

# INSTRUMENTS

FOR ELECTRICAL MEASUREMENTS  
AT COMMUNICATION FREQUENCIES

## CATALOG F PART 3

FILE THIS WITH  
CATALOG F *and* PART 2

*Revised to October 1, 1931*



**GENERAL RADIO COMPANY**  
**CAMBRIDGE A, MASSACHUSETTS**



## **BEFORE ORDERING**

please consult the indexes at the back of this booklet for references to additional information about the instruments you plan to purchase. The indexes previously published are obsolete.



Additional copies of Catalog F, Part 1, and of Catalog F, Part 2, are available if you need them to complete your files. We shall be glad to send either one or both by return mail if you will ask for them. Please mention your business affiliation to help us in tracing your name in our mailing list records.

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## FOREWORD TO PART 3

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Catalog F, the complete catalog of General Radio laboratory apparatus, now consists of three parts:

1. Catalog F, June, 1930 (known as "Part 1").
2. Catalog F, Part 2, April, 1931.
3. Catalog F, Part 3, October, 1931 (this booklet).

All previous catalogs and catalog supplements are obsolete and should be destroyed or marked "obsolete" to avoid possible confusion.

In the meantime, catalog supplements of the series F-400, F-401, F-402, etc., will be issued from time to time as the need arises. They will be announced in the General Radio *Experimenter*. Watch for them.

# TABLE OF CONTENTS

## FOR PART 1, PART 2, AND PART 3

I. CONDENSERS .....	5, 123, 171
II. RESISTANCE DEVICES .....	15, 126, 174
III. INDUCTORS .....	31, 129
IV. OSCILLATORS .....	35, 130, 181
V. AMPLIFIERS, COUPLING DEVICES, POWER-SUPPLY DEVICES, AND ACCESSORIES .....	42, 133, 183
VI. FREQUENCY- AND TIME-MEASURING DEVICES .....	51, 134, 186
VII. BRIDGES AND THEIR ACCESSORIES .....	74, 141, 191
VIII. RADIO-FREQUENCY TESTING DEVICES .....	88, 143, 194
IX. MISCELLANEOUS LABORATORY EQUIPMENT .....	93, 150, 203
X. METERS .....	99, 154, 213
XI. RELAYS, SWITCHES, AND MISCELLANEOUS ACCES- SORIES .....	108, 157
INDEX BY TYPE NUMBER .....	224
INDEX BY TITLE .....	226

## CONDENSERS

**T**HE following chapter describes three new additions to our line of variable air condensers.

The TYPE 222-M Precision Condenser is a unit calibrated to read directly the capacitance difference between a given setting near maximum and any other setting. It is designed for use in making measurements of capacitance by the substitution method.

The TYPE 539-T Variable Air Condenser is a straight-line-frequency model of the condensers described on page 123. It is recommended for use in laboratory work where a fairly close adherence to the straight-line law is desirable.

The TYPE 568 Variable Air Condensers are small units designed for short-wave circuits.

### TYPE 222-M PRECISION CONDENSER

**T**HIS condenser has been designed to provide a direct-reading, adjustable standard of capacitance for use in the substitution measurement\* of capacitance.

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

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

The micrometer drum is divided into 100 divisions, each corresponding to a change in capacitance of 1  $\mu\text{mf}$ . Ten turns of the drum cover the range of the instrument.

The mechanical construction of the condenser is similar to that of the TYPE 222-L Precision Condenser, described on page 6. The differences consist in the use of a 25:1 worm, a reduced number of plates, and means for the adjustment (in our laboratory) of two of these plates to give the desired calibration.

#### *Range:*

Change in capacitance, 1000  $\mu\text{mf}$ ; capacitance at zero scale reading about 1200  $\mu\text{mf}$ , the exact value being given with each instrument.

#### *Rotor Plates:*

Straight-line capacitance (semicircular).

#### *Insulation:*

Isolantite blocks; mica window for high-potential terminal.

#### *Figure of Merit:*

$R\omega C^2$  is about  $0.06 \times 10^{-12}$  based on

measurements at 1000 cps., the exact value being given with each instrument.

#### *Drive:*

Gear and spring-pressed worm lapped in position to remove backlash. Ten turns of the worm cover the entire range of the condenser. The micrometer drum is engraved with 100 equally spaced divisions.

#### *Backlash:*

Less than  $\frac{1}{2}$  of one division.

#### *Calibration:*

Each of the 100 divisions on the microm-

\* General Radio *Experimenter*, January, 1930, p. 3, and Instruction Book for TYPE 216 Capacity Bridge, pp. 5-6.

eter drum corresponds to 1  $\mu\text{mf}$ . Each condenser is individually adjusted in our laboratory so that all values of incremental capacitance are accurate to within 1  $\mu\text{mf}$  or 0.1% of the maximum. Divisions are spaced sufficiently to permit estimating to tenths (one part in 10,000) with practice.

*Mounting:*

Aluminum panel finished in black crackle lacquer, mounted in copper-lined walnut cabinet.

*Carrying Case:*

Each condenser is supplied in a storage case made of whitewood and fitted with a lock and carrying handle.

*Dimensions:*

9½ (length) x 8¼ (width) x 9¼ (height) inches, overall.

*Weight:*

14¼ pounds for the mounted condenser only, 24 pounds with the carrying case.

Type	Capacitance Change	Code Word	Price
222-M	1000 $\mu\text{mf}$	COBRA	\$100.00

TYPE 539-T VARIABLE AIR CONDENSER

THIS is a straight-line-frequency condenser which is similar in most details of construction to the straight-line-capacitance models described on page 123. Complete data describing the straight-line-frequency variation of this unit are given in the following specifications.

*Capacitance Range:*

30  $\mu\text{mf}$  to 500  $\mu\text{mf}$ . These are nominal values. Each condenser has actual capacitance values greater than the maximum and less than the minimum, respectively.

*Rotor Plates:*

Plates are cut to give a straight-line-frequency variation over 250° of a possible 270° angle of rotation when a capacitance of 25  $\mu\text{mf}$  is connected in parallel with the condenser. They are assembled on the shaft so that counter-clockwise rotation produces an increase in frequency.

*Frequency Ratio:*

3 to 1, starting from a condenser minimum of 50  $\mu\text{mf}$ .

*Insulation:*

Two bars of isolantite, specially treated to prevent absorption of moisture, support the stator assembly.

*Maximum Voltage:*

550 volts, breakdown.

*Figure of Merit:*

$R\omega C^2$  is approximately  $0.03 \times 10^{-12}$

(based on measurements at 1000 cps.).

*Drive:*

When mounted on a panel, the 3/8-inch steel shaft extends beyond the back face of the panel enough to attach a dial. No knob, dial, or friction drive is included, but the use of the TYPE 503-G Dial is recommended.

*Calibration:*

No calibration is included.

*Mounting:*

This condenser is carried in stock unmounted without panel or cabinet. A drilling template is furnished.

Mounted models, similar to the TYPE 539-A, TYPE 539-B, and TYPE 539-C Variable Air Condensers, described on page 123, can be built to order. Prices on request.

*Dimensions:*

This unit extends 7½ inches behind a panel and requires a panel space 5½ inches square.

*Weight:*

2¾ pounds.

Type	Capacitance		Maximum Voltage	Mounting	Code Word	Price
	Maximum	Minimum				
539-T	500 $\mu\text{mf}$	30 $\mu\text{mf}$	550 volts	Unmounted	CLOSE	\$12.00

## TYPE 568 VARIABLE AIR CONDENSERS

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

*Range:*

Two sizes are available. See the price list.

*Rotor Plates:*

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

*Insulation:*

Isolantite end plates.

*Maximum Voltage:*

500 volts, peak.

*Figure of Merit:*

$R_{\omega}C^2 = 0.03 \times 10^{-12}$  based on measurements at 1000 cps.

*Drive:*

The rotor is attached to a hollow shaft through which a  $\frac{3}{8}$ -inch insulating or conducting shaft may be slipped and fastened with two set screws. This permits driving several units which have been mounted in tandem with the same shaft. Bakelite shaft extending a maximum of  $1\frac{5}{8}$  inches from rear face of mounting panel is supplied with each condenser.

*Mounting:*

Three tapped inserts attached to one end plate on a  $\frac{1}{8}$ -inch radius are provided for mounting the condenser on a panel of any

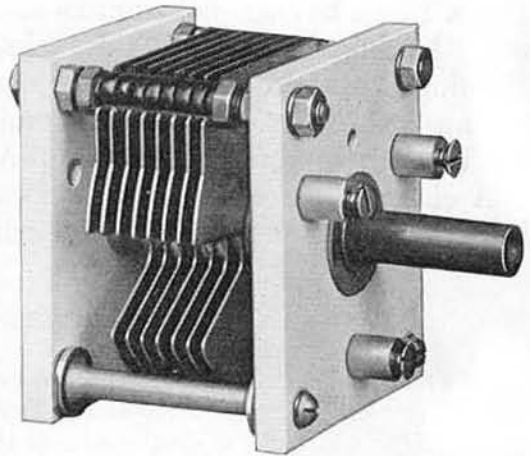
thickness between  $\frac{1}{8}$  and  $\frac{5}{16}$  inch. Drilling template and three flat head machine screws are furnished.

*Dimensions:*

Panel space,  $2\frac{1}{4} \times 2\frac{5}{8}$  inches required. Overall depth behind panel (exclusive of the shaft),  $2\frac{3}{4}$  inches.

*Weight:*

$\frac{3}{4}$  pound.



A TYPE 568-D Variable Air Condenser. Note the isolantite end plates and the removable bakelite shaft

Type	Capacitance		Plate Shape	Rotation Angle	Code Word	Price
	Maximum	Minimum				
568-D	175 $\mu\text{f}$	12 $\mu\text{f}$	SLC	180°	CLOVE	\$4.00
568-K	50 $\mu\text{f}$	12 $\mu\text{f}$	SLF	270°	CLOUD	4.00

## RESISTANCE DEVICES

**F**OUR new additions to our line of resistance devices are described in this chapter.

The TYPE 102 Decade-Resistance Boxes, hundreds of which are used in laboratories all over the world, are now superseded by the TYPE 602 Decade-Resistance Boxes. The principal change is in the mechanical construction by which the resistors are shielded and the contact surfaces protected from dust. The TYPE 510 Decade-Resistance Units are individual shielded decades which may be readily built into laboratory equipment constructed by the user.

As an extension to the General Radio Company's line of accessories there has been developed a new mounting case for circuit elements such as resistors and condensers. At present only the TYPE 500 Resistors are available. This unit is so designed that it may be equipped with TYPE 274-E Plugs having jack shanks and be plugged into any piece of equipment having the TYPE 274-J Jacks, or the TYPE 138-V or TYPE 138-X Binding Posts, provided these are mounted on the  $\frac{3}{4}$ -inch spacing which is standard in General Radio assemblies. They are a valuable addition to the recently announced TYPE 293-A Universal Bridge, for instance.

A change in the TYPE 214 Rheostats and Potentiometers, and a new low-cost volume control complete the list.

### TYPE 602 DECADE-RESISTANCE BOXES

**A** NEW line of decade-resistance boxes incorporating improvements resulting from our many years of experience with the TYPE 102 Decade-Resistance Boxes has been developed. The resistance characteristics of the TYPE 602 Decade-Resistance Boxes are in general quite similar to those of the TYPE 102 Decade-Resistance Boxes. Improvements have been made in the switching arrangement. The switch contacts of the TYPE 602 Decade-Resistance Boxes are behind the panel, enclosed within the cabinet, and are thus completely protected from dust accumulation. The contact areas have been very considerably increased and a new type of switch assembly is used. The net result of these changes has been to reduce the contact resistance greatly. The switch resistance has been reduced by this means to approximately 0.0015 ohm per switch. Cabinets are metal lined and panels are aluminum.

The types of resistance cards used in these boxes are described on page 15 of Catalog F. Types A and B are used.

These decade resistances are intended for use in all types of alternating-current measurements, such as bridge 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 neutralized by the tuning condenser, or whether it is used as a voltage-drop device. Such limits as have been ascertained are given in Data Table II. These resistances are equally useful in direct-current measurements, except where a complete absence of thermal electro-motive 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 0.0015 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:*

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

*Accuracy of Adjustment:*

See Data Table I for accuracy of direct-current adjustments at terminals of unit. Add 0.0015 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 either in a tuned circuit or in an untuned drop-wire circuit. The inductance of the wiring is about 0.1 microhenry per switch.

*Temperature Coefficient:*

Less than  $\pm 0.002\%$  per degree C. for both Manganin and Advance wire, 0.01% for Tophet.

*Maximum Current:*

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

*Mounting:*

Switches and resistances are entirely enclosed in a copper-lined cabinet of polished walnut with an aluminum panel finished in black crackle lacquer.

*Dimensions:*

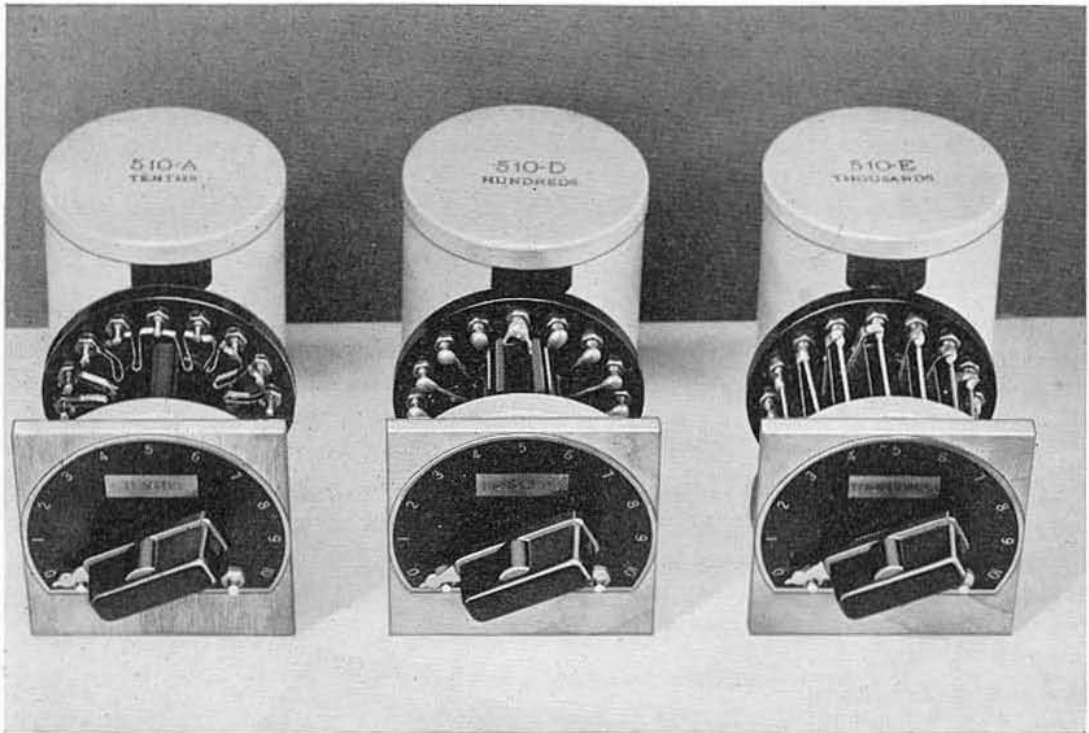
5 (width) x 5 inches (depth), overall. The length of each cabinet is given in the price list.



