

INSTRUMENTS

FOR ELECTRICAL MEASUREMENTS
AT COMMUNICATION FREQUENCIES

CATALOG F
JUNE, 1930



GENERAL RADIO COMPANY
CAMBRIDGE A, MASSACHUSETTS

FUTURE ANNOUNCEMENTS

Price changes, design modifications, and additions to the General Radio line will be announced in a series of Catalog Supplements. These will be mailed, when issued, to everyone receiving a copy of this catalog. ¶ In addition, a monthly technical bulletin, the *General Radio Experimenter*, is mailed without charge to users and prospective users of General Radio instruments. If the *Experimenter* reaches you regularly, you may be sure that your name is correctly listed and that you are receiving all Catalog Supplements.

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FOREWORD

Commercial acceptability has been the primary thought in the design of General Radio instruments. This should not be taken to mean that they are not precision instruments and, accordingly, lack accuracy, but rather that unusual ruggedness has been incorporated in their design. They have been designed to stand ordinary commercial laboratory use, without loss of accuracy.

A general classification of all instruments as laboratory working standards would, of course, be impractical. The very nature of some instruments as reference standards makes it necessary to give special attention to their precision. Even in these instruments, the construction is such that they may be referred to regularly, without the danger of injury to their accuracy of calibration.

A feature of particular interest in our line of laboratory equipment is the special parts that are available for quick laboratory set-ups. These parts consist of quick change-over switches, special plug and jack combinations, and bottle-neck binding posts. In a laboratory equipped with a few of these accessories it is possible to get along with a smaller number of instruments than would be required if permanent set-ups were used. This class of equipment will be found particularly useful where comparisons are being made between different kinds of instruments.

In looking through this catalog it is evident at once that the instruments listed are largely specialized ones for measurements at audio and radio frequencies. The fact, however, should not be lost sight of that many of these instruments are also particularly adapted for use at commercial frequencies and in direct-current work.

Aside from the items listed in this catalog, we manufacture a large number of special instruments and pieces of apparatus. These are built either to the customer's specifications or to meet his particular requirements. Your problems in this field are solicited.

SHIPMENT and TERMS

Unless specific shipping instructions accompany an 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 unless so stated with the price of the instrument.

When ordering by telegraph, please specify quantity and our code word. Foreign customers will find it convenient to use Bentley's Code. Our cable address is Genradco, Boston.

Terms are net thirty days or with 2 per cent. discount for payment within ten days from date of shipment. When cash accompanies the order, we shall pay transportation charges anywhere in the United States or Canada in place of allowing the usual cash discount.

Unless credit has already been established we shall make shipments C.O.D.

OUR DISCOUNT POLICY

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 a coöperative plan with the Central Scientific Company, of Chicago, Illinois, our instruments are not sold through dealers or brokers.

As our instruments are not sold through dealers, prices have been made on a basis that does not permit any discount. All prices are, therefore, strictly net. Quantity discounts as given in the next paragraph are the only discounts allowed.

When ten to nineteen of any item are ordered at the same time for a single shipment, there is a 5 per cent. discount. In quantities of twenty to ninety-nine, the discount is 10 per cent. In quantities of one hundred or over, special prices will be quoted on request.

Unless otherwise stated, quotations remain open for thirty days. Delivery promises are made subject to the usual classification of causes beyond our control. Catalog prices have been revised to May 31, 1930, but they are subject to change without notice.

Many of the instruments require special engineering correspondence to determine their adaptability to the particular conditions of the prospective user. As these problems are strictly of an engineering nature, we maintain an engineering staff to give particular attention to such problems. Your correspondence is solicited.

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CONDENSERS

THERE are few condenser needs either in precision measurements or experimental work that cannot be supplied from the stock items listed below. A variety of variable air dielectric condensers and fixed condensers with paper and mica dielectrics are described, and, if these are not suitable, we are prepared to design and build others to meet the specifications of the user.

Condensers are listed under the following three general headings:

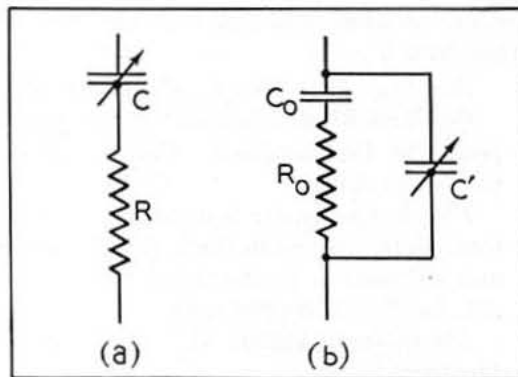
- a) Calibrated Air Condensers
- b) General-Purpose Air Condensers
- c) Calibrated Paper and Mica Condensers

CALIBRATED AIR CONDENSERS

LOW energy losses and the ability to duplicate settings are the most important requirements for laboratory condensers. These two conditions are incompatible because extremely low losses demand the use of an amount and shape of supporting dielectric which would sacrifice the ability of a condenser to hold a calibration. By a careful coördination of mechanical and electrical design, however, the condensers listed in this section have been made to have great stability with satisfactorily low losses.

The small amount of solid dielectric is placed in a weak and unvarying electric field so that the losses are small and constant with setting. The latter consideration is important when making loss measurements on other condensers because it permits the assumption that the condenser behaves as a loss-free variable condenser in parallel with a *fixed* condenser having all the losses. The figure of merit, $R\omega C^2$, is of the order of 0.06×10^{-12} (R in ohms, C in farads, and $\omega = 2\pi f$ in radians per second).

The choice of $R\omega C^2$ as the figure of merit for expressing the losses in an air condenser is based upon the following considerations: Any air condenser C having an



equivalent series resistance R may be represented by a condenser C_0 due to the solid dielectric supports and having all the losses, R_0 , in parallel with a loss-free condenser C' . Working out the energy relations in (a) and in (b) on the assumption that the losses are small, it is found that

$$R = \frac{R_0 \omega C_0^2}{\omega (C' + C_0)^2} = \frac{R_0 \omega C_0^2}{\omega C^2},$$

and

$$R\omega C^2 = R_0 \omega C_0^2.$$

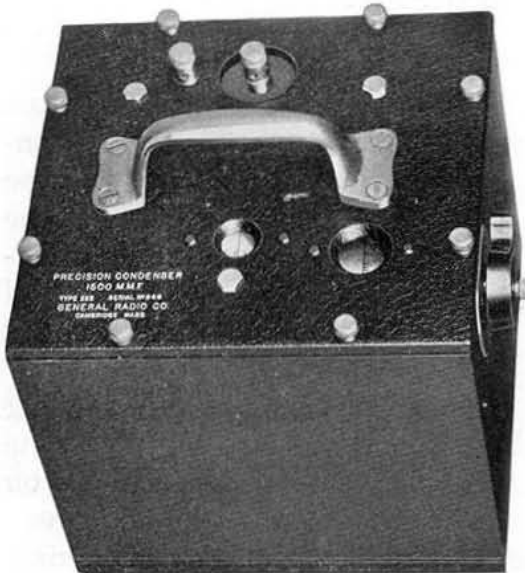
Since the losses for condensers described in this section are constant with setting, C_0 is a fixed condenser with an

isolantite or a hard-rubber dielectric. For different frequencies its power factor $R\omega C_o$ is essentially constant.

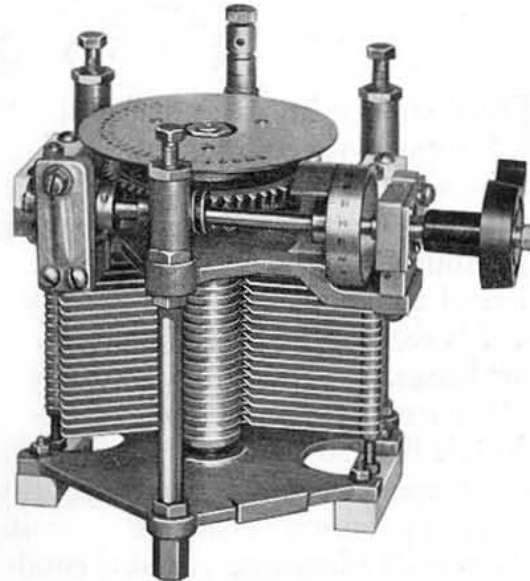
Hence, the quantity $R\omega C^2$ is constant for all values of ω and C and is a characteristic of the condenser. For this reason it is preferred to power factor $R\omega C$ as a figure of merit. Power factor can, of course, be obtained by dividing $R\omega C^2$ by C (in farads). The equivalent series resistance R of an air condenser may always be calculated 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 μmf capacitance at a frequency of 1000 cycles per second is 10 ohms. It will vary inversely with both frequency and capacitance.

We are prepared to design and build any of these condensers in other capacitance ranges, for other laws (shapes of plates), and for gang control of multiple units.

TYPE 222 PRECISION CONDENSERS



TYPE 222-L



TYPE 222-L (Unmounted)

THESSE condensers are intended for use as precise variable standards. Their mechanical design is such that they should hold their calibrations over long periods of time to better than 1 part in 1000. The plates are of heavy aluminum, widely separated by accurately turned spacers and clamped by hexagon nuts on threaded brass stator rods and on the large steel rotor shaft. This shaft turns in cone-shaped bronze bushings, adjusted after the condenser has been assembled and then locked.

Range: See price list.

Rotor Plates: Straight-line capacitance (semi-circular).

Insulation: Isolantite blocks; mica window for high-potential terminal.

Maximum Voltage: 800 volts, peak.

Figure of Merit: $R\omega C^2 = 0.06 \times 10^{-12}$.

Drive: Gear and spring-pressed worm, lapped in position to remove backlash, a method applied to precision dividing engines. 25 turns of worm rotate rotor plates 180° . Worm carries drum with 100 divisions.

Backlash: Less than $\frac{3}{4}$ of one division.

Calibration: Calibration chart for 26 points to $1\mu\text{mf}$ supplied. Can be set to 1 part in 10,000.

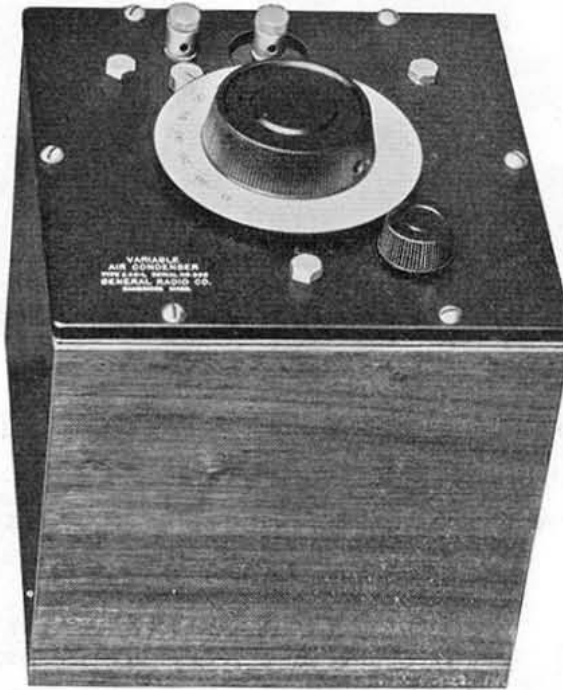
Finish: Condenser is mounted on aluminum plate finished in black crackle lacquer and enclosed in hand-rubbed walnut cabinet, lined with copper shield.

Dimensions: Panel, $8\frac{1}{4} \times 9\frac{1}{2}$ inches. Depth, 9 inches.

Carrying Case: Whitewood, with lock and handle.

Type	Capacitance		Weight	Code Word	Price
	Max.	Min.			
222-L	1500 μf	50 μf	15 lb.	COPAL	\$90.00
222-F	500 μf	40 μf	15 lb.	CORAL	85.00

TYPE 246 VARIABLE AIR CONDENSERS



TYPE 246-L

THESE condensers are similar in mechanical construction to the TYPE 222 Precision Condensers. The only difference is that the worm and gear drive is replaced by a spur-gear-driven slow-motion knob, and a direct connected knob with 4-inch dial. They cannot be set as accurately, but once set they will hold that setting as well, except that the models having the larger capacitances are longer, hence not quite as rigid mechanically.

Range: See price list.

Rotor Plates: Straight-line capacitance (semi-circular).

Insulation: Isolantite blocks; mica window for high potential terminal.

Maximum Voltage: See price list (values given are peak).

Figure of Merit: $R\omega C^2 = 0.06 \times 10^{-12}$.

Drive: TYPE 317 Dial with spur-gear-driven vernier.

Calibration: Calibration curve accurate to 0.5 per cent. of full-scale reading must be ordered separately.

Finish: Condenser is mounted on aluminum plate finished in black crackle lacquer and enclosed in hand-rubbed walnut cabinet, lined with copper shield.

Dimensions: Panel, $7\frac{1}{2} \times 7\frac{1}{2}$ inches. Depth, see price list.

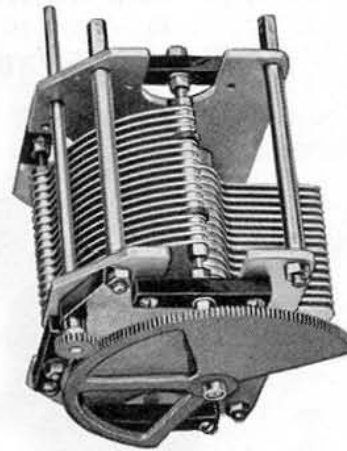
Type	Capacitance		Maximum Voltage	Depth	Weight	Code Word	Price
	Max.	Min.					
*246-L	1500 μf	55 μf	800	$8\frac{1}{4}$ in.	$11\frac{3}{8}$ lb.	CEDAR	\$38.00
*246-M	3000 μf	70 μf	800	$11\frac{1}{2}$ in.	$14\frac{3}{4}$ lb.	CHAOS	45.00
*246-P	5000 μf	72 μf	550	$11\frac{1}{2}$ in.	$15\frac{3}{4}$ lb.	CHARY	54.00
				Mounted Calibration Curve		CURVE	4.00

* Calibrations supplied only when ordered. Use compound code words, e.g., CEDARCURVE, CHAOSCURVE, etc.

TYPE 239 VARIABLE AIR CONDENSER



Mounted Model



Unmounted Model

TYPE 239-E

MOUNTED MODELS

THESE condensers are of lighter construction than the TYPE 246 Condensers, though the design is quite similar. The rotor plates are cut to give a straight-line-wavelength variation. All models are counterweighted.

Range: See price list.

Rotor Plates: Straight-line wavelength.

Insulation: Hard-rubber blocks; hard-rubber panel.

Maximum Voltage: 500 volts, peak.

Figure of Merit: $R\omega C^2 = 0.06 \times 10^{-12}$.

Drive: TYPE 317 Dial with or without spur-gear-driven vernier, as specified in price list.

Calibration: Calibration curve accurate to 1 per cent. of full-scale reading must be ordered separately.

Finish: Mounted on hard-rubber panel and enclosed in hand-rubbed walnut cabinet. No shielding. Also furnished unmounted; see price list.

Dimensions: Panel, 6 x 6 inches. Depth, see price list.

Type	Capacitance			Depth	Weight	Code Word	Price
	Max.	Min.					
*239-F	1000 $\mu\mu\text{f}$	25 $\mu\mu\text{f}$	..... Counterweight	7 in.	4 $\frac{1}{4}$ lb.	BABEL	\$15.00
*239-E	1000 $\mu\mu\text{f}$	25 $\mu\mu\text{f}$	..... Gear	7 in.	4 $\frac{3}{8}$ lb.	BANDY	18.00
*239-K	2000 $\mu\mu\text{f}$	30 $\mu\mu\text{f}$	..... Counterweight	9 in.	5 $\frac{1}{2}$ lb.	BASIN	18.50
*239-J	2000 $\mu\mu\text{f}$	30 $\mu\mu\text{f}$	..... Gear	9 in.	5 $\frac{3}{8}$ in.	BATTY	21.50
			Mounted Calibration Curve			CURVE	3.50

* Calibrations supplied only when ordered. Use compound code words, e.g., BABELCURVE, BANDYCURVE, etc.

UNMOUNTED MODELS

UNMOUNTED models are similar except that panels, cabinets, and dials are not supplied.

Dimensions: Panel, 4 $\frac{1}{2}$ x 4 $\frac{1}{4}$ inches. Depth, see price list.

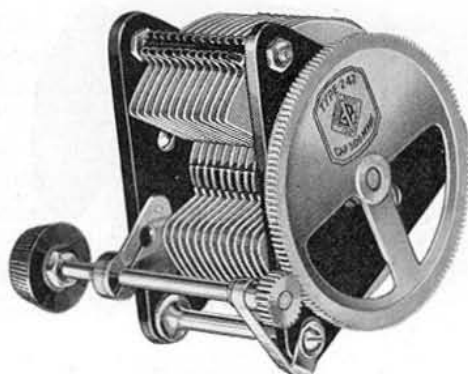
Type	Capacitance			Depth	Weight	Code Word	Price
	Max.	Min.					
239-H	1000 $\mu\mu\text{f}$	25 $\mu\mu\text{f}$	..... Counterweight	6 in.	1 $\frac{3}{4}$ in.	BARON	\$7.00
239-G	1000 $\mu\mu\text{f}$	25 $\mu\mu\text{f}$	..... Gear	6 in.	2 lb.	BASAL	10.00
239-M	2000 $\mu\mu\text{f}$	30 $\mu\mu\text{f}$	..... Counterweight	8 in.	2 $\frac{3}{4}$ lb.	BAYAN	10.50
239-L	2000 $\mu\mu\text{f}$	30 $\mu\mu\text{f}$	..... Gear	8 in.	2 $\frac{3}{4}$ lb.	BEFIT	13.50

GENERAL-PURPOSE AIR CONDENSERS

IN this section are listed condensers for radio receiver and transmitter construction and for general laboratory use where accurate calibrations are not the first consideration. A variety of models are available with maximum capacitances between $15\mu\mu\text{f}$ and $1000\mu\mu\text{f}$; with straight-line capacitance, wavelength, and frequency plates; and for panel and table mounting.

Dielectric losses are kept low by the use of a small amount of properly placed hard rubber. All plates are of brass. Rotor and stator sections are assembled in jigs and soldered. This makes a rugged mechanical as well as an exceptionally low-resistance electrical assembly. $R\omega C^2$ for these condensers depends upon the method of mounting but lies in the vicinity of 0.08×10^{-12} .

TYPE 247 VARIABLE AIR CONDENSERS



TYPE 247-H



TYPE 247-E

MOUNTED MODELS

THESE condensers have triangular hard-rubber end plates. All models are counter-weighted.

Range: See price list.

Rotor Plates: Straight-line capacitance (semi-circular).

Insulation: Hard-rubber end plates.

Maximum Voltage: 500 volts, peak.

Figure of Merit: $R\omega C^2 = 0.08 \times 10^{-12}$.

Drive: Modified TYPE 310 Dial. Spur-gear-driven vernier as shown in price list.

Calibration: Dial is calibrated directly in $\mu\mu\text{f}$ accurate to 3 per cent. of full-scale reading.

Finish: Mounted on hard-rubber panels and enclosed in drawn steel cases finished in black damaskene enamel.

Dimensions: Outside diameter, 5 inches. Depth, see price list.

Type	Capacitance		Code Word	Depth	Weight	Price
	Max.	Min.				
247-E	500 $\mu\mu\text{f}$	30 $\mu\mu\text{f}$	..... Counterweight	4½ in.	2 lb.	COUPE \$5.00
247-G	500 $\mu\mu\text{f}$	30 $\mu\mu\text{f}$	..... Gear.....	4½ in.	2¾ lb.	COLIC 5.75
247-J	250 $\mu\mu\text{f}$	30 $\mu\mu\text{f}$	..... Counterweight	4½ in.	1⅝ lb.	CANON 4.50
247-L	250 $\mu\mu\text{f}$	30 $\mu\mu\text{f}$	..... Gear.....	4½ in.	2 lb.	CAROM 5.25

(Continued on following page)

UNMOUNTED MODELS

UNMOUNTED models are similar except that panels, cases, and dials are not supplied, and rotor plates are straight-line wavelength.

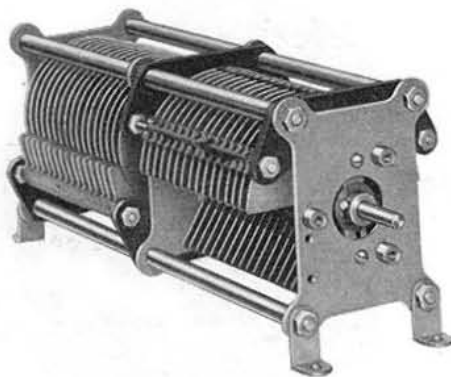
Rotor Plates: Straight-line wavelength.

Dimensions: Panel space, 4 inches diame-

Calibration: Supplied without either dials or calibrations. ter. Depth, see price list.

Type	Capacitance			Depth	Weight	Code Word	Price
	Max.	Min.					
247-F	500 μf	20 μf}	..... Counterweight	4½ in.	1¾ lb.	COCOA	\$3.00
247-H	500 μf	20 μf}	..... Gear.....	4½ in.	1¾ lb.	COMIC	3.75
247-N	350 μf	15 μf}	..... Counterweight	4½ in.	1¼ lb.	ABASE	2.75
247-P	350 μf	15 μf}	..... Gear.....	4½ in.	¼ lb.	ABBEY	3.50
247-K	250 μf	15 μf}	..... Counterweight	4 in.	7/8 lb.	CARGO	2.50
247-M	250 μf	15 μf}	..... Gear.....	4 in.	1 lb.	CTGAR	3.25

TYPE 334 VARIABLE AIR CONDENSERS



TYPE 334-Z



TYPE 334-F

LOW-VOLTAGE MODELS

THESE condensers have stamped metal end plates. The various models are either counterweighted or balanced, as specified in the price list. The high-voltage models are double spaced for use on transmitters.

Range: See price list.

Rotor Plates: Straight-line wavelength.

Insulation: Hard-rubber plates.

Maximum Voltage: 500 volts, peak.

Figure of Merit: $R\omega C^2 = 0.07 \times 10^{-12}$.

Drive: Spur-gear-driven vernier as specified in price list.

Finish: Unmounted only.

Dimensions: Panel space, 3¾ x 3¾ inches. Depth, see price list.

Type	Capacitance			Depth	Weight	Code Word	Price
	Max.	Min.					
334-F	500 μf	20 μf}	..... Counterweight	4¼ in.	1½ lb.	BEGIN	\$3.25
334-H	500 μf	20 μf}	..... Gear.....	4 in.	15/8 lb.	BELAY	4.00
334-N	350 μf	20 μf}	..... Counterweight	4 in.	13/8 lb.	BESET	3.00
334-P	350 μf	20 μf}	..... Gear.....	3¾ in.	1½ lb.	BEVEL	3.75
334-K	250 μf	15 μf}	..... Counterweight	3½ in.	1 lb.	BELOW	2.75
334-M	250 μf	15 μf}	..... Gear.....	3¼ in.	11/8 lb.	BERYL	3.50

HIGH-VOLTAGE MODELS

HIGH-VOLTAGE models are similar to the low-voltage models except that the spacing of the plates is doubled.

Maximum Voltage: 3500 volts, peak.
Spacing between rotor and stator plates: 0.088 inch.

Drive: Vernier gears cannot be supplied.
Finish: Four mounting feet furnished on all units.

Type	Capacitance			Depth	Weight	Code Word	Price
	Max.	Min.					
334-Z	500 μf	35 μf}	.....	Balanced Section	11 in.	4 lb.	BOGEY \$10.00
334-R	250 μf	30 μf}	.....	Counterweight	6½ in.	2 lb.	BISON 5.50
334-T	100 μf	15 μf}	.....	"	4 in.	1½ lb.	BILLY 2.75
334-V	50 μf	10 μf}	.....	"	3¾ in.	⅝ lb.	BIPED 2.50

TYPE 374 VARIABLE AIR CONDENSERS

THESE condensers are similar in construction to the TYPE 334 Variable Air Condensers, except that the rotor plates are cut to give a straight-line-frequency variation. The two smaller sizes are not counterweighted.

Range: See price list.

Rotor Plates: Straight-line frequency.

Insulation: Hard-rubber supports.

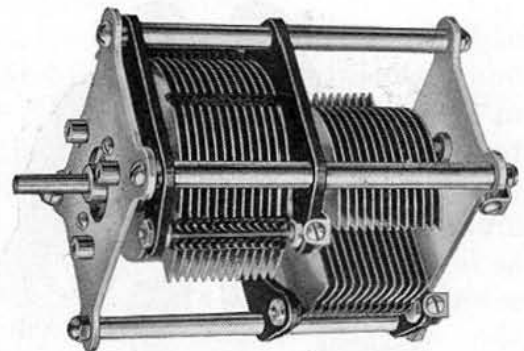
Maximum Voltage: 500 volts, peak.

Figure of Merit: $R\omega C^2 = 0.08 \times 10^{-12}$.

Drive: No vernier gears can be supplied.
The two single-section models are not counterweighted.

Finish: Unmounted only.

Dimensions: Panel space, 3¾ x 3¾ inches. Depth, see price list.



TYPE 374-F

Type	Capacitance			Depth	Weight	Code Word	Price
	Max.	Min.					
374-B	125 μf	15 μf}	.....	Single Section	3¼ in.	⅞ lb.	BONUS \$2.75
374-K	250 μf	20 μf}	.....	"	4¼ in.	1¼ lb.	BOSOM 3.50
374-N	350 μf	30 μf}	.....	Balanced Section	5 in.	1⅝ lb.	BOXER 4.25
374-F	500 μf	40 μf}	.....	"	6 in.	2 lb.	BRAVO 5.00

TYPE 335-Z VARIABLE AIR CONDENSER

THE TYPE 335-Z Variable Air Condenser is similar to the TYPE 334 Variable Air Condensers except that it has semi-circular plates. It is intended to be used with TYPE 380 and TYPE 219 Decade Condensers to furnish the continuously variable portion below the 0.001 μf decade.

Range: See price list.

Rotor Plates: Straight-line capacitance (semi-circular).

Insulation: Hard-rubber plates.

Maximum Voltage: 500 volts, peak.

Figure of Merit: $R\omega C^2 = 0.07 \times 10^{-12}$.

Drive: No vernier gears can be supplied.

Finish: Unmounted only.

Dimensions: Panel space, 3¾ x 3¾ inches. Depth, see price list.

Type	Capacitance			Depth	Weight	Code Word	Price
	Max.	Min.					
335-Z	1000 μf	40 μf}	.....	Balanced Section	5⅞ in.	2¼ lb.	BOGUS \$6.00

TYPE 557 AMATEUR-BAND CONDENSER

THIS condenser is designed for use in short-wave receivers, where it is desirable to cover only a narrow frequency band on one inductor. For this same reason it is used in our TYPE 558-P Amateur-Band Frequency Meter. It is similar in construction to our TYPE 247 Variable Air Condensers. The large zero capacitance is obtained by using two rotor plates which are complete circles.

Range: See price list.

Rotor Plates: Two circular (360°) and two straight-line-wavelength plates.

Insulation: Hard-rubber end plates.

Maximum Voltage: 3500 volts, peak.

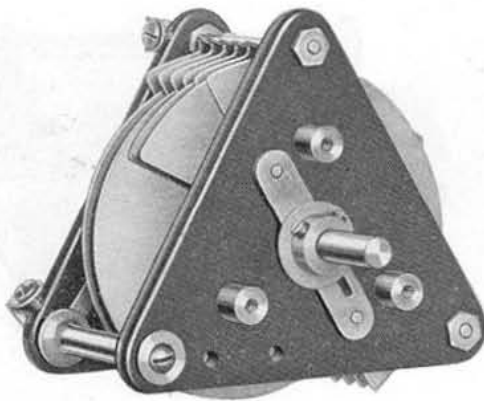
Figure of Merit: $R\omega C^2 = 0.10 \times 10^{-12}$.

Drive: No vernier.

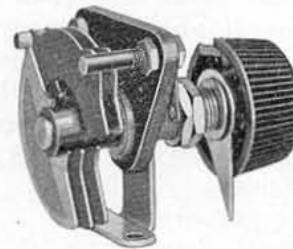
Finish: Unmounted only.

Dimensions: Panel space, 4 inches diameter. Depth, see price list.

Type	Capacitance		Depth	Weight	Code Word	Price
	Max.	Min.				
557	66 μmf	43 μmf	3 $\frac{5}{8}$ in.	$\frac{3}{4}$ lb.	BEGOT	\$3.25



TYPE 557



TYPE 368-A

TYPE 368 VARIABLE AIR CONDENSERS

THESE condensers are useful as balancing or vernier condensers in various vacuum-tube circuits, and many amateurs use them for tuning condensers on their receivers for the high-frequency (short-wave) bands. They have a single hard-rubber end plate, single bearing, and single-hole mounting as well as baseboard mounting.

Range: See price list.

Rotor Plates: Straight-line capacitance (semi-circular).

Insulation: Single hard-rubber end plate.

Maximum Voltage: 500 volts, peak.

Figure of merit: $R\omega C^2 = 0.004 \times 10^{-12}$.

Drive: TYPE 137-J Knob. No vernier.

Finish: Unmounted only.

Dimensions: Panel space, 2 inches diameter. Depth, see price list.

Type	Capacitance		Depth	Weight	Code Word	Price
	Max.	Min.				
368-A	15 μmf	4 μmf	1 $\frac{7}{8}$ in.	2 oz.	BULLY	\$0.75
368-B	50 μmf	4 μmf	2 in.	2 $\frac{1}{2}$ oz.	BURIN	1.00
368-C	100 μmf	4 μmf	2 $\frac{1}{4}$ in.	3 oz.	AZURE	1.75

CALIBRATED PAPER AND MICA CONDENSERS

LABORATORIES often need an adjustable condenser of large capacitance and reasonable stability of calibration in places where air condensers would be much too bulky. Here fixed mica-dielectric and paper-dielectric condensers are suitable, especially when the condenser units and a suitable switching mechanism are arranged so that practically any desired value of capacitance may be obtained.

The TYPE 219 Decade Condensers are built in this way. A cam switch selects the proper combination of units to give the desired capacitance, the value of which is read directly opposite the end of the control-knob pointer. A simple detent device makes definite the position of the switch for each setting. These condensers are cabinet-mounted combinations of the TYPE 380 Decade Switch and Condenser sections.

The TYPE 380 Decade Switch and Condenser sections are built in 0.001 μf , 0.01 μf , and 0.1 μf steps, the first two having mica dielectric, and the latter, paraffin impregnated paper. While the paper dielectric is, in general, inferior to mica, a well-built paper condenser is so satisfactory that the expense of mica in large sizes is seldom justifiable.

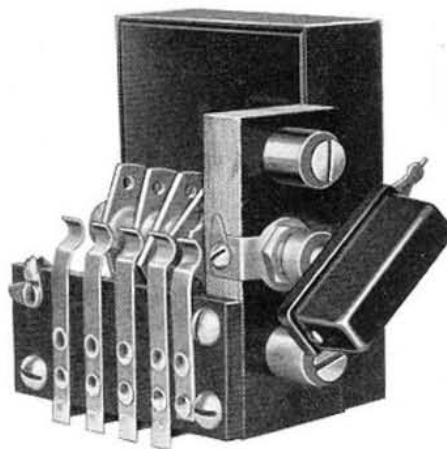
The paper condensers are thoroughly impregnated with molten paraffin during the winding process. Sufficient overlap is allowed on the foil so that successive layers make contact. This avoids the increase in power factor with frequency which occurs when connections are made at the ends of the coil only. They are subjected to a special heat treatment before being assembled, which makes them practically free from aging effects. Mica condensers are moulded in bakelite. The maximum direct-current voltage is 300 volts for both types.

The maximum peak alternating-current voltage should never be above the allowable direct-current voltage. Hence 200 volts is a root-mean-square maximum. The energy loss in a solid dielectric condenser is $E^2 R \omega^2 C^2$ watts (E in volts, R in ohms, C in farads, $\omega = 2\pi f$ in radians per second). The power factor, $R\omega C$ or (*p.f.*) of a solid dielectric is constant, independent of capacitance, and approximately constant with frequency. Hence the energy loss is $E^2 \omega C$ (*p.f.*) watts. This loss will heat the condenser and further increase the loss because the temperature coefficient of power factor is large and positive. There is, then, a frequency for each size of condenser, below which the alternating-current voltage may be kept at the maximum allowable value of 200 volts and above which it should be reduced inversely as the frequency.

<i>Decade</i>	<i>Power Factor $R\omega C$</i>	<i>Frequency for 300 volts peak</i>	<i>Accuracy</i>
.001	.002	1000 kc.	5 per cent.
.01	.001	100 kc.	2 " "
.1	.010	1 kc.	2 " "



TYPE 219



TYPE 380

TYPE 380 DECADE SWITCH AND CONDENSERS

THESE units are the component decade units as used in the TYPE 219 Decade Condensers. They are complete and ready for mounting.

Range: See price list.

Dielectric: Mica or paraffined paper as specified in price list.

Maximum Voltage: 300 volts, peak, with exceptions noted in preceding Data Table.

Power Factor: See Data Table.

Calibration: See Data Table.

Finish: Units mounted in brass cans

with bakelite panel and nickel-plated flat-head screws for mounting. Modified knob from TYPE 202 Switch (see illustration) supplied.

Dimensions: Panel space, height, $3\frac{3}{4}$ inches; width, see price list. Depth, $3\frac{3}{4}$ inches.

Type	Capacitance	Dielectric	Weight	Code Word	Price
380-A	0.010 μf in steps of 0.001.....	Mica	1 $\frac{1}{2}$ lb.	ADAGE	\$10.00
380-B	0.10 μf " " " 0.01.....	Mica	2 lb.	ADDER	20.00
380-C	1.0 μf " " " 0.1.....	Paper	1 $\frac{3}{4}$ lb.	ADDLE	10.00

TYPE 219 DECADE CONDENSER

THESE are merely convenient assemblies of the TYPE 380 Decade Switch and Condenser units. For technical data consult their description.

Range: See price list.

"Zero" Capacitance and Power Factor: For all switches set at "zero" capacitance, 40 μf ; power factor, 0.05.

Finish: Mounted on engraved bakelite panels in hand-rubbed walnut cabinets.

Dimensions: Panel width, 5 inches. Cabinet depth, 6 inches.

Type	Capacitance	No. of Dials	Panel Length	Weight	Code Word	Price
219-F	1.10 μf in steps of 0.01.....	2	9 $\frac{1}{2}$ in.	5 $\frac{1}{4}$ lb.	COVER	\$40.00
219-G	1.110 μf " " " 0.001.....	3	12 $\frac{3}{4}$ in.	8 lb.	BRIER	50.00
219-J	0.110 μf " " " 0.001.....	2	9 $\frac{1}{2}$ in.	5 $\frac{1}{4}$ lb.	CRONY	40.00

RESISTANCE DEVICES

RESISTORS may be calibrated for use in many different kinds of laboratory measurements, or they may be used simply as current- and voltage-controlling elements in a circuit. In the latter instance calibrations are seldom required.

The General Radio Company builds resistance devices of both kinds. They are listed under the following headings:

- a) Calibrated Resistors
- b) Calibrated Attenuation Networks and Voltage Dividers
- c) Volume-Control Devices
- d) Rheostats and Potentiometers
- e) Miscellaneous

CALIBRATED RESISTORS

CALIBRATED resistance devices must maintain their specified resistances for ordinary operating temperatures and for long periods of time, but when they are to be used in alternating-current measurements it is also essential that their phase angles be negligible at reasonably high operating frequencies. The General Radio Company has developed resistance units which meet all of these requirements.

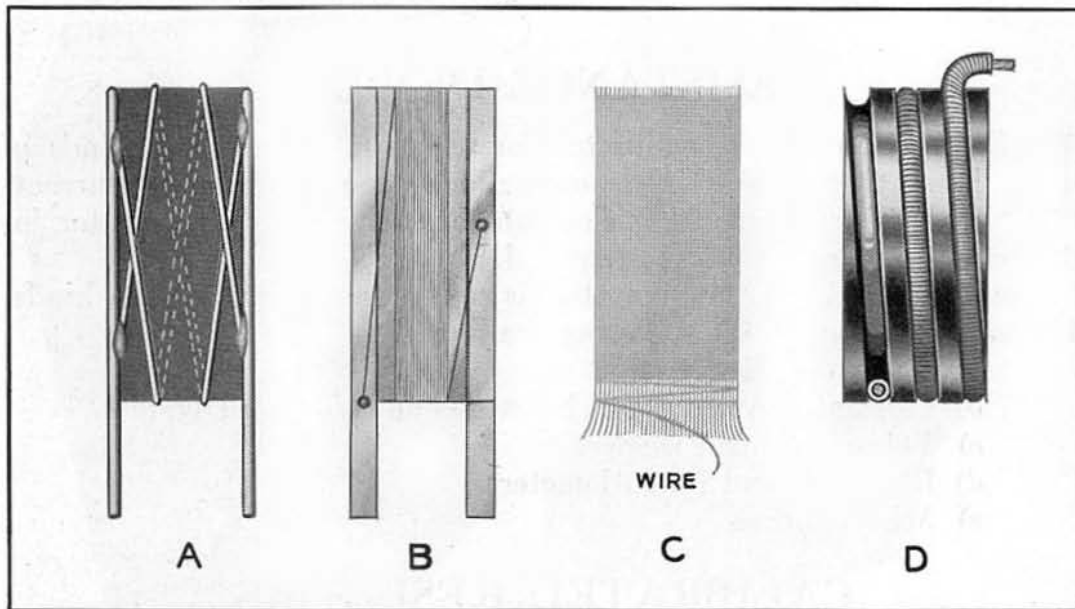
Depending upon the allowable deviation in resistance due to temperature and aging, manganin, constantan, and nichrome wire (in the order of their desirability) are used. Care in soldering insures freedom from corrosion. Wiring forms are designed for permanence so that the wire will not be subjected to changing stresses. Some of the units are aged for about six months before final resistance adjustments are made. This permits the metal to reach a state of rest following the stress incident to winding under tension.

