	15.193	15.208	15.224	15.239	15.254
5.8	15.269	15.284	15.298	15.313	15.328	15.343	15.358	15.373	15.388	15.402
5.9	15.417	15.432	15.446	15.461	15.476	15.490	15.505	15.519	15.534	15.549

TABLE II (continued)

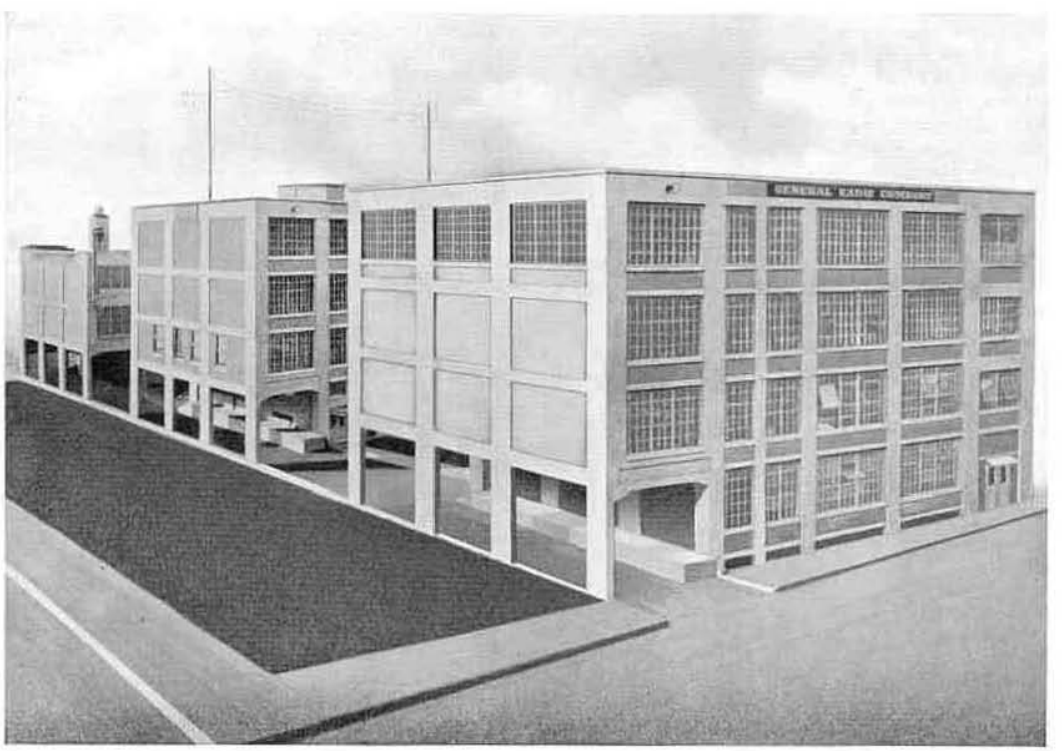
Voltage Ratio	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
6.0	**15.563**	**15.577**	**15.592**	**15.606**	**15.621**	**15.635**	**15.649**	**15.664**	**15.678**	**15.692**
6.1	15.707	15.721	15.735	15.749	15.763	15.778	15.792	15.806	15.820	15.834
6.2	15.848	15.862	15.876	15.890	15.904	15.918	15.931	15.945	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**	—	—	—	—	—	—	—	—	—

To find ratios outside the range of this table, see page 165

INDEX BY TYPE NUMBER

INDEX BY TYPE NUMBER



Laboratories, General Offices, and Factory of General Radio Company at Cambridge, Massachusetts

INDEX BY TITLE

INDEX BY TITLE (continued)