A TYPE 602-J Decade-Resistance Box, representative of a new line of boxes with submounted switches

DATA TABLE I

Decade	Type of Winding	Accuracy	Current for Temperature Rise of		Material
			20° C.	40° C.	
0.1 ohm	Bifilar	1 %	2.0 amperes	3 amperes	Advance
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 %	40 "	60 "	Manganin
1000 "	Unifilar	0.1 %	10 "	17 "	Manganin
10,000 "	Unifilar	0.1 %	10 "	17 "	Tophet



Three TYPE 510 Decade-Resistance Boxes with the individual shields removed to show the construction of the individual resistors

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.
1000 "	500 kc.	1000 kc.	—	—
10,000 "	100 kc.	200 kc.	—	—

Type	Maximum Resistance	No. of Dials	Panel Length	Weight	Code Word	Price
602-D	11.0 ohms in steps of 0.1	2	7 <sup>3</sup> / <sub>4</sub> in.	4 <sup>1</sup> / <sub>4</sub> lb.	DECOY	\$25.00
602-E	110.0 " " " " 1.0	2	7 <sup>3</sup> / <sub>4</sub> in.	4 <sup>1</sup> / <sub>4</sub> lb.	DECYR	25.00
602-F	111.0 " " " " 0.1	3	10 <sup>3</sup> / <sub>8</sub> in.	4 <sup>1</sup> / <sub>2</sub> lb.	DELTA	35.00
602-G	1110.0 " " " " 1.0	3	10 <sup>3</sup> / <sub>8</sub> in.	4 <sup>1</sup> / <sub>2</sub> lb.	DIGIT	35.00
602-K	1111.0 " " " " 0.1	4	13 in.	5 lb.	DEFER	45.00
602-J	11,110.0 " " " " 1.0	4	13 in.	5 lb.	DEBIT	50.00
602-N	11,111.0 " " " " 0.1	5	15 <sup>5</sup> / <sub>8</sub> in.	6 <sup>1</sup> / <sub>4</sub> lb.	DEMON	62.00
602-M	111,110.0 " " " " 1.0	5	15 <sup>5</sup> / <sub>8</sub> in.	6 <sup>1</sup> / <sub>4</sub> lb.	DEMIT	70.00
602-L	111,100.0 " " " " 10.0	4	13 in.	5 lb.	DECAY	58.00

## TYPE 510 DECADE-RESISTANCE UNITS

THE TYPE 510 Decade-Resistance Units are single decade-resistance units similar in construction and characteristics to the individual dials of the TYPE 602 Decade-Resistance Boxes. The individual decades, consisting of ten units with eleven steps (0 to 10 inclusive), are provided for panel mounting and include a shielding can and etched dial plate.

*Range:*

See price list.

*Type of Winding:*

Identical with corresponding resistance values in TYPE 602 Decade-Resistance Boxes.

*Accuracy of Adjustment:*

Identical with corresponding resistance values in TYPE 602 Decade-Resistance Boxes.

*Frequency Error:*

Identical with corresponding values for TYPE 602 Decade-Resistance Boxes.

*Temperature Coefficient:*

Less than  $\pm 0.002\%$  per degree C. for both Manganin and Advance wire.

*Maximum Current:*

Identical with corresponding resistance values in TYPE 602 Decade-Resistance Boxes. See Data Table I.

*Mounting:*

Panel mounting with shielding can. Combination dial plate and drilling template provided. Takes  $\frac{1}{4}$ - or  $\frac{3}{8}$ -inch panel.

*Dimensions:*

$3\frac{1}{16}$  inches diameter,  $3\frac{1}{16}$  inches depth behind panel, knob projects  $\frac{15}{16}$  inch in front of panel.

*Weight:*

11 ounces.

Type	Steps	Code Word	Price
510-A	Ten Tenths.....	ELATE	\$8.50
510-B	Ten Units.....	ELDER	8.50
510-C	Ten Tens.....	ELEGY	8.50
510-D	Ten Hundreds.....	ELBOW	8.50
510-E	Ten Thousands.....	ELECT	13.00
510-F	Ten Ten Thousands.....	ELVAN	16.00

## TYPE 500 RESISTORS

## SCREW-TERMINAL MODELS

THESE units contain non-inductive cards similar in construction to those used on the TYPE 602 Decade-Resistance Boxes and the TYPE 510 Decade-Resistance Units. Each resistor is contained within a moulded bakelite case, the latter being filled with an impregnating wax, thus assuring the stability of the electrical characteristics of the element. Screw terminals are mounted on a projecting lug.

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

Units with standard plug-and-jack terminals are also available, see page 178.

*Range:*

See price list for available values of resistance.

*Accuracy:*

All units are adjusted to be within 0.5% of their indicated resistance.



TYPE 500-D Resistor  
One of the screw-terminal models

*Load-Carrying Capacity:*

Each unit of this series will safely dissipate 2 watts.

*Dimensions:*

2½ (length) x 1¼ (width) x 1 inch (height), overall.

*Weight:*

2 ounces.

Type	Resistance	Current-Carrying Capacity	Code Word	Price
500-A	1 ohm	1.5 amperes	RESISTBIRD	\$2.00
500-B	10 ohms	0.5 ampere	RESISTDESK	2.00
500-C	50 "	0.2 "	RESISTFORD	2.00
500-D	100 "	150 milliamperes	RESISTFROG	2.00
500-E	200 "	100 "	RESISTGIRL	2.00
500-F	500 "	60 "	RESISTGOAT	2.00
500-G	600 "	60 "	RESISTGOOD	2.00
500-H	1000 "	50 "	RESISTHYMN	2.00
500-J	10,000 "	15 "	RESISTMILK	2.00

PLUG-TERMINAL MODELS

THESE are identical in construction with the units described above, except that they are provided with a pair of TYPE 274-E Plugs mounted on standard ¾-inch spacing, in such a way that a number of units may be connected in parallel by stacking one on top of the other.



TYPE 500-DP Resistor  
A plug-terminal model

Type	Resistance	Current-Carrying Capacity	Code Word	Price
500-AP	1 ohm	1.5 amperes	RESISTMOAT	\$2.00
500-BP	10 ohms	0.5 ampere	RESISTMUSH	2.00
500-CP	50 "	0.2 "	RESISTPALM	2.00
500-DP	100 "	150 milliamperes	RESISTPOKE	2.00
500-EP	200 "	100 "	RESISTRACK	2.00
500-FP	500 "	60 "	RESISTSEAT	2.00
500-GP	600 "	60 "	RESISTSHOE	2.00
500-HP	1000 "	50 "	RESISTSLOE	2.00
500-JP	10,000 "	15 "	RESISTTOAD	2.00

## TYPE 214 RHEOSTATS

THE 50-ohm and 2500-ohm rheostats are now carried in stock as potentiometers. The addition of the third terminal in no way interferes with the use as a rheostat, in fact either direction of rotation can now be obtained without altering the unit in any way.

The price list from pages 28 and 29 is repeated below with corrections for convenience in reference.

## PANEL-MOUNTING MODELS

Type	Total Resistance		Maximum Current	Code Word	Price
214-A	0.75 ohm	.....	4 amperes	SHINY	\$1.50
214-A	2 ohms	.....	2.5 "	RUDDY	1.50
214-A	7 "	.....	1.3 "	RURAL	1.50
214-A	20 "	.....	0.75 ampere	RAZOR	1.50

## TABLE-MOUNTING MODELS

Type	Total Resistance		Maximum Current	Code Word	Price
214-B	0.75 ohm	.....	4 amperes	SILLY	\$1.50
214-B	2 ohms	.....	2.5 "	RUMOR	1.50
214-B	7 "	.....	1.3 "	RUSTY	1.50
214-B	20 "	.....	0.75 ampere	READY	1.50

## TYPE 214 POTENTIOMETERS

IN addition to the two TYPE 214 Rheostats now supplied as potentiometers, the 100-, 200-, and 1000-ohm sizes are now carried in stock. Only panel-mounting models are regularly carried in stock.

The price list from page 29 is repeated below with corrections for convenience in reference.

Type	Total Resistance		Maximum Current	Code Word	Price
214-A	50 ohms	.....	500 milliamperes	RAPID	\$1.50
214-A	100 "	.....	350 "	RIVET	1.50
214-A	200 "	.....	250 "	EMPTY	1.50
214-A	400 "	.....	175 "	ROBIN	1.50
214-A	1000 "	.....	110 "	ENACT	1.75
214-A	2500 "	.....	70 "	SYRUP	2.00

## TYPE 652 VOLUME CONTROLS

THE General Radio TYPE 652 Volume Control employs an entirely new circuit and mechanical construction which makes possible a unit with excellent electrical and mechanical properties at a low cost. Technical information, in addition to that which follows, was published in the *General Radio Experimenter* for June, 1931.

*Design:*

The unit is very compact. Five can be mounted side by side on a standard 19-inch relay-rack panel.

The impedance is approximately constant at both the input and output to the control and the attenuation is linear from 0 to 45 decibels. Above 45 decibels, it increases continuously, but rapidly, to infinite attenua-

tion or cut-off. The units are assembled so that clockwise rotation of the knob reduces the attenuation; that is, an increase in volume occurs with clockwise rotation.

Most of the troubles inherent in the slide-wire type of control are due to the noise caused by the sliding contacts on the wire resistor. Every effort has been made in the TYPE 652 Volume Control to reduce such



The compactness and linear attenuation characteristic of the TYPE 652 Volume Controls make them ideal for monitoring installations

interference to a minimum. The circuit employed is such that only one sliding contact is necessary, which immediately reduces contact troubles by one-half.

The slider contact is made from Advance metal. The resistance unit is wound with the same material, which practically removes the noise due to contact potential. These contacts will withstand over 200,000 operations without serious wear. The resistance units are mounted on a bronze casting which spaces them about  $1\frac{1}{4}$  inches from the panel. This spacing is very desirable since it entirely eliminates the introduction of hum and extraneous disturbances due to the body capacity of the operator.

The photo-etched scale is engraved directly in decibels of attenuation.

The TYPE 652 Volume Control may be used in any voice circuit, but is particularly recommended for use as a microphone mixer. The noise level is extremely low and the controls may be used in circuits at levels as low as -60 to -80 decibels without introducing objectionable noise into the circuit.

*Attenuation Range:*

Linear from 0 to 45 decibels, increasing rapidly to infinity, continuously variable.

*Type of Winding:*

Unifilar on thin bakelite strips. Ladder network.

*Terminal Impedance:*

50, 200, or 500 ohms as specified in the price list.

*Shielding:*

A black japanned aluminum cover is provided as a protection against dust and dirt, and as an electrostatic shield. The wiring is also protected by a concentric aluminum tube inside of the main shield.

*Contacts:*

Advance metal backed by stiff phosphor-bronze spring. Connection to slider is made by flexible pigtail.

*Mounting:*

Panel mounting by using circular etched metal name plate, which carries scale and pointer stops, as a drilling template. Two mounting holes, diametrically spaced, standard distance of  $1\frac{1}{2}$  inches apart, are required. Same screws that mount attenuator to the rear of panel hold the scale to the front.

Size 8-32 mounting screws supplied with the instrument are long enough for panel thickness up to  $\frac{3}{8}$  inch. The shaft has two bearings, the rear one of bronze. Shaft is electrically dead.

*Dimensions:*

Scale and maximum diameter,  $2\frac{3}{4}$  inches. Overall depth,  $5\frac{1}{4}$  inches. Depth back of panel, 4 inches.

*Weight:*

$2\frac{1}{2}$  pounds.

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

# OSCILLATORS

**T**HE new TYPE 508-A Oscillator described below is an audio oscillator of fairly large output operated from the 110-volt alternating-current source.

## TYPE 508-A OSCILLATOR

(ALTERNATING-CURRENT OPERATED)



The TYPE 508-AM Oscillator; the cabinet-mounted model

**T**HIS instrument has been designed to meet the demand for a convenient source of alternating current for use in bridge measurements and in studies relating to electrical communication systems, where it is necessary that measurements be made at a number of different frequencies. The oscillator is arranged so that several frequencies, separated by approximately equal percentage intervals and covering the more commonly used portion of the audio range, are obtained by the manipulation of a single selector switch. In many measurements of the type for which this instrument is intended, considerable amounts of power are required; the TYPE 508-A Oscillator, therefore, operates at a high power level. It is entirely alternating-current operated, as in this way the power required is obtained at a minimum expense, and the necessity for maintaining an external power-supply system is avoided.

### *Frequency Range:*

The frequencies available are 200, 300, 400, 600, 800, 1000, 1600, 2000, 3000 and 4000 cps. Selection is made by a 10-point switch. By means of an external condenser, not supplied with the instrument, any intermediate frequency within this range may be obtained.

### *Power Output:*

0.5 watts into a load of 2000 ohms. The output is adjustable by means of a TYPE 371 Potentiometer.

### *Internal Output Impedance:*

2000 ohms, at maximum output.

*Waveform:*

On open circuit, the total harmonic content of the output wave is less than 8% of the fundamental amplitude. This increases as the load impedance is reduced, approaching a maximum of 11% when the output terminals are short-circuited. The maximum open-circuit hum voltage across the terminals is 0.5 volts.

*Frequency Stability:*

Within 5% of the indicated value.