The temperature coefficient of the manganin and constantan wire used is so small that the resistance may be considered constant with the temperature changes encountered in ordinary engineering work. Where nichrome is used, ordinary temperature variation will not cause the resistance tolerances to be exceeded.

To meet the third requirement, negligible frequency changes, four different winding methods are used for minimizing the effects of capacitive and inductive reactances:

a) *Ayrton-Perry Method.* 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, in 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.* The resistance wire is closely wound in a single layer on a thin



mica form, the ends of which are reinforced by the 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 special attenuation networks at frequencies of 1500 kc. and higher.

c) **Tape-wound Method.** The tape used in this winding has a warp of cotton threads and a woof of the resistance wire. In the assembled resistance units, the tape is wound flat like a bolt of cloth, adjacent layers being separated by oiled paper. This type of winding is nearly non-inductive and very compact.

d) **"Fish Line Method."** This is similar in principle to the tape method. 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 many purposes.

TYPE 102 DECADE-RESISTANCE BOXES

THese decade resistances are intended for use in all types of alternating-current measurements, such as bridges and tuned circuits, at all frequencies from the lowest commercial frequencies up through the broadcast band of frequencies and into the short-wave region. The frequency at which serious error appears depends on the size of the resistance and the use to which it is put; whether it is used in a tuned circuit, in which case its reactance is corrected for by the tuning condenser, or whether it is used as a voltage-drop device. Such limits as have been ascertained are given in the accompanying data table. These resistances are equally useful in direct-current measurements, except where *complete* absence of thermal electromotive forces is essential.

These resistances 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 total switch resistance, which amounts to about 0.003 ohm per switch. 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 in which the difference in two settings of a resistance box is significant. This difference is given correctly only when the individual resistances have been adjusted independently of switch resistance.

Each decade has eleven contact studs and ten resistance units. This feature is especially convenient when working at either end of a dial.

Range: See price list.

Type of Winding: See Data Table I for type of winding, size and material of wire.

Switches: TYPE 202. Multiple-leaf brushes of german silver with contact ends bent so as not to be tangent to arc of travel, thus reducing cutting; eleven phosphor-bronze contacts. This combination of metals has been chosen to reduce cutting.

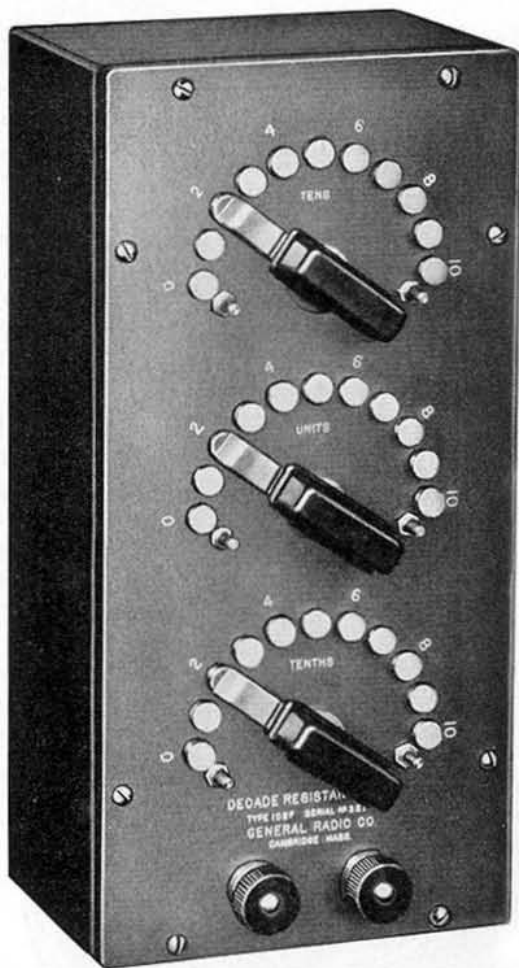
Accuracy of Adjustment: See Data Table I for direct-current adjustment at terminals of unit. Add 0.003 ohm per switch for correct resistance at terminals of box.

Frequency Error: See Data Table II for frequencies for which error is less than a given percentage when that decade is used in a tuned circuit and to provide a voltage drop. Three-decade box set at zero has about 0.2 mch. inductance and 1 ohm reactance at a frequency of 1000 kc.

Temperature Coefficient: Less than ± 0.002 per cent. per degree C. for both manganin and constantan wire.

Maximum Current: See Data Table I for values of current necessary to produce a temperature rise of 20° and 40° C. 20° C. is a safe temperature rise and 40° C. rise an upper limit.

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



TYPE 102-F

Dimensions: Panel width, $5\frac{1}{4}$ inches; depth, $5\frac{1}{2}$ inches; panel length, see price list.

DATA TABLE I

Decade	Type of Winding	Accuracy	Current for Temperature Rise of		Material
			20° C.	40° C.	
0.1 ohm	Unifilar	1 %	3 amperes	2.0 amperes	Constantan
1.0 "	Ayrton-Perry	0.25 %	600 milliamperes	1 ampere	Manganin
10 ohms	Ayrton-Perry	0.1 %	170 "	250 milliamperes	Manganin
100 "	Ayrton-Perry	0.1 %	75 "	120 "	Manganin
1000 "	Ayrton-Perry	0.1 %	20 "	35 "	Manganin
10,000 "	Tape	0.1 %	12 "	17 "	Constantan

DATA TABLE II

Frequencies in kc. for which error is less than value stated

Decade	Tuned Circuit Use		Voltage Drop Use	
	1%	5%	2%	10%
0.1 ohm	500 kc.	1000 kc.	100 kc.	500 kc.
1.0 "	1000 kc.	2000 kc.	50 kc.	100 kc.
10 ohms	2000 kc.	4000 kc.	20 kc.	50 kc.
100 "	1000 kc.	2000 kc.	10 kc.	20 kc.

(Continued on following page)

Type	Maximum Resistance	No. of Dials	Panel Length	Weight	Code Word	Price
102-D	11.0 ohms in steps of 0.1	2	7 $\frac{3}{8}$ in.	2 $\frac{1}{2}$ lb.	DECOY	\$22.00
102-F	111.0 " " " " 0.1	3	10 in.	4 lb.	DELTA	30.00
102-E	110. " " " " 1.0	2	7 $\frac{3}{8}$ in.	2 $\frac{1}{2}$ lb.	DECRY	24.00
102-K	1111.0 " " " " 0.1	4	12 $\frac{5}{8}$ in.	6 lb.	DEFER	42.00
102-G	1110. " " " " 1.0	3	10 in.	4 lb.	DIGIT	32.00
102-H	1100.0 " " " " 10.0	2	7 $\frac{3}{8}$ in.	2 $\frac{1}{2}$ lb.	DIVAN	25.00
102-N	11,111.0 " " " " 0.1	5	16 in.	7 $\frac{1}{2}$ lb.	DEMON	75.00
102-J	11,110. " " " " 1.0	4	12 $\frac{5}{8}$ in.	6 lb.	DEBIT	50.00
102-M	111,110. " " " " 1.0	5	18 $\frac{5}{8}$ in.	7 $\frac{1}{2}$ lb.	DEMIT	100.00
102-L	111,100. " " " " 10.0	4	16 in.	6 lb.	DECAY	75.00

TYPE 133 STANDARD RESISTANCES

SINGLE-VALUE MODELS

THESE resistances are similar in construction to individual units of the TYPE 102 Resistance Boxes.



TYPE 133-K

Range: See price list.

Type of Winding: Similar to TYPE 102 Decade-Resistance Boxes. See Data Tables, page 17.

Accuracy of Adjustment: 0.1 per cent.

Frequency Error: Essentially the same as for TYPE 102 Decade-Resistance Boxes.

Temperature Coefficient: Less than $\pm 0.002\%$ per degree C. for both manganin and constantan wire.

Maximum Current: See Data Tables.

Finish: Resistances are enclosed in moulded bakelite cases. Terminals are nickel-plated.

Dimensions: Diameter 3 $\frac{3}{4}$ inches; depth, 2 $\frac{1}{2}$ inches.

Weight: $\frac{1}{4}$ pound.

Type	Resistance	Maximum Current	Code Word	Price
133-A	1 ohm	250 milliamperes	RECUR	\$6.00
133-B	5 ohms	100 "	REFER	6.00
133-C	10 "	100 "	REGAL	6.00
133-D	50 "	50 "	RELAX	6.00
133-E	100 "	50 "	RELIC	6.00
133-F	500 "	50 "	REPAY	6.00
133-G	1000 "	50 "	REPEL	7.00
133-H	10,000 "	15 "	PETAL	8.00

TAPPED MODEL

THE TYPE 133-K Standard Resistance, with a total resistance of 25,000 ohms, 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 and 25,000 ohms may be obtained by suitable series and parallel connections.

Type	Resistance	Maximum Current	Code Word	Price
133-K	25,000 ohms	15 milliamperes	PASHA	\$15.00

TYPE 340 RHEOSTAT

THIS rheostat is useful in connecting a low-impedance instrument, such as the TYPE 338 String Oscillograph and 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 a direct-current voltage.

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 (not Ayrton-Perry) winding on cards; 30,000 and 100,000 ohms, "lavite" spool (graphite moulded into a spiral groove cut in a porcelain cylinder).

Switch: TYPE 202 with ten contacts.

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

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

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: $3\frac{3}{4} \times 3\frac{1}{2} \times 3\frac{1}{2}$ inches.

Weight: $1\frac{1}{8}$ pounds.



Type	Code Word	Price
340	SURLY	\$20.00

CALIBRATED ATTENUATION NETWORKS AND VOLTAGE DIVIDERS

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. The voltage divider may be regarded as a special case of an attenuation network.

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.*

It should be remembered that the values of impedance between which the attenuation box is to work, its range of values of attenuation, as well as the "type of section" must be specified. The "type of section" concerns the use to which the box is to be put and should be selected after consideration of the circuit requirements. Note, also, that the following discussion deals with the General Radio attenuation boxes and voltage dividers here described. The former are, unless otherwise noted, "symmetrical" sections (i.e., have the same image impedances at both ends) and any statements about terminology apply to these boxes only. The specified values of terminal impedance are all non-reactive, i.e., they have a zero phase angle.

Attenuation—The amount of attenuation or loss is expressed in decibels (db) where N (in db) = $10 \log_{10} \frac{P_2}{P_1}$. $\frac{P_2}{P_1}$ is the ratio between two amounts of power which is the same whether:

- a) $\frac{P_2}{P_1}$ = ratio of power entering the box to power delivered by it to the load circuit, or
- b) $\frac{P_2}{P_1}$ = ratio of power in the load without the box in circuit to the power resulting when the box is inserted. The term "insertion loss" has this definition behind it.

The alternative expression $N = 20 \log_{10} \frac{E_2}{E_1}$ or $N = 20 \log_{10} \frac{I_2}{I_1}$ where the E 's and I 's are the voltages and currents corresponding to the P 's, may also be used if the impedances in which they are measured are identical.

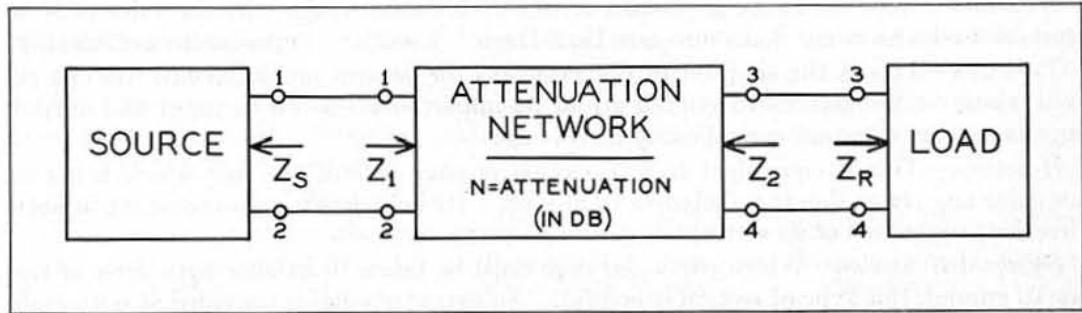
The real component of the "propagation constant" and "transfer constant" encountered in the literature are the same as "amount of attenuation," except that the units are different, usually nepers instead of decibels.

All but one of the devices described in this section are calibrated in decibels. However, attenuation boxes can be built for calibration in terms of arithmetical power ratios. The logarithmic (decibel) calibration is recommended because of its convenience and general usage, but we can build others to order if desired.

Terminal Impedances—These values of impedance are those between which the attenuation box is to work, if the calibration is to hold. The names surge impedance, characteristic impedance, iterative impedance, and image impedance which one encounters in the literature are all equivalent for the attenuation boxes here listed. If the wrong value of terminal impedance is used at either or both ends of the network, the calibration will be in error. The amount of this error can be computed.†

* Shea, *Transmission Networks and Wave Filters*; K. S. Johnson, *Transmission Circuits for Telephonic Communication*; Kennelly, *Electric Lines & Nets*; and Fleming, *Propagation of Electric Currents*. The first reference is a particularly fine treatment of the subject.

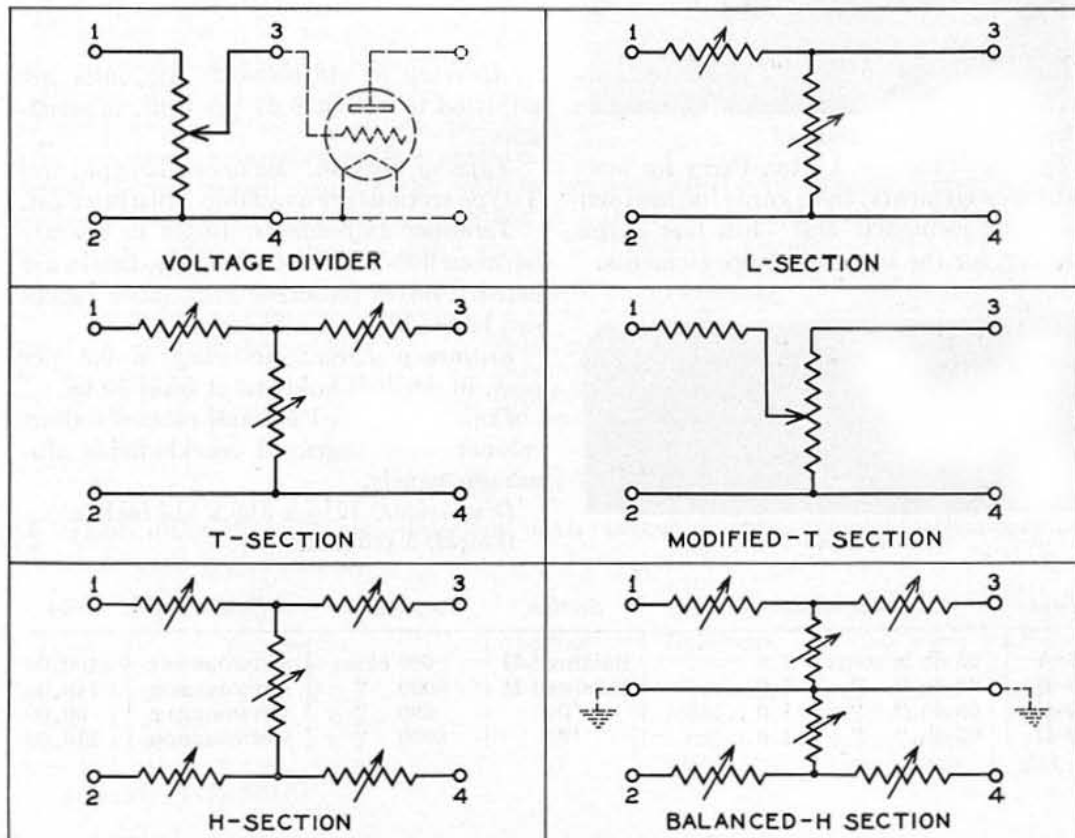
† Shea, op. cit., Chapter IV, pp. 100-121.



TYPES OF SECTIONS—The above figure shows a network working between the *correct* values of terminal impedance, Z_R and Z_S . These *correct* values are such that with Z_R connected, $Z_S = Z_1$ and with Z_S connected, $Z_R = Z_2$. Space does not permit more than a statement of some of the problems involved. For a more extended discussion consult the references.

In the descriptions of the different available types of section note that the “voltage-divider” and the “L-section” maintain constant impedance for all values of attenuation between only one pair of terminals. This means that they must be connected into circuit in the right way and that the effects of incorrect load impedances cannot be predicted from the same simple equations that cover the other networks.

Voltage Divider—This section must work into the grid of a vacuum tube or other high-impedance circuit (i.e., the load must draw no current). When it does, $N = 20 \log_{10} \frac{R}{r}$, where R is the total resistance and r is the portion between terminals 3-4. This expression can be reconciled with the definitions by considering the power in the output circuit of the tube and applying the second (b) definition of power ratio.



L-Section—Since the image impedance Z_2 of such a section varies with the value of N , it must be used with somewhat more care than the other sections in precise measurements.

T-Section—This is the simplest of the networks for general measurement. It can be used wherever unbalances to ground are of no importance. Both its input and output impedances are constant regardless of its setting.

H-Section—This is equivalent to a T-section in each side of the line which helps to minimize any errors due to unbalances to ground. Its impedance is also constant in both directions regardless of its setting.

Balanced-H-Section—Where particular care must be taken to balance both sides of the line to ground, this type of section is helpful. An extra terminal is provided at both ends for the ground or neutral connection.

Modified-T-Section—A T-section in which, to eliminate complications in switching, the resistance of one series arm remains constant over the entire range of attenuation. While the attenuation introduced by this section can be accurately computed, its terminal impedances change somewhat with setting. This does not interfere with the performance of the circuits to which it is connected. It is not suitable for measurement purposes and is used entirely for faders and other volume controls.

TYPE 249 ATTENUATION BOXES

SIX-SECTION MODELS

FOR many types of experimental work an attenuation box having one decibel as the smallest unit is sufficient. These boxes consist of six full sections, any one or all of which may be thrown into circuit by means of low-capacitance key switches. Since each attenuation section is built separately, these boxes have smaller stray admittances and a somewhat better accuracy for large values of attenuation at high frequencies than the TYPE 329 Attenuation Boxes.

Range: See price list. The six sections have, respectively, the following values: 1-2-4-8-16-32 decibels.

Type of Winding: Ayrton-Perry for low-resistance elements; mica cards for medium resistance elements; and "fish line"-type winding, for the high-resistance elements.



TYPE 249-T

Accuracy of Adjustment: All units are adjusted to within 0.25 per cent. in resistance.

Type of Section: Balanced-H-type and T-type sections are available. See price list.

Terminal Impedances: Boxes to operate between 600- and 6000-ohm impedances are listed. Boxes for other impedance values can be made on special order.

Frequency Error: Accuracy of 0.5 per cent. in decibels holds to at least 50 kc.

Finish: Mounted in hand-rubbed walnut cabinet with engraved crackle-finish aluminum panels.

Dimensions: $12\frac{1}{2} \times 5\frac{1}{4} \times 5\frac{1}{4}$ inches.

Weight: 5 pounds.

Type	Attenuation	Section	Impedance	Code Word	Price
249-A	63 db in steps of 1.0	Balanced-H	600 ohms	NETWORKANT	\$100.00
249-B	63 db " " " 1.0	Balanced-H	6000 "	NETWORKBOY	120.00
249-C	63 db " " " 1.0	T	600 "	NETWORKCAT	90.00
249-D	63 db " " " 1.0	T	6000 "	NETWORKDOG	110.00

EIGHT-SECTION MODELS

THESE are similar to the six-section models in every detail except that they are made up with eight sections.

Range: See price list. The eight sections have, respectively, the following values: 1-2-3-4-10-20-30-40 decibels. *Dimensions:* 16 x 5 $\frac{1}{4}$ x 5 $\frac{1}{4}$ inches. *Weight:* 7 $\frac{1}{8}$ pounds.

Type	Attenuation	Section	Impedance	Code Word	Price
249-H	110 db in steps of 1.0	Balanced-H	600 ohms	NETWORKROD	\$120.00
249-J	110 db " " " 1.0	Balanced-H	6000 "	NETWORKPIG	150.00
249-T	110 db " " " 1.0	T	600 "	NETWORKTOP	100.00
249-U	110 db " " " 1.0	T	6000 "	NETWORKEYE	140.00

TYPE 329 ATTENUATION BOXES

BALANCED-H-SECTION MODELS

THESE consist of two adjustable 10-step sections joined in series. The attenuation of each is adjusted by means of a switch which simultaneously introduces the correct amount of resistance in both the series and the shunt arms. The sections are arranged on the decade principle, one controlling large steps of attenuation, the other, small ones. This type of device is much easier and more convenient to operate than those having the key switches.

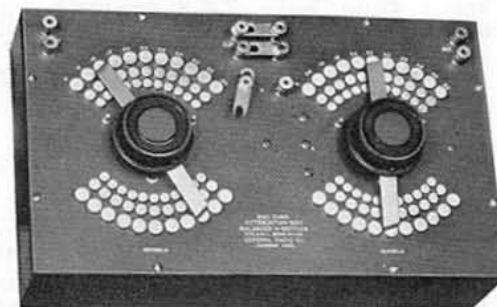
Range: See price list.

Type of Winding: } Same as for
Accuracy of Adjustment: } the TYPE 249
Terminal Impedances: } Attenuation
Boxes.

Type of Section: Balanced-H.

Frequency Error: An accuracy of 0.5 per cent. in decibels holds to at least 50 kc.

Finish: Mounted in hand-rubbed walnut cabinets with engraved bakelite panels. The switches are supplied with a positive detent device, which centers the switch blades on the contact points accurately at each step. This is a decided help when



TYPE 329-J

making rapid routine measurements.

Dimensions: 16 $\frac{7}{8}$ x 10 $\frac{3}{4}$ x 6 inches.

Weight: 12 pounds.

Type	Attenuation	Section	Impedance	Code Word	Price
329-J	55 db in steps of 0.5	Balanced-H	600 ohms	TENUTORPIG	\$155.00
329-L	55 db " " " 0.5	Balanced-H	6000 "	TENUTOREYE	190.00
329-N	22 db " " " 0.2	Balanced-H	600 "	TENUTORBOY	165.00
329-P	22 db " " " 0.2	Balanced-H	6000 "	TENUTORDOG	200.00

H-SECTION MODELS

THESE differ from the ones described in the preceding specifications in that they are made in H-type sections.

Type of Section: H-type.

Type	Attenuation	Section	Impedance	Code Word	Price
329-H	55 db in steps of 0.5	H	600 ohms	TENUTORROD	\$140.00
329-K	55 db " " " 0.5	H	6000 "	TENUTORTOP	185.00
329-M	22 db " " " 0.2	H	600 "	TENUTORANT	145.00
*329-R	22 db " " " 0.2	H	6000 "	TENUTORCAT	220.00

* Formerly, TYPE 329-O.

TYPE 429 ATTENUATION BOXES

THESE are similar electrically and mechanically to the TYPE 329 Attenuation Boxes described in the last section, except that the TYPE 429 Attenuation Boxes are available only in the T-type sections.

The demand for this type of section is not general enough to justify our carrying them in stock. Designs are on file, however, and the boxes can be supplied on short notice.



TYPE 429-H

Range: See price list.

Type of Winding:

Terminal Impedances:

Frequency Error:

Finish:

Accuracy of Adjustment:

} Same as TYPE
329 Attenuation
Boxes

Type of Section: T-type sections only are available.

Dimensions: 14 x 7 x 5 inches.

Weight: 11½ pounds.

Type	Attenuation	Section	Impedance	Code Word	Price
*429-H	55 db in steps of 0.5	T	600 ohms	ADMIT	\$150.00
*429-K	55 db " " " 0.5	T	6000 "	ADOBE	175.00
*429-M	22 db " " " 0.2	T	600 "	ADOPT	175.00
*429-R	22 db " " " 0.2	T	6000 "	ADORE	200.00

* Built to order, not carried in stock.

TYPE 529 ATTENUATION BOXES

THESE replace the TYPE 164 Audibility Meter (now obsolete) which has long been in use for comparing the intensity of two signals by listening test with telephones. The TYPE 529 Attenuation Box may be used in exactly the same way, but the units of comparison are now in decibels instead of the arbitrary "audibility" scale. When finding the audibility of a signal the instrument is inserted in circuit before the telephones. The attenuation is then increased until the signal is reduced to inaudibility. The ratio of the full-volume signal to the inaudible level may then be read on the scale of the instrument in decibels.



TYPE 529-A

Range: See price list.

Type of Winding: Random winding on bakelite cards.

Accuracy of Adjustment: ±0.25 per cent.

Type of Section: Available in the L-type section. See price list.

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

Finish: Mounted in hand-rubbed walnut cabinets with engraved bakelite panels.

Dimensions: 8 x 8 x 4 inches.

Weight: 2¾ pounds.

Type	Attenuation	Section	Impedance	Code Word	Price
529-A	60 db in steps of 2.0	L	600 ohms	ADULT	\$34.00
529-B	60 db " " " 2.0	L	6000 "	AFFIX	34.00

TYPE 452-C VOLTAGE DIVIDER

THIS instrument has a total resistance of 600,000 ohms, tapped for fifteen steps of 2 decibels each. Its extremely high impedance makes it valuable as a multiplier for use with the TYPE 426-A Thermionic Voltmeter. Its impedance is sufficiently high to permit its being bridged across nearly any circuit without causing a noticeable shunting effect.

Range: See price list.

Type of Winding: "Fish line".

Accuracy of Adjustment: ± 0.25 per cent.

Type of Section: Voltage divider.

Terminal Impedances: See price list.

Note that a voltage divider must be worked into an "infinite" impedance.

Frequency Error: An accuracy of 1 per cent. holds to at least 20 kc.

Finish: Hand-rubbed walnut cabinet with bakelite panel, engraved in both decibels and voltage ratio.

Dimensions: 7 x 7 x 5½ inches.

Weight: 4¾ pounds.



Type	Attenuation	Section	Impedance	Code Word	Price
452-C	30 db in steps of 2.0	V.D.	600,000 ohms	VISIT	\$60.00

TYPE 554 VOLTAGE DIVIDER

IT is often convenient to have a potentiometer of high accuracy, such as is obtained by connecting two decade-resistance boxes in series. The TYPE 554 Voltage Divider is the practical equivalent of this arrangement and the switching is so arranged that the total resistance remains constant no matter what proportion of the total resistance is used.

Range: See price list. By adding a resistance of 90,000 ohms in series, the range may be made 0.0001 to 0.1 in steps of 0.0001.

Type of Winding: All windings are wound by the Ayrton-Perry method.

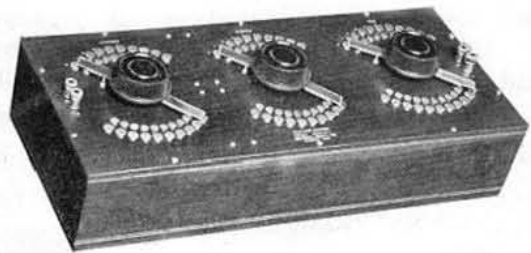
Accuracy of Adjustment: All units are adjusted to within 0.1 per cent. in resistance.

Total Resistance: 10,000 ohms.

Frequency Error: Accuracy of 0.5 per cent. in voltage ratio maintained to at least 30 kc.

Dimensions: 22 x 9½ x 5 inches.

Weight: 15½ pounds.



Type	Attenuation (Voltage Ratio)	Section	Impedance	Code Word	Price
554	0.001 to 1.000 in steps of 0.001	V.D.	10,000 ohms	DEPOT	\$175.00

VOLUME-CONTROL DEVICES

BECAUSE so many factors affect the design and manufacture of volume controls and because the voice-frequency transmission, recording, and projection industries have grown so rapidly, engineers responsible for specifying and installing these devices have had to content themselves with whatever has been available on the market. The

General Radio Company has been studying the requirements of the field and has completed the development of units that meet the most rigid and exacting service requirements. Full details will be given in a catalog supplement which will appear as soon as possible. The new line will include regular volume controls, mixing controls, and faders for sound projection. One of the latter is described here.

There are three primary factors to be considered when specifying volume controls of any kind:

a) The values of terminal impedance which the network (all volume controls are networks, see page 19 et seq.) must match to minimize reflection losses and the frequency discrimination resulting therefrom.

b) The range of attenuation that the volume control must have and the amount of attenuation per step.

c) The type of section (whether voltage divider, L-type, T-type, H-type, etc.) which involves the considerations mentioned in (a) as well as the possibility of crosstalk resulting from line unbalances to ground.

Other conditions which a good volume control must meet include: rugged mechanical design, ease of operation, freedom from reactance and stray admittances in the network, reasonable shielding from electrical disturbances and from dust, freedom from contact and switch noise. The latter is most frequently overlooked, probably because volume controls built from modified radio rheostats have been the cheapest and easiest to secure. (The General Radio Company's experience with sliding contacts on wire justifies the belief that they have no place in a high-grade permanent installation. We can, however, supply them.)

TYPE 598-A FADER

THIS fader is as rugged in construction, convenient to operate, and free from contact noise and service troubles as good workmanship and material can make it. The mounting and switching mechanism will withstand an indefinite amount of ordinary use. The instrument can be supplied either with or without a dummy control. If a dummy control is used, there is no appreciable backlash between the dial of the dummy and master units, because the connecting drive is direct and involves no gears. The resistance units and contacts are carefully shielded to protect them from electrical disturbances and dust.

Range: Fifteen steps on each side of zero, with 2 or 3 decibels per step as specified. *Type of Winding:* Unifilar winding on bakelite cards.

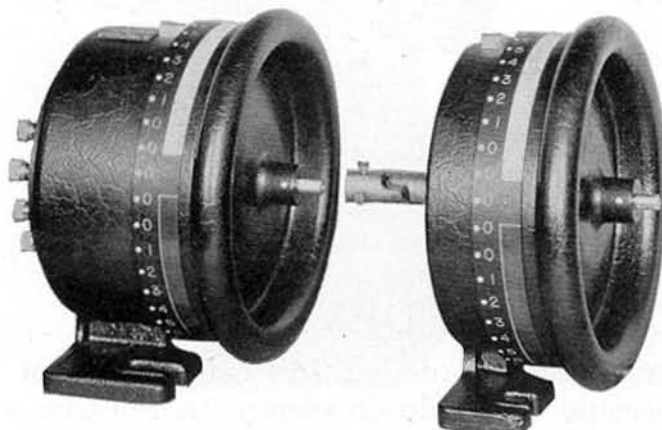
Accuracy of Adjustment: Resistors adjusted to within 0.5 percent.

Type of Section: Modified T-type.

Terminal Impedances: 200 or 500 ohms terminal impedance are the most usual. Can be built for any terminal impedance specified.

Frequency Error: The above-mentioned accuracy holds to at least 10 kc.

Finish: Crackle-finish cast aluminum with an engraved bakelite terminal plate and specially engraved scale with large numerals.



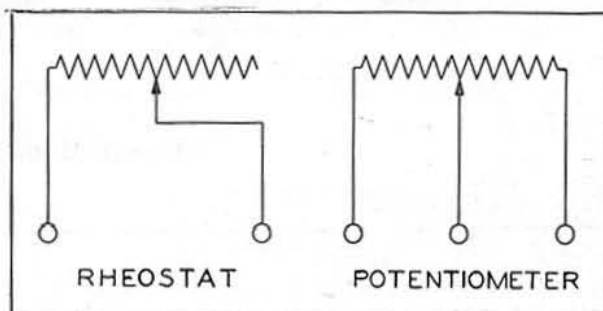
Type	Power Level Range	Section	Impedance	Code Word	Price
598-A	To Order	Modified T†	To Order	.....	.....

† As shown on page 21.

RHEOSTATS AND POTENTIOMETERS

THE ruggedness of these units makes them ideal for general-purpose resistance controls, especially for filament rheostats and volume controls in apparatus using vacuum tubes. Wire of suitable size and resistivity is wound on non-absorbent strips and these are held in place by bases of moulded bakelite. The sliders are designed for positive contact with a minimum of wear.

Their flexibility is an important feature in experimental work. All (except TYPE 410, which is for panel mounting only) may be mounted either on table or panel. When panel-mounted, the resistance of all rheostats decreases for clockwise rotation of the control knob; when table-mounted, the resistance of all rheostats but one* decreases for counter-clockwise rotation, but it is an easy matter to reverse the connections if necessary. Potentiometers used as rheostats will, of course, operate in either direction without changes, inasmuch as a potentiometer is merely a rheostat with a third terminal.



Current-carrying capacities are limited by allowable heat dissipation which is the principal characteristic that distinguishes one type of unit from another. The greater the allowable heat, the larger the winding form required, and, of course, the greater the total resistance that it is possible to secure.

For volume-control use, it is often convenient to make use of a potentiometer whose resistance is not proportional to the angle of rotation. The TYPE 371-T Potentiometer is wound on a tapered strip, the resistance corresponding to any setting being approximately proportional to the square of an angle equal to 80° plus the actual angle of rotation.

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

*TYPE 214, 50-ohm Rheostat.

TYPE 371 POTENTIOMETERS

Maximum Power Dissipation: 25 watts for linear model, 15 watts for tapered model.

Mounting: Supplied for 3-hole panel mounting, but can easily be converted for baseboard mounting. Machine screws, nuts, and drilling template furnished.

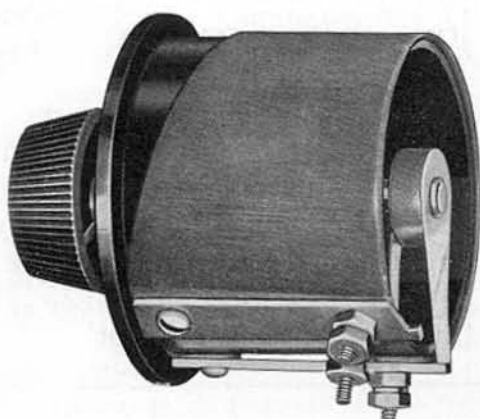
Dimensions: Over all radius including terminals, $1\frac{1}{8}$ inches; depth behind panel, $2\frac{3}{8}$ inches; shaft, $\frac{1}{4}$ inch.

Angle of Rotation: 305° . No "off" position.

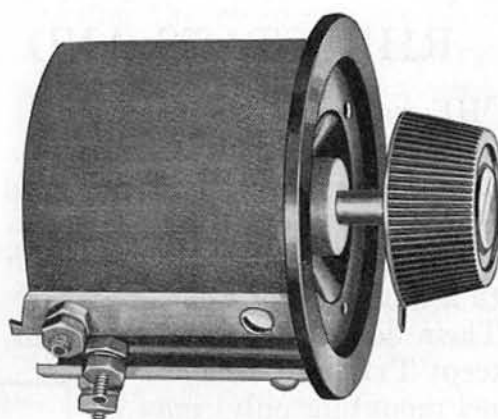
Knob: TYPE 137-D.

Weight: 7 ounces.

(Continued on following page)



TYPE 371-T



TYPE 371

LINEAR MODELS

Type	Total Resistance		Maximum Current	Code Word	Price
371	1	ohm	5 amperes	RALLY	\$5.00
371	5	ohms	2.2 "	RELAY	5.00
371	1000	"	150 milliamperes	REDAN	5.00
371	2500	"	100 "	REFIT	5.00
371	5000	"	70 "	ROTOR	5.00
371	10,000	"	50 "	ROWDY	5.00
371	18,000	"	37 "	RULER	5.00
371	50,000	"	22 "	SATYR	6.50

TAPERED MODELS

Type	Total Resistance		Maximum Current	Code Word	Price
371-T	10,000	ohms	40 milliamperes	SULLY	\$6.00

TYPE 214 RHEOSTATS

Maximum Power Dissipation: 12 watts.

Mounting: Supplied either for 3-hole panel mounting (TYPE 214-A) or for table mounting (TYPE 214-B). One type can be easily converted into the other by the customer. 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, $\frac{1}{4}$ inch.

Angle of Rotation: 300°. No "off" position.

Knob: TYPE 137-D.

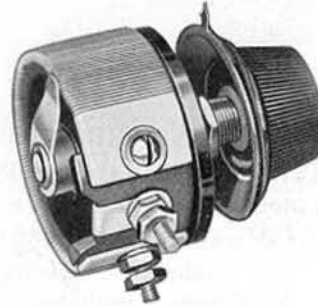
Weight: 7 ounces.

PANEL-MOUNTING MODELS

Type	Total Resistance		Maximum Current	Code Word	Price
214-A	0.75	ohm	4 amperes	SHINY	\$1.75
214-A	2	ohms	2.5 "	RUDDY	1.75
214-A	7	"	1.3 "	RURAL	1.75
214-A	20	"	0.75 ampere	RAZOR	1.75
214-A	50	"	0.50 "	RAPID	1.75
214-A	2500	"	70 milliamperes	SYRUP	2.00



TYPE 214



TYPE 410



TYPE 301

TABLE-MOUNTING MODELS

Type	Total Resistance	Maximum Current	Code Word	Price
214-B	0.75 ohm	4 amperes	SILLY	\$1.75
214-B	2 ohms	2.5 "	RUMOR	1.75
214-B	7 "	1.3 "	RUSTY	1.75
214-B	20 "	0.75 ampere	READY	1.75
214-B	50 "	0.50 "	RAVEL	1.75
214-B	2500 "	70 milliamperes	SYNOD	2.00

TYPE 214 POTENTIOMETERS

TYPE 214 Potentiometers are in every way like the TYPE 214 Rheostats described above except that they are provided with the third terminal. They are likewise available in both panel- and table-mounting models.