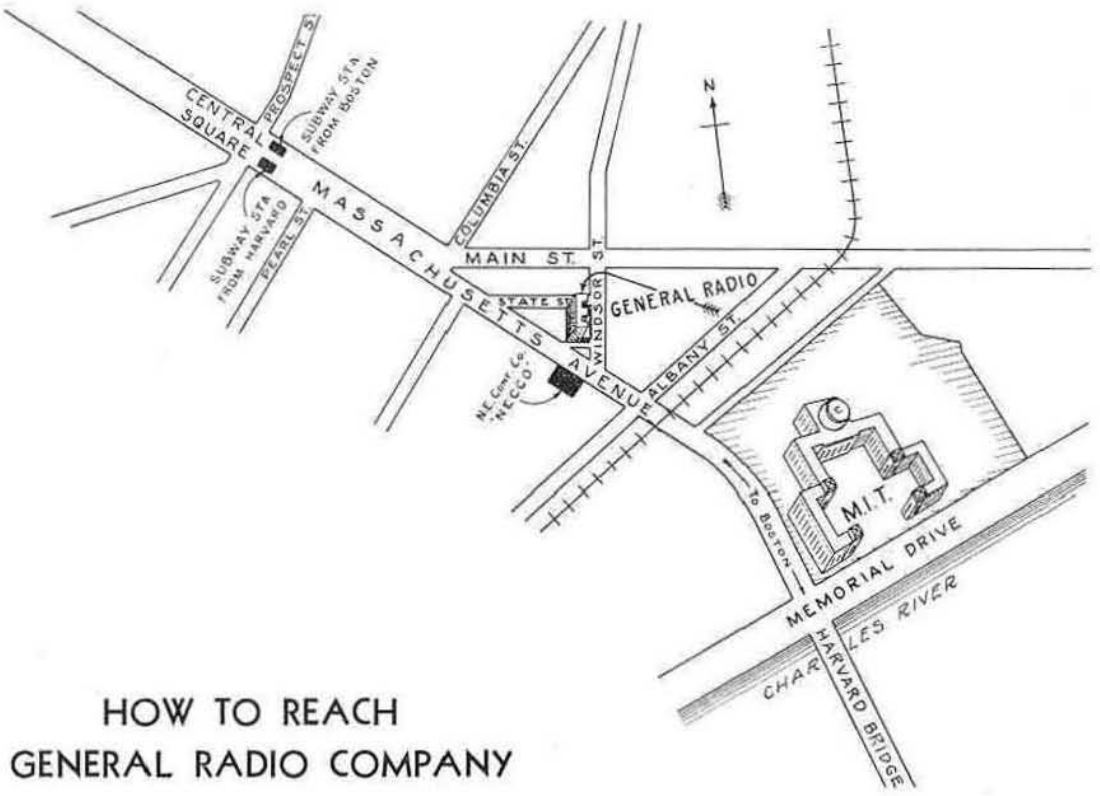
VISIT OUR LABORATORIES AND FACTORY

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 the corner of Windsor Street and State Street, just off Massachusetts Avenue. It is half way between Central Square and the main educational group of the Massachusetts Institute of Technology.

The accompanying map gives detailed instructions for reaching the plant from the subway station in Central Square, Cambridge. This can be reached directly from Boston or from Harvard Square.

HOURS: 9:00 a.m. to 5:00 p.m., every day except Saturday, Sunday, and Holidays.

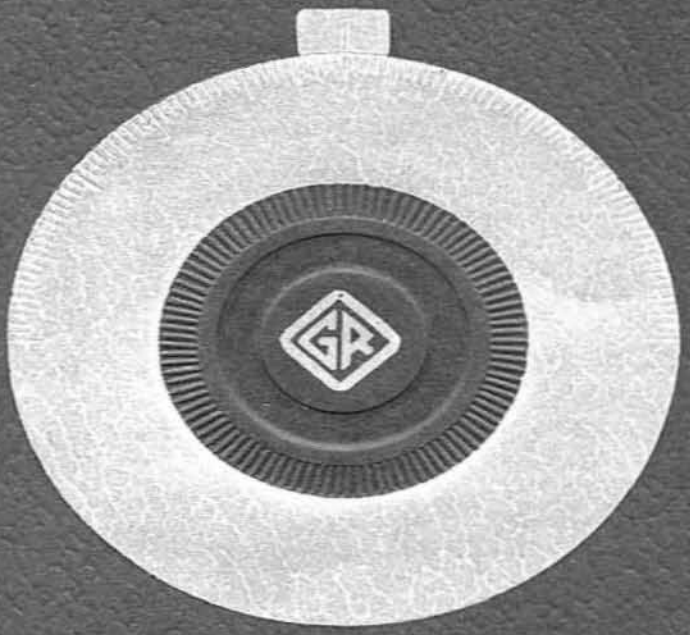


HOW TO REACH GENERAL RADIO COMPANY

By Subway from Boston or Harvard Square, Cambridge: Ask your way to the "Cambridge Subway" and take a train for Central Square. Walk down Massachusetts Avenue to State Street or take any Boston-bound surface car on Massachusetts Avenue and get off at Windsor Street. Note the location of your subway exit on the accompanying map as a guide to direction.

By Automobile: Follow Massachusetts Avenue, Cambridge, from either M. I. T. (Harvard Bridge from Boston) or from Central Square. Turn off at Windsor Street, at the "Necco Plant."

If you have difficulty finding us, call PORter 1760. Our telephone operator will be glad to give you further directions



CATALOG G

GENERAL RADIO CO.

CAMBRIDGE, MASS.