*Mounting:*

The apparatus is mounted on a metal shelf, secured to an aluminum front panel. The circuit is entirely enclosed in a metallic shield to prevent pickup to associated apparatus. As normally supplied, the shielded oscillator unit is mounted in a hand-rubbed walnut cabinet. The panel dimensions are such, however, that the unit may be re-

moved from the cabinet and provided with panel-extension plates by which it may be mounted upon a standard relay rack. (See ALTERNATIVE MOUNTING below.)

*Tubes:*

One 245-type tube and one 280-type rectifier tube, not included in the price of the instrument, are required.

*Power Supply:*

Power is obtained entirely from 110-volt alternating current, 60-cps. line. The power drain is 40 watts.

*Dimensions:*

Panel, 15 x 8 $\frac{3}{4}$  x  $\frac{1}{4}$  inches. Depth of shielded unit behind panel, 10 inches. Complete cabinet assembly, 18 x 10 x 12 $\frac{1}{4}$  inches.

*Weight:*

33 $\frac{3}{4}$  pounds.

<i>Type</i>	<i>Code Word</i>	<i>Price</i>
*508-AM   Cabinet mounting.....	ARROW	\$120.00

\*Panel is engraved "TYPE 508-A."

### TYPE 508-A OSCILLATOR

(ALTERNATIVE MOUNTING)

THE height of the panel has been made to conform to standard relay-rack specifications. The unit may be removed from the walnut cabinet and provided with panel-extension plates, which increase the panel length up to 19 inches. It may, therefore, be mounted in any standard relay-rack assembly.

*Dimensions:*

Panel, 19 x 8 $\frac{3}{4}$  x  $\frac{1}{4}$  inches.  
Depth behind panel, 10 inches.

*Weight:*

30 $\frac{1}{4}$  pounds.

<i>Type</i>	<i>Code Word</i>	<i>Price</i>
*508-AR   For relay-rack mounting.....	ARSON	\$105.00

\*Panel is engraved "TYPE 508-A."





# AMPLIFIERS

**I**N this chapter is listed a new high-gain amplifier in which stability and freedom from noise are important design features. It is intended for general laboratory work in conjunction with photocells, microphones, or bridge circuits.

## TYPE 514-A AMPLIFIER

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

### *Design:*

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

mirably as a high-impedance high-sensitivity voltmeter. By means of a volume control having a numbered scale it is possible to adjust the sensitivity to some predetermined calibration.

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

The TYPE 514-AM Amplifier (cabinet-mounted model). At the left is a TYPE 514-P1 Seven-Contact Plug Unit by means of which auxiliary equipment may be operated from the batteries inside the instrument.



from the batteries associated with the TYPE 514-A Amplifier through connections to the multi-contact receptacle.

*Input Impedance:*

One megohm. Interchangeable coupling units may be used to give other values as required.

*Output:*

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

*Amplification:*

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

*Frequency Range:*

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

*Mounting:*

The apparatus is mounted on a metal shelf secured to an aluminum front panel,

and is entirely enclosed in a metallic shield to prevent pickup from associated apparatus. This unit as normally supplied is mounted in a walnut cabinet having space for batteries. The amplifier unit can be supplied for relay-rack mounting as described below under "Alternative Mounting."

*Tubes:*

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

*Power Supply:*

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

*Dimensions:*

Panel size, 12 x 7 x 1/4 inches; overall cabinet size, 15 x 8 1/4 x 12 1/4 inches.

*Weight:*

14 1/2 pounds without batteries; 29 pounds with batteries.

Type		Code Word	Price
*514-AM	Cabinet mounting.....	ARGUS	\$70.00
* Panel is engraved "TYPE 514-A."			



The TYPE 514-AR Amplifier for mounting in a standard 19-inch relay rack

**TYPE 514-A AMPLIFIER**

(ALTERNATIVE MOUNTING)

**T**HE height of the panel has been made to conform to standard relay-rack specifications. The unit may be removed from the walnut cabinet and provided with panel-extension plates which increase the panel length to 19 inches. It may, therefore, be mounted in any standard relay-rack assembly. When so mounted, the batteries may be located in any convenient place not too distant, and connected by suitably shielded leads. A terminal strip is provided so that connections for the batteries may be made at the back of the panel.

*Dimensions:*

Overall depth behind panel, 6 inches;  
panel size with panel extensions, 19 x 7 x  $\frac{1}{4}$   
inches.

*Weight:*

10  $\frac{1}{8}$  pounds without batteries.

<i>Type</i>	<i>Code Word</i>	<i>Price</i>
*514-AR   For relay-rack mounting .....	ARMOR	\$56.00

\* Panel is engraved "TYPE 514-A."

**TYPE 514-P ACCESSORIES**

**F**OR customers who wish to construct units which may be used in conjunction with the TYPE 514-A Amplifier, or who wish to connect external batteries by means of a cable and plug, we can supply a separate multi-contact plug unit to fit the plug receptacle. This plug unit is the Yaxley No. 635 pin plug and is available in many retail radio stores.

<i>Type</i>	<i>Code Word</i>	<i>Price</i>
514-P1   Seven-Contact Plug Unit .....	ARRAY	\$1.00



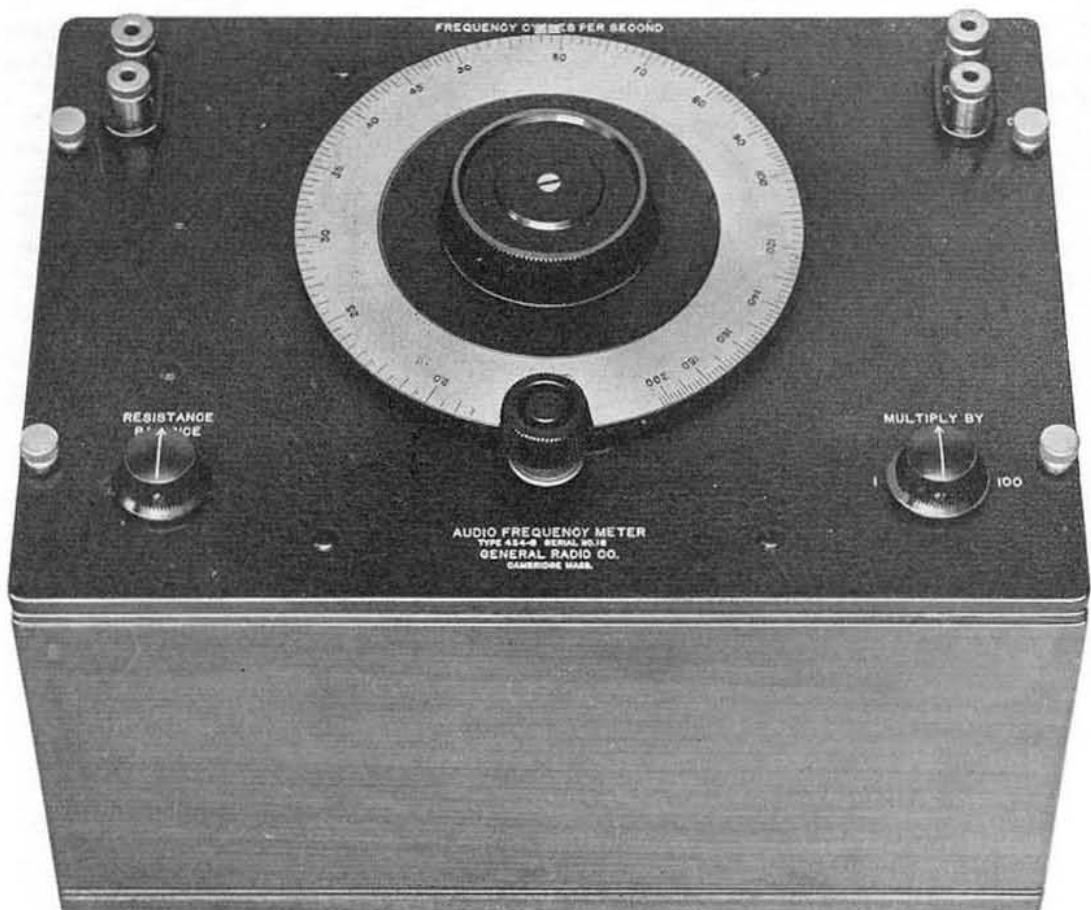
# FREQUENCY- AND TIME-MEASURING DEVICES

A BRIDGE-TYPE frequency meter for measuring audio frequencies and two wavemeters are the new instruments described in this chapter. All three meet a definite need not filled by other available apparatus.

## TYPE 434-B FREQUENCY METER

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

The meter is direct-reading with an extremely long scale. The meter has three frequency ranges differing by ratios of 10:1, obtained by varying the condensers by ratios of 10:1. Thus the same scale is used for all three frequency ranges with decimal multiplying factors.



A TYPE 434-B Frequency Meter with the multiplier switch set at 10 for a range of 200 to 2000 cycles per second

The different frequencies are distributed along the scale logarithmically, *i.e.*, equal frequency ratios occupy equal scale lengths. This makes the fractional accuracy constant over the entire scale. This very desirable feature is obtained by a suitable shaping of the tapered resistors, which are the variable units in the meter. The inductors used in other types of frequency meters cannot be shaped to yield any desired frequency distribution.

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

The null detector is usually a pair of high-resistance head telephones. They are sufficiently sensitive to enable the dial to be set to 0.5% with 2 volts applied to the bridge within the frequency range 300-3000 cps., if the waveform is pure. The dial may be set to 0.1% by applying a higher voltage to the bridge or by using an amplifier such as the TYPE 514-A Amplifier between the bridge and the telephones. When the harmonic content of the supply is large, a low-pass filter, such as TYPE 330 Filter Sections, or a tuned circuit may be used for frequencies less than the natural frequency of the telephones (about 900 cps.). The TYPE 488-DM Alternating-Current Voltmeter, preceded by the TYPE 514-A Amplifier and a TYPE 330 Filter Section, may also be used as a null detector.

*Frequency Range:*

20-20,000 cps. in three ranges by means of a selector switch, 20-200 cps., 200-2000 cps., 2000-20,000 cps.

*Calibration:*

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

*Accuracy:*

With sufficient supply voltage or sufficient amplification on the null detector and with a fairly pure waveform, the dial may be set to 0.1%. The engraving on the dial may be relied upon to within 0.5% at all positions.

*Drive:*

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

*Impedances:*

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

*Supply Voltage:*

50 volts, maximum.

*Accessories:*

A null detector will be required to operate the instrument. This may be head telephones such as the Western Electric Type 1002-C or an amplifier-meter combination such as a TYPE 514-A Amplifier and a TYPE 488-DM Alternating Current Voltmeter or a TYPE 426-A or TYPE 626-A Thermionic Voltmeter, used in conjunction with TYPE 330 Filter Sections. Even with head telephones an amplifier and filter sections may prove useful.

*Controls:*

Frequency dial, range selector switch, resistance balance knob.

*Mounting:*

Aluminum panel, 1/4-inch thick, finished in black crackle lacquer, mounted in copper-lined walnut cabinet.

*Dimensions:*

12 (length) x 8 3/4 (width) x 8 1/4 inches (height), overall.

*Weight:*

15 1/4 pounds.

Type	Frequency Range	Code Word	Price
434-B	20-20,000 cps.	COLOR	\$125.00



A TYPE 419-A Rectifier-Type Wavemeter with the four inductors and their individual calibration charts. The insert shows the method of plugging in an inductor

### TYPE 419-A RECTIFIER-TYPE WAVEMETER

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

#### *Frequency Range:*

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

#### *Calibration:*

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

rapid conversion of frequency into wavelength in meters.

#### *Accuracy:*

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

#### *Condenser:*

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

*Inductors:*

Any one of the four plug-in inductors may be mounted in position at the side of the cabinet by means of a plug and jack arrangement. Storage space is provided in the bottom of the cabinet for them when they are not in use. The nominal frequency range of each is shown in the following table. A sufficient amount of overlap is allowed on each inductor.

<i>Inductor</i>	<i>Frequency</i>	<i>Wavelength</i>
D	20- 40 Mc.	15-7.5 meters
C	40- 75 Mc.	7.5- 4 "
B	75-150 Mc.	4- 2 "
A	150-300 Mc.	2- 1 meter

*Resonance Indicator:*

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

Reaction methods may also be used with the same calibrations supplied with the

instrument so long as the tube is in its socket.

*Tubes:*

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

*Power Supply:*

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

*Mounting:*

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

*Accessories:*

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

*Dimensions:*

10 (length) x 7½ (width) x 7 (depth) inches, overall.

*Weight:*

7¾ pounds without tube or battery.

<i>Type</i>	<i>Frequency</i>	<i>Wavelength</i>	<i>Accuracy</i>	<i>Code Word</i>	<i>Price</i>
419-A	300-20 Mc.	1-15 meters	1%	CATER	\$100.00

**TYPE 574 WAVEMETER**

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

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

*Frequency Range:*

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

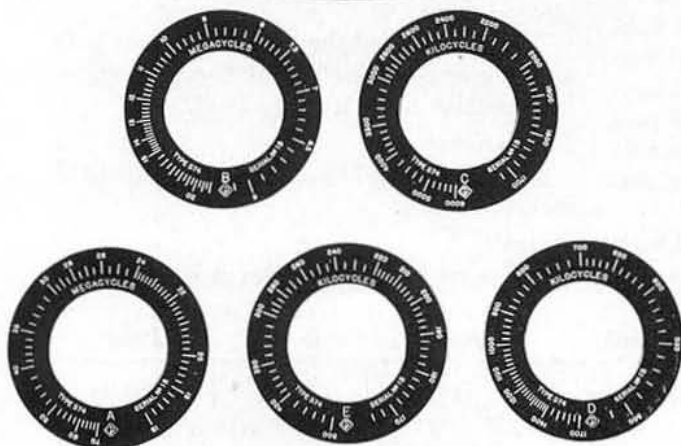
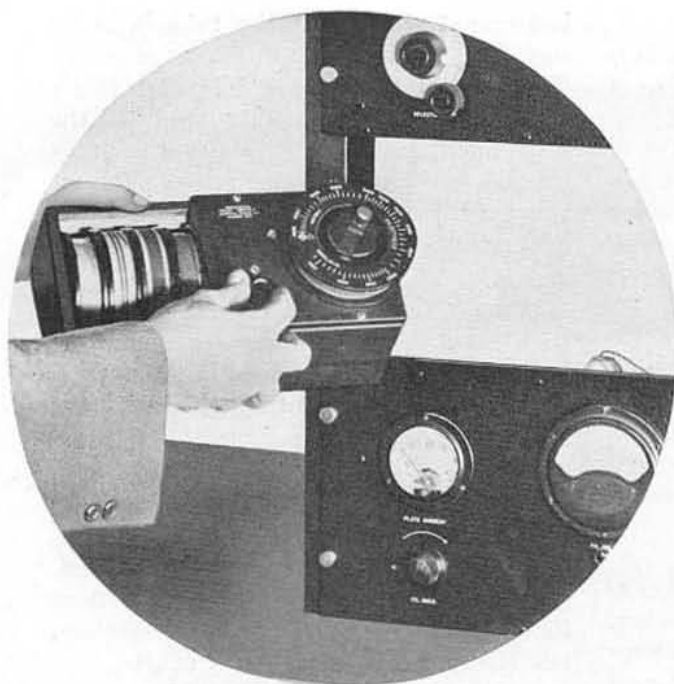
*Accuracy:*

The construction and calibration of this wavemeter are such that, if carefully made,

measurements can be relied upon to within 1% of the indicated frequency.