PANEL- AND TABLE-MOUNTING MODELS

Type	Total Resistance	Maximum Current	Mounting	Code Word	Price
214-A	400 ohms	175 milliamperes	Panel	ROSIN	\$1.75
214-B	400 "	175 "	Table	ROWEL	1.75

TYPE 301 RHEOSTATS

THESE units are small and occupy little space on the panel or baseboard. Quantities of them are used in General Radio instruments.

Maximum Power Dissipation: 6 watts.

Mounting: Supplied for 2-hole panel mounting, but can easily be converted for baseboard mounting. Machine screws and nuts furnished.

Dimensions: Over all radius including ter-

minals, 1 5/16 inches; depth behind panel, 2 3/8 inches; shaft, 1/4 inch.

Angle of Rotation: 255°. Has "off" position.

Knob: TYPE 137-J.

Weight: 4 ounces.

Type	Total Resistance	Maximum Current	Code Word	Price
301	1.5 ohms	2.0 amperes	PUPIL	\$1.00
301	6 "	1.0 "	PALSY	1.00
301	12 "	0.7 ampere	REMIT	1.00
301	25 "	0.5 "	RENEW	1.00

TYPE 301 POTENTIOMETERS

THESE are in every respect like the TYPE 301 Rheostats described above except that they are provided with the third terminal.

Type	Total Resistance	Maximum Current	Code Word	Price
301	200 ohms	175 milliamperes	REBUS	\$1.00

TYPE 410 RHEOSTATS

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

Maximum Power Dissipation: 6 watts. panel, $2\frac{3}{8}$ inches. Shaft, $\frac{1}{4}$ inch.

Mounting: Single-hole type. Outside diameter of bushing, $\frac{3}{8}$ inch. Maximum thickness of panel, $\frac{3}{8}$ inch. *Angle of Rotation:* 255°. Has "off" position.

Dimensions: Over all radius including terminals, $1\frac{3}{4}$ inches. Depth behind *Knob:* TYPE 137-L. *Weight:* 4 ounces.

Type	Total Resistance	Maximum Current	Code Word	Price
410	0.5 ohm	3.5 amperes	SAVOR	\$1.00
410	1.5 ohms	2.0 "	SAXON	1.00
410	6 "	1.0 ampere	SABOT	1.00
410	12 "	0.7 "	SALON	1.00
410	25 "	0.5 "	SALTY	1.00

TYPE 410 POTENTIOMETER

THIS is identical with the TYPE 410 Rheostats except that it has the third terminal and no "off" position.

Type	Total Resistance	Maximum Current	Code Word	Price
410	200 ohms	175 milliamperes	SATIN	\$1.00

MISCELLANEOUS

THE TYPE 125 Phantom-Antenna Resistors are 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. These instruments are also useful about the laboratory where a reasonably accurate resistor of high current-carrying capacity is required.

TYPE 125 PHANTOM-ANTENNA RESISTORS

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

Accuracy of Adjustment: 0.5 per cent.

Material of Resistor: Constantan ribbon.

Temperature Coefficient: ± 0.002 per cent. per degree C.

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

Finish: All exposed metal parts nickel-plated.

Type	No. of Sections	Resistance per section	Current per section	Dimensions	Weight	Code Word	Price
125-A	4	4 ohms	5 amp.	$7\frac{3}{4}$ x 6 x $4\frac{1}{4}$ in.	$3\frac{1}{4}$ lb.	RAVEN	\$18.00
125-G	2	2 "	15 amp.	$10\frac{3}{4}$ x $7\frac{5}{8}$ x $5\frac{1}{2}$ in.	7 lb.	REBEL	28.00

INDUCTORS

A WIDE variety of fixed and variable inductors is required in the laboratory, both for use in measurements and for general-purpose experimental work. They are listed under the following general headings:

- a) Calibrated Inductors
- b) Experimental Inductors

Filter chokes, radio-frequency chokes, and other accessories are described in the section beginning on page 49.

CALIBRATED INDUCTORS

PERMANENCE, and accuracy of calibration with frequency are the principal requirements of calibrated inductors. The fixed and variable standard inductors listed have been designed with this in mind.

The TYPE 106 Standard Inductances are fixed and are recommended where a bridge with adjustable ratio arms* is available, since it is possible to obtain a more reliable calibration than on an adjustable inductor such as the TYPE 107 Variable Inductor. Where the ratio arms are fixed, the variable inductor must, of course, be used.

* Such as the TYPE 193 Decade Bridge, see page 75.

TYPE 106 STANDARD INDUCTANCES

THE resistance of these instruments is low and constant over a wide frequency range. The resistance at 1000 cycles per second is the same as the direct-current resistance which is entered on a certificate on the bottom of the cabinet.

Construction: Wound with copper wire, separate strands insulated from each other. In order to minimize the effect of external fields, coils are wound in two sections so connected that their external fields oppose. Coils are form wound, bound with tape, and impregnated with wax. There is no metal in the concentrated field of a coil.

Finish: Walnut cabinets with bakelite panels, metal parts nickel-plated.

Dimensions: $5\frac{7}{8}$ x $5\frac{7}{8}$ inches. Depth, see price list.



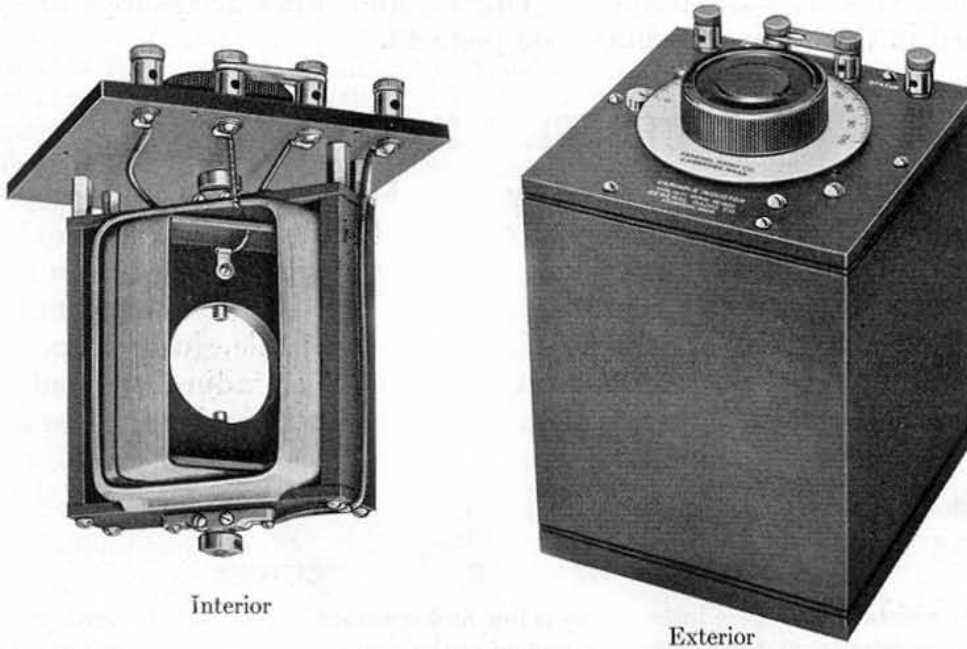
TYPE 106-L

Type	Inductance	Approx. D. C. Resistance	Maximum Current	Accuracy	Depth	Weight	Code Word	Price
106-L	0.1 mlh.	0.18 ohm	3.5 amperes	1.0%	3½ in.	2¾ lb.	INNER	\$25.00
106-G	1.0 mlh.	1.80 ohms	1 ampere	0.1%	3½ in.	2½ lb.	INERT	25.00
106-J	10.0 mlh.	12.2 "	0.5 "	0.1%	3½ in.	2¾ lb.	IRATE	25.00
106-K	100.0 mlh.	85.3 "	250 milliamperes	0.1%	3½ in.	3¼ lb.	ISLET	25.00
106-M	1.0 henry	545.0 "	150 "	0.1%	5⅝ in.	5 lb.	ISSUE	36.00

TYPE 107 VARIABLE INDUCTORS

AN adjustable standard is required where a fixed bridge ratio is used. It permits a more rapid manipulation of the bridge in applications where the less accurate calibration of the adjustable standard is permissible. The TYPE 107 Variable Inductors can be supplied calibrated for use in such bridge circuits. They are also satisfactory for tuning circuits.

Rotor and stator terminals are brought out separately so that the coils may be connected in series or in parallel, or the unit may be used as a variocoupler. The maximum and minimum inductances are supplied with each instrument, but a calibration curve is not furnished except when requested.



TYPE 107-G

Construction: Stranded wire on bakelite forms.

Accuracy: Calibration curve to 1 per cent. supplied on request. The inductance is practically constant for all frequencies up to 50 kc.

Finish: Mounted on bakelite panel in hand-rubbed walnut cabinet.

Dimensions: Panel, 5⁷/₈ x 5⁷/₈ inches. Depth, 8³/₄ inches.

Weight: 5 pounds.

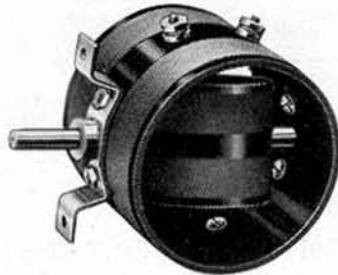
Type	Inductance (Series)		Resistance	Code	Price
	Max.	Min.			
*107-F	0.04 mlh.	0.4 mlh.	.55 ohm	HAPPY	\$27.00
*107-G	0.4 mlh.	4.0 mlh.	6.11 ohms	HARDY	27.00
*107-H	1.8 mlh.	18 mlh.	14.18 "	HAVEN	27.00
	Mounted Calibration Curve			CURVE	5.00

* Calibrations supplied only when ordered. Use compound code words, e.g., HAPPYCURVE, HARDYCURVE, etc.

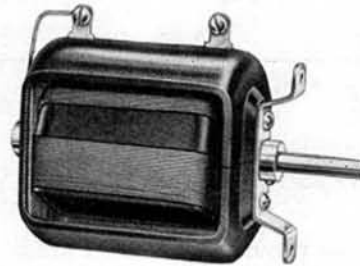
EXPERIMENTAL INDUCTORS

THE TYPE 268 Variocoupler and the TYPE 269 Variometer are ideal for experimental set-ups in the radio laboratory. They are compact, mechanically rugged, and electrically efficient.

The TYPE 577 Inductors are the result of an investigation of losses in coils and coil forms conducted by the General Radio Company several years ago when the "low-loss" coil and condenser craze was at its height. This study showed that the proper ratio of diameter to length and a bakelite coil form gave substantially lower losses than any of the then popular "low-loss" coils. The plug-in bases greatly increase their usefulness. (Note: The TYPE 577 Inductors are the same as the old TYPE 277 Inductors in every respect except arrangement of the holes for mounting pins.)



TYPE 268



TYPE 269

TYPE 268 VARIOCOUPLER

Inductance Values: See table below.
Shaft Diameter: 1/4 inch.

Dimensions: 4 x 4 x 2 1/2 inches.
Weight: 6 ounces.

Type	Stator Inductance	Rotor Inductance	Code	
			Word	Price
268	380 microhenrys	106 microhenrys	VALET	\$2.50

TYPE 269 VARIOMETER

Inductance Values: See table below.
Shaft Diameter: 1/4 inch.

Dimensions: 4 3/4 x 3 x 1 3/4 inches.
Weight: 7 ounces.

Type	Inductance (Series)		Code	
	Maximum	Minimum	Word	Price
269	820 microhenrys	100 microhenrys	VALID	\$3.50

TYPE 577 INDUCTORS

SINGLE-WINDING MODELS

THESE are available in three sizes to meet a need for high-grade tuning inductors for the laboratory.



TYPE 577-D

Inductance: See price list.

Tuning Range: See price list. Values given are maximum and minimum frequencies for inductors when used with 500- μ f variable air condenser.

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: $3\frac{1}{4} \times 3\frac{1}{4} \times 2\frac{1}{4}$ inches.

Weight: 3 ounces.

Type	Inductance	Tuning Range	Turns		Code Word	Price
577-A	16 mlh.	6000-2000 kc.	14	.....	NABOB	\$1.00
577-B	60 mlh.	3000-1000 kc.	27	.....	NABIR	1.00
577-C	190 mlh.	1500- 500 kc.	55	.....	NAIVE	1.15

COUPLING-COIL MODELS

THESE are provided with two windings as specified in the price list. They are similar in all other details to the single-winding models.

Inductance: See price list. Values given are for secondary winding. Values given are for secondary tuned by 500- μ f variable air condenser.

Tuning Range: See price list. Values

Type	Inductance	Tuning Range	Sec. Turns	Pri. Turns		Code Word	Price
577-D	190 mch.	1500- 500 kc.	50	13	.....	NAKED	\$1.15
577-D $\frac{1}{2}$	52 mch.	3000-1000 kc.	26	6	.....	NASAL	1.15
577-D $\frac{1}{4}$	15 mch.	6000-2000 kc.	13	4	.....	NASTY	1.15

UNWOUND MODEL

THIS is provided so that experimenters may wind their own inductors. Specifications are identical with those given for the single-winding models.

Type		Code Word	Price
577-U	.....	NATAL	\$0.70

OSCILLATORS

IN the communication laboratory, oscillators are required for measurement with bridges and other apparatus at a fixed frequency and for observation of characteristics and behavior of apparatus over a range of frequencies. For fixed frequencies in bridge measurements a microphone-driven tuning fork is satisfactory. Variable-frequency oscillators are generally of the vacuum-tube type. A number of such oscillators for specific purposes and frequency ranges are described in the following section. None of them are intended for use as frequency standards; oscillators for that purpose are listed in the section on frequency standards (page 51 et seq.).

The instruments described in this section are listed under the following headings:

- a) Vacuum-Tube Oscillators (Audio- and Low Radio-Frequency)
- b) Vacuum-Tube Oscillators (Radio-Frequency)
- c) Tuning-Fork and Microphone-Button Oscillators

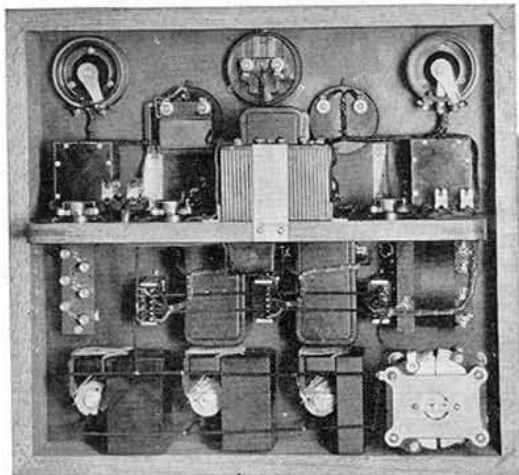
VACUUM-TUBE OSCILLATORS

(AUDIO- AND LOW RADIO-FREQUENCY)

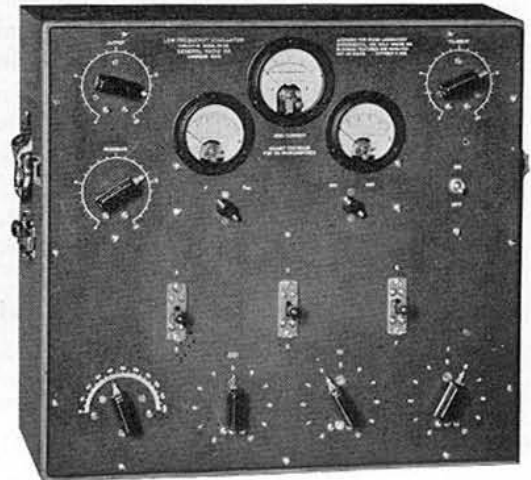
IN this section are described two vacuum-tube oscillators. The one is for general-purpose use throughout the audio- and carrier-frequency spectra; the other is for use at audio frequencies wherever it is desirable to sweep the band with a minimum of adjustments.

TYPE 377-B LOW-FREQUENCY OSCILLATOR

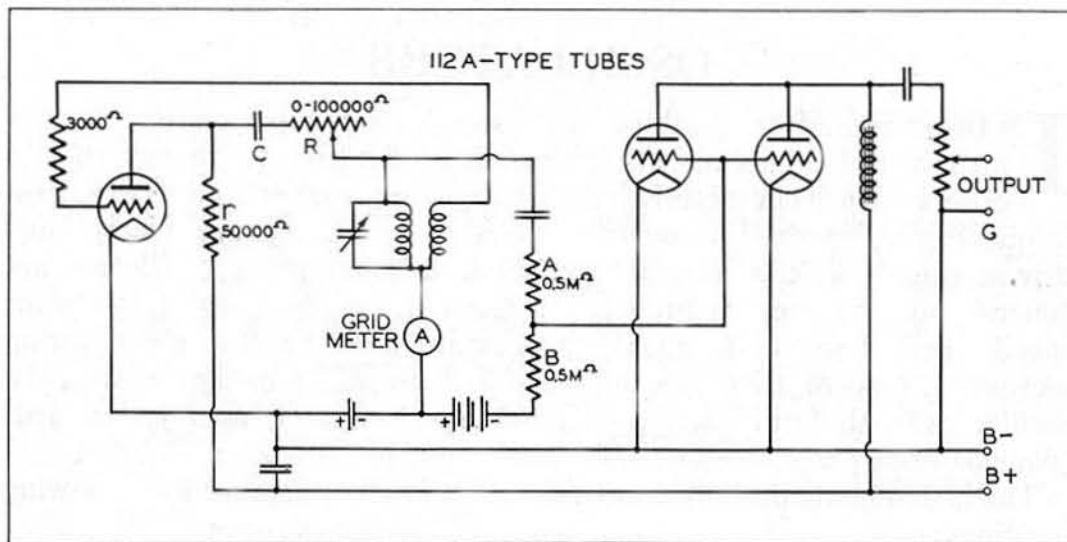
THIS is a vacuum-tube oscillator which covers the audio, carrier, and low radio frequencies. Its frequency stability, low harmonic content, and wide frequency range make it an extremely useful instrument for communication measurements. Among its uses are bridge measurements of all kinds, studies of the response curves of transformers



TYPE 377-B (Interior)



TYPE 377-B (Exterior)



FUNCTIONAL SCHEMATIC OF TYPE 377-B

and loud-speakers, the study of filter characteristics, and the study of cable and other dielectric behavior. The oscillator for the high frequencies is of the tuned-plate type, as shown by the functional circuit diagram. For lower frequencies, the Hartley circuit is used. An amplifier serves both to increase the power output and to isolate the oscillator from the load circuit.

Frequency Range: 25 to 70,000 cycles per second. Can be extended slightly in either direction by a change in construction, information about which will be supplied on application.

Power Output: 50 milliwatts with one amplifier tube; 100 milliwatts with two amplifier tubes. The output may be varied by means of a TYPE 371-T Potentiometer.

Waveform: The maximum harmonic content is in the vicinity of 3 per cent. of fundamental amplitude. Most of it is introduced by the amplifier. By method described in Instruction Book, signal level applied to amplifier may be reduced, which reduces harmonic content to 1 per cent. if load has impedance greater than 8000 ohms.

Calibration: Mounted calibration chart, accurate to 1 per cent., is supplied in duplicate.

Frequency Stability: Changes in tubes and

operating voltages have a minor effect on the frequency, a change of 25 per cent. in plate voltage, for example, producing about 0.1 per cent. change in frequency. Changing tubes causes about the same amount of shift.

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

Tubes: 112-A-type tubes (not included in price of instrument) are used, one as an oscillator and either one or two as amplifiers.

Power Supply: Batteries (not furnished) are used for the power supply. Using three tubes, the total plate current is about 16 milliamperes at 135 volts. The grid-biasing battery is supplied.

Dimensions: 19 1/8 x 18 x 10 1/2 inches.

Weight: 57 pounds.

Type	Frequency Range	Operated	Code Word	Price
377-B	25-70,000 cps.	Batteries	OMEGA	\$350.00

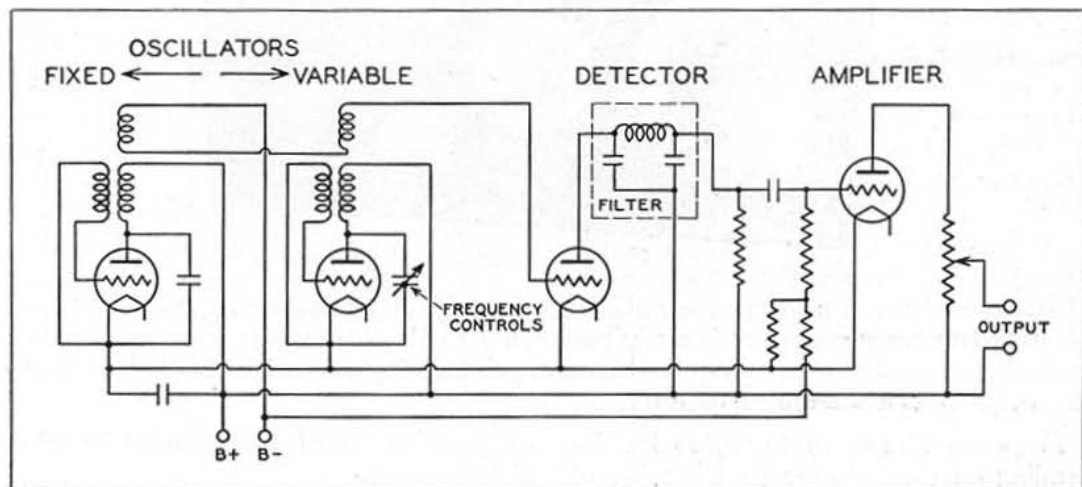
TYPE 413-B BEAT-FREQUENCY OSCILLATOR



THIS oscillator finds its greatest use where it is desirable to move quickly through the audio-frequency range. It is particularly helpful in the study of loud-speaker response curves, since the complete frequency range is available by one-half revolution of the main dial. Peaks or hollows in the loud-speaker response are immediately evident, and any tendency to blast at particular frequencies is quickly revealed. The conventional type of oscillator cannot cover this range without using several controls. Here, however, the desired frequency is obtained by beating together two high-frequency oscillators, a relatively small percentage change in the frequency of one producing a large percentage change in their difference or beat frequency. One control can be used to vary the output over the entire audio-frequency range.

The TYPE 413-B Beat-Frequency Oscillator consists of two oscillators, a detector, and an output amplifier. One oscillator is fixed at approximately 60 kc., the other is variable from approximately 50 kc. to 60 kc. The system of coupling the oscillators to the detector (supplying it with a low voltage from each oscillator) eliminates the tendency of the two to pull into synchronism as zero beat is approached.

(Continued on following page)



FUNCTIONAL SCHEMATIC OF TYPE 413-B

Frequency Range: 50 to 10,000 cycles per second.

Power Output: The output varies from 3.5 to 5 volts over the frequency range. A 10,000-ohm potentiometer is used as a voltage divider to vary the output.

Waveform: The maximum harmonic content is between 10 and 15 per cent. of the fundamental.

Calibration: Accuracy of calibration, 5 per cent.

Frequency Stability: Changes in tubes and battery voltages cause frequency changes, but when one point on calibration curve is made correct by means of zero-adjusting

condenser (by comparison with commercial-frequency power supply, for example), the entire calibration can be relied upon to within 5 per cent.

Mounting: Mounted on engraved aluminum panel finished in black crackle lacquer. Hand-rubbed walnut cabinet. Relay-rack mounting model available on special order.

Tubes: Four 199-type tubes (not included in price of instrument) are required.

Power Supply: Space is provided for both plate and filament batteries inside the cabinet.

Dimensions: 20 x 12 x 8 inches.

Weight: 25½ pounds.

Type	Frequency Range	Operated	Code Word	Price
413-B	50-10,000 cps.	Batteries	ORGAN	\$175.00

VACUUM-TUBE OSCILLATORS

(RADIO-FREQUENCY)

IN this section are described three vacuum-tube oscillators for use as radio-frequency drivers.

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.

Frequency Range: 10 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

on page 40. 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 an auxiliary heterodyne in frequency measurements.

Calibration: No calibrations can be supplied. The instrument is intended to be a

general-purpose laboratory oscillator, not a frequency standard.

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

Tubes: One of 199-type is required.

Power Supply: Battery space provided inside cabinet.

Dimensions: 18 x 9 $\frac{1}{8}$ x 9 $\frac{1}{8}$ inches.

Weight: 13 pounds.

Type	Frequency Range	Operated	Code Word	Price
384	10-20,000 kc.	Batteries	ODIUM	\$90.00

TYPE 584 ALTERNATING-CURRENT PORTABLE RADIO-FREQUENCY OSCILLATOR



THE TYPE 584 Alternating-Current Portable Radio-Frequency Oscillator has the same general characteristics as the TYPE 384 Portable Radio-Frequency Oscillator, except that it is designed for operation from a 110-volt, 60-cycle supply. It delivers a considerably higher output.

Frequency Range: 10 to 20,000 kc. using TYPE 384 Inductors listed on page 40. None are included in price of instrument.

Power Output: No logical basis for rating is available, but an average figure for the power developed in the oscillating circuit over the broadcast band (500 to 1500 kc.) is about 50 milliwatts. This information should serve to classify the oscillator.

Waveform: Harmonics of appreciable amplitude are present in the output. This is an advantage in many types of radio-frequency work.

Calibration: No calibrations can be supplied.

The instrument is intended to be a general-purpose laboratory oscillator, not a frequency standard.

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

Tubes: One 201-A-type tube as a rectifier, one 227-type tube as an oscillator. Neither included in purchase price of instrument.

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

Dimensions: 18 x 9 $\frac{1}{8}$ x 9 $\frac{1}{8}$ inches.

Weight: 22 $\frac{1}{2}$ pounds.

Type	Frequency Range	Operated	Code Word	Price
584	10-20,000 kc.	110 volts, 60 cps., a.c.	OZONE	\$140.00

TYPE 384 INDUCTORS

THESE are intended for use with the TYPE 384 Portable Radio-Frequency Oscillator and the TYPE 584 Alternating-Current Portable Radio-Frequency Oscillator, as specified in the descriptions of those instruments. 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

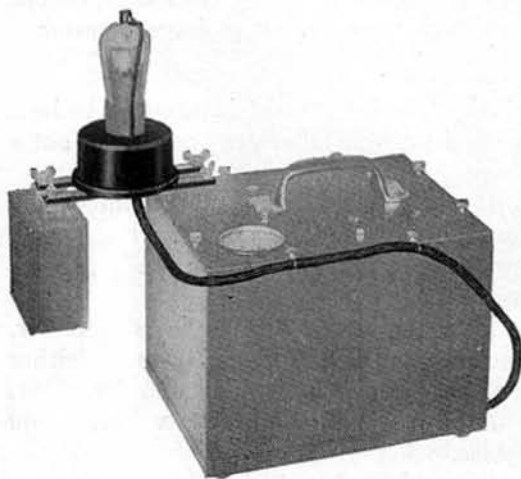
* This has a figure-8 winding, designed to have a minimum external field.

TYPE 423 VACUUM-TUBE OSCILLATOR

THIS is intended for use with the General Radio TYPE 224 Precision Wavemeters and is designed to take the place of the usual connecting bar. It converts the wavemeter from the ordinary resonant-circuit instrument into a heterodyne wavemeter, making it much more useful in laboratory measurements. It makes use of the negative-resistance characteristic of a screen-grid tube when operated at low plate voltage.

Frequency Range: This instrument usually oscillates over the entire range of the TYPE 224-A Precision Wavemeter and from 500 to 6000 kc. using the TYPE 224-L Precision Wavemeter.

Power Output: Adequate for heterodyne driver purposes.



Calibration: This oscillator can be calibrated with the wavemeter with which it is to be used. Further information will be furnished on request.

Frequency Stability: Much better than that of the conventional type using a 3-electrode tube. Compares favorably with a quartz-plate oscillator without temperature control. It is nearly as stable as the tuned circuit itself.

Mounting: The oscillator is mounted on a connecting bar of the type used to connect inductor and condenser in the wavemeter assembly.

Tubes: One tube 224-type is required. Not included in price of instrument.

Batteries: The filament supply may be either alternating or direct current. The plate and screen-grid supplies may be taken from a tapped 90-volt block battery. Cable and supporting clips supplied.

Dimensions: 4 x 6 x 6½ inches.

Weight: 2 pounds.

Type	Code Word	Price
423	ALTER	\$20.00

TUNING-FORK AND MICROPHONE-BUTTON OSCILLATORS

IN this section are described two microphone-button oscillators for use as power sources in bridge measurements and other general-purpose laboratory work.

TYPE 213 AUDIO OSCILLATORS

THE TYPE 213 Audio Oscillators are intended for measurements at fixed frequencies in general, and bridge measurements in particular. They are of the tuning-fork-controlled type, simple and rugged in construction and reliable in operation.

Frequency: Fixed, see price list below.

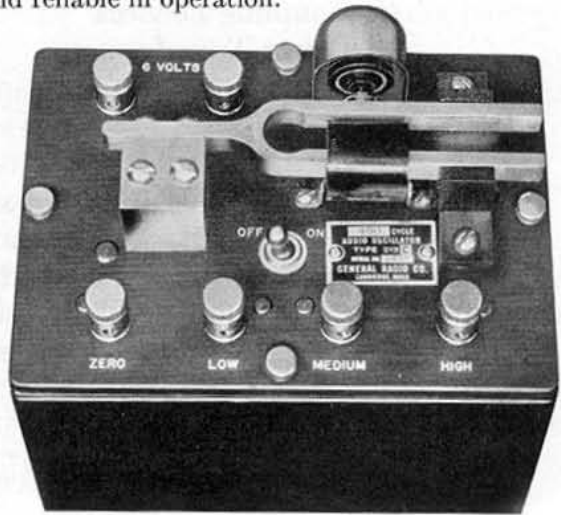
Power Output: 50 milliwatts maximum.

Harmonics: Harmonic content varies with load impedance. Its magnitude is from 3 to 8 per cent. with normal resistive loads.

Frequency Stability: The maximum change in frequency with load is about 0.1 per cent. This and variations introduced by temperature are entirely negligible for practically all bridge measurements. The actual frequency may be less than the rated value by 0.5 per cent. due to loading the fork with the microphone button.

Output Impedance: Three output ranges are provided permitting the use of loads from 20 to 10,000 ohms.

Power Supply: 6-volt battery, 130 milliamperes.



TYPE 213-C

Dimensions: Panel, 6 $\frac{1}{8}$ x 4 $\frac{3}{4}$ inches.

Depth, see price list.

Weight: See price list.

Type	Frequency	Operated	Depth	Weight	Code Word	Price
*213-B	1000 cps.	6 volts, d.c.	5 in.	5 lb.	ANGEL	\$34.00
*213-C	400 cps.	6 volts, d.c.	6 $\frac{1}{8}$ in.	5 $\frac{3}{4}$ lb.	AMUSE	42.00

* Oscillators for any 100-cycle multiple between 400 and 1500 cps. may be built to order. Code words and prices apply only to frequencies here listed.

TYPE 241 MICROPHONE HUMMERS

THIS instrument is of the reed type operated by a microphone button. It is intended for use as a low-power alternating-current source for bridge measurements.

Frequency: About 1000 cycles.

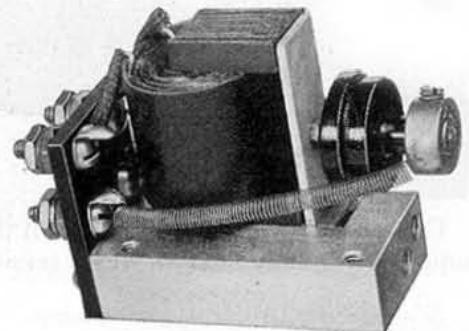
Power Output: About 20 milliwatts maximum.

Power Supply: A 4 $\frac{1}{2}$ -volt battery of the type used as grid-bias batteries in vacuum-tube circuits.

Mounting: Supplied unmounted, #25 holes.

Dimensions: 2 $\frac{7}{8}$ x 1 $\frac{3}{8}$ x $\frac{1}{16}$ inches.

Weight: 1 pound.



TYPE 241-A

Type	Frequency	Operated	Impedance	Code Word	Price
241-A	1000 cps.	4 $\frac{1}{2}$ volts, d.c.	350 ohms	APHIS	\$10.00
241-B	1000 cps.	4 $\frac{1}{2}$ volts, d.c.	4.5 "	APISH	10.00

AMPLIFIERS, COUPLING DEVICES, POWER-SUPPLY DEVICES, AND ACCESSORIES

IN this chapter is described our complete line of amplifiers and accessories. It includes everything needed for the construction of high-quality, low-frequency amplifiers except rheostats and sockets.

This equipment is listed under the following five general headings:

- a) Laboratory Amplifiers
- b) Coupling Devices
- c) Power Transformers
- d) Rectifier Filters
- e) Accessories

LABORATORY AMPLIFIERS

THE laboratory amplifier is one of several developed for experimental work in the General Radio Company's own engineering laboratories.

We are prepared to design and build other amplifiers than the one described and our engineering department is particularly interested in instruments for auxiliary use in alternating-current bridge and photoelectric cell measurements.

TYPE 645 LABORATORY AMPLIFIER

IN order to fill the need for a flexible, portable, general-purpose amplifier useful for laboratory experimenting, the TYPE 645 Laboratory Amplifier has been developed. Designed to operate on 105- to 115-volt, 50- to 60-cycle alternating-current lines, it consists of a two-stage amplifier using the 227-type tube for input and the 245-type for output. The input and interstage coupling units are removable. The base plates which receive these units are provided with jacks to receive the standard General Radio TYPE 274 Mounting Bases described on page 114. Two TYPE 274-HP Transformer-Mounting Bases are supplied to which any type of coupling unit may be attached.



Any type of coupling unit may be used with this amplifier or any part of the amplifier may be isolated and used separately by plugging into the proper terminals. Extra mounting bases should be ordered if more than two coupling units are to be used. The equivalent of a TYPE 587-B Speaker Filter is included so that any desired impedance-matching device may be connected externally.

Care has been taken to protect all parts of the circuit against overloads. The power supply is carefully filtered, which results in a low residual alternating-current hum.

Dimensions: 16 $\frac{3}{4}$ x 8 $\frac{1}{4}$ x 7 inches.

Weight: 18 $\frac{7}{8}$ pounds.

Type	Code Word	Price
*645	AMBLE	\$78.00

* Price includes two TYPE 274-HP Transformer Mounting Bases but no coupling units or tubes.

COUPLING DEVICES

THE group of coupling devices listed below includes instruments to meet nearly all requirements in the audio-frequency range. It includes both input, interstage, and impedance-matching transformers as well as coupling filters for use in coupling vacuum tubes to their output circuits. All of these transformers are sealed in drawn steel cases of the four types shown. Silicon steel cores are used for all types. Silicon steel has been chosen because it is not affected by mechanical shock, is uniform in quality, and heavy current overloads in the windings will not permanently affect it.

The TYPE 585 Amplifier Transformers and TYPE 541 Push-Pull Transformers are made with sectionalized windings. This is done to reduce coil capacitance and to decrease the natural period of the secondary, thus improving their efficiency at higher frequencies.

In the accompanying descriptive data listed, the range of the transformers is that frequency range over which the voltage ratio lies within the limit of ± 20 per cent. of its value over the flat portion of the characteristic. It will be noticed that all of the coupling devices listed adequately cover the audio-frequency spectrum. The impedance ranges listed are the impedance limits for the source out of which the transformer will operate within the specified limits of voltage ratio.

TYPE 285 AMPLIFIER TRANSFORMERS

THESE are inexpensive and satisfactory transformers for experimental installations. While they do not cover the wide frequency range possible with larger and higher priced transformers, they have proved quite successful, especially where a saving of space and weight are important considerations.

Mounting: Mounted in the case shown in illustration.

Dimensions: $2\frac{3}{8} \times 2\frac{5}{8} \times 3\frac{1}{2}$ inches (not described in table of dimensions on page 44).



Type	Use	Voltage Ratio	Range		Primary			Wt.	Code Word	Price
			Frequency	Impedance	Induct.	Max. D.C.	Resistance			
285-D	[1]	1:2.6	75-3200	5000-15,000	40 h.	8 mla.	2200	1½ lb.	TOTEM	\$4.00
285-H	[1]	1:5.9	150-5000	5000-15,000	15 h.	10 mla.	1200	1½ lb.	TOKEN	4.00

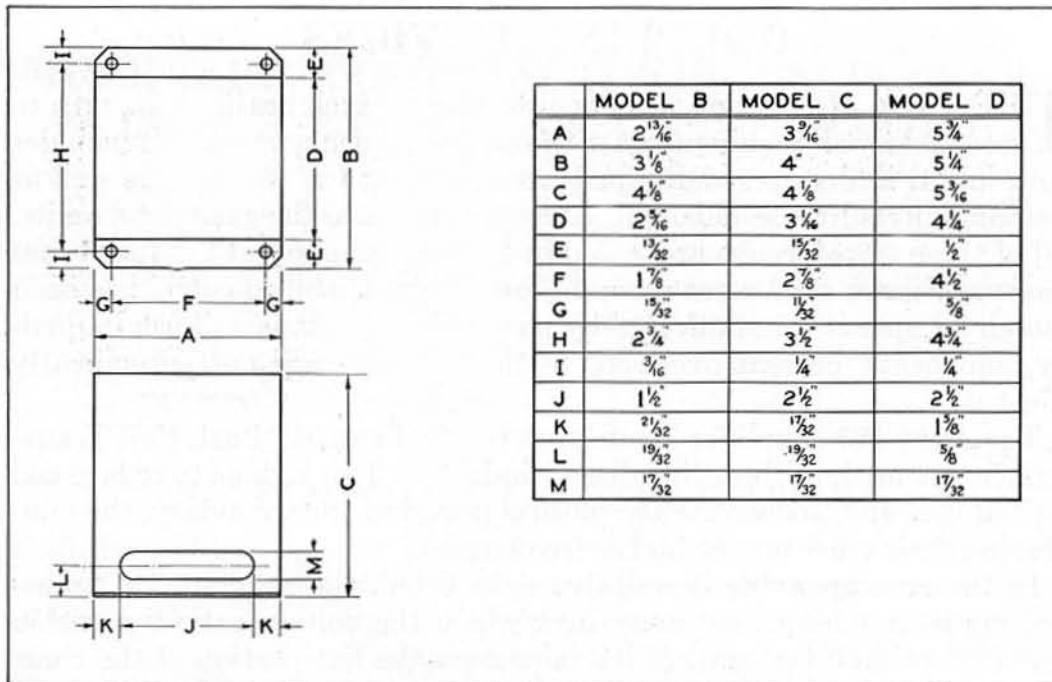
[1] Amplifier input and interstage

TYPE 585 AMPLIFIER TRANSFORMERS

INTERSTAGE-COUPLING MODELS

THESE are high-quality interstage transformers. They have a high primary inductance and low distributed capacitance in the windings. These factors combine to give the transformer a very flat characteristic over the audio range of frequencies. These transformers are recommended for all high-grade radio and public-address installations. They are mounted in Model B cases.

(Continued on following page)



DIMENSIONS OF GENERAL RADIO TRANSFORMER-MOUNTING CASES

LINE-TO-GRID MODELS

SIMILAR in electrical characteristics to the TYPE 585-D and TYPE 585-H, except that the impedance ratio is correct to couple the usual 500-ohm telephone lines to the grid of a vacuum tube, these transformers have a very excellent frequency characteristic. They are mounted in Model B cases.

MICROPHONE-TO-GRID TRANSFORMERS

THESE are high-quality transformers of the proper impedance ratio for coupling low-impedance, 100-ohm microphones to the grid of the first stage amplifier tube. TYPE 585-M Amplifier Transformers are for single microphones, the TYPE 585-M2 Amplifier Transformers have a center-tapped primary winding to permit the use of a double-button microphone. Both transformers have a high-voltage step-up ratio and will carry 100 milliamperes, considerably more current than is usually used in microphone circuits. Both are mounted in Model B cases.

OSCILLOGRAPH-COUPLING MODEL

THIS transformer has a voltage step-down ratio of 18:1 which adapts it for coupling the TYPE 338 String Oscillograph to a vacuum tube. The string circuit has an approximate impedance of 45 ohms. This transformer is designed to work into a load of 30 to 60 ohms. It is mounted in a Model B case.

TUBE-TO-DYNAMIC-SPEAKER MODEL

THIS transformer will operate without impairment of audio quality with a direct current of 55 milliamperes in the primary windings. It is, therefore, adapted for use with any of the power output tubes such as the 245- or 250-types. It has a turns ratio suitable for coupling tubes of this type to low-impedance (5- or 10-ohm) dynamic speakers. It is mounted in a Model B case.

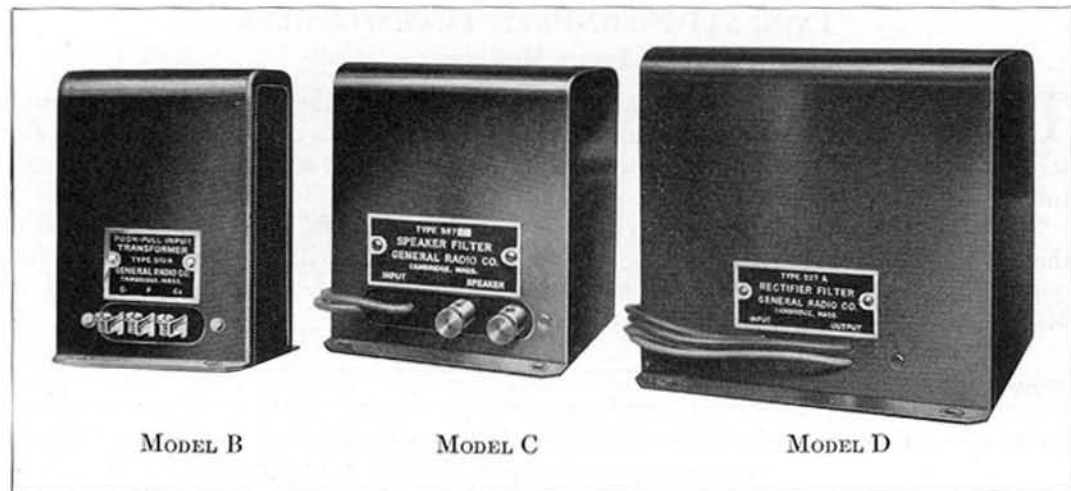


PLATE-TO-LINE MODEL

It is frequently necessary to couple the output of a vacuum tube to a 500- or a 600-ohm telephone line. The TYPE 585-P Plate-to-Line Transformer has been specially designed for this purpose. It is mounted in a Model B case.

Type	Use	Voltage Ratio	Range		Primary			Wt.	Code Word	Price
			Frequency	Impedance	Induct.	Max. D.C.	Resistance			
585-D	[1]	1:2	40-8000	5000-15,000	60 h.	12 mla.	2000	2½ lb.	TIMID	\$7.00
585-H	[1]	1:3	40-6000	5000-15,000	50 h.	12 mla.	2000	2½ lb.	TIPSY	7.00
585-M	[2]	1:15	40-5000	50-150	0.65 h.	100 mla.	20	2¾ lb.	TARDY	10.00
585-M2	[3]	1:11	80-10,000	150-250	2.4 h.	100 mla.	32	2¾ lb.	TARRY	10.00
585-G	[4]	1:10	25-5000	400-600	4.8 h.	30 mla.	80	2 lb.	KIOSK	12.00
585-O	[5]	25:1	60-6000	2000-6000	20 h.	55 mla.	464	2¼ lb.	TITLE	7.00
585-P	[6]	5:1	60-6000	5000-15,000	66 h.	10 mla.	1250	2 lb.	KORAN	12.00
585-N	[7]	18:1	60-5000	5000-15,000	40 h.	10 mla.	500	2¾ lb.	OBESSE	8.00

[1] Amplifier input and interstage

[2] Amplifier input, single-button microphone-to-grid

[3] Amplifier input, double-button microphone-to-grid

[4] Amplifier input, line-to-grid

[5] Amplifier output, plate-to-low-impedance speaker

[6] Amplifier output, plate-to-line

[7] For use primarily as an impedance-matching transformer with the TYPE 338 String Oscillograph

TYPE 573-A RESISTANCE-IMPEDANCE COUPLER

WHEN it is desired to build an amplifier having an exceptionally good frequency characteristic, it is often accomplished by using impedance coupling. The TYPE 573 Resistance-Impedance Coupler has been built up to furnish such a compact unit. It consists of a 400-henry inductance coil and a 1-megohm resistance coupled by a 0.2- μ f condenser. The voltage ratio of such an arrangement between input and output is unity, and the frequency characteristic is practically flat from 30 to 10,000 cycles. It is mounted in a Model C case.

Type	Use	Voltage Ratio	Range		Primary			Wt.	Code Word	Price
			Frequency	Impedance	Inductance	Max. D.C.	Resistance			
573-A	[1]	1:1	30-10,000	2000-20,000	400 h.	12 mla.	8500	3 lb.	JOLLY	\$10.00

[1] Amplifier input and interstage

TYPE 541 PUSH-PULL TRANSFORMERS

INPUT MODELS

THE push-pull connection is becoming almost universal for the output circuits of audio amplifiers. This connection results in the elimination of a considerable part of the second harmonic distortion that results when approaching the overload point of a single tube.

The windings of these transformers have been split into several sections and arranged so that each half of the double secondary has an equal coupling with the primary. The frequency and performance characteristics are unusually good. They are mounted in Model B cases.

Type	Use	Voltage Ratio	Range		Primary			Wt.	Code Word	Price
			Frequency	Impedance	Induct.	Max. D.C.	Resistance			
541-A	...	1:3	40-8000	2500-15,000	42.8 h.	10 mla.	1750 ohms	2¼ lb.	TALLY	\$7.50

OUTPUT MODELS

THESE two transformers have been designed for coupling the usual amplifier output tubes such as the 245-, 210-, or 250-types in the push-pull arrangement to their output circuits. The TYPE 541-B model is built with the auto-transformer connection for use with a magnetic (high-impedance) speaker. The direct current is eliminated from the speaker windings by two 4- μ f condensers. It is mounted in a Model C case.

The TYPE 541-C model has two windings with the proper turns ratio for use with the dynamic (low-impedance) speaker. It is mounted in a Model B case.

The primary windings are adequately built to carry the plate current of the larger size tubes. When used in conjunction with the TYPE 541-A Push-Pull Input Transformer, a high-quality push-pull amplifier with an exceptionally flat frequency characteristic results.

Type	Use	Voltage Ratio	Range		Primary*			Wt.	Code Word	Price
			Frequency	Impedance	Induct.	Max. D.C.	Resistance			
541-B	...	1.2:1	60-10,000	2500-15,000	15.0 h.	45 mla.	375 ohms	3 lb.	TORSO	\$7.50
541-C	...	35:1	30-10,000	2500-15,000	19.0 h.	45 mla.	375 "	3 lb.	TAPER	7.50

* Data is for one section of the double winding.

TYPE 359 VARIABLE-RATIO 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; also necessary in order to terminate calibrated networks properly so that the calibration will be correct.

The TYPE 359 Variable Ratio Transformers are provided with secondaries tapped at seven places. The turns ratio is conveniently varied by means of the switch on which is engraved the secondary-to-primary turns ratio. These transformers are available in several models for different types of winding, impedance, and turns ratio as listed below. All are provided with jack-top binding posts to fit the TYPE 274 Plugs, which feature facilitates circuit changes. They are mounted in Model C cases and weigh 3½ pounds.

TWO-WINDING MODELS

Type	Voltage Ratio	Range		Primary			Code Word	Price
		Frequency	Impedance	Inductance	Max. D.C.	Resistance		
359-A	[1]	40-4000	5000-20,000	10.3 h.	15 mla.	700 ohms	PILOT	\$20.00
359-B	[2]	30-5000	5000-20,000	10.3 h.	15 mla.	700 "	PIOUS	20.00
359-E	[1]	40-4000	500- 600	0.7 h.	40 mla.	41 "	POKER	20.00
359-F	[2]	30-4000	500- 600	0.7 h.	40 mla.	28 "	POLAR	20.00

AUTO-TRANSFORMER MODELS

Type	Voltage Ratio	Range		Primary			Code Word	Price
		Frequency	Impedance	Inductance	Max. D.C.	Resistance		
359-C	[1]	30-5000	5000-20,000	12.0 h.	15 mla.	470 ohms	PIVOT	\$20.00
359-D	[2]	40-4000	5000-20,000	12.0 h.	15 mla.	500 "	PLAZA	20.00
359-G	[1]	30-10,000	500- 600	0.7 h.	40 mla.	20 "	POLKA	20.00
359-H	[2]	30-10,000	500- 600	0.7 h.	40 mla.	20 "	POPPY	20.00

[1] Voltage ratio, secondary to primary: 0.25, 0.35, 0.5, 0.7, 1.0, 1.4

[2] Voltage ratio, secondary to primary: 0.06, 0.09, 0.13, 0.18, 0.25, 0.35

TYPE 166 TELEPHONE TRANSFORMERS

SIMILAR in use to the TYPE 359 Variable-Ratio Transformers, the TYPE 166 Telephone Transformer is particularly useful for bridge balancing when telephones are used for null detection. With this transformer it is possible to adjust the impedance of the detector circuit independent of the telephone-receiver impedance.

Taps are brought out to binding posts for both the primary and secondary windings so that the number of turns on either can be changed. The turns are engraved on the bakelite panel carrying the binding posts. Primary: 150, 300, 600. Secondary: 1200, 2400, 4800.

Mounting: Core supported in brackets without a case. *Weight:* 2 pounds.

Type	Frequency Range	Code Word	Price
166	150-5000 cps.	TOPIC	\$7.00

TYPE 387-A SPEAKER FILTER

THIS speaker filter is well suited for coupling the 112- or 171-type tube to its output circuit so that the plate current of the tube is eliminated from the windings of the speaker. This is an inexpensive instrument admirably suited for this type of work.

Weight: 2½ pounds.

TYPE 587-B SPEAKER FILTER

THIS speaker filter consists of a high-inductance winding constructed to carry the plate current of the 245-, 210-, or 250-type tubes. The direct current is kept from the speaker windings by two condensers of 4 µf each, which isolate both ends of the inductance from the speaker circuit, eliminating the danger of short circuit of the plate voltage in case either of the speaker windings becomes grounded.

Weight: 4 pounds.

TYPE 587-C SPEAKER FILTER

THIS instrument is built to carry an even higher plate current than the TYPE 587-B model, the relative current-carrying capacities being given in the table below. The coil inductance is consequently slightly less. The direct current is eliminated from the speaker windings in this filter by means of a single 4-µf condenser located at the high side of the windings. Care must be taken in using this speaker filter, since a ground in the reproducer circuit will short-circuit the plate-supply voltage. However, due to the fact that a series capacitance of 4 µf is in the speaker circuit, the TYPE 587-C Speaker Filter has a lower frequency range than the TYPE 587-B model.

Weight: 4¼ pounds.

Type	Range		C	Choke			Case	Code Word	Price
	Frequency	Impedance		Inductance	Max. D.C.	Resistance			
387-A	30-10,000	1500-7500	2 µf	30 h.	30 mla.	550	B	TOWEL	\$4.50
587-B	50-10,000	1500-5000	2 µf	30 h.	75 mla.	550	C	FATAL	9.00
587-C	40-10,000	1500-5000	4 µf	100 h.	100 mla.	700	C	FAVOR	8.00

POWER TRANSFORMERS

POWER transformers suitable for use with power-supply systems for all types of tubes used in radio receiver- and low-power-transmitter design are listed below.

TYPE 565 TRANSFORMERS

THESE are designed to supply plate and filament power for the 210- and 250-types of tube. They are supplied with an auxiliary filament winding for operating the 281-type rectifier tube, and are designed for operation from 105- to 115-volt, 50- to 60-cycle lines. They have a power rating of 200 watts. They are mounted in Model D cases.

HALF-WAVE MODEL

Type	Secondary I		Secondaries II & III		Secondary IV		Power	Weight	Code Word	Price
	Volts	Amp.	Volts	Amp.	Volts	Amp.				
565-A	600	0.2	7.5	2.5	2.25	4	200 watts	14¼ lb.	TABOO	\$13.50

FULL-WAVE MODEL

Type	Secondary I		Secondaries II & III		Power	Weight	Code Word	Price	
	Volts	Amp.	Volts	Amp.					
565-B	600-0-600	0.2*	7.5	2.5	200 watts	14¼ lb.	TACIT	\$13.50

* For two windings in parallel as used with full-wave rectifier.

TYPE 545 TRANSFORMERS

THESE are designed to supply the plate and filament power for the 245-type tube. They are provided with an auxiliary winding for the filament of the 280-type rectifier tube. They have a power rating of 70 watts and are designed to operate from a 105- to 115-volt line at 50 to 60 cycles. When heavy current drain or high resistance in the filter circuit make a higher transformer voltage advisable, the TYPE 545-B Transformer is recommended. They are mounted in Model D cases.

Type	Secondary I		Secondary II		Secondary III		Power	Weight	Code Word	Price
	Volts	Amp.	Volts	Amp.	Volts	Amp.				
545-A	300-0-300	0.08*	2.5	3.25	5.0	2.0	70 watts	4¾ lb.	POSSE	\$10.00
545-B	350-0-350	0.08*	2.5	3.25	5.0	2.0	70 "	5 lb.	PRIOR	10.00

* For two windings in parallel as used with full-wave rectifier.

TYPE 540 FILAMENT TRANSFORMER

THE heater-filament voltage for the popular 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 about ten of these tubes in parallel. Two 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 & II		Power	Weight	Code Word	Price
	Volts	Amp.				
540	2.5†	8	70 watts	5 lb.	TRIAD	\$10.00

† With center tap.

RECTIFIER FILTERS

THE equipment described in this section is intended for smoothing the output of a power transformer and rectifier so that it may be used for the plate supply of vacuum tubes. The inductors are conservative in rating and have the specified inductance at rated current.

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.

Inductance per Section: 15 henrys.

Voltage Rating of Condensers: 1000 volts.

Direct-current Resistance per Section: 175 ohms.

Current Rating of Inductors: 100 milliamperes.

Capacitance: 4-2-4 μ f.

Dimensions: Model D case. See table.

Weight: 9½ pounds.

Type	Inductor L			Condenser C		Code Word	Price
	Inductance	Max. Current	Resistance	Capacitance	Maximum Voltage		
527-A	15 h.	100 mla.	175 ohms	4-2-4 μ f	1000 volts	FATTY	\$17.50

TYPE 366 FILTER CHOKE

THIS consists of two inductors suitable for connection in a two-section filter of the type commonly used for smoothing filters. No condensers are included.

Inductance per Section: 20 henrys.

Current Rating of Inductors: 50 milliamperes.

Direct-current Resistance per Section: 350 ohms.

Dimensions: Model D case. See table.

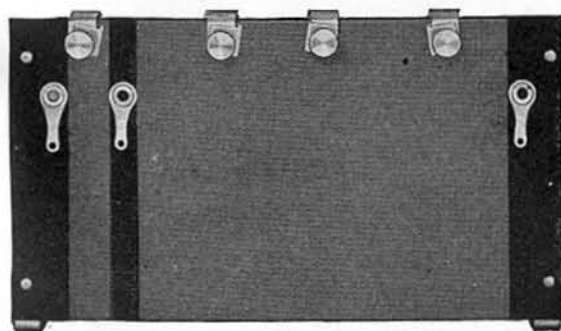
Weight: 4¾ pounds.

Type	Inductance	Max. Current	Code Word	Price
366	20 h. per choke	50 mla.	TEPID	\$5.00

ACCESSORIES

IN this section are described radio-frequency chokes, voltage dividers for the adjustment of output voltages on power-supply units, and center-tap resistors for use with alternating-current tubes. Sockets and rheostats are described elsewhere.

TYPE 446 VOLTAGE DIVIDER



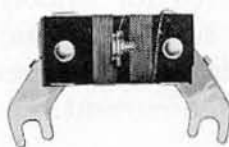
THE output of a plate-power supply for experimental work must be adjustable to meet a wide variety of tube conditions. The TYPE 446 Voltage Divider provides three adjustable voltages in the plate-supply sections, and one adjustable grid-bias voltage. Extra sliders may be purchased.

Resistance: Plate Section, 15,000 ohms; Grid Section, 1500 ohms.

Dimensions: 7½ x 4 5/16 x 1¼ inches.

Weight: 5 ounces.

Type	Total Resistance	Maximum Current	Code Word	Price
446	1500-0-1500 ohms	20 milliamperes	VISTA	\$2.75
446-P1	Extra Slider			0.10



TYPE 437



TYPE 439



TYPE 379

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 unit of hum by this means.

Characteristics: See price list.

Weight: 1 ounce.

Type	Total Resistance	Maximum Current	Center Tap	Code Word	Price
437	60 ohms	200 milliamperes	Fixed	PERIL	\$0.50
439	60 "	200 "	Adjustable	PASTY	0.35

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 $4\mu\text{f}$. Either model is suitable for use in circuits having a frequency up to 15,000 kc.

Dimensions: $2 \times 1\frac{3}{4} \times 1\frac{3}{4}$ inches.

Weight: 6 ounces.

Type	Frequency Range	D.C. Resistance	Allowable Current		Inductance	Code Word	Price
			Intermit.	Continuous			
379-T	1875-15,000 kc.	35 ohms	300 mla.	140 mla.	8 mlh.	JIMMY	\$1.25
379-R	470-15,000 kc.	140 "	90 mla.	65 mla.	60 mlh.	JEWEL	1.25

FREQUENCY- AND TIME-MEASURING DEVICES

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 (described below) is an example of this idea.

Developments in this field have been so rapid that it is possible to catalog only those items which have general application in many problems. Laboratories and others interested in particular phases of frequency or time measurements are reminded that work on new methods and equipment is in progress and that we are prepared to develop and manufacture special-purpose equipment to order.

There has, for example, been a demand for temperature-control units for use only with piezo-electric quartz plates, but we are prepared to build such units for use with other devices as well. We have also been investigating the frequency stability of various forms of vacuum-tube-driven tuning forks. Anyone interested is requested to communicate with our engineering department. Specific inquiries on all phases of frequency and time measurement are invited.

The items here listed are described under the following group headings:

- a) Standard-Frequency Assemblies
- b) Piezo-Electric Oscillators and Accessories (Including Temperature-Control Equipment)
- c) Magnetostriction Oscillators
- d) Precision Wavemeters
- e) Experimental Wavemeters
- f) Time-Measuring Devices

STANDARD-FREQUENCY ASSEMBLIES

THE standard-frequency assembly places within the reach of every laboratory a large number of standard frequencies throughout the entire communication-frequency spectrum, each of which is known with an accuracy of one part in a million or better. An assembly of the type here described was operated in the General Radio laboratories and had, for the two months preceding the appearance of this catalog, a maximum deviation from its average frequency of only five parts in ten million, as determined by the corrected time signals transmitted by the U. S. Naval Observatories.

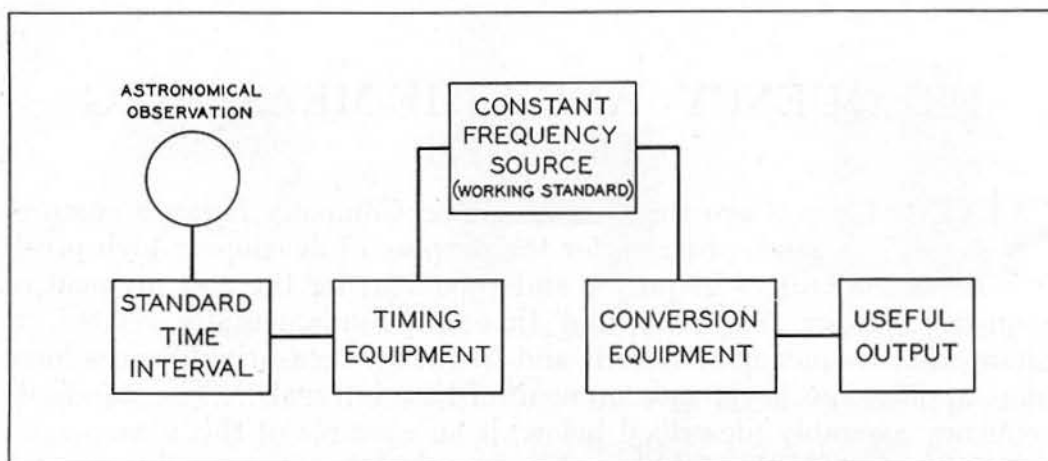


FIGURE 1

The determination of the frequencies is made with reference to the rotational frequency of the earth as the standard, by means of radio (or other) time-signal transmissions sent out by the observatories of various nations. The principles involved are simple and the equipment is rugged, easy to operate, and comparatively inexpensive.

Figure 1 is an outline chart, which shows without confusing detail the basic principles of the standard-frequency assembly. A source of radio-frequency voltage is first established, the frequency of which is nearly enough constant to justify the statement that its instantaneous frequency deviates from its mean frequency by a negligibly small amount. A means is next provided for counting the number of oscillations executed by this frequency standard during a standard time interval, which, for convenience, may take the form of a clock. The time interval for measurement is taken as the Mean Solar Day. The total number of oscillations executed by the standard in one Mean Solar Day, divided by the number of seconds in the day, gives its mean frequency in cycles per second.

In order that we may secure the output frequencies needed for use in the laboratory, we utilize the conversion equipment which is necessary for the reduction of the frequency of the working standard to the value employed in operating a synchronous-motor-driven clock. This equipment merely derives the desired frequencies (which may be expressed as harmonics and subharmonics of the frequency of the working standard) by frequency multiplication and division.

Figure 2 shows in more detail the actual standard-frequency assembly here catalogued. The *working standard* is a temperature-controlled piezo-electric quartz-crystal oscillator. The frequency of the working standard is, for convenience, chosen as any multiple of 10 kc. between 50 and 100 kc. For special work, other frequencies may be more suitable. Both the *timing* and *conversion* functions are performed by two *multivibrators* operating as frequency dividers, at fundamental frequencies of 10 kc. and 1 kc. respectively, under the direct and absolute control of the working-standard oscillator. The 1-kc. output voltage of the second multivibrator is amplified to operate a synchronous-motor-driven clock which is so geared that when the driving voltage has a frequency of exactly 1-kc., the clock

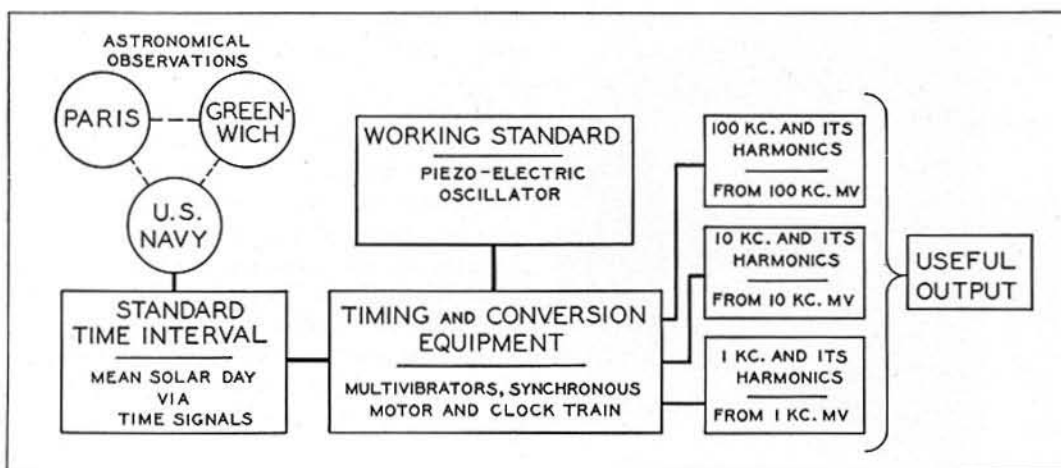


FIGURE 2

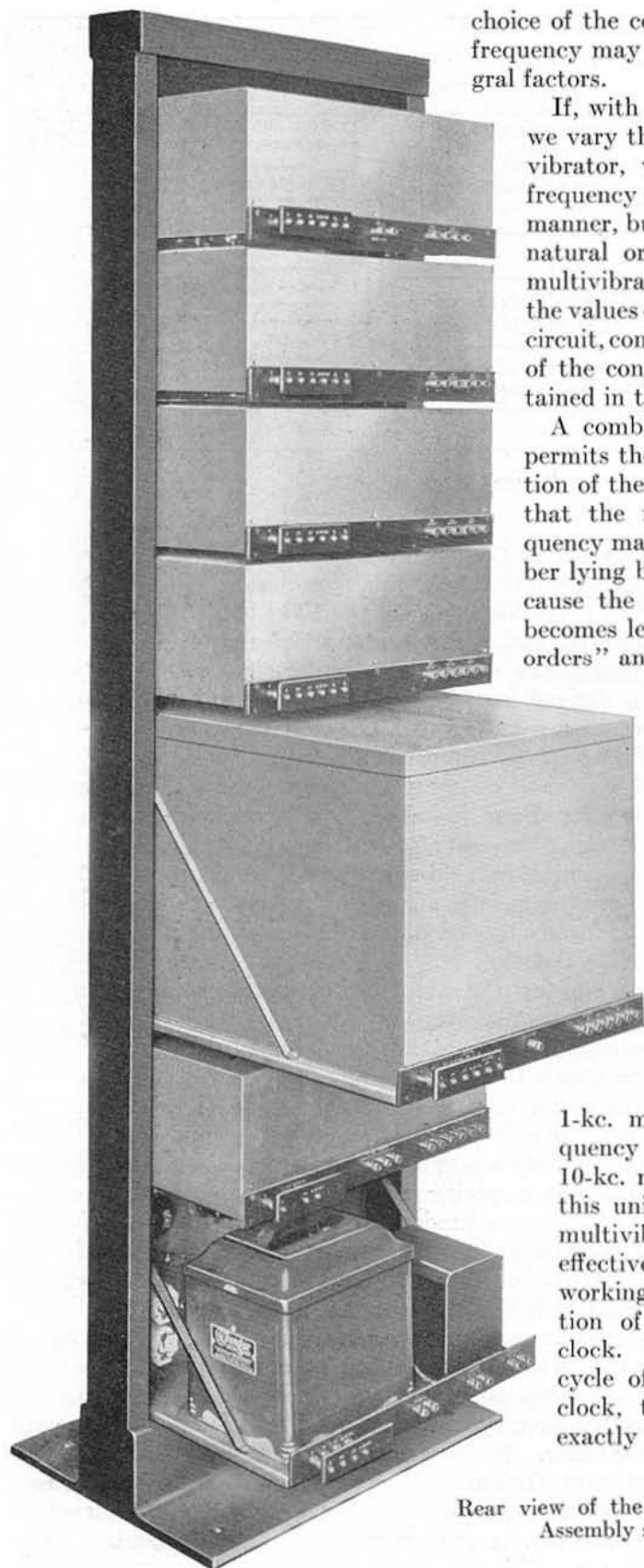
keeps correct time. A means of comparing the indicated clock time with standard time as given by radio or other time signals completes the timing sequence.

The "useful output" is derived from the harmonics of the 10-kc. and 1-kc. multivibrators as well as from the harmonics of a third multivibrator which may be operated at a fundamental frequency equal to that of the working-standard oscillator. Since each of the "useful output" frequencies is derived from the working standard by harmonic frequency multiplication and division, each is known with the same percentage accuracy as that with which the frequency of the working standard is known.

The only parts of the standard-frequency assembly that may cause confusion are the multivibrators, although this device has been described by a number of investigators. The multivibrator is one form of a relaxation oscillator and in one of its simplest forms is nothing more than a resistance-capacitance-coupled amplifier with the output connected back to the input. Under these conditions, the amplifier "motor-boats" or oscillates violently at a frequency determined mainly by the values of the coupling resistances and capacitances. The device has no "LC" circuit.

If the circuit constants are adjusted so that the multivibrator operates at approximately a given frequency, the introduction of a small harmonic voltage into the circuits of a frequency equal to that of the multivibrator fundamental or one of its multiples will cause the multivibrator frequency to fall into step with the controlling frequency either at a value equal to the frequency of the controlling voltage or a submultiple of this frequency. The introduced harmonic voltage actually controls the frequency of the multivibrator and this condition may be maintained in suitably arranged circuits over a long period of time. This process is perhaps best illustrated by a specific example.

Suppose that the multivibrator alone has a fundamental frequency of *approximately* 1 kc. and that we introduce a harmonic voltage from an ordinary oscillator having a fundamental frequency of 10.00 kc. On introducing a small voltage from the oscillator, we find that the multivibrator frequency may shift slightly, but careful measurement will show that this frequency is now exactly 1.000 kc. and that we can change the magnitude of the harmonic voltage and the values of the circuit constants of the multivibrator by comparatively large amounts *without* changing its frequency. Under these conditions, the 10th harmonic of the multivibrator has been synchronized with and is under the absolute electrical control of the 10.00-kc. oscillator. Suppose now that we increase the magnitude of the controlling voltage to a point where the multivibrator frequency suddenly shifts to a new value. We find that the multivibrator frequency is now one-ninth the frequency of the controlling oscillator, or, in other words, its ninth harmonic is under the control of the fundamental frequency of the oscillator. This operation may be extended, and by proper



choice of the control voltage the multivibrator frequency may be divided by a variety of integral factors.

If, with a given value of control voltage we vary the circuit constants of the multivibrator, we find that the multivibrator frequency does not change in a continuous manner, but in steps. For example, as the natural or uncontrolled frequency of the multivibrator is increased by reducing the values of resistance or capacitance in the circuit, control at one-ninth, one-eighth, etc., of the controlling frequency would be obtained in the example given above.

A combination of these two variations permits the choice of the controlled operation of the multivibrator in such a manner that the multivibrator fundamental frequency may be divided by any whole number lying between one and about 50. Because the controlled multivibrator action becomes less stable at the higher "control orders" and because the decimal system is convenient in furnishing "useful output" frequencies, the frequency-dividing multivibrators in the standard-frequency assembly are operated with "control orders" of 10 when the working standard has a frequency of 100 kc. In this manner, the 10-kc. multivibrator operates at exactly one-tenth of the working-standard frequency and provides a series of harmonics spaced 10 kc. apart on the frequency scale. In turn, the

1-kc. multivibrator operates at a frequency exactly one-tenth that of the 10-kc. multivibrator, and harmonics of this unit are also available. The two multivibrators, then, taken together, effectively divide the frequency of the working standard by 100 for the operation of the synchronous-motor-driven clock. Under these conditions, for each cycle of the frequency applied to the clock, the standard crystal executes exactly 100 oscillations.

Rear view of the Class C21-H Standard-Frequency Assembly shown on the opposite page

A complete standard-frequency assembly which experience has shown to be of general laboratory use may be purchased as a single assembly of units, complete, but without either tubes or batteries. It is given the designation "Class C21-H" and is illustrated in the accompanying photograph. Adaptations of this standard-frequency assembly are easily made by the omission or insertion of special units. Communications addressed to our engineering department relative to any special applications will receive prompt attention.

A Class C21-H Standard-Frequency Assembly includes the following units, each of which is described on the page indicated:

<i>Item</i>	<i>Reference</i>
1—TYPE 576-A Quartz Bar (and Holder).....	page 63
1—TYPE 590 Piezo-Electric Oscillator.....	page 59
1—TYPE 591 Temperature-Control Unit.....	page 61
3—TYPE 592 Multivibrators.....	page 56
1—TYPE 593 Timing Unit.....	page 73
1—TYPE 594 Heat-Control Unit.....	page 62
1—TYPE 595 Power-Supply Unit.....	page 56
1—TYPE 480 Relay Rack.....	below
Price, without tubes or batteries....	\$1,860.00

TYPE 480 RELAY RACK

THIS is similar to the Western Electric Company's 101-A pattern for mounting standard 19-inch panels. Mounting screws, washers, and bridle rings for cabled wiring are supplied.

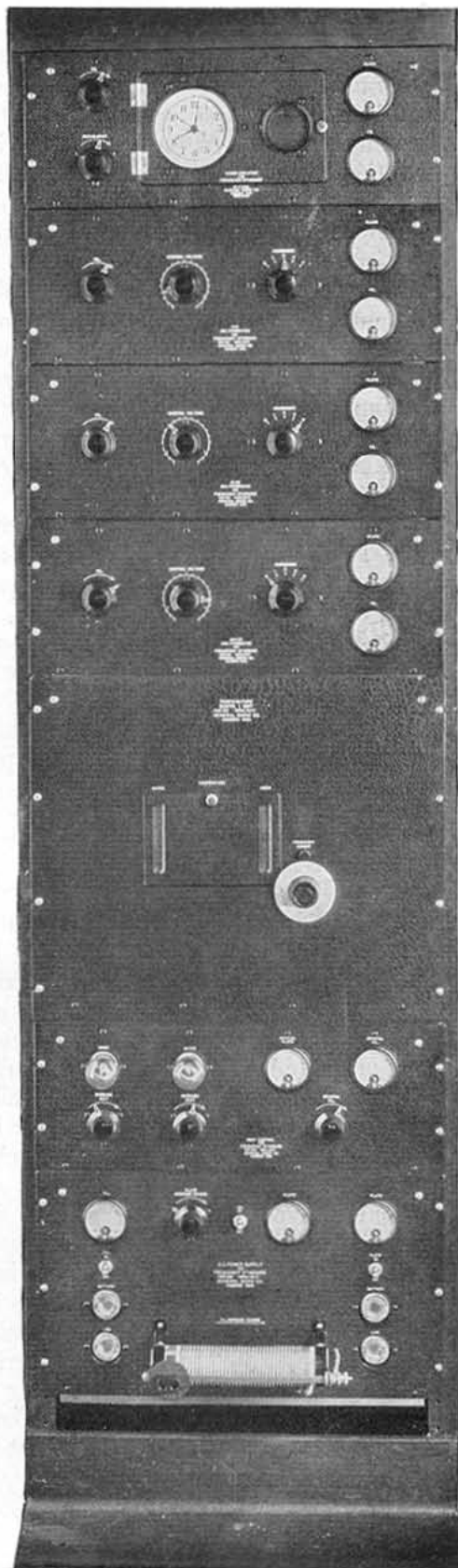
Material: Steel, gas-welded, and finished in black lacquer.

Dimensions: Frame, 69 x 20 x 3 inches; base, 20 x 15 inches. Mounting space, 63 inches.

Weight: 100 pounds.

<i>Type</i>	<i>Code Word</i>	<i>Price</i>
480	\$40.00

Front view of a Class C21-H Standard-Frequency Assembly. The seven panels (numbered from top to bottom) are as follows: (1) Timing Unit; (2), (3), and (4) Multivibrators; (5) Temperature-Control Unit; (6) Heat-Control Unit; and (7) Power-Supply Unit.



TYPE 592 MULTIVIBRATORS

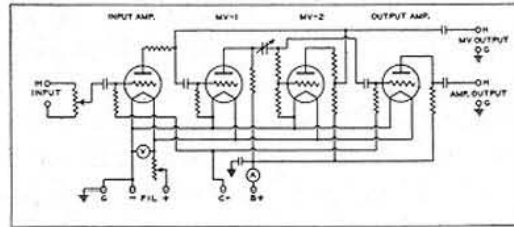
THESE are well adapted to general laboratory and experimental use as well as in more permanent standard-frequency assemblies. For example, one such unit might be employed with a TYPE 275 Piezo-Electric Oscillator with any low-frequency quartz plate for obtaining a number of desired frequencies for laboratory and experimental purposes.

All three models have identical circuits, differing only in the values of circuit constants as chosen to facilitate operation in the region of the rated frequency. They may be easily adapted by the user for operation at other frequencies than those specified.