*Calibration:*

Each inductor is individually calibrated at five points in terms of the General Radio Company's primary standard of frequency, and intermediate points are secured by interpolation. The scales themselves are



Top: The TYPE 574 Wavemeter may easily be held in one hand when measuring the frequency of an oscillator by the plate-current reaction method. Bottom: The five inductors showing a typical calibration

engraved on the inductors, thus making the instrument direct-reading. Coil A and Coil B are engraved in units of megacycles per second, others in kilocycles per second.

Inductor	Frequency	Equivalent Wavelength
E	166- 500 kc.	[1800- 600] meters
D	500- 1700 kc.	[ 600- 176] "
C	1700- 6000 kc.	[ 176- 50] "
B	6000-18,000 kc.	[ 50- 16.6] "
A	18-70,000 kc.	[ 16.6- 4.3] "

Type	Frequency	Equivalent Wavelength	Accuracy	Code Word	Price
574	166-70,000 kc.	1800-4.3 meters	1%	CARRY	\$50.00

*Condenser:*

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

*Inductors:*

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

*Resonance Indicator:*

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

*Mounting:*

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

*Dimensions:*

11 (length) x 5 (width) x 5½ inches (height), overall.

*Weight:*

4⅝ pounds.

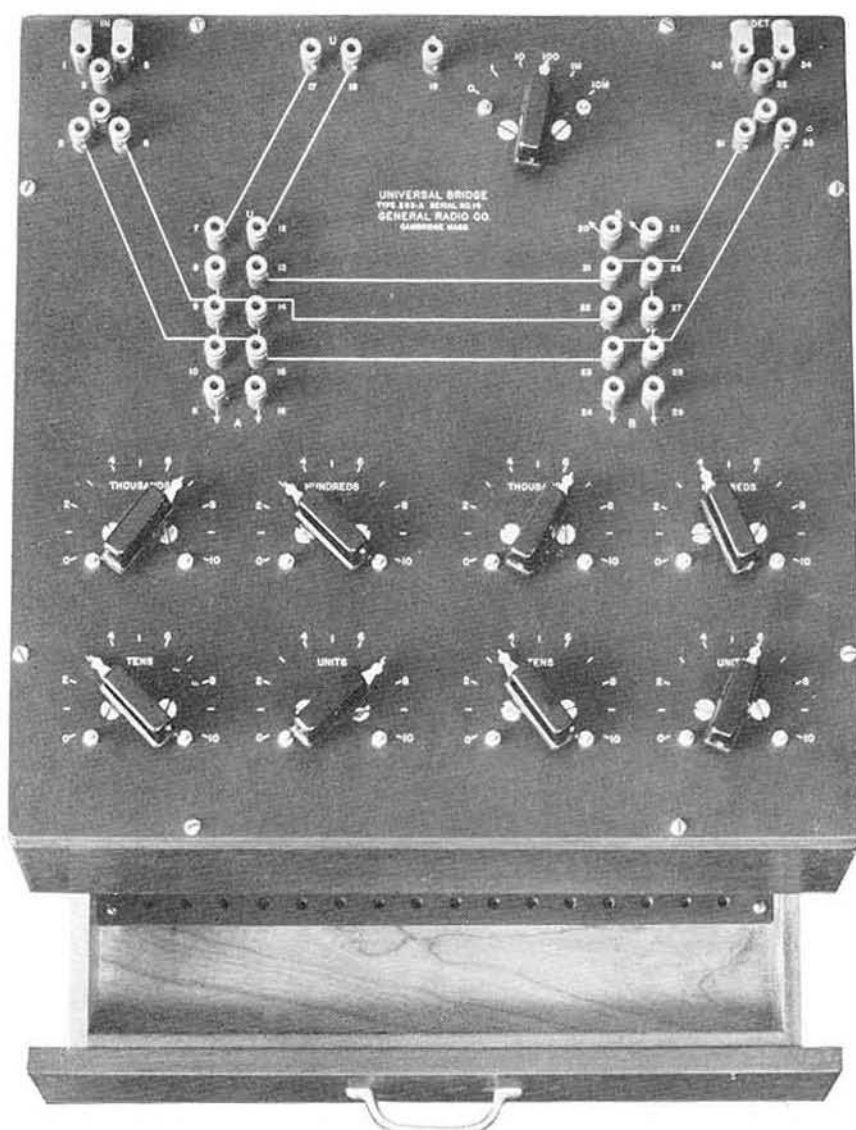


## BRIDGES AND THEIR ACCESSORIES

THE design of the new bridge described in this chapter is based on the fact that almost all bridges have the same basic components arranged in different ways. The TYPE 293-A Universal Bridge has all these components (except power source and null detector) with terminals so arranged that a large number of different bridge circuits can be set up.

### TYPE 293-A UNIVERSAL BRIDGE

THE TYPE 293-A Universal Bridge is designed to present a fundamental circuit which may be connected to produce a wide variety of standard direct- and alternating-current circuits. The instrument consists of three resistance arms and a terminal board by means of which the various circuits can be set up with plugs and jacks. The bridge arrangement permits the measurement of inductance, capacitance, and resistance over a wide fre-



TYPE 293-A Universal Bridge. The drawer is used for storing accessories  
[ 191 ]

quency range (0–50,000 cps.). The bridge can also be set up as a frequency meter. The instrument has, therefore, a much wider general usefulness in a college or measurement laboratory than the usual form of permanently assembled bridge circuit.

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

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

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

Because of the multiplicity of possible connections of the bridge circuit, it is feasible to state accuracy only in a general way. The user will find it desirable to select the particular bridge circuit best suited to the problem in hand.\*

The arrangement of the units and wiring is symmetrical. The bridge cabinet is shielded, and shields are placed between the *A* and *B* arms and between these arms and the rest of the bridge. The dial handles on the *A* and *B* arms are also shielded.

Resistances are adjusted to 0.1%. The series resistance of each plug is approximately 0.002 ohm. The switch contact resistance is approximately 0.0015 ohm for each contact. As there will be several plugs and switch contacts in series in all bridge circuits, this factor should be considered in the measurement of low resistances.

A particularly useful feature of the bridge is its high accuracy with very high ratios. Tests on the bridge arranged in the standard Wheatstone bridge circuit have shown that it is possible to use ratios as high as 1000:1 with excellent accuracy in making resistance measurements. When substitution methods are used, extremely high accuracy of comparison is possible. This can be of the order of one part in 10,000 with the bridge as normally supplied. Using the TYPE 293-P3 Slide-Wire Resistor, an extra significant figure may be obtained. This unit may be used to extend the decade arms from 1 ohm to approximately zero resistance. The absolute accuracy of the measurement, of course, depends upon that of the standard. Inductances as high as 1000 henrys can be measured with a 1-henry standard. Capacity unbalance of the order of 0.01  $\mu\text{mf}$  can be observed. The shielding and arrangement of the bridge are such that accurate results can be obtained at frequencies as high as 50,000 cps. when properly constructed input and output transformers are used. Impedances of the order of 10 ohms to 1000 ohms can be measured at this frequency.

The bridge is supplied with plugs and connector cords, but does not include input or output transformers. The bridge cabinet contains a drawer for the storage of these accessories.

#### *Bridge Arms:*

*A* and *B* arms each consist of four decade resistances, 1–11,110 ohms, variable by 1-ohm steps, identical with TYPE 602-J Decade-Resistance Box. The *S* arm is a resistor containing 1, 10, 100, 1000, and 10,000 ohm units. Its characteristics are similar to the TYPE 602 Decade-Resistance Boxes.

\* B. Hague, *Alternating Current Bridge Methods*.

#### *Accuracy of Adjustment:*

0.1% (0.25% on 1-ohm units).

#### *Type of Winding:*

All units are identical with corresponding TYPE 602 Decade-Resistance Boxes.

#### *Frequency Range:*

0–50 kc.

**Shielding:**

Copper lining in cabinet. *A*, *B*, and *S* arms shielded from each other. Panel shielding over *A* and *B* arms.

**Construction:**

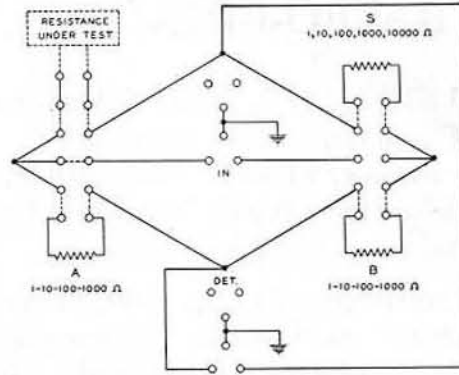
Resistance units are mounted beneath a hard rubber panel. Contact surfaces are enclosed within the cabinet. Shielding consists of copper lining for the cabinet and internal compartments. The cabinet is of walnut. Exposed metal parts are nickel-plated.

**Accessories Supplied:**

Ten double plugs, two double-shielded connector cords, two single connector cords.

**Accessories Required:**

Power source (General Radio TYPE 508-A Oscillator recommended); null indicator (General Radio TYPE 514-A Amplifier and TYPE 488-DM Alternating-Current Voltmeter recommended); standards of inductance (General Radio TYPE 106 Standard Inductances and TYPE 107 Variable Inductors recommended), standards of capacitance (General Radio air condensers such as the TYPE 222 Precision Condensers



Circuit diagram for a TYPE 293-A Universal Bridge set up as a Wheatstone Bridge for measuring resistance

or corresponding types of lower precision when desired are recommended).

**Optional Accessories:**

Shielded input and output transformers (General Radio TYPE 293-P1, TYPE 293-P2), and TYPE 293-P3 Slide-Wire Resistors.

**Dimensions:**

15½ (width) x 16¾ (depth) x 8¾ inches (height), overall.

**Weight:**

22½ pounds.

Type	Code Word	Price
293-A	BACON	\$140.00

**TYPE 293-P ACCESSORIES**

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

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

Type	Turns Ratio	Inductance High Side	Frequency Range	Circuit Impedance		Code Word	Price
				High Side	Low Side		
293-P1	3:1	2.5 h	50-5000 cps.	2700	300	BADGE	\$12.00
293-P2	2.55:1	2.5 h	50-5000 cps.	25,000	4000	BAFFY	12.00
293-P3						BAGGY	16.00



# RADIO-FREQUENCY TESTING DEVICES

GENERAL RADIO introduced the first commercially practicable standard-signal generator or "microvolter" to the radio industry in the summer of 1928. Since then, the leading manufacturers of America and Europe have designed and tested their products with General Radio standard-signal generators.

Improvements have been made from time to time as the results of research showed us how the accuracies could be bettered and the usefulness of the instrument enhanced. Broadcast engineers have, for example, found that field-intensity surveys, made with the signal generator, pay big dividends in a more profitable coverage of their radio audience. Power companies concerned with inductive interference and co-ordination problems have used it to measure radio interference quantitatively.

The fact that so many units are in everyday use is testimony to the soundness of our original belief that signal generators could be built in regular production and that the industry would accept them as an important development aid.

Improvements have had to do with the bettering of attenuators, reducing leakage and perfecting the modulating system. Design problems encountered in doing this have sometimes seemed insurmountable to the engineer faced with the necessity for making one instrument do many jobs, for keeping down the number of tubes and battery drain, for working at low power levels to prevent leakage and, for avoiding, if possible, the use of multistage tuning controls.

Modulation difficulties never dreamed of by the broadcast engineer are met when it becomes necessary to design for a minimum of frequency modulation and fly-wheel effect, for a high percentage modulation without distortion and for maximum power output, all at power levels that can be effectively shielded.

The first of two new standard-signal generators described here is, so far as design and production laboratories are concerned, an outstanding achievement. A tremendous range of output voltages, with an absolutely negligible amount of leakage, is obtained, and the modulation system permits 100% linear amplitude modulation. Frequency modulation and fly-wheel effect are also negligible for even the most careful measurements, as a reference to the specifications will show.

The TYPE 600-A Standard-Signal Generator was designed after several conferences with the engineers of the most advanced laboratories in the field. We asked them how the ideal signal generator should be built, and this instrument is the result. All the usual routine measurements of sensitivity, selectivity and fidelity can be made with a high degree of precision and rapidity.

The second of these new instruments, the TYPE 601-A Standard-Signal Generator, is an answer to the industry's request for an inexpensive generator which can do the following things:

- A. Measure the sensitivity of receivers in production.
- B. Provide two frequency ranges (such as broadcast and intermediate frequency) which can be used without opening the shield to change inductors.
- C. Be rugged enough for use in the production line.
- D. Be cheap enough to use for servicing police radio and aircraft receivers in the field.

A description of these two new standard-signal generators and a note about a modification in the design of the TYPE 403-C Standard-Signal Generator follows:

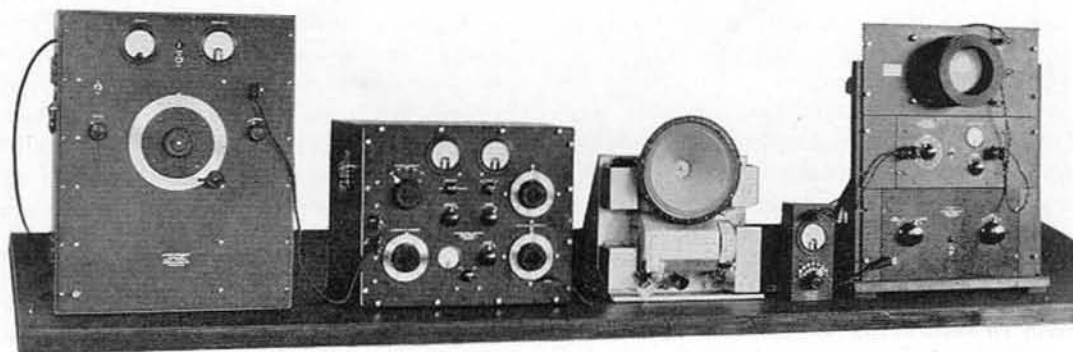
#### TYPE 403-D STANDARD-SIGNAL GENERATOR

**T**HE TYPE 403-C Standard-Signal Generator, used by so many laboratories for receiver tests and for field intensity measurements, has been redesigned to permit the use of the new 230-type tubes. Filament drain is reduced by one-half so that batteries do not need to be changed so often. The new tubes are also much more nearly uniform and are easily obtainable from commercial tube stocks.

All specifications are the same as for the TYPE 403-C Standard-Signal Generator described on pages 88 and 145 of Catalog F. The price remains the same, *i.e.*, \$600.

#### TYPE 600-A STANDARD-SIGNAL GENERATOR

**T**HIS instrument is designed primarily for measurements on radio broadcast receivers. Particular attention has been given to the mechanical arrangement in order to facilitate routine observations of the fundamental performance characteristics. The choice of frequencies and ranges covered have been chosen to agree with the recommendations of the



Testing a radio chassis for fidelity with a TYPE 600-A Standard-Signal Generator, a TYPE 513-B Beat-Frequency Oscillator, a TYPE 483 Output Meter, and the General Radio Cathode-Ray Oscillograph

Institute of Radio Engineers and of the Standardization Committee of the Radio Manufacturers' Association.

Any one of five frequencies may be selected by a frequency-control switch. At three of these frequencies there is connected into the circuit a condenser having straight-line frequency plates and covering a frequency band of  $\pm 50$  kc. This arrangement facilitates the taking of selectivity curves.

In order to provide for the measurement of very sensitive receivers, special precautions have been taken against stray electrical and magnetic fields. In addition to the usual electrostatic shielding, the oscillating circuit has been enclosed in a heavy aluminum casting which makes stray magnetic fields entirely negligible. The output voltage is controlled by an attenuator adjustable in increments of 6% and covering the range from 0.1 to 316,000 microvolts.

On the attenuator controls there is marked a supplementary scale which gives the output level directly in decibels above a zero level of one microvolt. This latter scale will be found most convenient for routine measurements in the development laboratory and on the production line.

The use of a special type of oscillating circuit minimizes frequency modulation and permits linear amplitude modulation up to 100%. A direct-reading modulation meter is included on the panel. The calibration of this meter is independent of the oscillator battery voltage, and an internal 400-cps. audio oscillator is provided. In addition, a switch permits the use of an external modulation of other frequencies, if desired, for taking fidelity characteristics.

So effective is the shielding system that absolutely no error due to interference could be found when measuring a receiver capable of detecting 0.03 microvolts.

#### *Carrier-Frequency Range:*

For sensitivity and fidelity tests five channels are available: 600, 800, 1000, 1200, and 1400 kc. Selectivity tests can be made at 600, 1000, and 1400 kc., a control calibrated directly in kc. enabling  $\pm 50$ -kc. deviations to be obtained.

#### *Frequency Calibration:*

Accurate to 0.5% as shipped. Trimmers permit adjusting each channel frequency more closely, if desired. Variations in battery voltages have a negligible effect on frequency. The calibration of the "off channel" dial is accurate to within  $\pm 5\%$ .

#### *Modulation:*

An internal 400-cps. vacuum-tube oscillator provides linear amplitude modulation up to 100%. Its total harmonic content is less than 3% of the fundamental voltage.

Modulating voltages for fidelity tests must come from an external source, which for 100% modulation should be able to deliver 15 volts across 5000 ohms. The TYPE 513-B Beat-Frequency Oscillator or the TYPE 377-B Low-Frequency Oscillator are recommended. The following maximum

values of percentage modulation are possible for the corresponding modulating frequencies: 400 cps., 100%; 1 kc., 95%; 6 kc., 50%; 10 kc., 30%.

A direct-reading modulation meter, whose reading is independent of battery voltage, indicates percentage modulation for both internal and external modulation.

#### *Output System:*

By means of a vacuum-tube voltmeter, a constant voltage is maintained across the input to a two-stage resistance attenuator consisting of a 120-db 10-ohm ladder network, adjustable in 10-db steps, followed by a 10-db 10-ohm T-type network, adjustable in 0.5-db steps. The attenuator scales are direct-reading in microvolts and in decibels referred to one microvolt as zero level. The internal output resistance is 10 ohms at all settings, which, with the dummy antenna furnished, makes the resistance zero as far as the receiver under test is concerned.

#### *Output Voltage Range:*

0.1 to 316,000 microvolts or  $-20$  db to  $+110$  db referred to one microvolt as zero level.

*Output Voltage Accuracy:*

The calibration of the attenuator has an absolute accuracy of better than 10% at all settings; adjacent attenuator ratios, to within  $\pm 0.5\%$ . The input to the attenuator can be held to within  $\pm 3\%$  provided the vacuum-tube voltmeter is adjusted for the particular tubes used. Otherwise it will be correct to  $\pm 10\%$ .

*Frequency Modulation:*

Less than 150 cps. (total swing) up to 50% modulation.

*Stray Fields:*

All external points on the panel (meters, binding posts, etc.) are equipotential to within one microvolt. Magnetic field is less

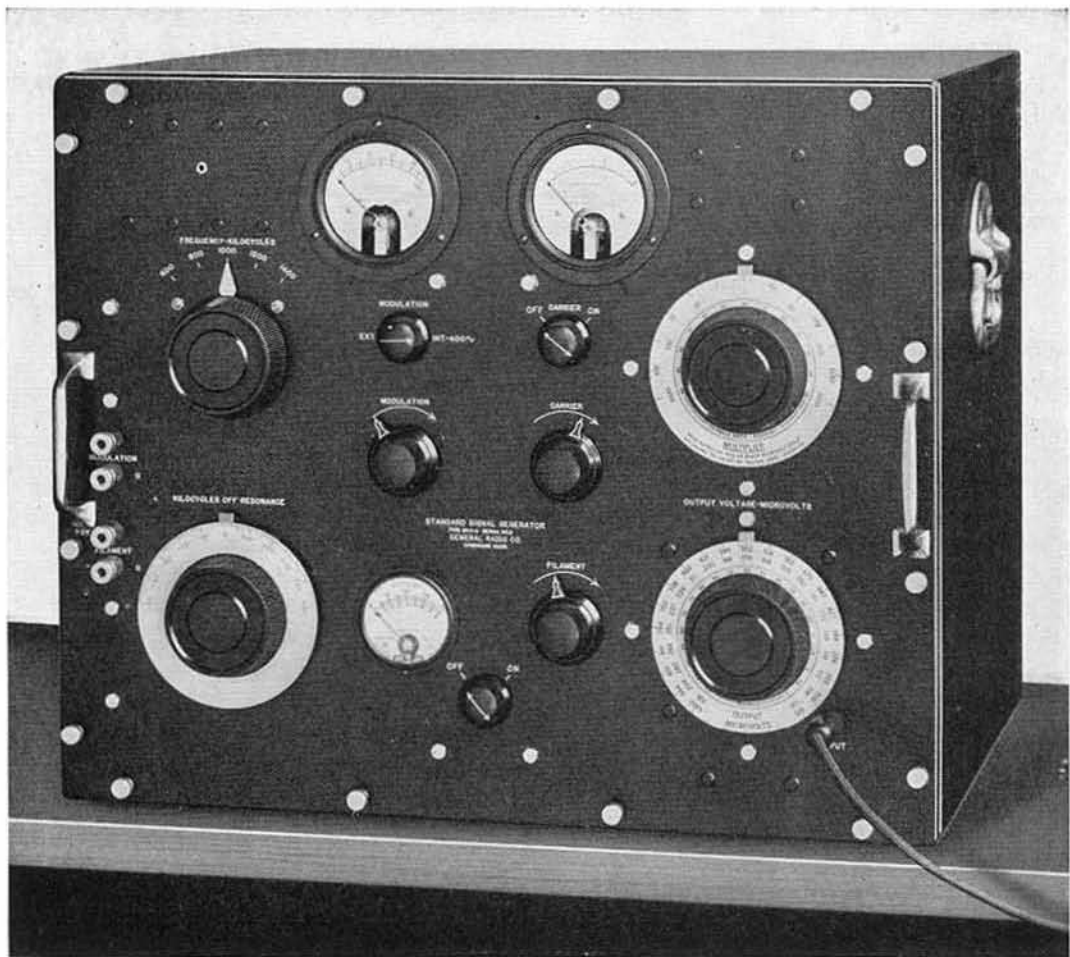
than two microvolts per meter at all external points.

*Construction Features:*

The carrier-frequency oscillator is completely enclosed in an aluminum casting; a small covered hand hole in this facilitates changing tubes. Leads to the attenuator are doubly shielded concentric conductors. The 120-db attenuator is built in three sections, each housed in an aluminum casting and operated by an insulated shaft. In addition to the inner shields, the outer cabinet is completely shielded, electro-magnetically.

*Controls:*

Channel selector,  $\pm 50$ -kc. tuning control for selectivity tests, internal-external modu-



Panel view of the TYPE 600-A Standard-Signal Generator. At the upper left is the channel selection switch and immediately below it is the selectivity or "kilocycles-off-resonance" control. At the right is the two-stage attenuator and to the left of it the voltmeter for indicating attenuator input

lation switch, modulation voltage amplitude control, carrier on-off switch, carrier amplitude control, filament rheostat and switch, and two-dial attenuator.

*Meters:*

Filament-plate voltmeter, percentage modulation meter and micro-ammeter for vacuum-tube voltmeter.

*Terminals:*

The output voltage is brought out through a detachable plug and shielded test lead with terminals for connecting to the dummy antenna. Terminals are also provided on the panel for the filament battery and for the external modulation source.

*Tubes:*

Two 112-A-type and two 227-type tubes, included in the price of the instrument, are required.

*Power-Supply:*

For plate, self-contained block batteries, 180 volts, 12 milliamperes. Space pro-

vided inside cabinet of instrument. For filament, external storage battery, 6 volts, 1.8 amperes, leads provided. Batteries are not included in the price of the instrument.

*Accessories:*

A TYPE 418-B Dummy Antenna, output test lead filament-supply cable, and tubes are furnished as regular equipment.

*Mounting:*

Aluminum panel finished in black crackle lacquer, mounted in hand-rubbed walnut cabinet.

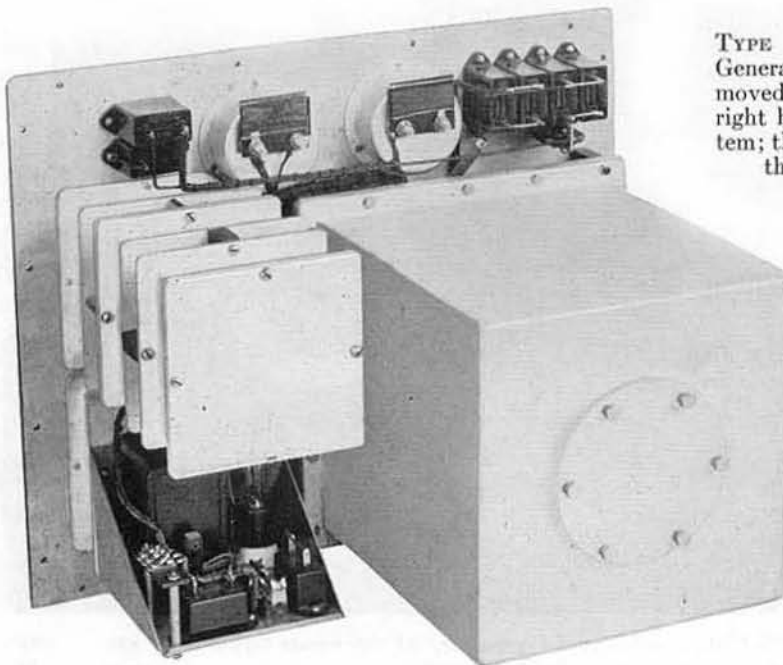
*Dimensions:*

Panel, (width) 19 x (height)  $15\frac{3}{4}$  x (thickness)  $\frac{1}{4}$  inches. Overall, including handles, (width) 20 x (height)  $15\frac{3}{4}$  x (depth)  $15\frac{3}{8}$  inches.

*Weight:*

85 pounds with plate batteries, 75 pounds without batteries.