Design: Includes voltage divider for adjusting magnitude of control voltage, isolating input amplifier, multivibrator, and output amplifier. Plug-in resistances are supplied for operation near rated frequency, others may be substituted by customer for operation at other frequencies. Circuit capacitance is adjustable in five steps from front of panel.

Mounting: Standard 19-inch aluminum panel, black crackle lacquer. Shelf and dust cover of nickel-plated brass. Obtainable in oak cabinets on special order.

Terminals: Jack-top binding posts mounted on rear of shelf. Plug-in plate for power supply is provided.



Power Supply: 6-volt filament; 150-volt plate supply.

Tubes: Four 112A-type tubes required.

Dimensions: Panel, 19 x 7 inches. Apparatus behind panel, 17 $\frac{1}{4}$ x 10 x 6 $\frac{3}{4}$ inches.

Weight: 20 pounds.

Type	Fundamental Frequency	Code Word	Price
592	1 kc.	STANFREANT	\$150.00
592	10 kc.	STANFREBOY	150.00
592	100 kc.	STANFRECAT	150.00

TYPE 595 ALTERNATING-CURRENT POWER-SUPPLY UNIT

THIS unit is intended primarily to meet the requirements for operating a standard-frequency assembly continuously. Power supply of such units is conveniently obtained through the use of storage batteries which are continuously trickle-charged from a 115-volt, 60-cycle power circuit. Such a system provides for continued operation in the event of failure of the alternating-current supply.

Design: Includes 6-volt, 6-ampere charger for filament supply; 150-volt, 100-milliamperer charger, with smoothing filter for plate supply. Necessary fuses and switches for all circuits furnished. Meters are provided in both battery circuits to indicate the charging current taken by the batteries and the voltage of the plate battery. In operation, when the ammeters indicate zero, the batteries are neither charging nor discharging and the loads are carried entirely by the rectifiers. The unit may be used as a straight charger by simply connecting the batteries to be charged to the battery terminals, leaving the load terminals unconnected. Rheostats are provided in both

circuits for regulating the charging current.

Mounting: Standard 19-inch aluminum panel, black crackle lacquer. Shelf of nickel-plated brass. No dust cover is used, so that heat may be freely radiated.

Terminals: Jack-top binding posts mounted on rear of shelf. Plug-in plate for load circuit connections is provided.

Power Supply: 110-115-volt, 50-60 cycle, alternating current.

Tubes: One 6-ampere Tungar bulb supplied; one 280-type rectifier required.

Dimensions: Panel, 19 x 10 $\frac{3}{4}$ inches. Apparatus behind panel, 17 $\frac{1}{4}$ x 10 $\frac{1}{2}$ x 13 inches.

Weight: 50 pounds.

Type	Input	Output		Code Word	Price
		Voltage	Current		
595	115 volts, 60 cps, a.c.	150 volts 6 volts	60 mla. 5 amp.	STANFREDOG	\$200.00

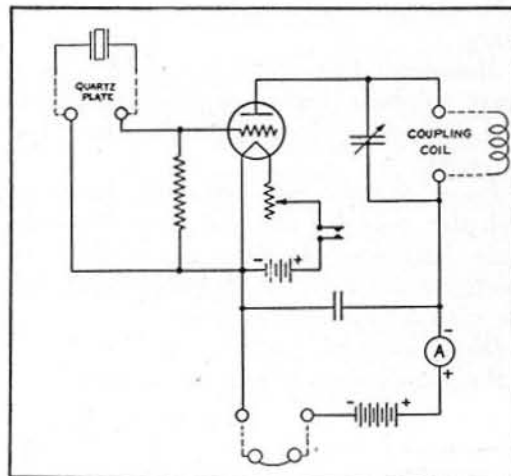
PIEZO-ELECTRIC OSCILLATORS AND ACCESSORIES

(INCLUDING TEMPERATURE-CONTROL EQUIPMENT)

THE piezo-electric quartz crystal offers one of the best possibilities now available for the realization of a constant-frequency electric oscillator for general use. For this reason, a great deal of attention has been devoted to the development of these crystal oscillators to improve their frequency stability and general reliability. To meet the general requirements, the General Radio Company has developed several types of both oscillators and crystal plates, each of which is intended to meet certain specific requirements. The choice of the type of oscillator, as well as the type of quartz mounting, is determined mainly by the constancy with which it is desired to maintain the frequency of the system. In general, it will be found that quartz plates without temperature control may be relied upon to maintain their frequency within approximately 0.03 per cent. under ordinary variations in room temperature. For higher accuracies it is necessary to control the temperature of the quartz plate. For precision frequency standards, the temperature must be controlled very accurately, requiring highly developed forms of temperature-control equipment, controlling not only the temperature of the quartz plate itself, but of the entire circuit used to excite the plate. The various types of oscillators and plates are described in detail in the succeeding subsections.

TYPE 275 PIEZO-ELECTRIC OSCILLATOR

THE TYPE 275 Piezo-Electric Oscillator is intended for general laboratory use where intermittent operation is generally desired. The oscillator may be used with quartz crystals of practically any available frequency when a suitable driving-circuit inductor is inserted in the jacks. A condenser is provided in shunt with the driving-circuit inductor for adjusting the output load of the oscillator tube to an appropriate value to maintain



the oscillation of a quartz plate without the necessity of using a large number of plug-in inductors. A direct-current milliammeter provides a positive indication as to whether the crystal is oscillating or not.

Design: Jacks are provided for both the quartz-plate holder and driving-circuit inductor, facilitating changes from one plate to another. Binding posts are provided for telephones, or audio-frequency-amplifier connection, for listening to beats between the frequency of an external oscillator and that of the crystal or one of its harmonics.

Mounting: All circuit elements are

mounted on a bakelite panel. Space is provided in the walnut cabinet for all batteries required for use with dry-cell tubes.

Power Supply: Three 6-inch dry cells and two small 22.5-volt plate-battery units are adequate for most purposes.

Tubes: One UX-112A-type.

Dimensions: Cabinet is 11 x 11 x 8 inches.

Weight: 10 pounds without batteries.

Type	Code Word	Price
275	LABEL	\$60.00

TYPE 275-P INDUCTORS

THESE are available for use with the TYPES 275 and 375 Piezo-Electric Oscillators in which they cover the approximate frequency ranges listed below.

Type	Frequency Range	Code Word	Price
275-P1	60- 140 kc.	.....	\$5.00
275-P2	140- 350 kc.	.....	5.00
275-P3	350- 900 kc.	.....	5.00
275-P4	900-2300 kc.	.....	5.00

TYPE 375-A STATION PIEZO-ELECTRIC OSCILLATOR

THIS oscillator is designed primarily for routine monitoring purposes, such as checking the frequency of a broadcast transmitter.

Design: The crystal-oscillator circuits are entirely contained within cabinet; they are identical with those of the TYPE 275 Piezo-Electric Oscillator. Two stages of audio-frequency amplification of the beat between the crystal and transmitter frequencies. Jack-top binding posts are provided so that 0, 1 or 2 stages may be used. A loud-speaker may be used. Where continuous monitoring is desired, the side-band tones may be very largely suppressed by connecting a condenser of about 1 μ f across the loud-speaker; the beat note with the station-carrier frequency will be but slightly reduced in intensity. Jacks, connected to the crystal terminals of the oscillator circuit, are provided on the panel for use of this oscillator

with an external temperature-control unit, such as the TYPE 547. (TYPE 375 Piezo-Electric Oscillators manufactured before this change was incorporated may be fitted with the necessary jacks at a moderate charge.)

Mounting: The circuit assembly is on a brass sub-base behind a bakelite panel. The cabinet is of walnut, with space for batteries.

Power Supply: Self-contained, three 6-inch dry cells for filament, two 22.5-volt plate batteries. Jacks are provided for connection to external filament supply for use with 5-volt filament tubes.

Dimensions: 13½ x 13 x 8 inches.

Weight: 20 pounds without batteries.

Type	Code Word	Price
375-A	LATIN	\$100.00

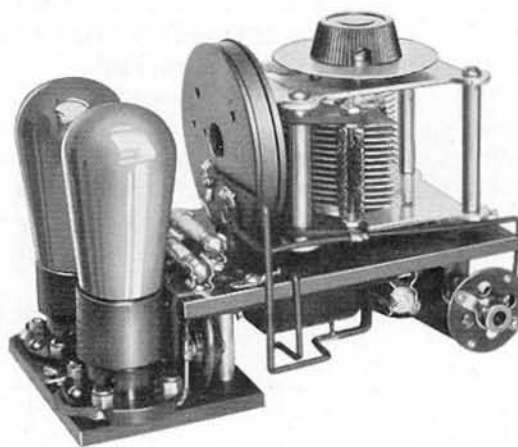
TYPE 590 PIEZO-ELECTRIC OSCILLATOR

THIS is a specially designed unit, intended for use in the TYPE 591 Temperature-Control Unit, to serve as a precision standard.

Design: The unit is as compact as is practical. The oscillator circuit is the same as that of the TYPE 275 Oscillator but is fitted with a small variable condenser connected across the crystal terminals for regulation of the crystal frequency to the exact value desired. An output amplifier is provided so that the connection of external equipment to the unit will react upon the crystal frequency to as small an extent as possible. The oscillator is furnished with an inductor suitable for operation with a crystal of specified frequency.

Mounting: All parts are carried upon a bakelite base and sub-base. Support is through three mounting pillars.

Terminal: Soldering lugs, to which the external connections are soldered.



Tubes: Two UX-112A-type or equivalent.
Dimensions: 7³/₄ x 6 x 3³/₄ inches.
Weight: 5 pounds.

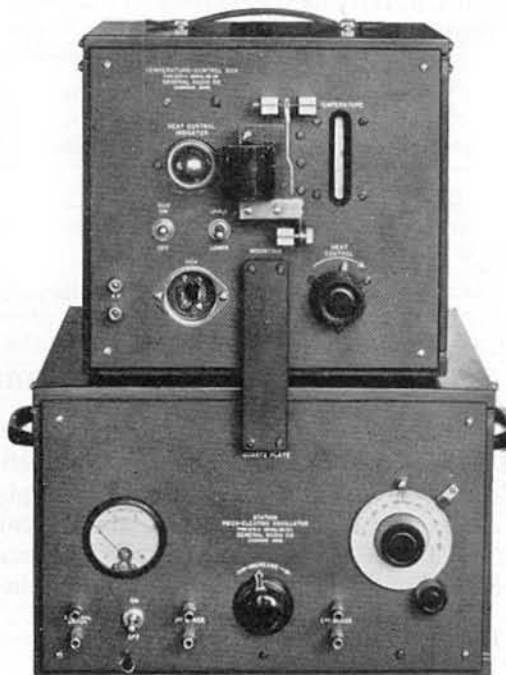
Type	Code Word	Price
590	STANFREROD	\$75.00

TYPE 547 TEMPERATURE-CONTROL BOXES

MERCURY-THERMOSTAT MODEL

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 Temperature-Control Boxes are particularly intended for use with the TYPE 275 or TYPE 375 Piezo-Electric Oscillators, but are by no means restricted to these uses. 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.

Construction: Within the cabinet are placed, in order, 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 1-degree C. divisions, reading from 40° to 60° C. and mounted behind a slot in the panel, indicates the air temperature in the inner space. Both models are



TYPE 547-A, TYPE 547-P1 and TYPE 375

(Continued on following page)

fitted with a rheostat for heat regulation and a heat-control-indicator lamp for signaling the operation of the thermostats. Plugs and cords for connection of the heater circuits to the 115-volt alternating-current or direct-current mains are provided.

Thermostat: Adjustable mercury type, operating through a relay mounted on front panel to control the current through the heaters. Relay circuit arranged so that failure of the 6-volt relay battery simply causes the heater circuits to remain open.

Regulation: The unit will control the

temperature of the inner space to within $\pm 0.1^\circ \text{C.}$ against changes in room temperature of from $\pm 11^\circ \text{C.}$ to 20°C. If the amount of heat is regulated by adjustment of the heat-control rheostat, to maintain the same ratio of "ON" to "OFF" time in the operation of the thermostat, somewhat better control may be obtained.

Mounting: Walnut cabinet with bakelite panel.

Dimensions: Cabinet, 12 x 10 x 10 inches. Temperature-controlled inner chamber, $4\frac{1}{8} \times 4\frac{1}{8} \times 3\frac{5}{8}$ inches deep.

Weight: 18 pounds.

Type	Control Accuracy	Operating Limits	Code Word	Price
547-A	$\pm 0.1^\circ \text{C.}$	$40^\circ - 60^\circ \text{C.}$	BURLY	\$150.00

TYPE 547-B TEMPERATURE-CONTROL UNIT

BIMETALLIC-THERMOSTAT MODEL

THESE differ from the mercury-thermostat models only in the kind of thermostat employed and in the poorer temperature regulation resulting therefrom.

Thermostat: Bimetallic type, adjustable from outside of unit while in operation. No relay is used, the heater current being handled directly by the thermostat contacts.

Regulation: The unit will control the temperature of the inner space to within $\pm 1.0^\circ \text{C.}$ against changes in room tempera-

ture of $\pm 11^\circ \text{C.}$ from 20°C.

Mounting: Walnut cabinet with bakelite panel.

Dimensions: Cabinet, 12 x 10 x 10 inches. Temperature-controlled inner space, $4\frac{1}{8} \times 4\frac{1}{8} \times 3\frac{5}{8}$ inches deep.

Weight: 17 pounds.

Type	Control Accuracy	Operating Limits	Code Word	Price
*547-B	$\pm 1.0^\circ \text{C.}$	$40^\circ - 60^\circ \text{C.}$	BUXOM	\$140.00

* Recommended for use only where it is essential that operating temperature be adjustable while unit is in operation.

TYPE 547-P ACCESSORIES AND REPLACEMENTS

THE TYPE 547-P1 Connector Plate is intended for use with the TYPE 547 Temperature-Control Boxes when used in conjunction with either the TYPE 275 or TYPE 375 Piezo-Electric Oscillator. When the former is placed on top of the latter, the connector plate makes a neat and convenient means of joining the two together.

The TYPE 547-P2 Mercury-type Thermostat and the TYPE 547-P3 Thermometer are provided so that users may replace them in case of breakage.

Type	Code Word	Price
547-P1 Connector Plate		\$1.50
547-P2 Mercury-type Thermostat (same as TYPE 591-P3)	LIBEL	20.00
547-P3 Thermometer, $40^\circ - 60^\circ \text{C.}$, graduated in 1.0° steps	LILAC	4.00

TYPE 591 TEMPERATURE-CONTROL UNIT

DESIGNED particularly for use in precision frequency-standard operation where every reasonable precaution must be taken to insure constancy of temperature of both quartz crystal and driving circuit. Consists of two mercury-thermostat controlled units, one within the other.

Design: The inner unit is identical in construction with that of the interior assembly of the TYPE 547-A Temperature-Control Unit, complete with heaters and thermostat. Sufficient space is available for mounting one TYPE 576-A Quartz Bar, or arrangement may be made for mounting two TYPE 376 Quartz Plates.

The outer heat-control unit provides space for mounting a TYPE 590 Piezo-Electric Oscillator. The outer unit is provided with its own heaters and thermostat.

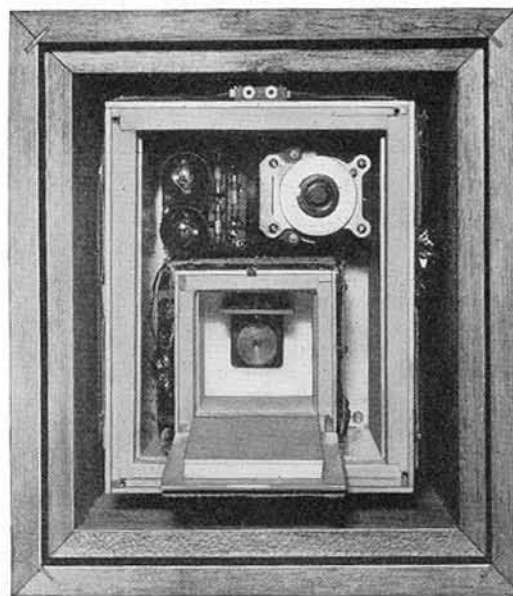
The entire assembly is housed in a balsa-wood container having 2-inch walls. The balsa cover and the top of the outer heat-control unit are readily removed for access to the oscillator and inner temperature-control unit.

Mechanical coupling is provided between a dial on the panel and the small variable condenser of the TYPE 590 Piezo-Electric Oscillator for regulation of the crystal frequency.

Necessary relays, rheostats, and meters mounted on TYPE 594 Heat-Control Unit.

Thermometers: Inner, 46°-54° C. (0.1° C. graduations); outer, 40°-60° C. (0.5° C. graduations). Both thermometers removable through door in panel.

Normal Temperatures: Inner, 50° C.; outer, 45° C.



TYPE 591 (Interior) TYPE 590 and TYPE 376

Mounting: Standard 19-inch panel; black crackle lacquer; balsa-wood given varnish coat. Cabinet-mounting models available on special order.

Dimensions: Panel, 19 x 15³/₄ inches; behind panel, 17¹/₄ x 19¹/₂ x 14¹/₂ inches.

Weight: 60 pounds.

Type	Control Accuracy		Operating Limits	Code Word	Price
	Inner Chamber	Outer Chamber			
591	±0.01°C.	±0.1°C.	46°-54°C. (inner)	STANFREPIG	\$450.00

TYPE 591 REPLACEMENTS

THESE replacement units are provided so that users may replace them in case of breakage.

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., " " 0.1° steps	..... LOCAL	4.00
591-P3	Mercury-type Thermostat (same as TYPE 547-P2)	..... LIBEL	20.00

TYPE 594 HEAT-CONTROL UNIT

THIS supplies the auxiliary control equipment required for satisfactory operation of the TYPE 591 Temperature-Control Unit.

Design: Heat-control rheostats, relays, and indicators for both inner and outer heater circuits are provided. Rheostat, plate milliammeter, and filament voltmeter for TYPE 590 Piezo-Electric Oscillator are included in this unit.

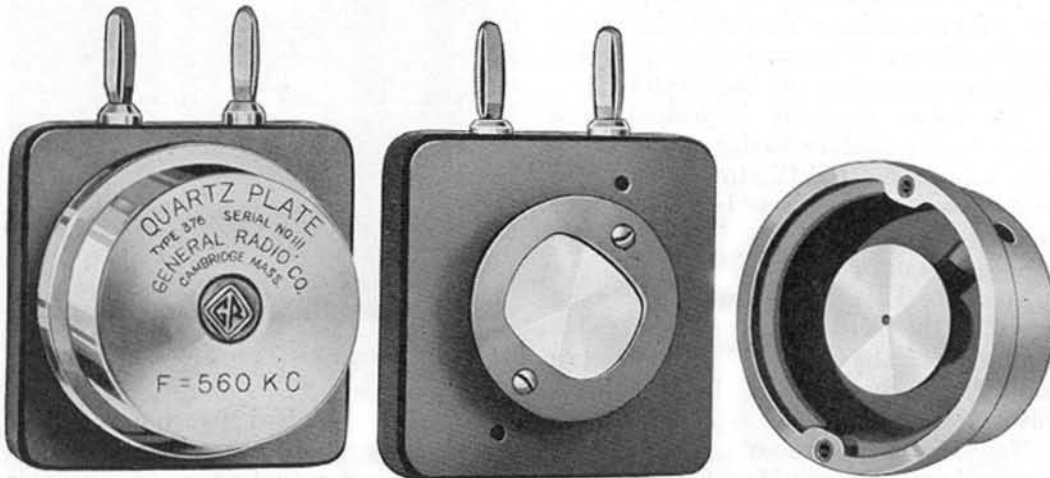
Mounting: Standard 19-inch panel, black crackle finish, with dust cover of nickel-plated brass.

Dimensions: Panel, 19 x 7 inches, behind panel, 17 $\frac{1}{4}$ x 10 x 6 $\frac{3}{4}$ inches.

Weight: 25 pounds.

Type	Code Word	Price
594	STANFRETOP	\$100.00

TYPE 376 QUARTZ PLATES



HOLDER FOR TYPE 376 QUARTZ PLATE

THE TYPE 376 Quartz Plates are mounted in the General Radio standard quartz-plate holder fitted with plugs for connection into the circuits of the TYPE 275 and TYPE 375 Piezo-Electric Oscillators.

Frequency Range: Plates in these mountings are available in the following frequency ranges: 100–200 kc. and 400–1800 kc. Plates in the frequency range from 200–400 kc. cannot be accommodated in the standard holder because of their dimensions and will be furnished in an appropriate holder on special order only.

Frequency Adjustment Tolerance: See price list. This requirement and the accuracy of calibration determine the type number.

Calibration: Plates are ground to approximate frequency and final changes made by adjusting air gap. After air-gap adjustment has been locked and sealed, frequency is measured with the greatest possible accuracy in terms of a

standard-frequency assembly (page 51). The result of this measurement, expressed with the proper number of significant figures, becomes the certified frequency. A certificate of calibration is furnished which states the frequency of the plate, the conditions under which the calibration was made, and the range of operating conditions over which the guarantee of accuracy is valid. The certified frequency and the percentage accuracy are marked upon the plate holder.

Mounting: Air-gap type, gap adjustment locked and sealed. Holder practically dust proof. Bakelite base and gold-plated brass cap.

Dimensions: 2 $\frac{3}{4}$ x 2 x 1 $\frac{1}{4}$ inches.

Weight: 1 pound.

Type	Adjusted Within	Accuracy	Temperature	Code Word	Price
376-B	25% of specified frequency	0.1%	18°-32°C.	LAGER	\$40.00
376-C	5% " " "	0.1%	18°-32°C.	LAPEL	45.00
376-D	0.1% " " "	0.1%	18°-32°C.	LARVA	60.00
*376-F	0.03% " " "	0.03%	20°-24°C.	LEPER	70.00
*376-H	0.01% " " "	0.01%	50±0.25°C.	LEVEL	85.00

* Must be adjusted and calibrated in oscillator with which it is to be used. Oscillator must be approved by us.

TYPE 576-A QUARTZ BAR (AND HOLDER)

THIS unit is intended for use with low-frequency quartz bars for precision frequency work. It is used in standard-frequency assemblies.

Design: The holder is designed to clamp the bar in position independently of the electrode adjustment. It is arranged to incorporate the latest information on mounting of bars of this type to obtain the best mechanical and frequency stability. The holders are normally furnished for use

with 50-kc. bars, but are available for bars of frequencies between 20 and 100 kc. on special order.

Dimensions: Base, 3⁵/₈ x 3 x 5/16 inches; electrodes, 1 x 2¹/₄ inch faces.

Weight: 1 pound.

Type	Frequency	Code Word	Price
576-A	50 kc.		\$145.00

TYPE 276-A QUARTZ PLATE

THE TYPE 276-A Quartz Plate is adjusted to have a frequency somewhere in the 160-meter amateur band. The crystals are not mounted and are calibrated only to within 0.25 per cent.

Weight: 2 ounces.

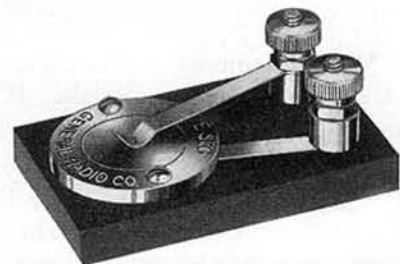
Type	Adjusted Within	Accuracy	Code Word	Price
276-A	2000-1715 kc.	0.25%	LABOR	\$15.00

TYPE 356 QUARTZ-PLATE HOLDER

THE TYPE 356 Quartz-Plate Holder is intended for amateur and experimental use, primarily with the TYPE 276-A Quartz Plates. The top electrode rests upon the crystal, but is held in place by a pin passing through a hole in a light spring.

Dimensions: 2¹/₂ x 2¹/₂ inches.

Weight: 2 ounces.

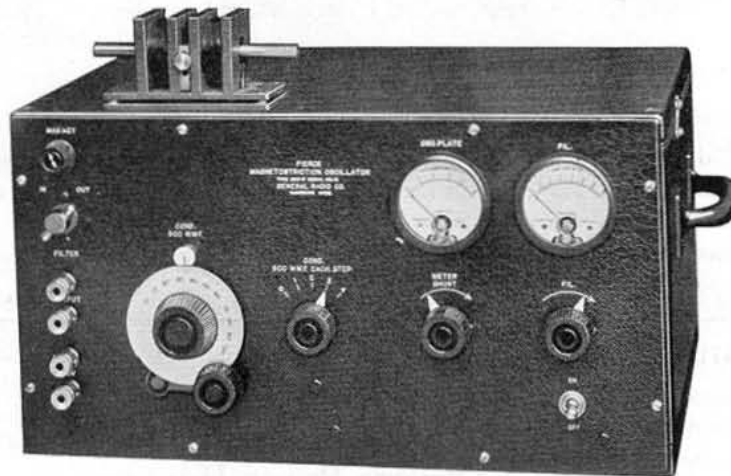


Type	Code Word	Price
356	LASSO	\$1.50

MAGNETOSTRICTION OSCILLATORS

MAGNETOSTRICTION is the name given to a property possessed by nickel, alloys of nickel, and certain other magnetic alloys which expand when subjected to a longitudinal magnetic field. A pulsating magnetic field will, accordingly, produce vibrations which, since the decrement of a properly supported rod is low, will attain a pronounced maximum amplitude at its natural frequency of longitudinal vibration. If such a rod supplies the regenerative coupling in an oscillating vacuum-tube circuit, a stabilizing action upon the frequency will occur so that the rod may serve as a standard of frequency in a manner similar to the piezo-electric quartz crystal. When supported at its mid-point, the fundamental stabilized frequency of the rod is found by dividing the velocity of sound in the material by twice the length of the rod. As the circuit is tuned, this stabilizing action is indicated by a deflection upon the plate circuit milliammeter. Use is made of these phenomena in the General Radio magnetostriction oscillators which were developed in collaboration with Dr. G. W. Pierce of Harvard University.

TYPE 389-B PIERCE MAGNETOSTRICTION OSCILLATOR



TYPE 389-B

THIS instrument provides a convenient means for utilizing the magnetostrictive properties of various materials. It consists of the oscillator tuning controls, tube controls, and an output amplifier.

Frequency Range: Determined by the TYPE 416 Magnetostriction-Oscillator Rod used.

Waveform: Output is rich in harmonics, a great advantage for calibration work.

Design: The various control units are mounted upon the front of the panel and the rod is supported in a removable inductor unit located on top of the cabinet. The plate supply and grid-biasing batteries are

housed within the cabinet. The filament-supply battery is attached externally. Tubes, batteries, inductors and rod mountings, and rods not included in purchase price of instrument.

Tubes: One 240-type and one 112A-type required.

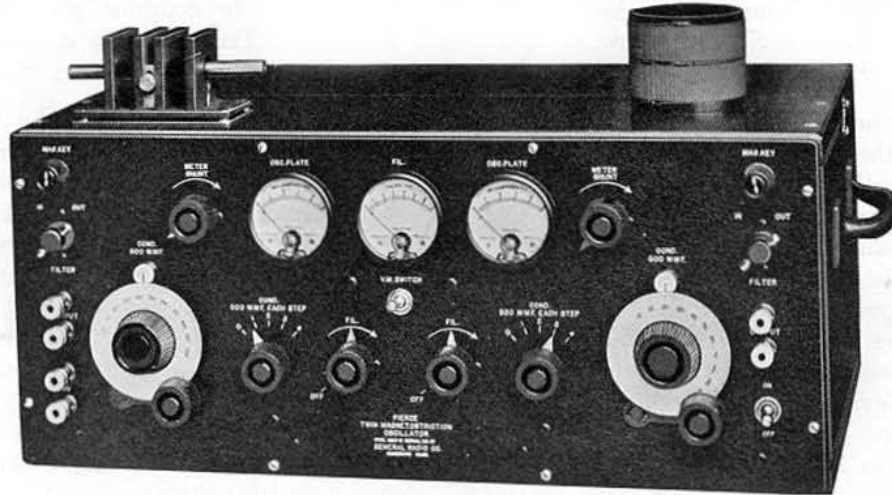
Batteries: Plate, 135 volts; grid, 9 volts; and external 6-volt filament battery.

Output Device: Speaker filter in amplifier plate circuit. May be cut out with switch if plate current is required to appear in

output. Impedance, 5000 to 8000 ohms.
Dimensions: 15¼ x 10½ x 8¼ inches.
Weight: 21 pounds.

Type	Code Word	Price
389-B	MAGNETOCAT	\$150.00

TYPE 489-B PIERCE TWIN MAGNETOSTRICTION OSCILLATOR



TYPE 489-B

IT is frequently desirable to compare two magnetostriction rods or to compare one rod with an adjustable-frequency vacuum-tube oscillator when making measurements or calibrations by heterodyne methods. This instrument has been designed for that purpose. It consists of two TYPE 389-B Pierce Magnetostriction Oscillators, either one of which may be used as a vacuum-tube oscillator with the TYPE 384 Inductors.

Frequency Range: Same as TYPE 389-B.

Waveform: Same as TYPE 389-B.

Design: All controls present on the TYPE 389-B Pierce Magnetostriction Oscillator are provided in duplicate. Instead of inductor shown in photograph, a second TYPE 389-P Inductor and Rod Mounting may be inserted. Tubes, batteries, inductors and rod mountings, and rods not

included in purchase price of instrument.

Tubes: Two each, 240-type and 112 A-type required.

Batteries: Same as TYPE 389-B.

Output Device: Supplied in duplicate, each the same as TYPE 389-B.

Dimensions: 19¼ x 10½ x 8¼ inches.

Weight: 29 pounds.

Type	Code Word	Price
489-B	MAGNETODOG	\$245.00

TYPE 389-P INDUCTORS AND ROD MOUNTINGS

ALTHOUGH they are by no means restricted to operation in these frequency ranges, the TYPE 389 and TYPE 489 Pierce Magnetostriction Oscillators operate most readily between 5 and 50 kc. To cover this range effectively, the following inductors and rod mountings have been developed. One of them is required for the TYPE 389 and one or two for the TYPE 489 Pierce Magnetostriction Oscillator, as necessary. This assembly includes the mounting for the rod, but no rod.

Type	Frequency Range	Code Word	Price
389-P1	20-50 kc.	.....	\$30.00
389-P2	10-50 kc.	.....	30.00
389-P3	7.5-20 kc.	.....	30.00
389-P4	5-10 kc.	.....	30.00

TYPE 416 MAGNETOSTRICTION-OSCILLATOR RODS

SPECIALLY annealed nichrome rods have been found to combine good magnetostrictive activity with low temperature coefficient. They provide a satisfactory frequency standard for a wide variety of purposes.

Frequency Range: Rods are adjusted within the percentage of specified frequency as set forth in the price list for the frequency range between 5 and 50 kc.

Frequency-Adjustment Tolerance: See price list. This requirement determines the type number, since both types are calibrated with the same accuracy.

Calibration: Rods are ground to specified frequency, after which the frequency is measured with the greatest possible accuracy in terms of a standard-frequency assembly. The result of this measurement, expressed with the proper number of

significant figures, becomes the certified frequency. A certificate of calibration is furnished, which states the frequency of the rod, the conditions under which the calibration was made, and the range of operating conditions over which the guarantee of accuracy is valid.

Temperature Coefficient: Approximately 0.0001 per degree C. If the temperature is maintained constant, a frequency can be relied upon within accuracy of calibration.

Dimensions: Diameter, $\frac{3}{8}$ inch; length, depends on frequency.

Weight: Depends on frequency.

Type	Adjusted Within	Accuracy	Code Word	Price
416-A	0.1% of specified frequency	0.01%	LIMIT	\$40.00
416-B	2 % " " " "	0.01%	LIVER	25.00

PRECISION WAVEMETERS

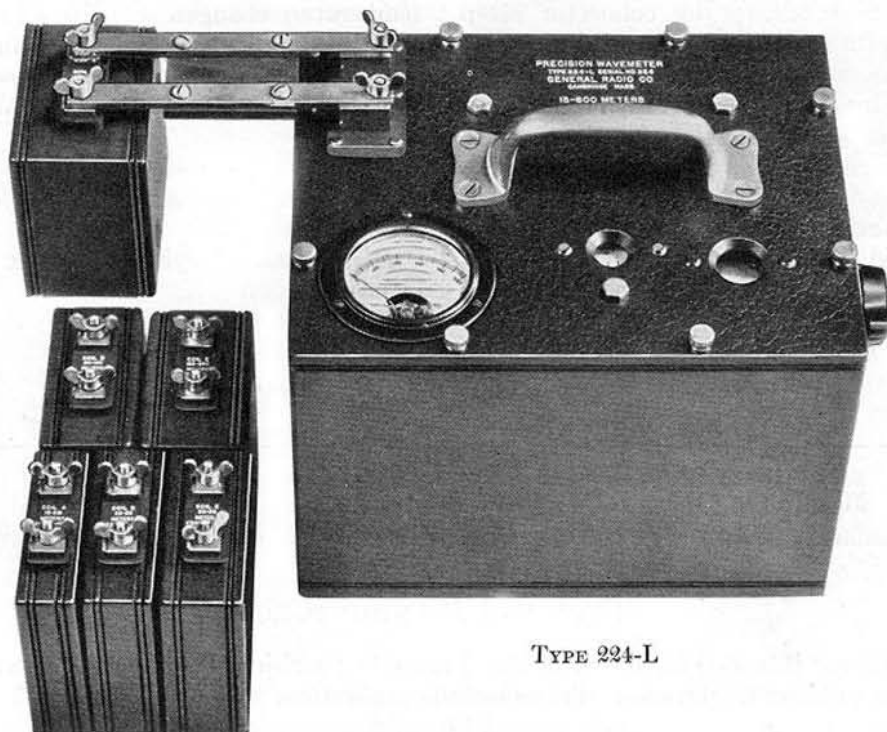
THE two types of wavemeters described in this section consist of tuned circuits associated with thermogalvanometers for indicating resonance. A high order of frequency stability is obtained by careful design of the tuned circuit. Use of the micrometer control on the condensers enables settings to be duplicated with ease.

The precision obtainable with these instruments is as high as it is economically feasible to expect from a tuned circuit. For higher orders of precision we recommend the use of piezo-electric oscillators and auxiliary interpolation equipment. Requests for our recommendations on specific problems are solicited.

All of the General Radio wavemeters described in this and the following section are calibrated in terms of a General Radio standard-frequency assembly. The wavelength calibration is obtained from this by the use of 299.82×10^6 meters per second as a conversion factor.

For the present at least, the General Radio Company uses the term "wavemeter" to mean "tuned-circuit or resonant-type frequency meter." This seems to be in fairly common use throughout the field, although the trend is toward the use of "frequency meter." We make one exception in the TYPE 558-P Amateur-Band Frequency Meter, which is so named to distinguish it from the obsolete instrument it replaced.

TYPE 224 PRECISION WAVEMETERS



TYPE 224-L

THESE instruments are intended for general laboratory and service uses where a rapid and fairly accurate measurement of frequency is required. A thermogalvanometer is used as a resonance indicator.

Condenser: Worm-drive precision type (similar in construction to TYPE 222). Straight-line-capacitance variation.

Inductors: Mounted in individual cases with terminal and name-plate strip. Connected to condenser by means of connector strap which is furnished.

Calibration: A chart, reading in both frequency and wavelength, mounted in aluminum chart-holder, is furnished with

each coil; accuracy 0.25 per cent. A capacitance calibration like that for TYPE 222 is also furnished.

Carrying Case: A stout wooden carrying case with provision for all parts and charts is furnished with the instrument.

Dimensions: Carrying case, 20 x 12 x 11 inches.

Weight: 30 pounds.

Type	Frequency	Wavelength	Accuracy	No. of Coils	Condenser	Code Word	Price
224-A	4290-12.5 kc.	70-24,000 meters	0.25%	5	1500 μf	WAGER	\$190.00
224-L	20,000- 500 kc.	15-600 "	0.25%	6	250 μf	UNDER	200.00

TYPE 624 PRECISION WAVEMETER

INTENDED particularly for use under service conditions where the greatest accuracy obtainable with commercial tuned-circuit wavemeters is required. It is similar in appearance to TYPE 224.

Condenser: Construction similar to TYPE 222, worm-drive. Straight-line-frequency variation.

Inductors: Mounted in individual cases with terminal and name-plate strip. Connected to condenser by connector strap which is furnished.

Extension of Range: Two additional inductors for extending the range to 3200 kc. (94 meters) are available. The instrument is not recommended for use at lower frequencies.

Resonance Indicator: Thermogalvanometer used in conjunction with a push-button-controlled incremental capacity. Accuracy of setting of the order of one part in 20,000.

Temperature Correction: A thermometer is mounted on the instrument to indicate temperature of instrument at time of measurement. Data is provided for making correction of calibration to include effect of temperature changes.

Calibration: Chart-holders containing calibration data are furnished for each coil. Capacity calibration furnished only when ordered.

Carrying Case: A stout wooden container for all parts and charts is furnished with each instrument.

Dimensions: Carrying case, 20 x 12 x 11 inches.

Weight: 30 pounds.

Type	Frequency	Wavelength	Accuracy	No. of Coils	Condenser	Code Word	Price
*624	25,000-5670 kc.	12-53 meters	0.1%	6	135 μ f	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

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

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

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

EXPERIMENTAL WAVEMETERS

IN general laboratory work and in many of the problems associated with station operation, a compact wavemeter which may be used for the rapid determination of the approximate wavelength or frequency of a transmitter or other oscillator is of great service.

TYPE 558-P AMATEUR-BAND FREQUENCY METER

THE TYPE 558-P Amateur-Band Frequency Meter was developed primarily for use by amateurs, and for this reason it covers only narrow ranges of frequency centered in the vicinity of the amateur-frequency bands. The accuracy is 0.25 per cent.

Calibration: In frequency.

Condenser: TYPE 557 Amateur-Band Condenser; fixed air condenser in parallel with variable condenser.