Type	Frequency Range	Output Range	Code Word	Price
600-A	600, 800, 1000, 1200, 1400 kc.	0.1 to 316,000 microvolts	ASKEW	\$885.00

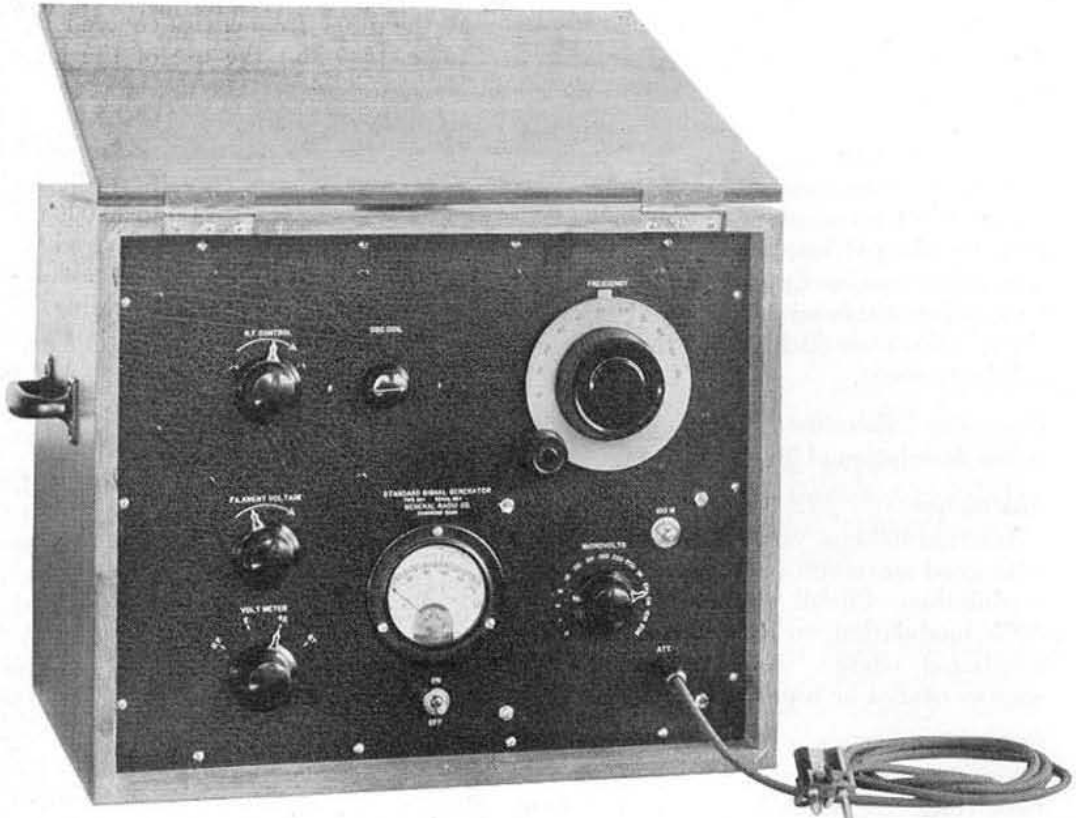


TYPE 600-A Standard-Signal Generator with the cabinet removed. The casting at the right houses the oscillator system; the ones at the upper left, the 120-db attenuator



## TYPE 601-A STANDARD-SIGNAL GENERATOR

**T**HIS instrument is designed to provide a generator of radio frequencies for use in the frequency range from 90 kc. to 6000 kc. to be easily portable, and to deliver either a modulated or unmodulated signal having an amplitude adjustable from one to 150,000 microvolts.



TYPE 601-A Standard-Signal Generator, an inexpensive dual-range instrument

Since it is often desirable to cover two frequency bands in one instrument without the time delay and inconvenience usually involved in changing inductors, the TYPE 601-A Standard-Signal Generator is provided with internal mountings for two inductors and a convenient switch for transferring from one to the other. Any two inductor combinations may be used; for example, the intermediate-frequency and broadcast bands (150 kc.-200 kc. and 550 kc.-1500 kc.), or the broadcast and aircraft bands (550 kc.-1500 kc. and 1400 kc.-4000 kc.). All inductors are mounted on plug bases and are easily removable, if other combinations are required.

The radio-frequency oscillator is adjustable over a frequency range of approximately 3 to 1 by a variable condenser. A fixed shunt capacitance is used across the 150 kc.-200 kc. inductor in order to spread out the calibration between these two points.

The inductors are toroidal in form, which reduces their external field to a negligible amount, and the whole unit is carefully shielded so that it may be used to test the most sensitive unshielded receivers.

The TYPE 601-A Standard-Signal Generator may be used for making accurate sensitivity tests on all types of receivers, either regenerative or non-regenerative, operating within its frequency range. It may be used for lining and adjustment tests for superheterodyne

intermediate frequency amplifiers. Because of its relatively low price, simplicity of operation and ruggedness, it is quite suitable for production testing work of radio receivers. The particular value of the TYPE 601-A Standard-Signal Generator is for portable work, such as the periodical testing of receivers already installed on police cars, ships, airplanes and other places where receivers are apt to get severe usage which may gradually put them out of adjustment. It may also be used for making field-intensity measurements by the familiar comparison method on broadcasting stations, airplane beacons, and point-to-point radio installations at frequencies not covered by the TYPE 403-D Standard-Signal Generator (*i. e.* 1500 kc.-6000 kc.). At the other frequencies covered by the TYPE 403-D Standard-Signal Generator (*i. e.* 15 kc.-1500 kc.) the use of the latter is preferable.

#### *Frequency Range:*

90 kc.-6000 kc. covered by the use of the six TYPE 601-P Inductors, any two of which may be plugged into the instrument and selected by means of a switch. These may be supplied either with or without calibrations. None are included in the price of this instrument.

#### *Frequency Calibration:*

See description of TYPE 601-P Inductors.

#### *Modulation:*

Internal 400-cps. vacuum-tube oscillator, with good waveform adjusted to give 30% modulation. Circuit may be adjusted for 50% modulation on special order at no additional charge. External modulation sources cannot be used.

#### *Output System:*

Input to the attenuator read by vacuum-tube voltmeter which is calibrated at two points to provide a multiplying factor of 1 or 1.5 for the attenuator reading. The attenuator which has a resistive ladder structure is calibrated directly in microvolts. The resistance units are wound on very small, thin mica cards having essentially no reactance. The internal resistance of the output circuit is constant at 10 ohms, except at the 10M, 20M and 100M points, where it is 20, 40 and 200 ohms respectively.

The attenuator is tapped near the high potential end and a separate "high output" terminal brought out on the panel above the attenuator control knob.

#### *Output Voltage Range:*

The attenuator is calibrated in the following steps which correspond to a meter setting of 1: 0-1-2-5-10-20-50-100-200-500-1M-2M-5M-10M-20M.

The voltmeter multiplying factor of 1.5 makes available microvolt readings between these points from 1.5 to 30,000 microvolts. The "high output tap" gives an output of 100,000 or 150,000 microvolts depending upon the voltmeter reading. The output of the attenuator when set at zero is never as large as one-tenth of the one-microvolt output.

#### *Output Voltage Accuracy:*

Output voltage calibration for outputs below 10 microvolts and through the frequency range from 90 kc.-1500 kc. about 10% between adjacent attenuator ratios. For same output voltage range and through frequency range from 1500 kc.-6000 kc. about 20% between adjacent attenuator ratios. At output above 10 microvolts the errors are less than 5% and 10% respectively for the above-mentioned frequency ranges. The accuracy of comparison, that is, the ability of the instrument to repeat readings when no tubes have been changed, is about 1%. The accuracy of comparison is the figure of merit which must be considered when receivers are to be tested against a nominal output voltage or a standard receiver. The absolute value of output voltage depends upon adjustment of vacuum tube voltmeter. If calibrated by comparison with a General Radio TYPE 426-A Thermionic Voltmeter, or equivalent, the adjustment will not change until it becomes necessary to replace a tube. Changes in tubes without calibration will not affect the calibration by more than 20%.

#### *Frequency Modulation:*

Varies with the inductor and frequency adjustment. Percentage is less at frequencies above 1500 kc. For 30% modulation always less than 0.03% at more than

half scale on tuning condenser; at highest frequency on any inductor not more than 0.1%. For 50% modulation, figures are proportionally higher.

*Stray Fields:*

The use of toroidal inductors and careful shielding reduces stray fields to a negligible amount.

*Construction Features:*

Radio-frequency circuits in separately shielded compartment on metal shelf. Entire assembly mounted in copper-lined oak cabinet. Attenuator divided into three shielded sections, to reduce stray effects.

Connection to the set under test is made by means of the flexible shielded lead provided, which connects to the output of the signal generator through a specially constructed plug and submounted jack. This construction eliminates binding posts and provides a completely shielded path from the receiver to the attenuator output. All high-frequency wiring which is not double shielded is run in concentric shielded cable.

All low frequency, battery and meter circuits are connected through choke and bypass condenser filters, eliminating practically all of the radio frequencies in these units. All of the low-frequency circuits and batteries are enclosed in the copper-lined cabinet for additional protection against leakage.

*Controls:*

Carrier amplitude control, filament rheostat, voltmeter selector switch, inductor selector switch, frequency control and attenuator.

*Terminals:*

The attenuator output and the "high output" terminals are plugs located be-

hind the panel to which connections are made by means of a shielded plug and test lead. The latter is fitted with terminals for making connections to a dummy antenna or directly to a circuit under test.

*Meter:*

A meter, connected to a multi-point switch, is provided to read filament and plate voltages as well as radio-frequency output amplitude.

*Tubes:*

Three 230-type tubes, not included in the price of the instrument, are required.

*Power-Supply:*

From dry batteries placed inside shielded cabinet. For plate, block batteries, 45 and 67.5 volts, 2 mla. For filament, two No. 6 dry cells, 180 mla.

*Accessories:*

A shielded plug and test lead, but no dummy antenna, are furnished as regular equipment. A TYPE 418-B Dummy Antenna must be ordered separately.

*Mounting:*

Aluminum panel, 1/4 inch, finished in black crackle lacquer, mounted in natural finish oak cabinet, with five-ply veneer hinged oak cover and carrying handles. Panel is slightly recessed into the cabinet to protect it.

*Dimensions:*

Panel, 15 x 12 x 1/4 inches. Overall, (width) 16 x (height) 13 1/2 x (depth) 12 1/2 inches.

*Weight:*

50 1/2 pounds with batteries, 40 pounds without batteries.

Type	Frequency Range	Output Range	Code Word	Price
601-A	90-6000 kc.*	1-150,000 microvolts	JUROR	\$210.00

\*Inductors must be ordered separately.

**TYPE 601-P INDUCTORS**

THESE are intended for use with the TYPE 601-A Standard-Signal Generator. No inductors are supplied with the instrument and we particularly recommend that, if calibrated inductors are required, they be ordered with the standard-signal generator, since they must be calibrated in the generator with which they are to be used. The TYPE 601-P Inductors are carried in stock without calibrations, but a chart giving calibration data at five appropriately equal-spaced discrete frequencies can be supplied on order. A continuous calibration curve can also be supplied on order. Both chart and curve give data accurate to within  $\pm 1\%$ .

Type	Frequency Range		Code Word	Price
*601-P1	2500-6000 kc.	.....	STANSIGTOP	\$7.00
*601-P2	1400-4000 kc.	.....	STANSIGBIB	7.00
*601-P3	550-1500 kc.	.....	STANSIGHUM	7.00
*601-P4	200- 550 kc.	.....	STANSIGSUN	7.00
*†601-P5	150- 200 kc.	.....	STANSIGSIN	9.00
*601-P6	90- 200 kc.	.....	STANSIGGAS	12.00
Frequency Calibration Chart (per inductor) .....			CHART	5.00
Frequency Calibration Curve (per inductor) .....			CURVE	8.00

\* Frequency calibrations supplied only when ordered. When ordering calibrated inductors by telegraph, use compound code words, e.g., STANSIGTOPCHART, STANSIGTOPCURVE, etc.

† Has a fixed shunt capacitance in order to spread out the calibration through the superheterodyne intermediate-frequency range.

**TYPE 418-B DUMMY ANTENNA**

THIS unit is designed for use with General Radio standard-signal generators to replace the TYPE 418 Dummy Antenna described on page 91. It is made in accordance with dummy-antenna specifications of the Institute of Radio Engineers for use in making standard-signal measurements on radio receivers. Its effective height is taken as 4 meters.

A dummy antenna is supplied with the TYPE 403-D and TYPE 600-A Standard-Signal Generators but one must be ordered separately for the TYPE 601-A Standard-Signal Generator.

*Resistance:*

15 ohms at broadcast frequencies. This, with the 10-ohm internal output impedance of General Radio standard-signal genera-

tors, makes up the 25 ohms called for in the I. R. E. specifications.

*Inductance:*

20 microhenrys.

*Capacitance:*

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

*Mounting:*

Moulded bakelite case with input and output binding posts arranged to accommodate a TYPE 274-M Plug.

*Dimensions:*

2  $\frac{1}{8}$  (length) x 1  $\frac{3}{8}$  (width) x 2 inches (height), overall.

*Weight:*

4 ounces.



TYPE 418-B Dummy Antenna

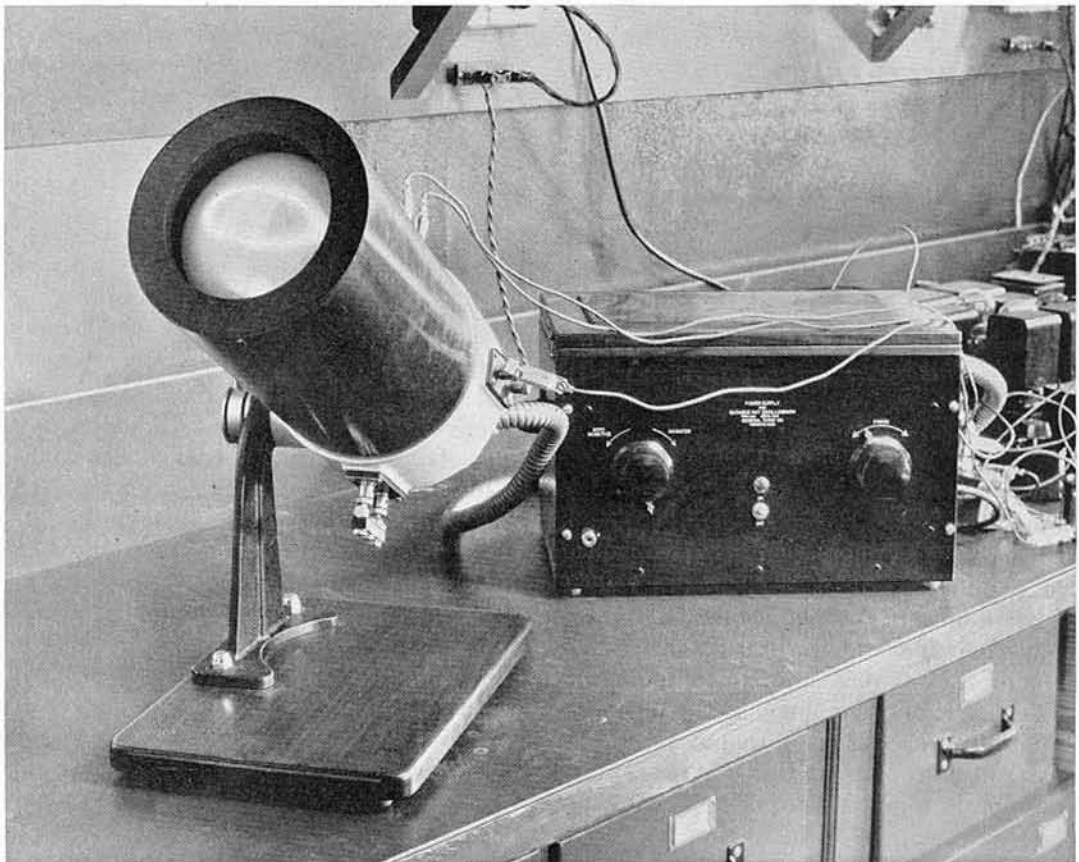
Type		Code Word	Price
418-B	.....	EPHOD	\$6.00

## MISCELLANEOUS LABORATORY EQUIPMENT

**T**HIS chapter describes the General Radio cathode-ray oscillograph and a new instrument for the determination of distortion factor in audio-frequency circuits.

The TYPE 536-A Distortion-Factor Meter measures the total harmonic content of the alternating-current wave under test and gives directly the ratio between the square root of the sum of the squares of the amplitude of all harmonics and the amplitude of the fundamental. This is the distortion factor, an excellent measure of the objectionableness of the distortion introduced by amplifiers, lines, or other circuit elements.

The cathode-ray oscillograph is a well-known and justly popular laboratory tool for the observation and recording of phenomena, especially where high frequencies and very short time intervals are involved.



Brilliant images are obtained with this new cathode-ray oscillograph. From an unretouched photograph

[ 203 ]

Because the "moving element" is a beam of cathode rays or electrons, it is inherently more suitable for most purposes than oscillographs of the string or moving-coil types. Distortions due to inertia and resonance effects encountered in vibrating mechanical elements are absent and, since the rays are usually deflected by electrostatic means, the power sensitivity is much higher.

Although the General Radio oscillograph is a complete equipment, it is, for convenience in cataloging, considered to consist of the following three components:

a. The TYPE 478-A Cathode-Ray Oscillograph Tube is the heart of the instrument. It is listed separately to facilitate ordering replacements.

b. The TYPE 497-A Tube Mounting is the support for the tube, providing a means for holding the tube in position, for making connections to it and for protecting it against breakage.

c. The TYPE 496-A Power-Supply Unit supplies all the voltages necessary to operate the tube from the 110-volt alternating-current supply.

For the complete table-mounting oscillograph, the following material should be ordered:

1—TYPE 478-A	Cathode-Ray Oscillograph Tube.....	(See page 207)
1—TYPE 497-A	Tube Mounting.....	(See page 209)
1—TYPE 496-AM	Power-Supply Unit.....	(See page 211)
COMPLETE EQUIPMENT ( <i>Code Word: COMET</i> ) .....		\$280.00

### TYPE 536-A DISTORTION-FACTOR METER

**M**OST of the methods of measuring harmonic distortion that have been employed either have been laborious, or have involved elaborate equipment. The TYPE 536-A Distortion-Factor Meter has been developed to enable distortion measurements to be made accurately and rapidly. This instrument has a further important advantage over earlier apparatus in that its input impedance is very high. It may therefore be connected almost anywhere without causing appreciable disturbance of the circuit under test.

In order that these ends might be achieved, two important simplifications of the problem have been made at the outset. Only a single fundamental frequency is employed, and only the total harmonic distortion is measured.

The first of these limitations is not as serious as it at first appears because harmonic production is essentially an amplitude phenomenon. Frequency usually enters into the problem only secondarily. For this reason a study at a single frequency of the harmonic production in a given piece of apparatus under various operating conditions yields valuable information. The technique of measurement is simplified to such an extent that the required data may be very rapidly obtained.

The measurement of total harmonic content is for most purposes preferable to the measurement of the several components separately. We obtain in this way a single quan-



TYPE 536-A Distortion-Factor Meter

tity as a measure of the impurity of the voltage source. The "Distortion Factor" measured by the instrument is

$$D = \frac{\sqrt{E_2^2 + E_3^2 + E_4^2 + \dots}}{E_1}$$

This is the ratio to the fundamental of the effective value of the combined harmonics. This quantity is an excellent measure of the objectionableness of the distortion present in the transmission of speech or music. For example, a second harmonic of 5% with a third harmonic of 5% is seen to give a smaller distortion factor than a single harmonic of 10%, and is correspondingly less objectionable.

*Testing of Audio Amplifiers:* The present general use of the pentode output tube makes a dependable means of studying the output capabilities of an amplifier especially desirable. Output measurements without some indication of the distortion present are of doubtful significance. The use of the TYPE 536-A Distortion-Factor Meter in conjunction with the TYPE 483 Output Meter in making these measurements gives truly reliable data for the comparison of various types of amplifiers.

*Measurement of Modulation Distortion in Broadcast Transmitters:* If a suitable linear rectifier is available for demodulation, the TYPE 536-A Distortion-Factor Meter provides a means of measuring the impurity of the modulated output of a radio-telephone transmitter. Such a high-quality linear rectifier is contained in the TYPE 457-A Modulation Meter, and terminals are provided for connection to the distortion-factor meter. The use of these two instruments in conjunction, therefore, makes possible the direct determination of modulation distortion.

#### *General Description:*

The principal elements of the instrument are a special type of high-pass filter and a calibrated resistance network by means of

which the filter output is compared with the input voltage. A dial is rotated until the same indication is obtained for two positions of a switch. The distortion factor is

then given directly by the dial reading. Two ranges are provided giving 3% and 30%, respectively, at the maximum dial setting. The characteristics of the filter are such that the fundamental is attenuated about 75 db more than the harmonics. Power-supply hum voltages are likewise suppressed. All harmonics up to the fifteenth are transmitted equally within 0.4 db. The filter is so designed that no appreciable harmonic distortion is produced by the inductors, even when large input voltages are applied. A resistance pad is provided ahead of the filter so that the calibration is not altered by the impedance out of which the instrument works.

*Auxiliary Equipment:*

The distortion-factor meter must be used with a suitable amplifier and indicating instrument. The TYPE 514-A Amplifier and TYPE 488-HM Alternating-Current Galvanometer are recommended for general use. The amplifier must have a flat characteristic, variable gain, and an input impedance greater than half a megohm. The indicating instrument should be sensitive and have a square-law characteristic in order to indicate the effective value of the combined harmonics.

Where a 400-cps. voltage is applied to the apparatus under test, it must usually be filtered to obtain sufficient purity. The extent to which this is necessary depends, of course, on the magnitudes of the distortion factors to be measured.

One or more TYPE 330-A or TYPE 330-C Filter Sections may be employed if extreme purity is not required. A special band-pass filter TYPE 530-A and TYPE 530-C has been developed for use with the TYPE 536-A Distortion-Factor Meter. This filter is described elsewhere.

*Range and Sensitivity:*

With the recommended auxiliary equipment, 10 volts across the input terminals makes possible the measurement of distortion factors as low as 0.02. If larger distortion factors are to be measured, the input voltage may be reduced in the same proportion. Similarly, if larger input voltages are available, proportionately smaller distortion factors may be measured.

For special uses, the range and sensitivity may be very greatly extended by employing more amplification. If desired, two TYPE 514-A Amplifiers may be used in tandem for special work.

*Frequency Range:*

380 - 420 cps.

*Input Impedance:*

About 175,000 ohms.

*Accuracy:*

When the TYPE 488-HM Alternating-Current Galvanometer is used as indicator, the error is less than 5% for distortion factors as low as 0.005. If necessary, greater accuracy can be obtained by substituting an instrument of the thermocouple type, as this indicates more accurately the effective value of a composite voltage. Inasmuch as the thermocouple instrument is less sensitive, more sluggish, and has a much smaller overload capacity, the TYPE 488-HM Alternating-Current Galvanometer is usually to be preferred.

*Dimensions:*

Panel, 12 x 7 x 1/4 inches. Depth behind panel, 10.5 inches. Complete cabinet assembly, 15 x 8 1/4 x 12 1/4 inches.

*Weight:*

31 pounds.

<i>Type</i>	<i>Frequency Range</i>	<i>Code Word</i>	<i>Price</i>
536-A	380-420 cps.	DRAFT	\$140.00





TYPE 530-A AND TYPE 530-C BAND-PASS FILTERS

THESE filters are designed primarily for use with the TYPE 536-A Distortion-Factor Meter to purify the voltage applied to apparatus under test. They are useful in any other cases where an extremely pure 400-cps. voltage is desired. The use of one of these filters reduces the harmonic content by at least 50 decibels. They may be used with a fundamental frequency of from 375 to 425 cps. Sufficient attenuation is provided at the low-frequency end to remove any power-supply hum voltage which may be present. The two types differ only in characteristic impedance. These filters are not carried in stock but are supplied on order. They are mounted in Model D cases. (See page 44.)

Weight: 8½ pounds.

Type	Pass Band	Impedance	Code Word	Price
530-A	375-425 cps.	600 ohms	FOCAL	\$37.50
530-C	375-425 cps.	6000 ohms	FURRY	37.50

TYPE 478-A CATHODE-RAY OSCILLOGRAPH TUBE

THIS tube is of the so-called hot-cathode, low-voltage type, employing a hot filament and an anode voltage which is low as compared with the oscillographs associated with the names of Braun and of Dufour. Provision is made for deflecting the electron beam with the electric field between two pairs of small condenser plates, but, if proper arrangements are made, magnetic deflecting fields may be substituted. Patterns appear on a fluorescent screen at the end of the tube, the material of which was selected to yield the maximum of visual and photographic brilliance.

The cathode-ray tube used in the General Radio oscillograph was developed by Manfred von Ardenne and is manufactured by him in Germany.

Operating Principles:

The operating principle of the tube is simple. Electrons emitted by the oxide-coated filament are drawn toward the high-potential anode, thus acquiring a velocity sufficient to pass through a hole in it and strike a fluorescent screen on which a spot of light appears. A negatively charged cylinder around the filament serves to concentrate the electrons into a small beam.

Between the anode and the fluorescent screen, the electron beam passes between the plates of two very small condensers, so arranged that an electric field between one pair causes a deflection of the beam (and the spot) in a direction perpendicular to the deflection caused by a field between the other pair. These are the deflecting plates across which the voltages to be observed are impressed. When alternating voltages are applied, the spot traces figures like those represented in the accompanying

sketches. These are the fundamental patterns upon which more complicated uses of the cathode-ray oscillograph are based.

Construction:

The cutaway view on page 208 shows in detail the arrangement of the electrodes within the tube. From top to bottom they are: the two pairs of deflecting plates, the anode and the filament surrounded by the focusing cylinder.

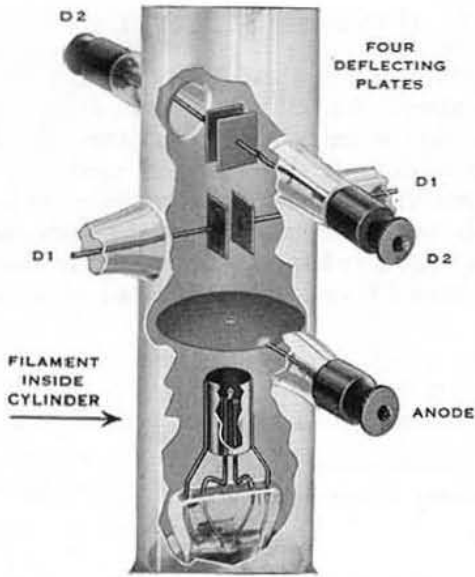
Brilliance:

Patterns are brilliant and easily visible even in broad daylight.

Photographs may be taken of single transits of the spot across the screen at velocities up to 400 inches per second with an *f*4.5 lens, a plate as fast as the Eastman



The Cathode-Ray Oscillograph Tube



Electrode Structure in the Cathode-Ray Oscillograph Tube

Hyper-press and an anode voltage of 2000 volts. This lens and plate would, for instance, record one transit of a spot moving fast enough to complete a 2-inch (diameter) circle in  $1/60$ th of a second. A faster lens or plate would increase the permissible velocity correspondingly. Photographs at much greater velocities may be obtained by allowing the spot to repeat the pattern several times.

#### Voltage Sensitivity:

Over the normal range of anode voltages, 500-2500 volts, the voltage sensitivity is a linear function of anode voltage, being about one volt per millimeter at 500 volts, and 5 volts per millimeter at 2500 volts.

The greater the anode voltage, the greater the brilliance and the lower the sensitivity.

#### Terminals:

Terminals for the deflecting plates and the anode are brought out of the tube through glass arms. This construction materially lowers the inter-electrode capacitance and eliminates insulation troubles in the anode circuit. Connections to the filament and focusing cylinder are brought out to the plug-type base.

#### Power Supply:

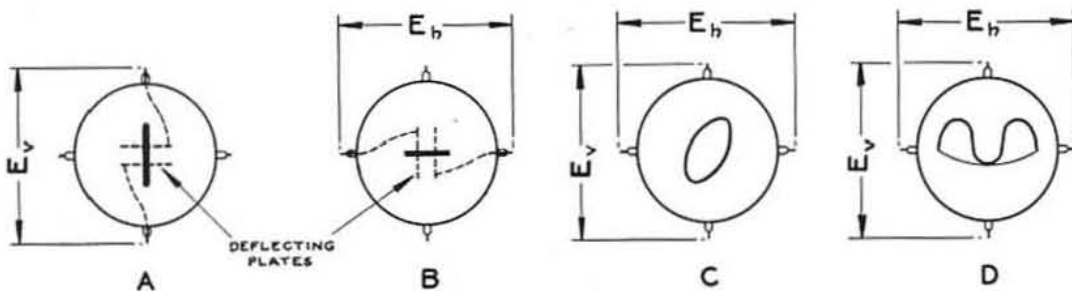
The following values of voltage, which may best be obtained from the TYPE 496-A Power-Supply Unit, are required: filament, 0.7 volt, 1.5 amperes, approximately, the exact value being marked on each tube; anode, 500-2500 volts direct current, 50-100 micro-amperes; focusing cylinder, 50-400 volts direct current, no current when properly adjusted. The maximum anode voltage recommended is 2000 volts, but this may be increased to 2500 volts for short periods in order to obtain additional brilliancy.

#### Deflecting Plates:

Capacitance of either pair is less than  $1.5 \mu\mu\text{f}$ . Even at frequencies of 30 megacycles per second, the envelope patterns are fairly good, especially when the radio-frequency deflection is used in one direction only and the time axis obtained with a rotating mirror or a moving film camera.