Inductors: The instrument is furnished with five inductors. The forms are 1¼-inch diameter, fitted with mounting pins to fit condenser terminals.

Resonance Indicator: None. Designed for use with reaction methods, particularly as indicated by heterodyne methods.

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

Dimensions: 11¾ x 7½ x 5½ inches.

Weight: 4½ pounds.



Type	Frequency	Accuracy	Code Word	Price
558-P	56,000-60,000 kc.	[5.36- 5.00 meters]	UNION	\$18.00
	28,000-30,000 kc.	[10.71-10.00 "		
	14,000-14,400 kc.	[21.43-20.83 "		
	7000- 7300 kc.	[42.86-41.1 "		
*558-P6	3500- 4000 kc.	[85.7 -75.0 "	WOVEN	\$6.00
	1715- 2000 kc.	[175.0-150.0 "		

* Frequency meter with which this coil is to be used must be submitted with order so that calibration can be made.

TYPE 358 WAVEMETER

THE TYPE 358 Wavemeter is intended for use as an inexpensive general-purpose device covering a rather wide frequency range with an accuracy of 1 per cent. The instrument 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.

Calibration: In wavelength; accuracy, 1 per cent.

Condenser: TYPE 247 Condenser in shielded case.

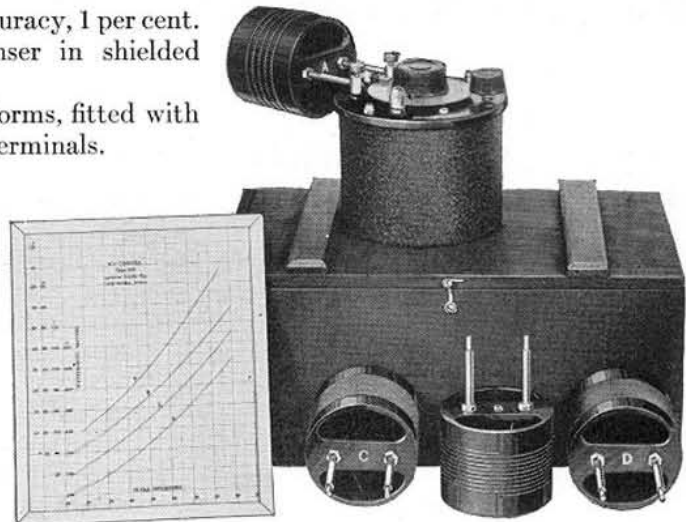
Inductors: Four on TYPE 277 forms, fitted with mounting pins to fit condenser terminals.

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.

Weight: 4½ pounds.



(Continued on following page)

Type	Wavelength	Accuracy	Code Word	Price
358	[20,000-1364 kc.] 15-220 meters	1%	UPPER	\$15.00

TYPE 174 DIRECT-READING WAVEMETER

THE TYPE 174 Direct-Reading Wavemeter is designed for general-purpose use in commercial or experimental work. It is adapted for use with either transmitters or receivers, is self-contained, and a direct-reading feature makes it particularly suitable for rapid work.



Calibration: In wavelength, direct-reading, 1 per cent.

Resonance Indicators: Hot-wire galvanometer; crystal detector (with connections for telephones); buzzer.

Inductor: Three sections with selector switch.

Condenser: TYPE 239 with slow-motion gear.

Mounting: Contained in walnut cabinet with panel-protecting cover.

Dimensions: 9 x 7 x 6 inches.

Weight: 9½ pounds.

Type	Wavelength	Accuracy	Code Word	Price
174-C	[4000-200 kc.] 75-1500 meters	1%	WEARY	\$68.00
174-D	[1500- 75 kc.] 200-4000 "	1%	WINDY	68.00

TIMING DEVICES

THE development of highly stable vacuum-tube oscillator circuits has made it possible for laboratories to secure electrical 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. The devices described in this section are all synchronous-motor-driven clock trains, with the necessary auxiliaries for adapting them to specific problems.

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 clocks, or Syncro-Clocks, described in this section may have, in addition to the clock mechanism, a number of other accessories. The only one here described 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 frequency impulses is provided.

Attention is invited to the section describing the TYPE 338 String Oscillograph (page 93) since this device is very useful in many cases for making frequency and time comparisons. When fitted with a camera, the oscillograph becomes a chronograph and provides a permanent record of such comparisons.

TYPE 511 SYNCRO-CLOCKS

MODELS WITH MICRO-DIAL

THE TYPES 511-C and -D Syncro-Clocks are designed to meet the demand for a dependable, durable unit that may be easily adapted to the various attachments or variations so often desirable for particular conditions. Requests for special-purpose attachments are solicited by our engineering department.

Frequency Range: Standard models are designed to keep correct time on 1.0-kc. circuit. Special designs cover the field from 60 to 5000 cycles per second. Motors may be operated through wide range above and below rated frequency. *Starting:* Clocks are hand started and will not run except in synchronism.

(Continued on following page)

Synchronism Indicator: A small neon lamp illuminating the motor teeth gives a visual indication of synchronism stroboscopically.

Reset Device: A differential gear train makes it possible to adjust second hand by 0.5-second intervals, without interfering with clock or motor action.

Stabilizer: A "sealed-in" mercury damping device minimizes "hunting."

Micro-dial: A cam switch is built into the unit that accurately closes a circuit once a second. This switch may be rotated about the cam, allowing the contacts to work at any point in a complete revolution. In aural reception of time signals, this dial is rotated to cut off the end of the time-signal dot until only a very short pulse is heard. This adjustment is rapid, accurate, and reproducible. The dial is graduated to read directly to 0.01 second.

Power Supply: Output of two 171-A type tubes, with 180 volts on plate and plate current of 20 to 30 milliamperes supplied to magnetize windings. Drop across motor terminals should be approximately 100 volts.

Special Clocks: Clocks for operation on circuits of other than 1 kc. can be supplied at a slightly increased cost. Contactors for producing impulses of from 1 to 1/25 second may be attached to the cross shaft, while magneto generators for frequencies of from 10 to 100 cycles are also available. A clock thus equipped becomes a very accurate source of time impulse for frequencies within the range and may be used in connection with or to replace other equipment.



TYPE 511-B

Mounting: Table or portable models have clock face in a horizontal plane. These are mounted in walnut cabinet.

Dimensions: $9\frac{1}{4} \times 10\frac{3}{4} \times 7\frac{1}{2}$ inches.

Weight: 15 pounds.

Vertical or panel-mounting models are available when it is desirable to "build in" the clock in connection with other equipment (see TYPE 593 Timing Unit, page 73). The clock will center the dial in a 7-inch panel section.

Dimensions: $8 \times 9 \times 6\frac{1}{2}$ inches.

Weight: 11 pounds.

Type	Frequency		Code Word	Price
*511-C	1.0 kc.	Panel Mounting	SYNCRGOOD	\$220.00
511-D	1.0 kc.	Table Mounting	SYNCRTOAD	225.00

* Built to order, not carried in stock.

MODELS WITHOUT MICRO-DIAL

THESE are identical in every respect with the TYPE 511-C and TYPE 511-D Syncro-Clocks described in the preceding paragraphs except that they have no micro-dials. Micro-dials may be added later at the factory.

Type	Frequency		Code Word	Price
*511-A	1.0 kc.	Panel Mounting	SYNCRFORD	\$160.00
511-B	1.0 kc.	Table Mounting	SYNCRFROG	160.00

* Built to order; not carried in stock.

TYPE 511-P REPLACEMENT

THE TYPE 511-P Neon Synchronizing Lamp is supplied as a replacement for all TYPE 511 Syncro-Clocks. It is used for making stroboscopic observations of rotor teeth in the driving motor as an aid to starting.

Type	Description	Code Word	Price
511-P1	Neon Synchronizing Lamp	.....	\$4.00

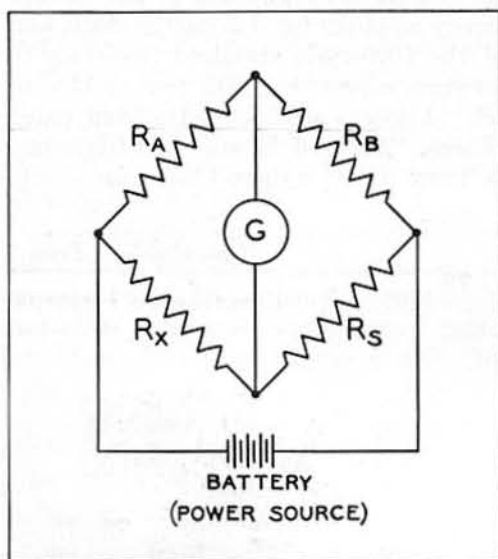
TYPE 593 TIMING UNIT

THIS unit is mounted on a standard 19-inch relay-rack panel and is furnished with dust cover. The units may be obtained in an oak cabinet on special order. The TYPE 593 Timing Unit includes a voltage control for regulation of the voltage applied to the amplifier, a two-stage audio-frequency amplifier for driving the clock, and a one-stage output amplifier for distribution of the 1000-cycle standard frequency to various points about the laboratory. The output stage is provided with two sockets so that two power tubes may be employed in parallel. A door is provided in the front panel for access to the clock and micro-dial mechanisms. As used in standard-frequency assemblies, the timing unit is equipped with a TYPE 511-C Syncro-Clock, previously described in detail.

Type	Frequency	Code Word	Price
593	1 kc.	STANFREBUG	\$400.00

BRIDGES AND THEIR ACCESSORIES

THE simplicity and accuracy of bridge methods have led to their general adoption for the determination of resistance, inductance, and capacitance. They are also used for the measurement of vacuum-tube characteristics. While there are a large number of bridge circuits, differing in detail according to the electrical quantities compared and the frequency and voltage used, all depend on balancing the voltage drops across the several arms of an impedance network so that no current flows through a null indicator connected across the network.



The simplest bridge circuit is the Wheatstone bridge, originally designed for the measurement of direct-current resistance.* It consists of four resistors, a battery, and a galvanometer, connected as shown in the accompanying drawing. R_a and R_b are the ratio arms, R_s the known or standard resistance, and R_x the unknown resistance. When the bridge is balanced, so that no current flows in the galvanometer G , $\frac{R_a}{R_b} = \frac{R_x}{R_s}$ or $R_x = \frac{R_a}{R_b} R_s$. A single adjustment of the ratio $\frac{R_a}{R_b}$ or of the standard resistance R_s is sufficient to balance the bridge.

When this bridge is used with an alternating-current source and an alternating-current null indicator, two inductances

or two capacitances may be compared. Two separate adjustments of the bridge, one for resistance, the other for reactance, are required to balance the bridge.

$$\frac{R_a}{R_b} = \frac{R_x}{R_s} = \frac{L_x}{L_s} \quad \text{or} \quad \frac{R_a}{R_b} = \frac{R_x}{R_s} = \frac{C_s}{C_x}$$

Two resistors may also be compared, but there will always be sufficient residual reactances in the bridge and in the resistors themselves so that the reactance balance must be made.

An inductance and capacitance may be compared by connecting them in series in the X -arm and tuning them to the frequency of the alternating-current source. At resonance they act as a pure resistance.

$$\frac{R_a}{R_b} = \frac{R_x}{R_s} \quad \text{and} \quad \omega L = \frac{1}{\omega C}$$

This bridge is usually called the resonance bridge.

Other bridges which may be built up from the simple four-arm bridge as a base are the Anderson bridge for comparing inductance and capacitance, the Heaviside bridge for comparing self- and mutual inductance, and the Wien bridge for comparing resistance and capacitance at a known frequency.

* Bridge methods are discussed in all but the most elementary textbooks on electricity. The best text on alternating-current bridges is that by B. Hague, *Alternating Current Bridge Methods* (London: Pitman and Sons).

Bridges are described under the following three headings:

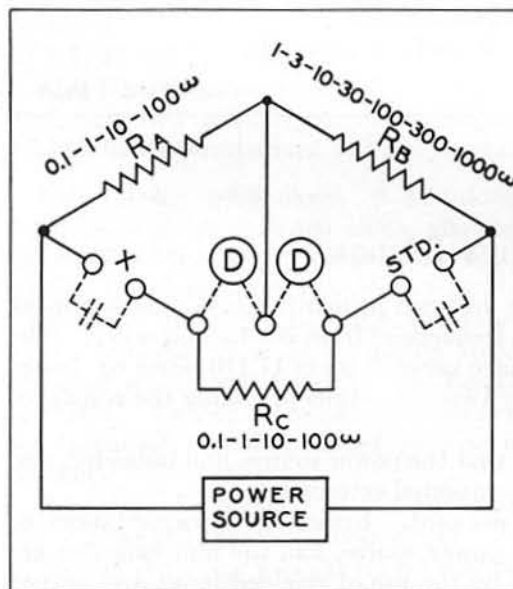
- a) General-Purpose and Capacitance Bridges
- b) Bridges for Vacuum-Tube Measurements
- c) Bridge Accessories

GENERAL-PURPOSE AND CAPACITANCE BRIDGES

IN this section are described three bridges for the measurement of capacitance and one general-purpose impedance bridge for measuring capacitance, resistance, and inductance at audio frequencies. A complete description of each is given under its own heading.

TYPE 193 DECADE BRIDGE

THIS bridge may be used for all kinds of bridge measurements of resistance, inductance, and capacitance over the entire range of audio frequencies and for the measurement of direct-current resistance. Both its ratio arms are variable, the one up to 1111.1 ohms by 0.1-ohm steps, the other from 1 ohm to 1000 ohms in six approximately equal steps.



A third resistance, variable up to 1111.0 ohms by 0.1-ohm steps, may be connected into either of the other two arms of the bridge, thus providing the resistance adjustment in all alternating-current measurements and the standard resistance in a measurement of direct-current resistance.

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

The accuracy of adjustment of the various resistances is 0.1 per cent, so that bridge balances may be obtained to 0.2 per cent. This should also be the accuracy of direct-

current-resistance measurement. The error in inductance and capacitance measurement is always greater than this figure of 0.2 per cent., dependent on the error introduced by capacitances (mutual and to ground) of the unsymmetrical ratio arms and the other arms of the bridge, the power source and null indicator, the magnitude of the reactances being compared, and the frequency used. No definite limits can be set for this error. It increases as the inductances or capacitances compared decrease, as the frequency increases, and as the ratio of the ratio arms diverges from unity. For capacitances of less than 1000 $\mu\mu\text{f}$, one of the special-purpose bridges, TYPE 216 Capacity Bridge or TYPE 383 Portable Capacity Bridge, should be used except for rough comparisons.

The errors due to capacitances to ground may be minimized by the use of a Wagner ground.

This bridge may also be used as the basis for the Anderson and resonance bridges.

Ratio Arms: A, 4-decade resistance, 0.1 to 1111 ohms variable by 0.1-ohm steps, identical with TYPE 102-K Decade-Resistance Box. B, 7 resistors, 1-3-10-30-100-300-1000 ohms, identical with one-half of TYPE 210 Ratio-Arm Box.

Standard Resistor: 4-decade resistance, 0.1 to 1111 ohms variable by 0.1-ohm steps, identical with TYPE 102-K Decade-Resistance Box. Can be connected in either arm.

Accuracy of Adjustment: 0.1 per cent.

Type of Winding: Ayrton-Perry. All resistances have characteristics identical with those given for TYPE 102 Decade-

Resistance Boxes (page 16).

Frequency Range: 0 to 20 kc.

Shielding: Copper lining in cabinet.

Finish: Resistances are mounted on a hard-rubber panel and enclosed in hand-rubbed walnut cabinet with separate dust cover. All exposed metal parts (except contact faces) nickel-plated.

Accessories Required: Power source, null indicator, standards of inductance and capacitance. See list of bridge accessories at end of this chapter, page 84.

Dimensions: Panel, 10½ x 17 inches; depth, 5 inches.

Weight: 13¼ pounds.

Type	Code Word	Price
193	BIGOT	\$115.00

TYPE 216 CAPACITY BRIDGE*

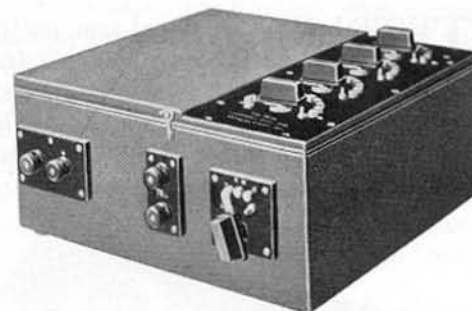
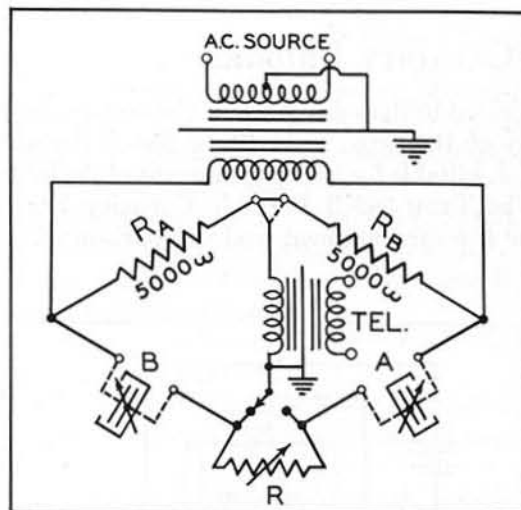
THIS bridge is an equal-arm shielded bridge designed primarily for the measurement of small capacitances over a range of audio frequencies from 200 to 10,000 cps. The ratio arms are 5000 ohms each. A third resistance variable up to 11,110 ohms by 1-ohm steps may be connected into either of the other 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 1 $\mu\mu\text{f}$, 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 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

*See *General Radio Experimenter*, January, 1930, for a general discussion of the uses of this bridge.



error of 0.05 per cent. or $0.05\mu\text{mf}$, whichever is the larger. With a power source of 100 volts at a frequency of 1 kc. 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 the TYPE 222 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-L Precision Condenser ($1500\mu\text{mf}$) 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.

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 per cent.

Standard Resistor: 4-decade resistance 1-11,110 ohms, variable by 1-ohm steps, identical with TYPE 102-J Decade-Resistance Box. Can be connected in either arm by means of switch mounted on side of cabinet.

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

Type of Winding: Unifilar for ratio arms. Ayrton-Perry for standard resistance, which has characteristics identical with those given for TYPE 102 Decade-Resistance Boxes (page 16).

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: $1\mu\text{f}$ to $10\mu\text{f}$. Frequency, 200 to 10,000 cycles per second.

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

Finish: 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 84).

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

Weight: $19\frac{1}{4}$ pounds.

Type	Code Word	Price
216	CIVIC	\$175.00

TYPE 383 PORTABLE CAPACITY BRIDGES

THESE bridges are equal-arm, partially shielded bridges designed for the measurement of small capacitances at a single frequency of 1000 cps. The TYPE 383-A Portable Capacity Bridge has a maximum range of $30\mu\text{f}$, suitable for the measurement of the inter-electrode capacitances of vacuum tubes. The TYPE 383-B Portable Capacity Bridge has a maximum range of $600\mu\text{f}$, suitable for the measurement and comparison of the tuning condensers of radio receivers.



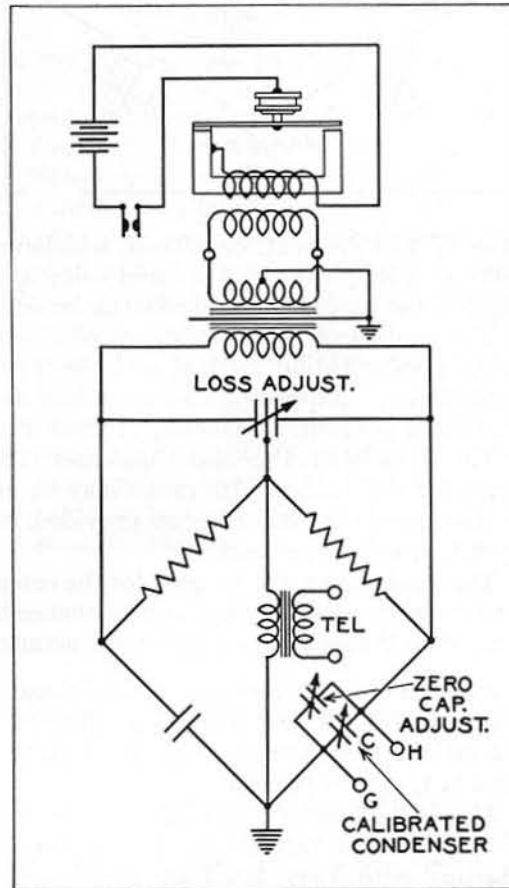
TYPE 383-A

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 the error due to inequality of the ratio arms and ground capacitances.

The resistance balance is made by means of a double stator condenser connected in parallel with the ratio arms with its rotor connected to their common junction. This method of providing the resistance balance limits the power factor which the unknown condenser may have. All air condensers and tube capacitances are well within the limits specified. There is an unshielded, unsymmetrical output transformer.

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. A convenient socket adapter is provided as an accessory which makes this connection by the mere act of plugging it into the terminals provided. Its own capacitance is eliminated by including it in the circuit during the initial balancing of the bridge.



LOW-CAPACITANCE MODEL

Ratio Arms: Carbon resistor, 100,000 ohms.

Standard Condenser: TYPE 334, straight-line capacitance, 30 μmf .

Balancing Condenser: TYPE 334-V, 50 μmf .

Vernier Condenser: TYPE 368-A, 15 μmf .

Zero-Adjusting Condenser: TYPE 368-B, 50 μmf with double stator.

Range: Capacitance, see price list. Power factor, 4 per cent. for 30 μmf .

Accuracy: 5 per cent. of full-scale reading. Bridge balance, 0.2 per cent. of full-scale reading.

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 cps., 4.5-volt dry battery supplied.

Shielding: Aluminum shield around balancing condenser.

Finish: 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.

Accessories Required: Null indicator, socket adapter. See list of bridge accessories (pages 80 and 84).

Dimensions: Panel, $6\frac{1}{8}$ x 18 inches; depth, $6\frac{1}{2}$ inches.

Weight: $14\frac{3}{4}$ pounds.

Type	Range		Code Word	Price
	Max.	Min.		
383-A	30 μmf	0	BRUIN	\$80.00

HIGH-CAPACITANCE MODEL

Ratio Arms: Carbon resistance, 50,000 ohms.

Standard Condenser: TYPE 334, straight-line capacitance, 600 μmf .

Balancing Condenser: TYPE 334, straight-line capacitance, 600 μmf .

Vernier Condenser: TYPE 368-B, 50 μmf .

Zero-Adjusting Condenser: TYPE 368-B, 50 μmf with double stator.

Range: Capacitance, see price list. Power factor, 2 per cent. for 600 μmf , varying inversely with capacitance.

Accuracy: 2 per cent. of full-scale reading. Bridge balance, 1 per cent. of full-scale reading.

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 cps., 4.5-volt dry battery supplied.

Shielding: Aluminum shielding around balancing condenser.

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

Accessories Required: Null indicator, socket adapter. See list of bridge accessories (pages 80 and 84).

Dimensions: Panel, $6\frac{1}{8}$ x 18 inches; depth, $6\frac{1}{2}$ inches.

Weight: $14\frac{3}{4}$ pounds.

Type	Range		Code Word	Price
	Max.	Min.		
383-B	600 μmf	0	BUGLE	\$80.00

TYPE 383-P ACCESSORIES

THE TYPE 383-P Bases are for use with the TYPE 383-A Portable Capacity Bridge in the measurement of inter-electrode capacitance of vacuum tubes. Sockets for the UX- and for the UY-base are provided.

Type		Code Word	Price
383-P1	For UY-Base Tubes (TYPE 438 Socket)	.....	\$4.00
383-P2	For UX-Base Tubes (TYPE 349 Socket)	.....	3.00

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 μf 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 $\mu\mu\text{f}$.

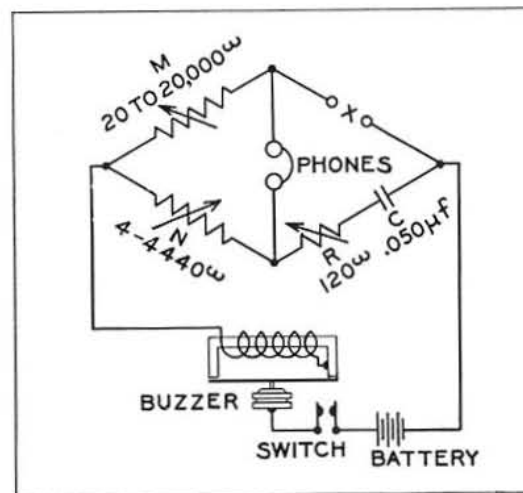
This bridge is portable and completely self-contained. The power source, a microphone hummer, is connected directly to the bridge between the junction of the ratio arms and the junction of the condensers. The standard capacitance is a fixed mica condenser. The added resistance providing the resistance balance is a TYPE 214 Rheostat, calibrated directly in power factor up to 4 per cent. The accuracy of the power-factor setting depends on the actual frequency of the microphone hummer, which may differ from 1000 cycles by 10 per cent., and upon the setting of the ratio arms. This latter dependence is due mainly to the dissymmetry of the ratio arms. It may cause an error in the power-factor reading of 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 indicator of high or low losses.



Ratio Arms: Unifilar winding, accuracy of adjustment, 0.1 per cent. *M* (four resistances) 20-200-2,000-20,000 ohms. *N* (three-decade resistance) 4-4440 by 4-ohm steps.

Standard Condenser: Mica condenser, 0.05 μf , accuracy of adjustment, 0.25 per cent.

Added Resistance: TYPE 214 Rheostat, 120 ohms.



Range: Capacitance, 1000 $\mu\mu\text{f}$ to 11.1 μf . Power factor, 0 to 4 per cent.

Accuracy: Capacitance, 0.3 per cent. of maximum reading. Power factor, 0.5 per cent. (error in power-factor reading expressed in per cent.).

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

Null Indicator: Murdock head telephone, approximately 10,000 ohms impedance at 1000 cps.

Finish: Resistances 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.

Weight: 107⅞ pounds.

Type	Range		Code Word	Price
	Max.	Min.		
240	11.1 μ f	1000 μ mf	CYNIC	\$85.00

BRIDGES FOR VACUUM-TUBE MEASUREMENTS

THE important static characteristics of a three-element vacuum tube are the curves showing the variation of plate current with grid voltage at constant plate voltage, the variation of plate current with plate voltage at constant grid voltage, and the variation of plate voltage with grid voltage at constant plate current.

The important dynamic characteristics are amplification factor, plate resistance, and mutual conductance, which are not constants but vary with the plate and grid voltages applied to the tube. They may be obtained graphically from the static characteristics, but in an easier, quicker, and more accurate manner, dynamically, by a null or bridge method. In this method a small alternating-current voltage, usually of about 1000 cycles per second, is applied to the grid of the tube, and a portion of the amplified voltage appearing in the plate circuit is balanced against a portion of the input voltage.

TYPE 361-B VACUUM-TUBE BRIDGE

ALL the important static and dynamic characteristics of three-electrode receiving tubes, both the alternating-current and direct-current types, may be measured on this bridge. Plate voltage is limited to 200 volts and plate current to 25 milliamperes. These limits may be exceeded by the use of external meters, or in the case of plate current by the use of an external shunt on the plate-current meter. The plate voltmeter serves also as filament voltmeter on a 10-volt scale.

All batteries and their control rheostats, as well as the alternating-current power source, must be provided separately and connected externally. A shielded astatic input transformer connects the alternating-current power source to the bridge.

The connections of the bridge for the different measurements are shown in the accompanying figures. Changes from one to another are made by means of three two-way telephone keys, one for each dynamic factor. The normal maximum values for the three dynamic factors are: amplification factor 100, plate resistance 100,000 ohms, mutual conductance 10,000 micromhos.

A variable mutual inductance is connected with one branch in the telephone circuit and the other in the plate or input circuit to balance out the reactance component due to tube capacitances.

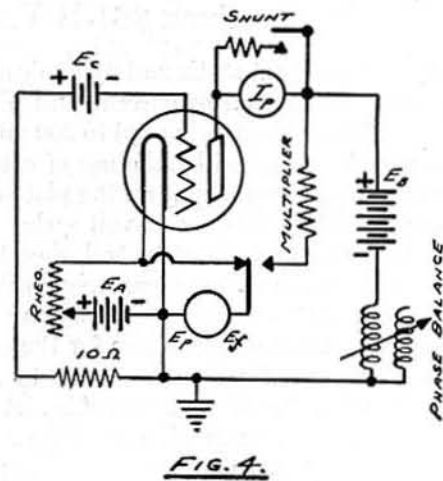
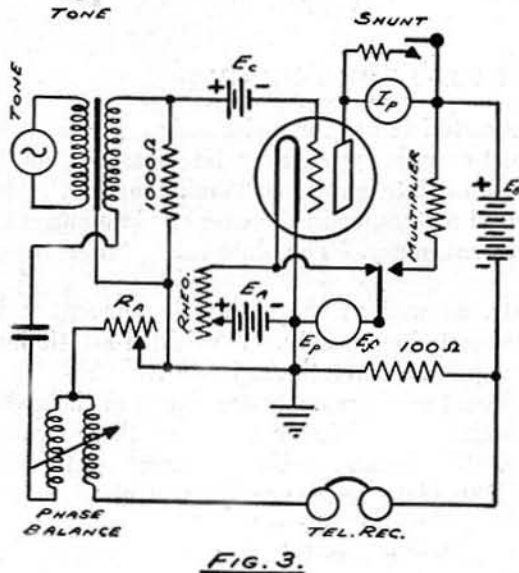
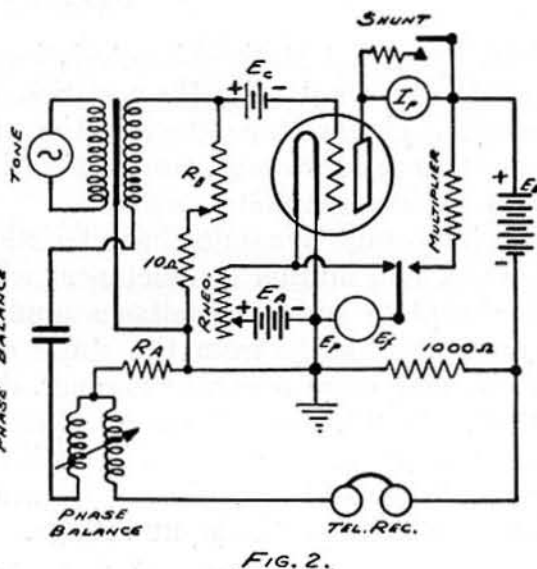
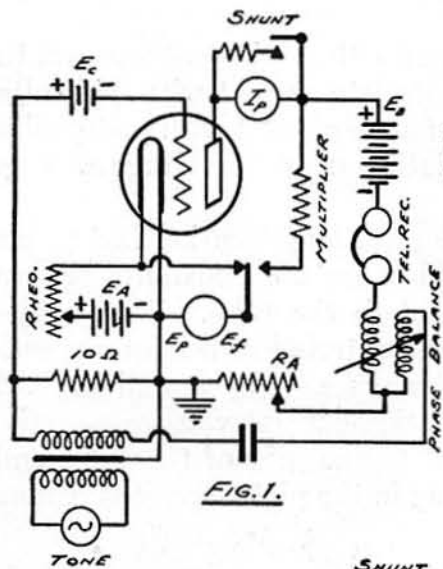
The accuracy of measurement of the three dynamic factors varies greatly with their magnitude. It may be set roughly at 0.5 per cent. for normal values: 8; 10,000 ohms; and 10,000 micromhos, respectively. The error increases rapidly when the plate current is decreased to 0.1 milliamperes or less or the negative grid bias is increased, for then the plate resistance becomes comparable with the reactance of the tube capacitances. This bridge is, however, entirely satisfactory for measuring the mutual conductance of screen-grid tubes. The introduction of the various balancing resistances into the grid and plate circuits of the tube introduces errors in some of the measurements. They introduce into the measurement of mutual conductance a fractional error equal to $+ 100/r_p$ which can be allowed for if the plate resistance is known.

Range: Amplification factor, 0 to 100. Plate resistance, 0 to 100,000 ohms. Mutual conductance, 0 to 10,000 micromhos.

Meters: Plate and filament voltmeter

and plate ammeter, Weston Model 301.

Resistances: Two 4-decade resistances 0.1 to 1111 ohms by 0.1-ohm steps, identical with TYPE 102-K Decade-Resistance Box.



10-ohm, 100-ohm, 1000-ohm cards identical with TYPE 133 Standard Resistance, all adjusted to 0.1 per cent.

Mutual Inductance: Special TYPE 269 Variometer.

Input Transformer: Shielded astatic transformer, ratio 1 to 2.5 step-up, connected to input terminal by shielded leads.

Accessories: Filament, plate, and grid batteries, filament rheostat, plate and grid potentiometers, alternating-current power

source, telephones, socket adapters for UV-bases. See list of bridge accessories.

Sockets: TYPE 361-P1 and TYPE 361-P2 Socket Adapters for UX- and UY-bases supplied. (See page 84.)

Finish: Units mounted on bakelite panel and enclosed in hand-rubbed walnut cabinet with dust cover. All exposed metal parts (except contact faces) nickel-plated.

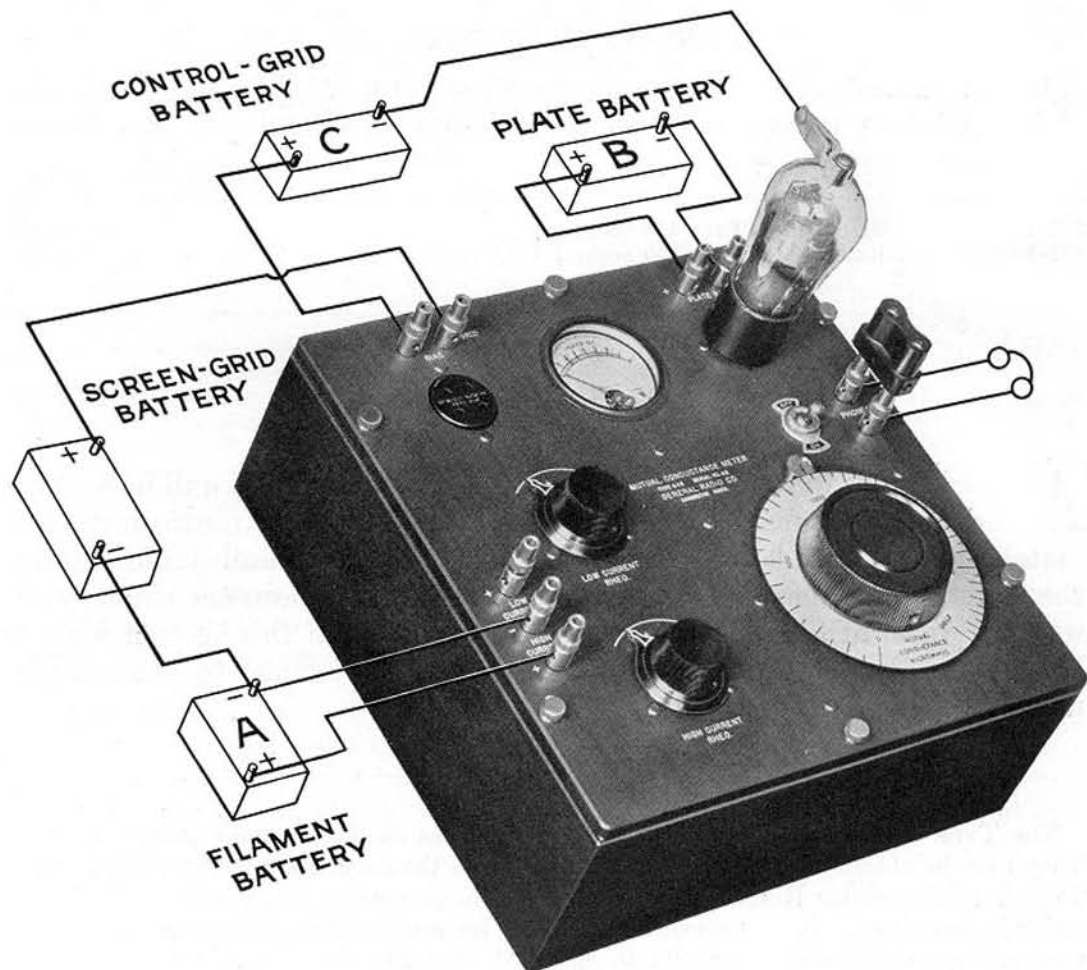
Dimensions: Panel, 14 x 16 inches; depth, 8 inches.

Weight: 21 pounds.

Type	Code Word	Price
361-B	BIBLE	\$220.00

TYPE 443 MUTUAL-CONDUCTANCE METER

OF the three important dynamic factors of the three-element vacuum tube, amplification factor, plate resistance, and mutual conductance, the last is the best figure of merit for a tube. While mutual conductance is not a complete indication of the comparative merit of tubes of different types, it offers positive indication among tubes of the same



type. This mutual-conductance meter will measure the mutual conductance of any receiving tube with direct-current or alternating-current filament up to a maximum of 2500 micromhos.

The circuit used is similar to Figure 3 on page 82. A TYPE 241 Microphone Hummer and rheostats for low- and high-current filaments are included in the instrument, but the phase-balancing mutual inductance is omitted.

Range: 0 to 2500 micromhos.

Meter: Filament voltmeter, Weston Model 506, 8-volt.

Resistances: Variable resistance, TYPE 214 Rheostat, tapered, 250 ohms. Fixed resistance, 100-ohm and 1000-ohm cards, unifilar winding, accuracy 0.25 per cent.

Power Source: TYPE 241-B Microphone Hummer, 1000 cps.

Filament Rheostats: TYPE 214 Rheostat, 4.5 ohms; TYPE 214 Rheostat, 50 ohms.

Sockets: TYPE 349 Socket for UX-base, TYPE 438 Socket for UY-base.

Accessories: Filament, plate, and grid batteries, 4.5-volt dry battery for hummer, plate and grid voltmeters, telephones. See list of bridge accessories, below.

Finish: Units mounted on bakelite panel and enclosed in hand-rubbed walnut cabinet.

Dimensions: Panel, 10 x 10 inches; depth, 4½ inches.

Weight: 6½ pounds.

Type	Code Word	Price
443	MUCUS	\$55.00

TYPE 361-P ACCESSORIES

THESE two adapters for use with the TYPE 361-B Vacuum-Tube Bridge are here listed as replacement parts. One of each is included with each bridge.

Type	Code Word	Price
361-P1 | For UY-Base Tubes (TYPE 438 Socket)	\$3.00
361-P2 | For UX-Base Tubes (TYPE 349 Socket)	3.00

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 0.4 to 1.5 kc. 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 TYPE 240 Capacity Meter.

TYPE 377-B Low-Frequency Oscillator is satisfactory as a variable-frequency power source. TYPE 413-B Beat-Frequency Oscillator has a higher harmonic content in the output and is less stable in frequency. The output voltage is lower, but it is easier to set at a given frequency.

The output from any of these oscillators may be amplified to about 100 volts by the TYPE 645 Laboratory Amplifier. This amplifier cannot, however, be used to amplify the output from a bridge, because its alternating-current hum, although negligible in comparison with 100 volts, is sufficient to blur a sharp null setting.

<i>Instrument</i>	<i>Range</i>	<i>Page</i>	<i>Price</i>
TYPE 213-B Audio Oscillator	1000 cps.	41	\$ 34.00
TYPE 213-C Audio Oscillator	400 cps.	41	42.00
TYPE 241 Microphone Hummer	1000 cps.	41	10.00
TYPE 377-B Low-Frequency Oscillator	25-70,000 cps.	35	350.00
TYPE 413-B Beat-Frequency Oscillator	20- 9000 cps.	37	175.00
TYPE 645 Laboratory Amplifier	25-10,000 cps.	42	78.00

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 cps. Below these frequencies and down to 50 cps., the TYPE 338-G Vibration Galvanometer provides a tuned null indicator. The TYPE 426-A Thermionic Voltmeter may be used over the whole range of audio frequencies and up to perhaps 1500 kc., but is much less sensitive than either of the other null indicators and is not selective. Any of these null indicators may be preceded by a one- or two-stage amplifier, in order to increase its sensitivity.

<i>Instrument</i>	<i>Range</i>	<i>Page</i>	<i>Price</i>
Western Electric Head Telephones (W.E. type number 1002-C)	200 cps.-10,000 cps.		\$ 12.00
TYPE 338-G Vibration Galvanometer	50 cps.- 1000 cps.	95	175.00
TYPE 426-A Thermionic Voltmeter	10 cps.- 1500 kc.	99	160.00

STANDARDS AND BALANCING REACTANCES

The TYPE 102 Decade-Resistance Boxes, TYPE 133 Standard Resistances, 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.

<i>Instrument</i>	<i>Page</i>	<i>Price</i>
TYPE 102 Decade-Resistance Boxes	16	\$22.00-\$100.00
TYPE 133 Standard Resistances	18	6.00- 15.00
TYPE 106 Standard Inductances	31	25.00- 36.00
TYPE 107 Variometers	32	27.00
TYPE 219 Decade Condensers	14	40.00- 50.00
TYPE 222 Precision Condensers	6	85.00- 90.00
TYPE 246 Condensers	7	38.00- 54.00

TRANSFORMERS AND FILTER SECTIONS

The TYPE 359 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 and TYPE 285 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.

<i>Instrument</i>	<i>Page</i>	<i>Price</i>
TYPE 359 Variable-Ratio Transformers	46	\$ 20.00
TYPE 166 Telephone Transformers	47	7.00
TYPE 585 Transformers	43	7.00-12.00
TYPE 285 Transformers	43	4.00
TYPE 330 Filter Sections	97	12.00

WAGNER GROUNDS

Since a Wagner ground of the resistance type is merely a fixed resistance with a variable tap, the TYPES 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, 335, and 374 Condensers having balanced sections, these condensers become satisfactory Wagner grounds of the capacitance type.

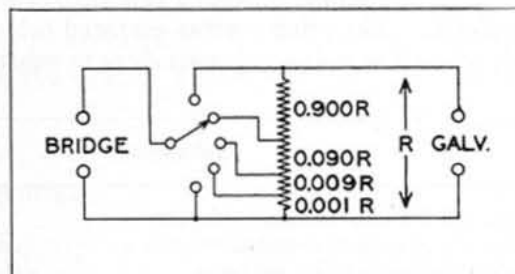
<i>Instrument</i>	<i>Page</i>	<i>Price</i>
TYPE 371 Potentiometers	27	\$ 5.00
TYPE 214 Potentiometers	29	1.75
TYPE 410 Potentiometers	30	1.00
TYPE 301 Potentiometers	30	1.00
TYPE 334 Condensers	10	2.75-10.00
TYPE 335 Condenser	11	6.00
TYPE 374 Condensers	11	2.75- 5.00

TYPE 229 GALVANOMETER SHUNTS

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,



TYPE 229-L



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 be used as a voltage divider.

Total Resistance: See price list.

Shunt Ratios: 0.000; 0.001; 0.01; 0.1; 1.0.

Accuracy of Adjustment: 0.1 per cent.

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-point.

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, $3\frac{1}{2}$ x $5\frac{1}{2}$ inches; depth, $3\frac{1}{2}$ inches.

Weight: 1 pound.

Type	Resistance	Code Word	Price
229-L	1000 ohms	GAVOT	\$15.00
229-H	10,000 "	GIANT	18.00

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.

Resistances: Each arm, 1, 3, 10, 30, 100, 300, 1000 ohms.

Accuracy of Adjustment: 0.1 per cent.

Type of Winding: Ayrton-Perry, manganin wire, having characteristics identical with those listed under TYPE 102 Decade-Resistance Boxes.

Switches: TYPE 202, 7-point.

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 $7\frac{1}{2}$ inches; depth, 4 inches.

Weight: $2\frac{3}{8}$ pounds.



Type	Code Word	Price
210	RABID	\$28.00

RADIO-FREQUENCY TESTING DEVICES

THE intense commercial development of radio-receiving sets that has been going on for the past few years has made it more than ever important that designers, manufacturers, and servicemen be able to secure quantitative performance data. The General Radio Company has done a large amount of development work in this field, of which the two instruments described in this chapter are examples.

The standard-signal generator is a laboratory instrument, by means of which sensitivity, selectivity, and fidelity characteristics of radio receivers may be obtained. The test oscillator here described is a general-purpose radio-frequency driver for the serviceman. Our engineering department is ready to design and develop new instruments to meet specific needs, and inquiries are solicited.

A modified standard-signal generator for the serviceman has been under development for the past twelve months and will be ready to announce in Catalog Supplement F-200 shortly after this catalog appears.

The instruments here described are listed under two headings:

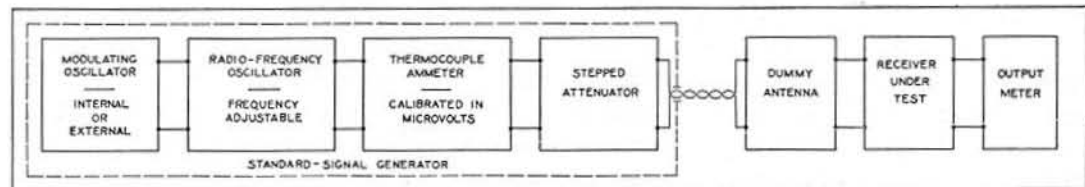
- a) Standard-Signal Generators
- b) Oscillators for Radio-Service Testing

STANDARD-SIGNAL GENERATORS

THE standard-signal method of rating radio receivers, represented on page 89, is the foundation for a complete test of receiver performance. It permits rating a receiver on the basis of sensitivity and selectivity data.* This principle of measurement and type of equipment can also be used in investigating the operation of portions of the receiver circuit; for example, a single radio-frequency stage or the entire radio-frequency amplifier can be measured, or detector characteristics investigated. Similar equipment may also be used for field-strength measurements by the comparison method. The requirements of a standard generator for these measurements are that it supply modulated radio-frequency voltages of known magnitudes.

The principal component is a modulated radio-frequency oscillator with means for adjustment of its output voltage to known values over a wide range. The essential requirement is that it produce an accurately known voltage between its output terminals and nowhere else, for, if the receiver picks up energy in addition to that measured at its input terminals, the test will be of no value. The first two requirements of a standard-signal generator are, therefore, adequate shielding and a means of adjusting and accurately determining its output voltage over a wide range, including very small magnitudes.

*L. M. Hull, *Proceedings of the Radio Club of America*, October, 1928; *I. R. E. Yearbook*, 1929, pp. 106-128.



SCHEMATIC DIAGRAM FOR THE STANDARD-SIGNAL METHOD OF OPERATING A RADIO RECEIVER

It is necessary to obtain output voltages of a few microvolts. Since there is no known method of measuring such voltages directly, it is necessary to attenuate a measurable voltage by means of a calculable network. The design of an attenuator which is accurate at broadcast frequencies is a problem of considerable difficulty, involving as it does the design and layout of non-reactance elements, having negligible admittance between elements, as well as the location of grounds and return conductors.

Further difficulty is involved in checking the accuracy of the finished attenuator, since there is no absolute standard of comparison. The accuracy of these measurements is, therefore, of materially lower order than that of the common measurements of circuit parameters. It is not possible to obtain a voltage-attenuation ratio of 2:1 at 1000 kc. with a smaller probable error than 1 per cent. The possible cumulative error of an attenuator having a large number of 2:1 ratios may, therefore, become comparatively large.

TYPE 403-C STANDARD-SIGNAL GENERATOR

THIS instrument is designed specifically for the "Standard-Signal" method of measurement. It consists essentially of a modulated radio-frequency oscillator tuned continuously over a frequency range of approximately 3:1 by a variable condenser. In addition, a secondary control is provided for use in taking selectivity curves when a small change in frequency is desired. This consists of a copper sector which moves in the field of the tuning coil and changes its inductance. Since the frequency change due to this adjustment results in a change in inductance, the percentage change in frequency for a given setting is not directly affected by the setting of the main tuning control, which changes the capacitance in the circuit. A change in frequency of ± 1 per cent. is possible by means of the auxiliary control.



TYPE 403-C AND TYPE 418

Frequency Range: See price list.

Modulation: Internal 400-cycle vacuum-tube oscillator. Terminals provided for external modulation. External oscillator must maintain 15 volts across 2500 ohms to produce 30 per cent. modulation. Potentiometer control for both modulators. Voltage read on rectifier-type voltmeter with 25-volt scale corresponding to an approximate modulation percentage of 75.

Accuracy: Frequency calibration, 0.25 per cent. Output voltage, 15 per cent. Adjacent attenuator ratios, 1 per cent.

Construction: The entire assembly is enclosed in a shielded cabinet. Internal shields between sections of the circuit are also provided where necessary. The entire attenuator assembly is placed in a separately shielded compartment electrically isolated from the main shielding except for a connection at one point. The wiring to the attenuator is a concentric cable in which the low potential side of the circuit forms a shield.

Shielding: Filter circuits are included in the leads to the meters, making screening in front of the meters unnecessary. The instrument can be used with unshielded receivers without any pickup from the generator. The entire generator with all batteries is contained in a single cabinet, which is of particular advantage in field-strength measurements.

Output System: Input to attenuator read on thermocouple calibrated in microvolts. L-type-resistance attenuator calibrated as multiplier. Output impedance 10 ohms, resistive.

Accessories: Type 418 Dummy Antenna included.

Tubes: Two 12-type tubes required. Not included in purchase price of instrument.

Batteries: Plate, 67.5 volts; filament, 1.5 volts. Space provided inside cabinet.

Mounting: Aluminum panels finished in black crackle lacquer, mounted in hand-rubbed walnut cabinet.

Dimensions: 27 $\frac{1}{4}$ x 13 x 10 $\frac{1}{2}$ inches.

Weight: 41 pounds.

Type	Frequency Range	Output Range	Internal Modulation	Code Word	Price
403-C	500-1500 kc.*	2-200,000 microvolts	400 cps.	SCALY	\$600.00

* If other frequency ranges are required, we recommend that the necessary TYPE 403-Q Inductors be ordered with the standard-signal generator, since they must be calibrated in the generator with which they are to be used.

TYPE 403-P AND TYPE 403-Q INDUCTORS

THESE are intended for extending the frequency range of the TYPE 403-C Standard-Signal Generator. The TYPE 403-P Inductors are uncalibrated; the TYPE 403-Q Inductors are calibrated.

Type	Frequency Range	Code Word	Price
*403-P2	500-1500 kc.	.....	12.00
*403-P3	175- 500 kc.	.....	12.00
*403-P4	70- 175 kc.	.....	22.00
*403-P5	33- 70 kc.	.....	22.00
*403-P6	15- 33 kc.	.....	22.00
	Frequency Calibration (per inductor) . . . . .	.....	8.00

* Frequency calibrations supplied only when ordered. The type numbers for calibrated inductors are: 403-Q2, 403-Q3, etc. Standard-signal generator with which calibrated inductors are to be used must be submitted with order so that we can make calibrations and check the performance of the instrument.

TYPE 418 DUMMY ANTENNA

THIS is made in accordance with specifications of the Institute of Radio Engineers for a standard dummy antenna for use in making standard-signal measurements on radio receivers. Its effective height is taken as 4 meters.

Inductance: 20 microhenrys.

Capacitance: 200 $\mu\mu\text{f}$.

Resistance: 25 ohms.

Mounting: Moulded bakelite case with binding posts and mounting straps for con-

necting directly to input terminals of receiver under test.

Dimensions: 2 x 3 $\frac{1}{4}$ x 1 $\frac{5}{8}$ inches.

Weight: 6 ounces.

<i>Type</i>	<i>Code Word</i>	<i>Price</i>
418	AGENT	\$6.00

OSCILLATORS FOR RADIO-SERVICE TESTING

THE modern radio receiver with gang-tuning controls and enclosed chassis construction presents a difficult service problem. The cost of servicing such complicated equipment justifies the installation of proper test equipment wherever any considerable volume of service work is being done.

The troubles that may arise in a modern radio receiver may be roughly classified into the following three groups: (a) those due to defective tubes, (b) those due to defects in the audio-amplifier system, and (c) those that appear in the radio-frequency amplifier and detector units. Tube troubles will be disclosed by any one of a number of tube-testing units now on the market; many audio-amplifier troubles may be quite satisfactorily investigated by simple direct-current continuity tests. For making checks upon the radio-frequency system, however, the fundamental testing device that must be used is a modulated radio-frequency oscillator, furnishing a test signal at one or more points in the broadcast band. When neutralizing, when adjusting trimming condensers, when aligning gang-tuning controls, when making general radio-frequency continuity tests, and when making any one of a number of other investigations in the absence of a reliable signal from several different broadcasting stations, a test oscillator is an absolute necessity if an intelligent test is to be made.

TYPE 360 TEST OSCILLATOR

TO meet the demand for a general-purpose driving oscillator, the General Radio Company has developed its TYPE 360 Test Oscillator. This instrument consists of a modulated radio-frequency oscillator which will operate at any point in the broadcast band (500 to 1500 kc.) and in addition, deliver a signal at 175 and 180 kc. for making tests upon the intermediate-frequency stages of superheterodyne receivers. A meter for measuring the power output of the receiver as a means of indicating the optimum adjustment is included.

Frequency: 500 to 1500 kc. continuous, as well as 175 kc. and 180 kc. adjustable, over a 5-kc. band on either side of specified channel frequencies for "peaking" intermediate-frequency transformers in superheterodynes.

Calibration: Broadcast-band control calibrated directly in frequency with accuracy of ± 2 per cent.; 175 kc. and 180 kc. channels adjusted to ± 0.25 per cent.

Modulation: By means of grid leak and

condenser combination at frequency of approximately 800 cycles, 100 per cent.

Output Meter: Consists of TYPE 488-A Alternating-Current Voltmeter connected at will across 4000-ohm resistance network for simulating high-impedance (cone-type) speaker or directly across a low-impedance voice coil. Pin jacks, connecting cable, and provision for telephone receivers provided.

Tubes and Batteries: One 112-type tube (not included in price of instrument) is required. Replacement through hand-hole in bottom of cabinet. Battery cable for connecting 6-volt filament and 45-volt plate supplies provided. External batteries required. Connecting leads supplied.

Test Tool (shown in lid of box): Consists of bakelite rod with heavy closed loop at one end and flat spade at other. Used for aligning gang-controlled tuning condensers. Closed loop acts as short-circuited turn to reduce inductance of the coil; spade increases effective capacitance of the condenser.

Pilot Lamp: Provided to show when oscillator tube is in operation.

Finish: Engraved bakelite panel mounted in hand-rubbed walnut cabinet with cover and carrying handle. No shielding. All metal parts nickel-plated.

Dimensions: $10\frac{3}{4}$ x $10\frac{3}{4}$ x 7 inches.

Weight: $11\frac{1}{2}$ pounds.



Type	Frequency Range	Code Word	Price
360	175, 180, and 500-1500 kc.	OVATE	\$110.00

MISCELLANEOUS LABORATORY EQUIPMENT

IN this chapter are listed three important pieces of miscellaneous laboratory equipment: the General Radio string oscillograph and vibration galvanometer, electric wave-filter sections, and artificial-cable boxes. Each is described under its own heading:

- a) String Oscillograph Vibration Galvanometer
- b) Electric Wave-Filter Section
- c) Artificial-Cable Boxes

STRING OSCILLOGRAPH AND VIBRATION 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.

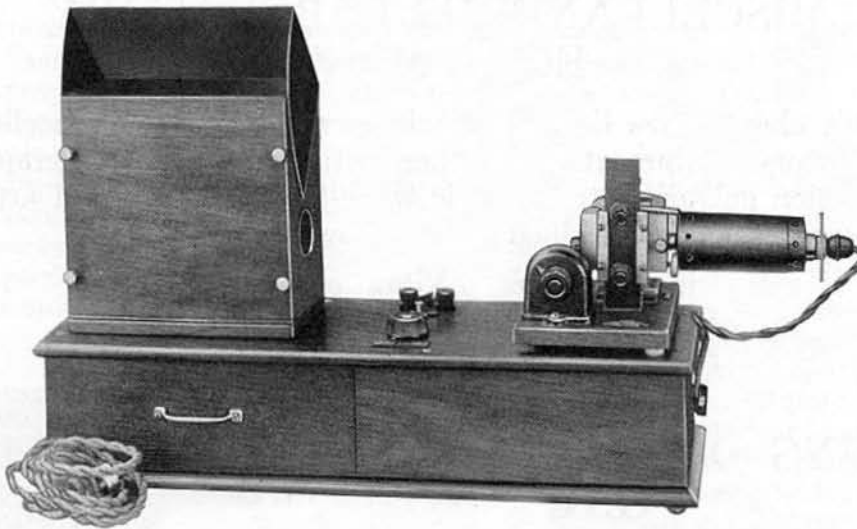
The vibrating element of the oscillograph is a fine tungsten wire fixed in a magnetic field supplied by permanent magnets. The current under observation passes through this string and is deflected by the interaction of its own field with that supplied by the permanent magnet. The string, being suspended 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 may 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.

TYPE 338 STRING OSCILLOGRAPH AND VIBRATION GALVANOMETER OSCILLOSCOPE MODEL

THIS instrument 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 which is non-synchronous drives the octagonal rotating mirror. Its speed may be



TYPE 338-L

adjusted so as to synchronize with any desired impressed frequency and to produce thereby a stationary image of any recurrent waveform. The observed waveform consists of a shadow line projected upon an illuminated field.

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 is arranged in the arc of a circle, approximately 6 inches long by $2\frac{1}{2}$ inches wide, and is printed with rectangular coordinates 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 later

under TYPE 338 Accessories. Two TYPE 338-P1 Single String-Holders are supplied.

Frequency Range: Optimum, 0 to 200 or 300 cycles per second. Usable, 0 to 3000 cycles per second.

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.

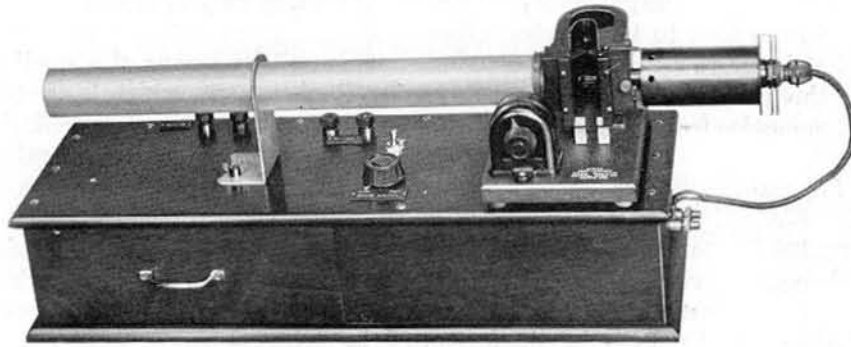
Power Supply: 110 volts, 60 cycle. About 40 watts required.

Dimensions: Table space required, 24 x 8 inches. Over all height, 14 inches.

Weight: 30 pounds without carrying case; 54 pounds with carrying case.

<i>Type</i>	<i>Code Word</i>	<i>Price</i>
338-L | .....	OFFER	\$250.00

VIBRATION GALVANOMETER MODEL



TYPE 338-G

BY omitting the rotating mirror box and substituting therefor a projection tube $1\frac{3}{4}$ 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.

Galvanometer and String: The galvanometer is sensitized by two permanent magnets which eliminate the need for direct-current excitation. The characteristics of the strings are described under TYPE 338 Accessories. Two TYPE 338-P1 Single String-Holders are supplied.

Frequency Range: 0 to 2000 cycles per second.

Light Source: Transformer operated from 110-volt, 60-cycle power supply, delivers

8 volts for lighting standard automobile headlight lamp.

Mounting: Whitewood carrying case supplied.

Power Supply: 110 volts, 60 cycle. About 40 watts required.

Dimensions: Table space required, 24 x 8 inches. Over all height, 12 inches.

Weight: 26 pounds without carrying case; 50 pounds with carrying case.

Type	Code Word	Price
338-G	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.

Various types of wires may serve as the string elements in the TYPE 338 String Oscillograph, but those supplied are wired with tungsten, 0.0004 inch in diameter. This material has been found to be most suitable for general work. The string has a resistance of about 45 ohms and is about 3 inches in length. When used in the standard galvanometer unit, the following data will give an indication of the sensitivity obtained.

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. Two adjustment screws are provided. One varies the tension on the string and thereby adjusts its sensitivity and its natural period of vibration, while the other serves to displace the string as a whole across the light beam to center the image on the screen. Provision is made for damping the vibration of the string, if desired, by means of a drop of oil. By the choice of a proper grade of oil, the string may be rendered essentially aperiodic over a wide frequency range not too closely adjacent to the natural period of the string. This is, of course, highly important whenever a good reproduction of waveform is desired.

The string-holder is removable from the galvanometer, electrical contact being made through two springs on the galvanometer base. The string may be stretched to a natural frequency of from 3500 to 4000 cycles before breaking.

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 string will carry several times the aperiodic full-scale deflection current without danger of burnout. This is a desirable feature.

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. These two strings must vibrate in the same plane and, therefore, their images must be projected adjacent but not overlapping. One of the strings connects to the galvanometer in a manner identical with that of the single string-holder, while the other string terminates in two binding posts mounted on the holder unit, and requires an additional potentiometer (not supplied with string-holder) if a device to control the string sensitivity is needed.

Four adjustment screws are used to control individually the tensions on the two strings, their transverse separation, and the centering of both on the 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

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 microwatts
- At 250 cycles 0.025 microwatts
- At 500 cycles 0.144 microwatts
- 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 338-P2

Type		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 45)		
340	Rheostat (see page 19)		
	Restringing TYPE 338-P1 (including string)		\$1.25
	Restringing TYPE 338-P2 (including strings)		3.00

ELECTRIC WAVE FILTERS

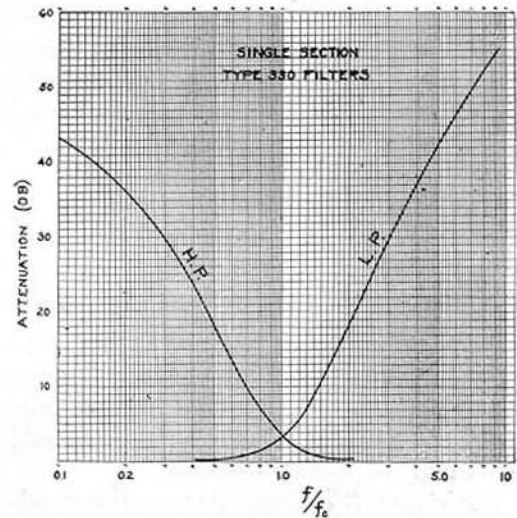
ELECTRIC wave filters, used extensively in studying the transmission characteristics of communications equipment, consist of capacitance and inductance networks so designed that they pass certain frequencies and attenuate others. Filters may be divided into four general classes: low-pass filters, high-pass filters, band-elimination filters, and band-pass filters. For references, consult the section on attenuation networks, page 19.

TYPE 330 FILTER SECTIONS

WE have developed a series of simple high-pass and low-pass filter sections mounted in individual cases. The high-pass filters are T-type sections, while the low-pass filters are π sections. These individual sections are built into shielded metal cans and each comprises a suitably designed laminated iron-core inductor, with two paper or mica 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 types listed have arbitrarily chosen values of impedance and cut-off frequency. 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 and the iterative impedance should be specified when ordering such special section. Low-pass and high-pass section may be combined to make band-pass and band-elimination filters.

Mounted in Model C cases. (See page 44.)



LOW-PASS MODELS						
Type	Cut-off Frequency	Impedance		Weight	Code Word	Price
330-A	500 cps.	600 ohms	.....	3 1/4 lb.	FILTERGOAT	\$12.00
330-C	500 cps.	6000 "	.....	3 1/8 lb.	FILTERSHOE	12.00
330-E	1000 cps.	600 "	.....	3 lb.	FILTERTOAD	12.00
330-G	1000 cps.	6000 "	.....	3 1/8 lb.	FILTERSIGN	12.00
330-J	2000 cps.	600 "	.....	3 1/8 lb.	FILTERHEAD	12.00
330-L	2000 cps.	6000 "	.....	3 1/8 lb.	FILTERBELL	12.00

HIGH-PASS MODELS						
Type	Cut-off Frequency	Impedance		Weight	Code Word	Price
330-B	500 cps.	600 ohms	.....	3 1/4 lb.	FILTERGIRL	\$12.00
330-D	500 cps.	6000 "	.....	3 1/8 lb.	FILTERSEAT	12.00
330-F	1000 cps.	600 "	.....	3 1/4 lb.	FILTERMUSH	12.00
330-H	1000 cps.	6000 "	.....	3 1/4 lb.	FILTERPIPE	12.00
330-K	2000 cps.	600 "	.....	3 1/8 lb.	FILTERFOOT	12.00
330-M	2000 cps.	6000 "	.....	3 1/8 lb.	FILTERWALK	12.00

ARTIFICIAL-CABLE BOXES

WHEN studying transmission characteristics of various types of cable, it is not always convenient to have an actual cable upon which to experiment. This difficulty may be overcome by employing artificial-cable boxes, built up of series resistance elements and shunt capacitance elements. The boxes described in the following paragraphs are extremely convenient.

TYPE 321 ARTIFICIAL-CABLE BOXES

ADJUSTABLE MODELS

THESE cable boxes contain a series of H-type sections, each having a loop resistance of $\frac{1}{2}R$ and a shunt capacitance of C .

Although a single section will represent any desired length of cable, an artificial cable will reproduce a real cable in its electrical behavior more perfectly as it is subdivided into a greater number of uniform sections. In practice, however, a limit to this subdivision, as indicated below, is reached at which the artificial cable represents with a sufficient approximation, the genuine cable.

The amount of inductance present in a cable is so small in comparison with the capacitance that its effect at voice frequencies is generally negligible. The following boxes each contain the electrical equivalent of 32 miles of standard paper cable of a gauge frequently used in practice. Other cables may be built on special order.

Subdivision: Seven units of 16-8-4-2-1- $\frac{1}{2}$ - $\frac{1}{2}$ miles on individual sections.

Composition: 16-, 8-, and 4-mile units built of 2-mile sections; 1- and $\frac{1}{2}$ -mile units built of $\frac{1}{2}$ -mile sections.

Resistance Windings: Ayrton-Perry adjusted to 0.25 per cent.

Condensers: Low-loss rolled waxed-paper condensers calibrated to 1 per cent.

Peak Voltage Rating: 300 volts.

Mounting: Shielded walnut cabinet, aluminum panel.

Dimensions: 15 x 8 x 6 inches.

Weight: 9 pounds.

Type	Total Length	Cable Characteristics †			Code Word	Price	
		Gauge	Resistance	Capacitance			
*321-A	32 miles in steps of	0.5	16 B & S	42.2 ohms	62 μf	NETWORKBUG	\$180.00
*321-B	32 " " " "	0.5	19 B & S	83.2 "	62 μf	NETWORKBIB	180.00
*321-C	32 " " " "	0.5	22 B & S	171 "	73 μf	NETWORKSUN	180.00

* Built to order. Not carried in stock

† Resistances and capacitances are in units per loop mile

FIXED MODELS

FOR the convenience of those desiring to experiment with longer lengths of cable, the fixed models contain 32 miles of any one of the standard gauges listed above, built as a single unit with a switch for throwing the whole box in or out of the circuit. This unit is subdivided into sixteen 2-mile sections. The specifications are the same as those of the adjustable models.

Type	Total Length	Cable Characteristics †			Code Word	Price
		Gauge	Resistance	Capacitance		
*321-D	32 miles	16 B & S	42.2 ohms	62 μf	NETWORKSIN	\$150.00
*321-E	32 "	19 B & S	83.2 "	62 μf	NETWORKFAD	150.00
*321-F	32 "	22 B & S	171 "	73 μf	NETWORKBAG	150.00

* Built to order. Not carried in stock

† Resistances and capacitances are in units per loop mile

METERS

TO meet the varied needs of the communications laboratory, a specialized type of meter is required. Certain requirements demand a voltmeter with infinite impedance. For some purposes high sensitivity is necessary. Ruggedness is usually desirable. Flexibility is often the governing factor in choosing a meter.

Listed below are several meters designed for specific needs in the laboratory and in communications work.

The vacuum tube is used in the infinite-impedance meter since the grid-filament impedance is practically infinite until very high frequencies are reached, so long as the grid is maintained negative. The more common moving-coil and hot-wire instruments are made available to cover various ranges of sensitivity. The copper-oxide-rectifier unit has been adapted to several instruments and has proved very satisfactory over the audio-frequency range where the commercial dynamometer instruments fail. Used in the power-level indicator, it has provided a simplified method of measuring voice-power levels.

General Radio meters are described under the following six general headings:

- a) Thermionic Voltmeters
- b) Copper-Oxide-Rectifier Voltmeters
- c) Pointer Galvanometers
- d) Hot-Wire Meters
- e) Ohmmeters
- f) Output Meters and Power-Level Indicators

THERMIONIC VOLTMETERS

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 described below, 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 micro-ammeter. It therefore measures the potential impressed.

TYPE 426-A THERMIONIC VOLTMETER

Range: See price list.

Power Supply: 22.5-volt battery which supplies filament, grid and plate potentials. Space provided in instrument case to ac-

commodate two 22.5-volt batteries connected in parallel. External battery recommended, however. Connections provided.

Method of Calibration: The meter is cali-

brated against root-mean-square values of a sinusoidal wave.

Accuracy of Calibration: Within 0.5 per cent. 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 per cent. of full scale at 20 kc. Less than 3 per cent. at

300 kc. Although calibration is not reliable at broadcast and higher radio frequencies, the voltmeter may be used for making voltage comparisons in that range.

Waveform Error: 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.

Overvoltage: Will withstand 50 volts momentarily.

Tube: Special tube, similar to 199-type, soldered in place.

Mounting: Polished walnut case.

Dimensions: 9 x 7 $\frac{3}{4}$ x 10 $\frac{1}{4}$ inches.

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

COPPER-OXIDE-RECTIFIER VOLTMETERS

THESE instruments are designed for the measurement of alternating-current voltages at frequencies from 20 to 10,000 cycles per second. The indicating element consists of 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 the meter circuit. The direct current is 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 two types listed below, the proper choice of resistances external to the indicating element has provided a suitable means for meeting this problem.

TYPE 427-F ALTERNATING-CURRENT VOLTMETER

THIS is a precision laboratory instrument of the portable type, having a high impedance. It consists of a rectifier unit working in conjunction with an accurately balanced d'Arsonval movement of the two-pivot type. The double-pivot movement is mounted on selected jewels. The large hand-drawn legible scale with mirror to prevent parallax, and with a knife-edge pointer, has 100 scale divisions, thus insuring accurate

determinations. This instrument is particularly suitable for comparison methods because of the precision of reading.

Range: See price list.

Impedance: Approximately 2000 ohms per volt.

Length of Scale: $5\frac{1}{2}$ inches.

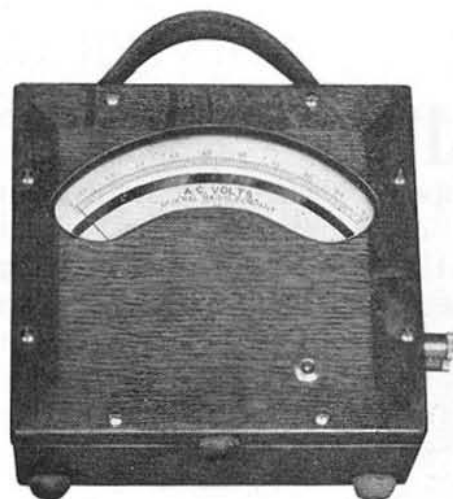
Accuracy of Calibration: Within 2 per cent. of full-scale at frequencies up to 3000 cycles. Within 5 per cent. to 5000 cycles. Within 10 per cent. to 10,000 cycles.

Adjustment: A small screw is provided for making the zero adjustment.

Mounting: Polished walnut case, fitted with leather handle.

Dimensions: $3\frac{1}{2}$ x $6\frac{1}{2}$ or $7\frac{1}{4}$ inches.

Weight: $5\frac{1}{2}$ pounds.



Type	Range	Code Word	Price
427-F	0-5 volts, r.m.s.	FAUNA	\$75.00

TYPE 488-A ALTERNATING-CURRENT VOLTMETER

THIS instrument is of panel-mounting type and consists of a copper-oxide-rectifier meter in conjunction with a micro-ammeter. In order to maintain its impedance at a constant value, this meter is shunted by a resistance, thus reducing the change in the impedance of the instrument with applied voltage. The scale has 30 divisions and the movement is of the d'Arsonval type.

Range: See price list.

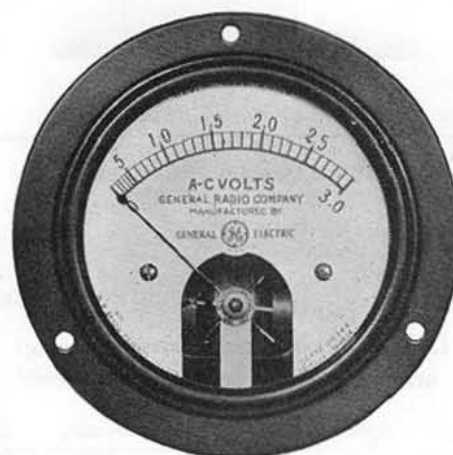
Impedance: When used for voltage determinations, impedance changes in the meter cause no appreciable error. Maintained approximately constant at 4000 ohms with 2 volts applied. In error 10 per cent. from 20 to 1000 cycles with 3 volts applied. In error 5 per cent. from 20 to 10,000 cycles with one volt applied.

Length of Scale: $2\frac{1}{2}$ inches.

Accuracy of Calibration: Within 2 per cent. of its full-scale reading at frequencies up to 2000 cycles. Within 5 per cent. to 5000 cycles. Within 10 per cent. to 10,000 cycles.

Adjustment: A screw is provided under the glass face for making the zero adjustment. Glass face can be removed by unscrewing it from frame.

Mounting: Moulded bakelite case.



Dimensions: Diameter, $3\frac{1}{2}$ inches; depth, $2\frac{1}{4}$ inches over all. Mounting hole diameter, $2\frac{27}{32}$ inches.

Weight: 12 ounces.

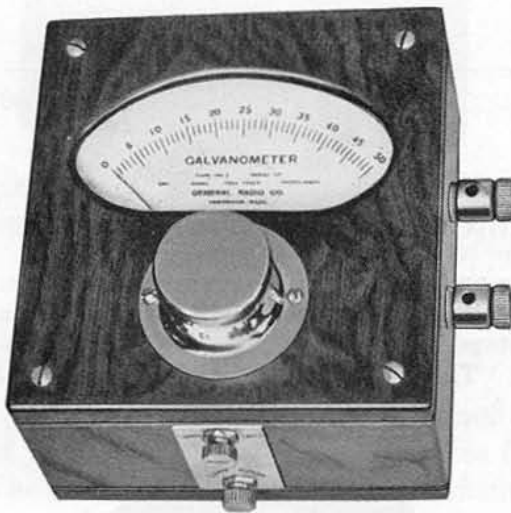
Type	Range	Code Word	Price
488-A	0-3 volts, r.m.s.	FELON	\$20.00

POINTER GALVANOMETERS

MOST laboratories require a rugged, sensitive, portable instrument for the measurement of direct currents of the order of 10 to 150 microamperes. The TYPE 189 Galvanometer is adapted to just such service. Its combination of portability and sensitivity makes this instrument suitable for a variety of uses ranging from indicating a bridge balance to the measurement of a radio signal when used with a rectifier.

TYPE 189 GALVANOMETER

ZERO-LEFT MODELS



Range: Approximate only. See price list.
Resistance: Approximate only. See price list.

Method of Calibration: Calibrated to read approximately listed value of current at full-scale deflection. Scale has 50 divisions. See price list.

Scale Length: 3 inches.

Movement: d'Arsonval type. Phosphor-bronze suspension. Spring supporter to take up shock. Requires no leveling. Reasonably stable zero.

Adjustments: Two knurled screws for providing zero adjustment and clamping.

Mounting: Polished walnut case. Leather carrying strap provided.

Dimensions: 5½ x 5½ x 4½ inches.

Weight: 2½ pounds.

Type	Approximate Range	Approximate Resistance	Code Word	Price
189-E	0-150 mca.	10 ohms	.....	\$36.00
189-H	0- 50 mca.	100 "	.....	36.00
189-L	0- 10 mca.	2000 "	.....	36.00

ZERO-CENTER MODELS

THESE are identical in every respect with the zero-left models, except that the zero mark on the scale appears at the center.

Type	Approximate Range	Approximate Resistance	Code Word	Price
189-F	75-0-75	10 ohms	.....	\$36.00
189-J	25-0-25	100 "	.....	36.00

HOT-WIRE METERS

AN instrument for the measurement of currents at high frequencies must keep its inductance and capacitance as small as possible. High reactance would cause the readings to vary with frequency. For many radio-frequency measurements a suitably designed hot-wire ammeter has the necessary characteristics which particularly adapt it to this work. It should, however, be recognized that a hot-wire ammeter is inherently less accurate than an ammeter of the moving-coil type, which of course is unsuitable for measuring current at high frequencies. In the TYPE 127 Hot-Wire Meter, careful design and good workmanship have produced instruments which are electrically and mechanically rugged and reliable. These meters are used extensively in wavemeters for determining the resonance point and are also used for measuring the radiation, filament, and plate currents in experimental transmitting stations. They are equally suitable for use on direct and alternating current.

TYPE 127 HOT-WIRE METERS



TYPE 127-A



TYPE 127-B



TYPE 127-C

FLUSH-MOUNTING MODELS

Range: See price list.

Resistance: See price list.

Scale Length: 2 inches.

Movement: Hot-wire type. The expanding strip is of a platinum-silver alloy, proportioned to work at a low temperature. Its low resistance permits reasonable overload and minimizes losses.

Adjustment: A knurled screw is provided for making the zero adjustment.

Dimensions: Diameter, $3\frac{3}{8}$ x 2 inches over all. Mounting hole diameter, $2\frac{5}{8}$ inches.

Weight: 8 ounces.

Type	Range	Approx. Resistance	Code Word	Price
127-A	100 milliamperes	23.0 ohms	MEDAL	\$6.00
127-A	250 "	8.5 "	MERCY	6.00
127-A	0.5 ampere	2.5 "	MERIT	6.00
127-A	1 "	0.9 ohm	MERRY	6.00
127-A	3 amperes	0.25 "	MIMIC	6.00
127-A	5 "	0.07 "	MINIM	6.00
127-A	10 "	0.052 "	MINNY	6.00
*127-A	270 milliamperes (approx.)	9.0 ohms	MITER	5.75

* When ordering, specify TYPE 127-A Galvanometer

(Continued on following page)

PANEL-MOUNTING MODELS

PANEL-MOUNTING models differ from other hot-wire meters only in the method of mounting. See the illustration.

Dimensions: 3 x 3 $\frac{3}{4}$ x 1 $\frac{1}{2}$ inches.

Weight: 4 ounces.

Type	Range	Approx. Resistance	Code Word	Price
127-B	100 milliamperes	23.0 ohms	MAYOR	\$6.00
127-B	250 "	8.5 "	MADAM	6.00
127-B	0.5 ampere	2.5 "	MAJOR	6.00
127-B	1 "	0.9 ohm	MANOR	6.00
127-B	3 amperes	0.25 "	MASON	6.00
127-B	5 "	0.07 "	MATIN	6.00
127-B	10 "	0.052 "	MAXIM	6.00
*127-B	270 milliamperes (approx.)	9.0 ohms	MAGIC	5.75

* When ordering, specify TYPE 127-B Galvanometer

CASE-MOUNTING MODELS

CASE-MOUNTING models differ from other models only in the method of mounting. See the illustration.

Dimensions: 3 x 3 x 2 $\frac{1}{2}$ inches over all.

Weight: 6 ounces.

Type	Range	Approx. Resistance	Code Word	Price
127-C	100 milliamperes	23.0 ohms	MUGGY	\$6.50
127-C	250 "	8.5 "	MOCHA	6.50
127-C	0.5 ampere	2.5 "	MOGUL	6.50
127-C	1 "	0.9 ohm	MOLAR	6.50
127-C	3 amperes	0.25 "	MORAL	6.50
127-C	5 "	0.07 "	MUMMY	6.50
127-C	10 "	0.052 "	MUSTY	6.50
*127-C	270 milliamperes (approx.)	9.0 ohms	MOTTO	6.25

* When ordering, specify TYPE 127-C Galvanometer

OHMMETERS

THERE are many occasions in laboratories, service stations, and factories when an approximate measurement of resistance is required. The TYPE 287 Direct-Reading Ohmmeter is designed for simplifying the determination of resistance where an approximate value is sufficient.

TYPE 287 DIRECT-READING OHMMETER

THIS instrument consists of a battery and meter in series with a resistance, and a rheostat shunted across the meter to provide a zero adjustment. The dial is calibrated directly in ohms. Clip leads are provided for convenience in connecting the ohmmeter to the device to be measured.

Range: See price list.

Operation: Before using the ohmmeter, the zero should be checked by connecting the terminals together and adjusting the knob until the meter registers zero resistance. The short-circuiting connection is then removed and the meter is ready for use.

Battery: A 4.5-volt battery for TYPE 287-A and a 1.5-volt battery for TYPE 287-B are furnished with the instrument.

Mounting: Polished walnut. Leather strap provided for carrying.

Dimensions: $6\frac{3}{4} \times 5\frac{3}{4} \times 4\frac{1}{2}$ inches.

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



TYPE 287-A

Type	Range		Code Word	Price
287-A	0-10,000 ohms, 500 ohms, center-scale	.....	ONION	\$30.00
287-B	0- 2000 " , 100 " , " "	.....	ORBIT	30.00

OUTPUT METERS AND POWER-LEVEL INDICATORS

UNTIL the development of copper-oxide-rectifier-type meters, the vacuum-tube voltmeter was practically the only instrument suitable for making voltage measurements over the audio-frequency spectrum. It has the obvious disadvantage of requiring tubes and batteries, both of which require frequent replacement and limit the portability of any instrument in which they are used.

The two instruments described in this section, an output meter and a power-level indicator, make use of the copper-oxide-rectifier voltmeter for the measurement of voice-frequency power. The output meter consists of a 0-3-volt voltmeter and a network for extending its range to 150 volts. Since the input impedance remains practically constant at 4000 ohms regardless of frequency and setting of multiplier, it furnishes a convenient means of measuring the power output of a radio receiver.

The power-level indicator is similar to the output meter, except that the voltmeter and the multiplier network are calibrated in decibels. It is useful for monitoring as well as measuring the voice-power level in all kinds of transmission and recording circuits.

TYPE 486 OUTPUT METER

THIS instrument, designed primarily to measure the output power of any device operating over the frequency range of from 20 to 10,000 cycles per second, is admirably adapted for use as a general-purpose multirange alternating-current voltmeter. It consists of an indicating meter preceded by a suitable multiplier for extending the range of the instrument. The multiplier unit, essentially an L-type attenuator, maintains the input impedance of the instrument at 4000 ohms, thus simulating the impedance of the usual cone speaker. It was designed primarily for determining the power output of radio sets. Its uses are many. In the laboratory it is readily available for determining line voltage, as well as for measuring the voltage applied to the filaments of alternating-current tubes.



Range: See price list.

Impedance: With multiplier set at 1, the impedance is the same as for the TYPE 488-A Alternating-Current Voltmeter described previously. With multiplier set at 5, 20, or 50, the impedance is 4000 ohms ± 2 per cent. and is non-reactive.

Scale Length: 2½ inches.

Accuracy of Calibration: Same as TYPE 488-A Alternating-Current Voltmeter.

Adjustment: Zero adjustment same as for TYPE 488-A model.

Mounting: Polished walnut case.

Dimensions: 7¾ x 5 x 3½ inches.

Weight: 2½ pounds.

Type	Range	Code Word	Price
486	0-3-15-60-150 volts across 4000 ohms, or 5.6 watts, max.	MALAY	\$38.00

TYPE 586 POWER-LEVEL INDICATORS

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 near-by channels.

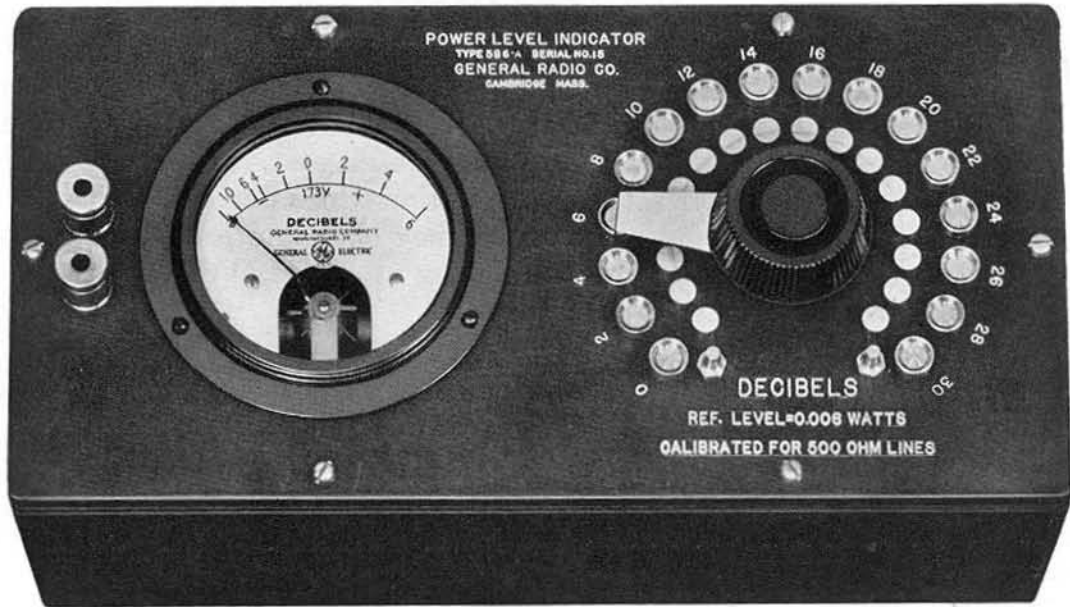
The TYPE 586 Power-Level Indicator has many advantages for work of this kind. It is portable, compact, rugged, accurate, low in price, and requires no batteries or replacements.

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.

CABINET MODEL



TYPE 586-A

Range: See price list.
Impedance: 5000 ohms.

Scale Reading: Zero level at mid-scale. This corresponds to 6 milliwatts or 1.73 volts when connected across a 500-ohm line. Graduated in steps of 2 decibels to cover the range from -10 to +6 decibels. Network adjustable in steps of 2 decibels.

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. Effect greatest at -10-decibel mark on meter where the reading may be 0.5 decibel low.

Average error is from 0.1 to 0.2 decibel, entirely negligible. No appreciable frequency error up to 10,000 cycles per second.

Uses: Monitoring the power level of a voice circuit. Power and voltage measurements. Amplifier gain and circuit loss determinations. Equalization measurements on voice circuits.

Calibration: Calibrated to read directly when across a 500-ohm line. Constant correction term taken from a correction chart furnished with the instrument must be applied when instrument is used across lines of impedance other than 500 ohms.

Dimensions: 10 x 5 x 5 inches.

Weight: 2 $\frac{7}{8}$ pounds.

Type	Range	Dimensions	Weight	Code	Price
586-A	-10 db to +36 db with zero level at 0.006 watts and 500-ohm line	10 x 5 x 5 in.	2 $\frac{7}{8}$ lb.	HABIT	\$60.00

RELAY-RACK MODEL

THIS model is identical with the cabinet model except for the method of mounting. It is arranged for mounting on a standard 19-inch relay rack. It has a $\frac{1}{4}$ -inch bakelite panel and is protected by a dust cover of nickel-plated brass.

Dimensions: 19 x 5 $\frac{1}{4}$ x 5 inches.

Weight: 4 pounds.

Type	Range	Dimensions	Weight	Code	Price
586-B	-10 db to +36 db with zero level at 0.006 watts and 500-ohm line	19 x 5 $\frac{1}{4}$ x 5 in.	4 lb.	HANDY	\$64.00

RELAYS, SWITCHES, AND MISCELLANEOUS ACCESSORIES

CAREFULLY designed and well made accessories are essential in all kinds of experimental work around the laboratory. The General Radio Company has always given due attention to its line of accessories and several new items are added each year.

Particular attention is directed to the section which describes the TYPE 274 Jacks, Plugs and Mounting Bases. They offer limitless possibilities and the engineer responsible for the building up of a well equipped laboratory will find them indispensable.

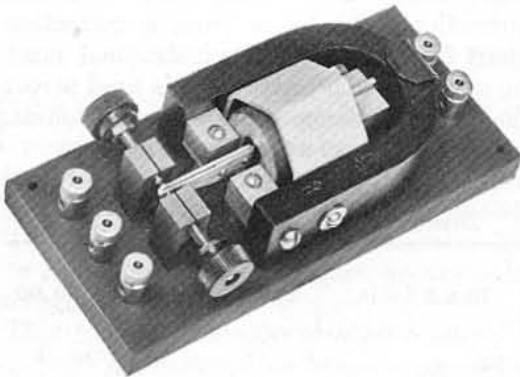
- a) Relays
- b) Switches
- c) Knobs and Dials
- d) Vacuum-Tube Sockets
- e) Binding Posts, Switch Contacts, and Stops
- f) Plugs, Jacks, and Mounting Bases
- g) Porcelain Insulators

RELAYS

IN this section are described three sensitive relays that have been developed for general-purpose use. All of them are rugged, inexpensive, and conservatively rated.

TYPE 481 POLAR RELAY

THIS relay has a permanent horseshoe magnet which provides the field and at the same time forms a protecting shield about the coil and reed. An unusual feature is the wide separation between the pole pieces (0.47 inch) which provides a uniform magnetic field in the region through which the reed moves. It also makes the mutual position less critical.



Operating Characteristics: See price list.
Current-carrying Capacity: The contact points are rugged and will break one ampere without undue burning.
Dimensions: 6 x 2 x 1 inches.
Weight: 2¼ pounds.

Type	Resistance	Normal Operating Current	Maximum Frequency	Code Word	Price
481	1500 ohms	2 milliamperes	125 cycles/second	NOMAD	\$20.00

TYPE 507 NON-POLAR RELAY

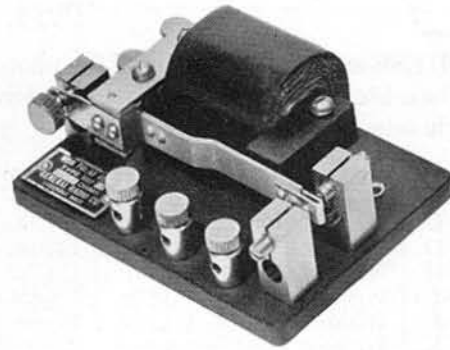
THESE relays contain an armature which has no permanent magnetization and which will not therefore distinguish between the direction of current flow.

Sensitivity: See price list. Values given are for currents corresponding to positive operation in either vertical or horizontal positions.

Resistances: Held to within ± 10 per cent.

Dimensions: $4\frac{1}{8} \times 3 \times 2$ inches.

Weight: 1 pound.



Type	Resistance	Current to close	Current to open	Code Word	Price
507-A	250 ohms	10 milliamperes	6 milliamperes	NITRE	\$12.00
507-B	4000 "	2 "	1 milliampere	NOBLE	15.00

KNOBS AND DIALS

ALL General Radio dials are of brass, finished to resemble frosted silver, with graduated scale in black. A vernier is available for use with TYPE 302 and TYPE 303 Dials. The mechanism for this is shown in the illustration.

All knobs are moulded bakelite and with one exception are normally supplied for mounting on a $\frac{1}{4}$ -inch shaft.

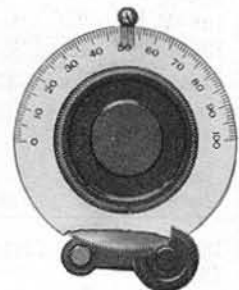
TYPE 310 AND TYPE 317 DIALS

TWO sizes of these dials are available, one 4 inches in diameter, the other $2\frac{3}{4}$ inches in diameter. Both have 100 divisions to cover 180° of the circumference. Each dial is packed with celluloid indicator and a drilling template.

Type	Shaft	Diameter	Height	Weight	Code Word	Price
310	$\frac{7}{8}$ in.	$2\frac{3}{4}$ in.	$\frac{7}{8}$ in.	$\frac{1}{8}$ lb.	DANDY	\$0.50
317	1 in.	4 in.	1 in.	$\frac{1}{4}$ lb.	DEBUT	1.00

TYPE 302 AND 303 GEARED DIALS

THESE are similar in every way to the TYPE 310 and TYPE 317 Dials except that they are provided with a vernier attachment, consisting of a fiber pinion mounted below the dial which engages with a brass gear behind the dial. The pinion is mounted on a floating arm and is held in close contact with the gear by means of a spring. But one mounting hole is required for the entire attachment. A celluloid indicator and a template are provided with each unit.



TYPE 302

Type	Shaft	Diameter	Height	Weight	Gear Ratio	Code Word	Price
302	$\frac{1}{4}$ in.	$2\frac{3}{4}$ in.	$\frac{3}{4}$ in.	$\frac{1}{4}$ lb.	1:5 $\frac{1}{4}$	DAISY	\$1.25
303	$\frac{1}{4}$ in.	4 in.	$\frac{3}{4}$ in.	$\frac{1}{2}$ lb.	1:7 $\frac{3}{4}$	DALLY	2.00

TYPE 137 KNOBS

THESE are shown half-size in the photographs on page 111. They are made of moulded bakelite with inserts of brass, and all but the TYPE 137-K Knob are furnished with a single setscrew.

Type	Shaft	Diameter	Height	Weight	Code Word	Price
137-D	With Pointer	1/4 in.	1 1/2 in.	5/8 in.	2 oz.	..... \$0.30
137-D	Without	1/4 in.	1 1/2 in.	5/8 in.	1 oz.	..... .25
137-H	Without	1/4 in.	2 5/8 in.	7/8 in.	1 oz.	..... .50
137-J	With	1/4 in.	1 1/8 in.	1/2 in.	1 oz.	..... .20
137-J	Without	1/4 in.	1 1/8 in.	1/2 in.	1 oz.	..... .15
137-K	Without	10-32	13/16 in.	7/16 in.	1 oz.	..... .15
137-L	With	1/4 in.	1 11/16 in.	7/8 in.	1 oz.	..... .20

BINDING POSTS, SWITCH CONTACTS, AND STOPS

ALL of these items are used on General Radio instruments. The TYPE 138-V and TYPE 138-X Binding Posts are recessed to receive a TYPE 274-P Plug. They are extremely useful for use on portable instruments in the laboratory.

TYPE 138 BINDING POSTS, SWITCH CONTACTS, AND SWITCH STOPS

THE dimensions of these accessories are given in the price list. They are shown half-size in the photographs on page 111.

BINDING POSTS

Type	Material	Diameter	Height	Max. Panel Thickness	Thread	Code Word	Price
138-A	Bakelite and N.P. Brass	3/4 in.	5/8 in.	3/8 in.	10-32	.....	\$0.18
138-W	Nickel-Plated Brass	7/16 in.	13/32 in.	1/4 in.	6-32	.....	0.08
*138-V	" " "	3/8 in.	11/16 in.	3/8 in.	10-32	STANPARANT	0.20
*138-X	" " "	1/2 in.	11/16 in.	3/8 in.	10-32	STANPARBOY	0.20
138-Y	" " "	1/2 in.	3/4 in.	1/4 in.	10-32	.....	0.14
138-Z	" " "	3/8 in.	5/8 in.	1/4 in.	6-32	.....	0.07

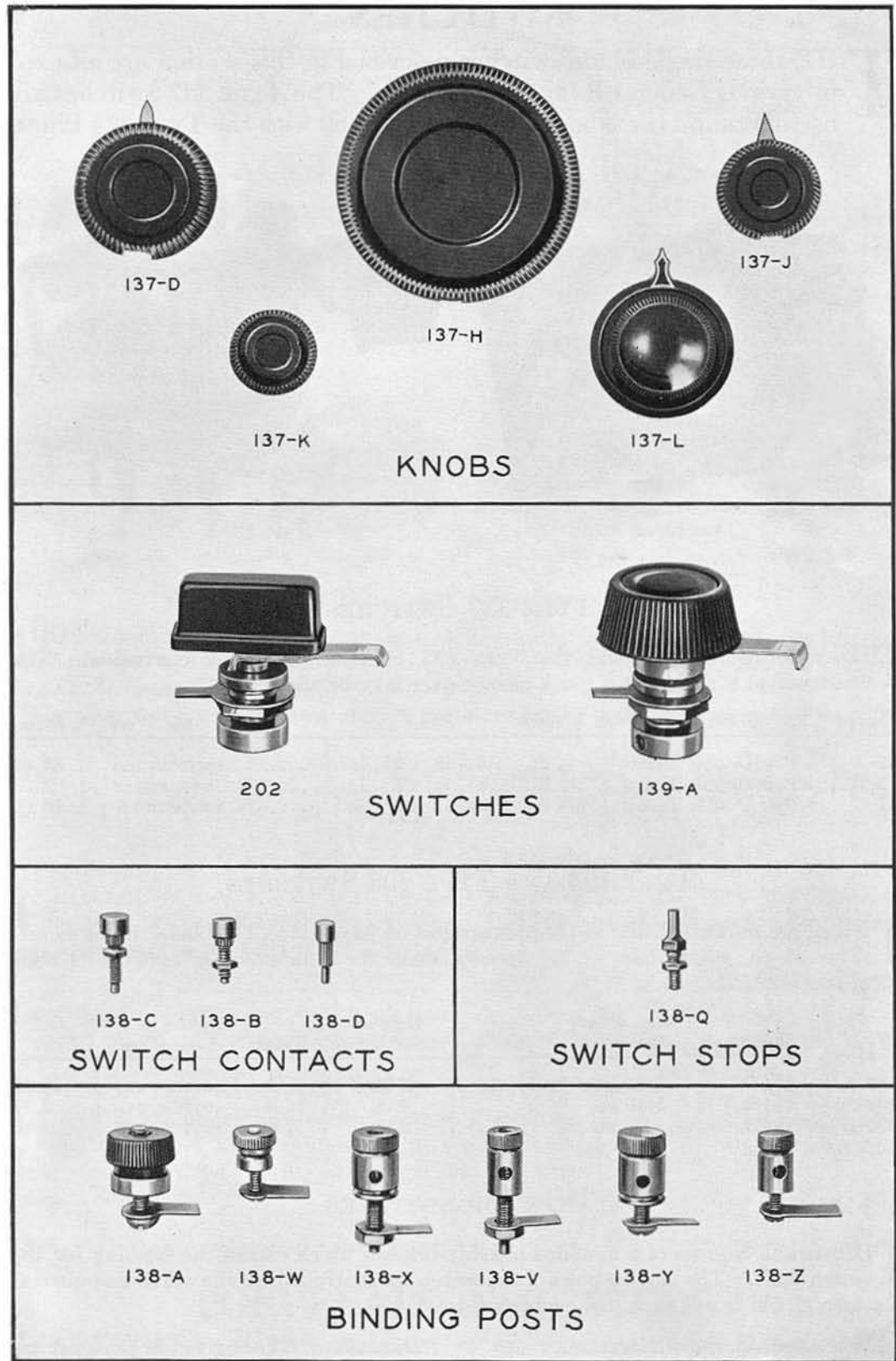
* See also, TYPES 274-K and 274-L Binding Post Assemblies

SWITCH CONTACTS

Type	Material	Diameter	Height	Max. Panel Thickness	Thread	Code Word	Price
138-B	Nickel-Plated Bronze	1/4 in.	0.190 in.	5/16 in.	6-32	.....	\$0.04
138-C	" " "	5/16 in.	0.190 in.	7/16 in.	6-32	.....	0.04
138-D	" " "	3/16 in.	0.195 in.	7/16 in.	.....	.....	0.03

SWITCH STOPS

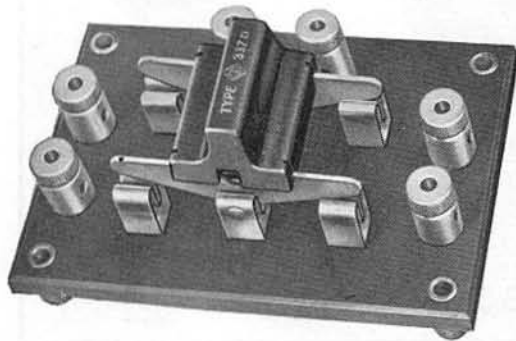
Type	Material	Diameter	Height	Max. Panel Thickness	Thread	Code Word	Price
138-Q	Nickel-Plated Brass	1/8 in.	7/8 in.	5/16 in.	6-32	.....	\$0.04



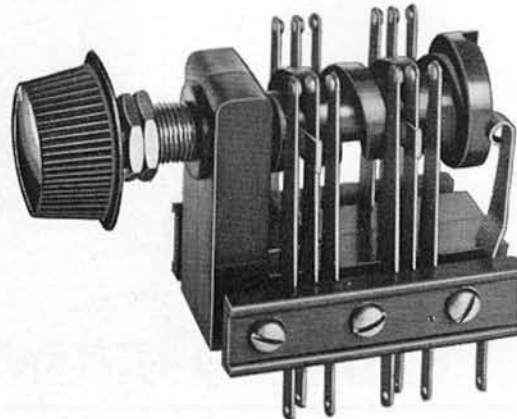
(ONE-HALF SCALE)

SWITCHES

THE three single-blade switches described in this section are all used in various General Radio instruments. The TYPE 337 Switches are useful around the laboratory and fit in well with the TYPE 274 Plugs.



TYPE 337-A



TYPE 339-A

TYPE 337 SWITCHES

THE experimenter will find the TYPE 337 Switches extremely convenient. The construction is such that a quick change-over may be effected.

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 139 AND TYPE 202 SWITCHES

THESE are shown half-size in the photographs on page 111. The blades are of nickel-silver which, with bronze contact points, make for a minimum of cutting. Knobs are of moulded bakelite.

Type	Radius	Max. Panel Thickness	Knob	Over all Axial Length	Weight	Code Word	Price
139-A	1⅜ in.	5/16 in.	137-D	2 in.	¼ lb.	SWITCHFORD	\$0.50
202-A	1⅜ in.	5/16 in.	.....	2 in.	⅛ lb.	SWITCHTOAD	0.75
202-B	1⅜ in.	⅜ in.	.....	2 in.	⅛ lb.	SWITCHGOOD	0.75

TYPE 339 SWITCHES

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.

Knob: Special. See illustration.

Mounting: Entire switch supported from panel by the bushing.

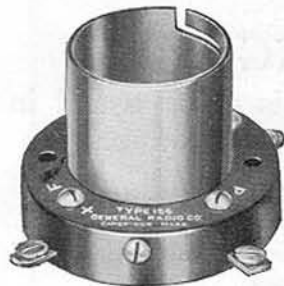
Dimensions: Those given in price list are over all. Shaft, ¼ inch.

Weight: 6 ounces.

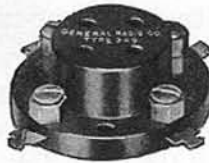
Type	Description	Dimensions	Code Word	Price
339-A	4 Pole Double Throw	13 x 2 inches	PUPPY	\$2.50
339-B	2 Pole Double Throw	13 x 2 inches	PUTTY	2.00

VACUUM-TUBE SOCKETS

IN the design of all General Radio vacuum-tube sockets, care has been taken in each case to see that they meet all size requirements of the tubes with which they are to be used.



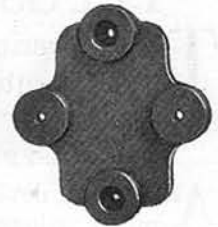
TYPE 156



TYPE 349



TYPE 438



TYPE 309

TYPE 156 SOCKET

THIS is designed for tubes having the large UV- or UX-base. If desired, the location of the shell and its bayonet holder may be shifted through 45° for use with Western Electric Company's "E"-tubes.

The phosphor-bronze contact springs are arranged to make positive contact on the sides of the tube prongs.

Type	Base	Diameter	Height	Weight	Code Word	Price
156	UX and W.E. "E"-tube	2 7/16 in.	1 3/16 in.	1/4 lb.	SOBER	\$0.75

TYPE 349 AND TYPE 438 SOCKETS

THE TYPE 349 socket is designed for the UX-type of tube; the TYPE 438 Socket is designed for the UY-type (5-prong) base. Positive contacts are made with double-gripping springs to the sides of the tube prongs.

Type	Base	Diameter	Height	Weight	Code Word	Price
349	UX	1 7/8 in.	3/4 in.	1/8 lb.	SEDAN	\$0.35
438	UY	1 7/8 in.	3/4 in.	1/8 lb.	STUDY	.35

TYPE 309 SOCKET CUSHION

MANY of the undesirable noises heard in a radio set are due to microphonic action of the tubes. This condition may be somewhat reduced by the use of this sponge-rubber socket cushion. It fits all General Radio sockets.

Type	Code Word	Price
309	SABER	\$0.25

PORCELAIN INSULATORS

CAREFULLY glazed porcelain is an extremely satisfactory insulator for high-voltage, high-frequency work.

(Continued on following page)

TYPE 260 AND TYPE 280 PORCELAIN INSULATORS

THE TYPE 280 Strain Insulator will be found particularly useful for antenna installations. The TYPE 260 Wall Insulator is equipped with a threaded brass rod at its upper end so that it may be used for supporting wiring or instruments as well as lead-in and ground wires.



TYPE 260 TYPE 280

Type	Description	Code Word	Price
260	Wall Insulator	CONIC	\$0.20
280	Strain Insulator	CULER	.12

PLUGS, JACKS, AND MOUNTING BASES

THE experimenter will find the items listed in this group useful in experimental work, especially the transformer-mounting bases.

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

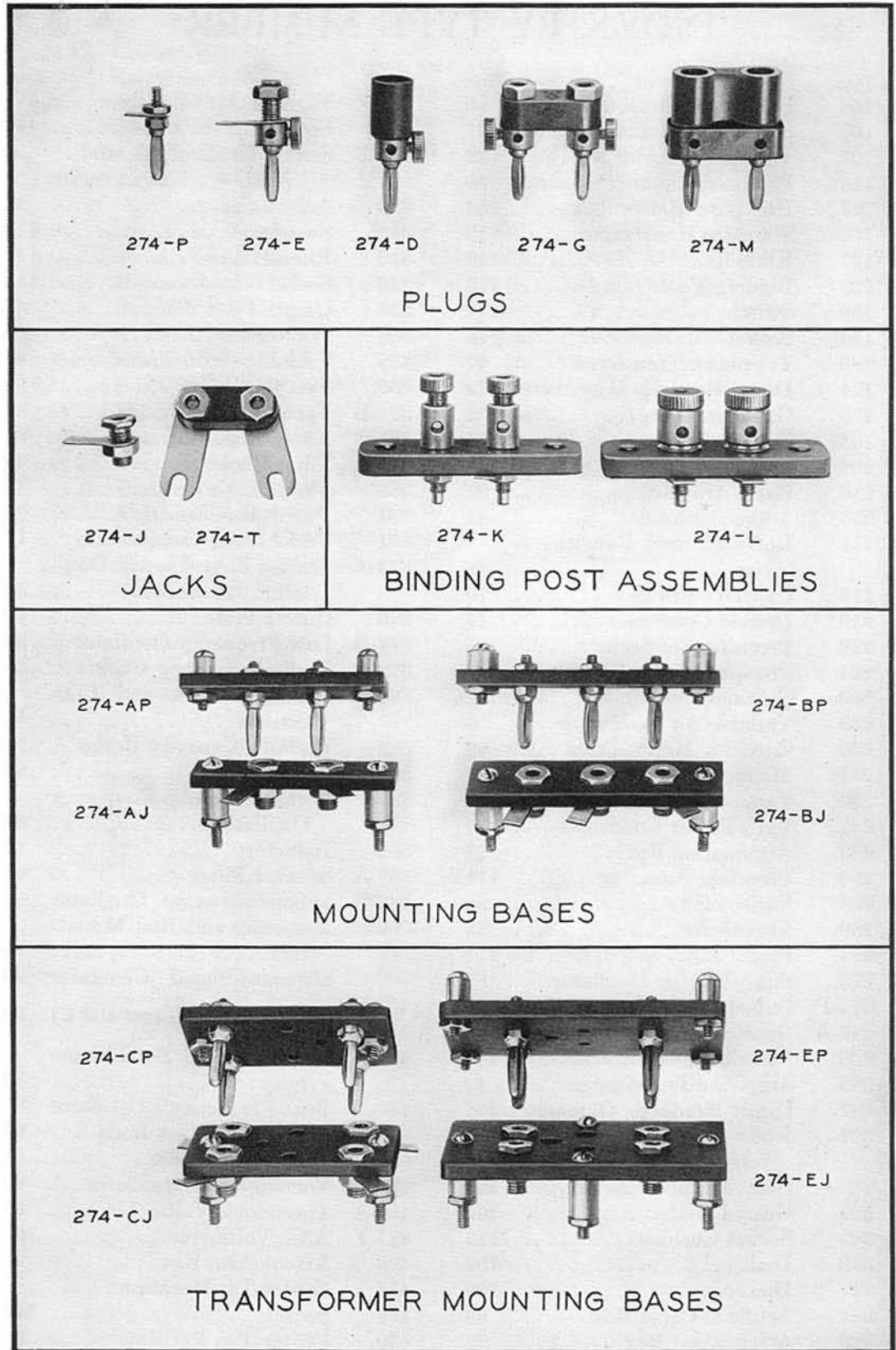
Type	Description	Code Word	Price
274-AP	2-Gang Plug Base	STANPARBIB	\$0.50
274-AJ	2-Gang Jack "	STANPARHUM	.50
274-BP	3-Gang Plug "	STANPARSUN	.60
274-BJ	3-Gang Jack "	STANPARSIN	.60
*274-CP	4-Gang Plug "	STANPARSUM	.60
*274-CJ	4-Gang Jack "	STANPARGIN	.60
*274-EP	4-Gang Transformer Mounting Plug Base	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-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. TYPE 274-Q Locating Pins for preventing insertion of jack bases in wrong position are supplied, although the illustration does not show them.

† Added to line after illustrations were prepared. Locating pins supplied.

BINDING-POST ASSEMBLIES

Type	Description	Code Word	Price
274-K	With Type 138-V Binding Posts	STANPARBAG	\$0.65
274-L	" Type 138-X " "	STANPARTAG	.65



(ONE-HALF SCALE)

NOTE: Locating pins now supplied with TYPE 274-CJ and TYPE 274-EJ.

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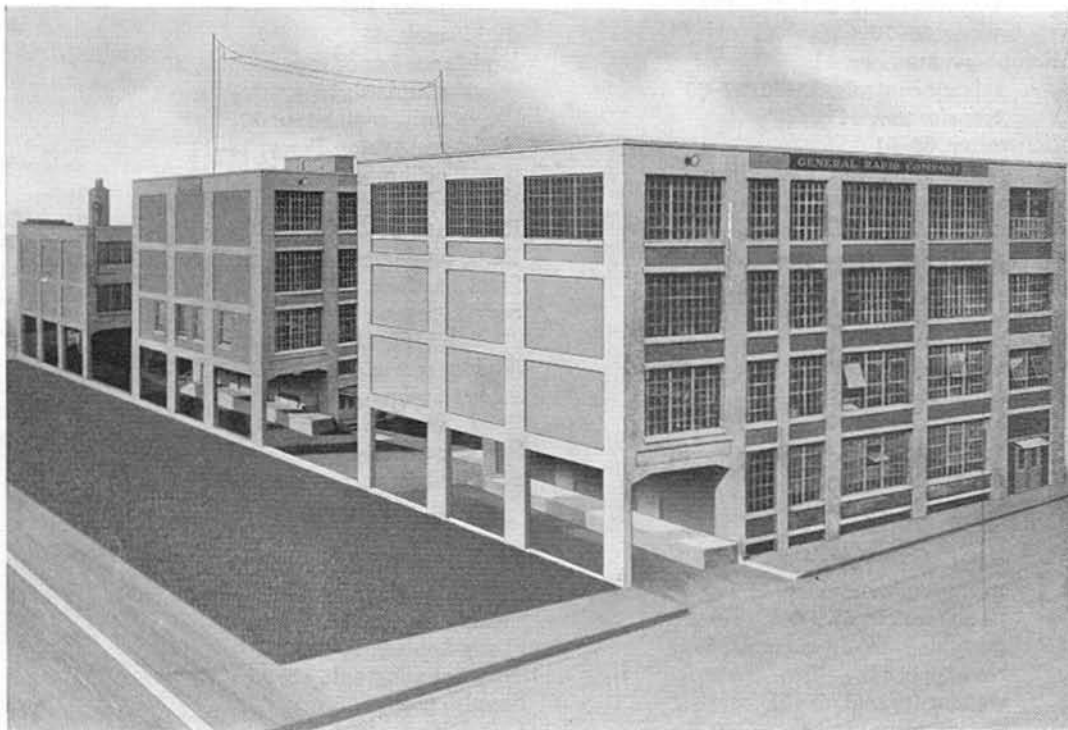
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