#### Mounting:

The tube is intended to be mounted in the TYPE 497-A Tube Mounting described below.



Fundamental cathode-ray oscillograph patterns. Alternating voltages may be applied to the vertical or horizontal deflecting plates as in A and B. Pattern C results when  $E_v$  and  $E_h$  are applied simultaneously, the frequencies  $f_v$  and  $f_h$  being the same. If  $E_h$  is derived from a "linear sweep circuit," and  $E_v$  is derived from an alternating voltage, the wave shape of  $E_v$  appears in Pattern D. The true wave shape of  $E_v$  can also be obtained from Pattern A with a moving film camera or a rotating mirror



The General Radio Cathode-Ray Oscillograph for table mounting. At the left is the TYPE 496-AM Power-Supply Unit; at the right, the TYPE 497-A Tube Mounting containing the tube

*Dimensions:*

The diameter of the fluorescent screen is 4.5 inches. For other dimensions, see the

description of the TYPE 497-A Tube Mounting.

*Weight:*

1 pound.

<i>Type</i>	<i>Code Word</i>	<i>Price</i>
478-A	APPLY	\$95.00

### TYPE 497-A TUBE MOUNTING

(FOR CATHODE-RAY OSCILLOGRAPH)

**T**HIS is a universal mounting for holding the tube in any desired position and for making connections between the tube and the TYPE 496-A Power-Supply Unit (see page 203 for illustration). It has a number of features which facilitate the use of the oscillograph, make for convenience in operating and prolong the life of the tube by minimizing the danger of accidental burnout or breakage. Terminals are provided for connecting the voltages to be analyzed.

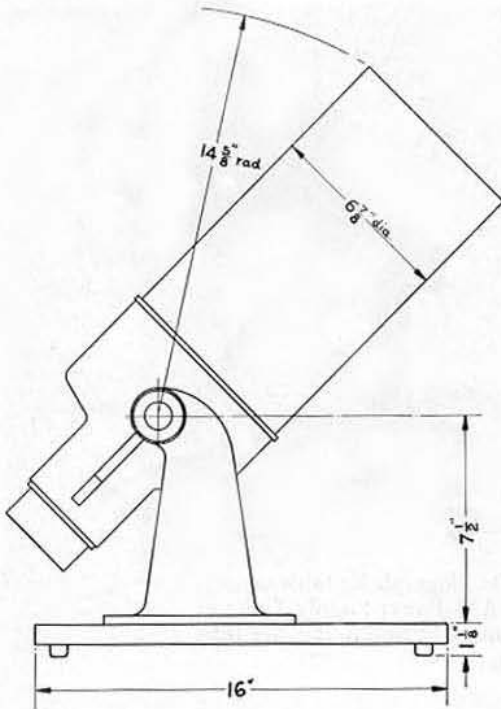
*Construction:*

The unit consists of an aluminum casting carried on a horizontal shaft attached to a bracket which, in turn, is bolted to a walnut base large enough to provide the necessary stability. The casting contains the tube socket and an adjustable three-arm clamp for holding the tube securely in place, and it may be swung about the horizontal axis and locked in any desired angular position as shown in the accompanying profile drawing.

Attached to the casting and surrounding the tube is a protecting cylinder of bakelite, which serves the double purpose of excluding extraneous light and of preventing accidental breakage of the tube.

*Mounting:*

The supporting bracket may, if desired, be removed from the base and mounted on the under side of a table, on a relay rack panel or in any other convenient manner. For most purposes, however, the standard wooden base will be found entirely satis-



Profile View of Complete Tube Mounting  
(to scale)

factory. A suitable panel for adapting the instrument to rack-mounting is described under "TYPE 497-P Accessories."

**Terminals:**

All power-supply wiring between the tube and the power-supply unit is carried

in a 5-foot flexible shielded cable, on one end of which is the tube socket and on the other, the special plug base which fits the corresponding jack plate in the power-supply unit. This cable is supplied as regular equipment with the tube mounting.

Binding posts are mounted at the top and side of the tube mounting, to which the voltages to be analyzed may be connected by means of standard TYPE 247-M Plugs. Provision is made for short circuiting either or both pairs of deflecting plates and for using them either with or without grounded terminals.

For some purposes it is often desirable to introduce voltages in series with the power supply to the anode. To facilitate this, two terminals are provided at the bottom of the unit. These are normally short circuited, and, since they are at ground potential, their exposure introduces no hazard.

**Accessories:**

The unit is supplied complete with the shielded cable but without the cathode-ray oscillograph tube.

**Dimensions:**

See the accompanying sketch. The base is  $9\frac{1}{8}$  inches wide.

**Weight:**

$17\frac{1}{2}$  pounds, without the tube.

Type	Code Word	Price
497-A	ARBOR	\$75.00

## TYPE 497-P

## ACCESSORIES

FOR those users who wish to adapt the cathode-ray oscillograph for mounting on a standard 19-inch (TYPE 480) relay rack, we can supply a suitable drilled panel to which the supporting bracket of the tube mounting may be attached. The bakelite protecting tube then extends through the front of the panel as shown in the photograph of the rack-mounting model.

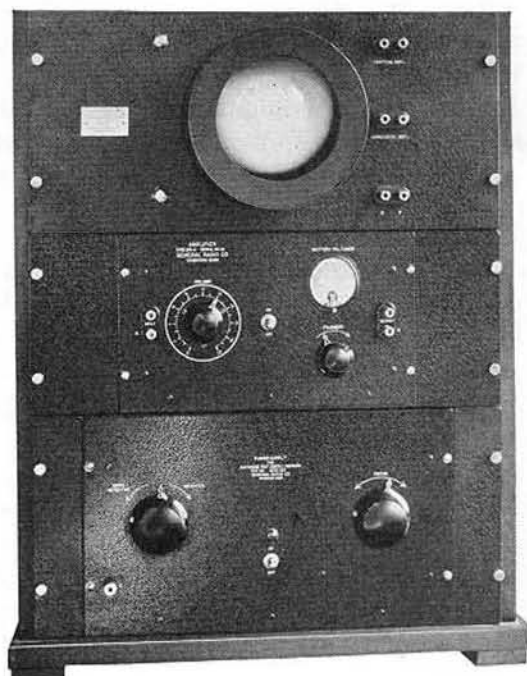
When mounted on a relay rack, the tube mounting should be separated by at least 7 inches from the power-supply unit to minimize the effect of stray magnetic fields on the cathode-ray beam.

*Terminals:*

Three sets of binding posts are provided on the front of the panel to which are attached wires for making connections to the terminals on the tube mounting.

*Weight:*

1½ pounds.



The rack-mounting Oscillograph with a TYPE 514-AR Amplifier. The latter instrument was, in this set-up, used to amplify one of the voltages being analyzed

*Dimensions:*

Panel, 19 x 8¾ x ¼ inches. When assembled, the viewing tube extends 6⅞ inches in front of the panel, other parts extend 13⅞ inches behind it.

<i>Type</i>	<i>Code Word</i>	<i>Price</i>
497-P1	AMEND	\$12.00

## TYPE 496-A POWER-SUPPLY UNIT

(FOR CATHODE-RAY OSCILLOGRAPH)

THE power-supply unit is a complete solution to the voltage supply and control problem for the TYPE 478-A Cathode-Ray Oscillograph Tube, wherever a 110-volt alternating-current source is available. It contains every feature desirable for convenience and safety. It eliminates the possibility of burning out the tube due to accidental contact of high voltages with the filament circuit.

There are only two principal controls and these are placed on the panel within easy reach. One adjusts the brilliancy and the sensitivity of the tube by changing the anode voltage, the other adjusts the focus of the electron beam by changing the voltage applied to the focusing cylinder. A third control, the filament rheostat (and its associated ammeter), is placed inside the cabinet, out of the way, because once set it need never be changed during the life of the tube.

Safety for the user is an important design feature since anode potentials as high as 2500 volts are employed. High voltage terminals cannot be exposed except when the tube is removed from the socket or when the cover of the power-supply unit is raised. Both of these operations open the low-voltage input circuit to the high-voltage supply and make access to dangerous voltages an impossibility. The safety switches do not, however, interrupt the filament-supply circuit.

*Power Supply:*

105-115 volts, 50 or 60 cps. alternating current. An ON-OFF switch and a pilot lamp are mounted on the panel.

*Output Voltages:*

Sufficient to operate TYPE 478-A Cathode-Ray Oscillograph Tube.

*Terminals:*

A receptacle is placed on the right end of the cabinet for the 110-volt input. Output voltages are delivered to a jack plate inside the cabinet, which fits the plug plate on the connecting cable supplied with the tube mounting.

*Tubes:*

One 280-type and one 866-type are required. Neither is supplied with the unit.

*Mounting:*

Everything is carried on an aluminum panel finished in black crackle lacquer which, in turn, is mounted in a polished walnut cabinet.

A rack-mounting instrument is described below under "Alternative Mounting."

*Accessories:*

A 7-foot cord, fitted with attachment plugs for making connections to the power supply, is furnished.

*Dimensions:*

Panel, 15 x 8 $\frac{3}{4}$  inches; overall cabinet size exclusive of carrying handles, width 15 $\frac{1}{4}$ , height 9 $\frac{5}{8}$ , depth 9 $\frac{1}{2}$  inches.

*Weight:*

30 pounds.

<i>Type</i>		<i>Code Word</i>	<i>Price</i>
496-AM	Cabinet mounting .....	ARGON	\$110.00

TYPE 496-A POWER-SUPPLY UNIT

(ALTERNATIVE MOUNTING)

THE power-supply unit may, if desired, be supplied for mounting in a standard 19-inch (TYPE 480) relay rack. To do this we supply, instead of the cabinet, a pair of panel extensions for increasing the panel length to 19 inches. A brass shield takes the place of the cover of the cabinet, the raising of which opens the safety switch referred to in the preceding description.

The instrument itself is identical with the TYPE 496-A Power-Supply Unit previously described.

*Dimensions:*

Panel size, with panel extensions, 19 x 8 $\frac{3}{4}$  x  $\frac{1}{4}$  inches.  
Overall depth, behind panel, 8 $\frac{1}{2}$  inches.

*Weight:*

21 $\frac{1}{2}$  pounds.

<i>Type</i>		<i>Code Word</i>	<i>Price</i>
496-AR	For relay-rack mounting .....	ANNEX	\$100.00



## METERS

**T**HE new meters and auxiliaries described below include a thermionic voltmeter, a line of output meters and power-level indicators more sensitive than those heretofore available, contact-type and separate-heater vacuum thermocouples, a mounting base for navy-type flush-mounting meters, and several copper-oxide rectifier voltmeters of high sensitivity.

### TYPE 626-A VACUUM-TUBE VOLTMETER

(ALTERNATING-CURRENT OPERATED)

**T**HE wide applicability of the thermionic type of alternating-current voltmeter introduced the need for such an instrument designed to be operated wholly by 60 cps., 110-volt alternating current.

The TYPE 626-A Voltmeter is a direct-reading, serviceable, moderately precise instrument of the compensated, depressed-zero type. The filaments of the tubes used are run at subnormal voltages so that their normal life is considerably increased. A rugged d'Arsonval type of meter having a full-scale deflection of 300 micro-amperes serves as the indicating device.

The design of the circuits and the type of tubes used result in a minimum wandering of the zero point or aging, the chief source of error being fluctuations in the line voltage (see below). A rheostat is provided on the panel for adjusting the instrument so that all values of line voltage between 100 and 120 volts may be used. Sudden erratic changes in line voltage are not in general detrimental, owing to the large thermal capacity of the cathode of the thermionic tube.

#### *Range:*

0-3 volts, r.m.s.

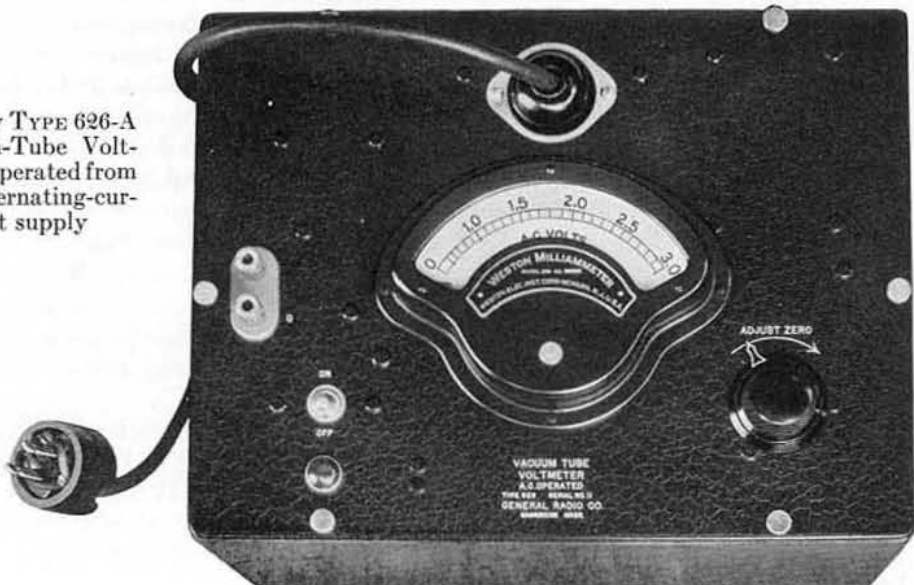
#### *Power Supply:*

Alternating current, 50-60 cps., 100-120 volts. The instrument draws a current of approximately 0.15 amperes from the power supply. A pilot lamp and "on-off" switch are mounted on the panel.

#### *Tubes:*

One 227-type for the thermionic voltmeter, one 171-type for the rectifier unit, and one 874-type ballast tube for stabilizing the plate voltage are required. These are supplied with the instrument. In the event of failure of the voltmeter tube, the instrument should be returned to us for recalibration.

The new TYPE 626-A Vacuum-Tube Voltmeter, operated from the alternating-current supply



*Calibration:*

Each instrument is individually calibrated and is accurate to within 1% of full-scale value.

*Line-Voltage Error:*

A drop of one volt in the power supply will reduce the reading of the meter at any given point on the scale by 0.015 volts (0.5% of full-scale). This error is linear. The meter is adjusted for different values of line voltage by a control rheostat which restores the needle to zero.

*Frequency Error:*

Below 1500 kc., this error is negligible. At 3000 kc., the frequency error is less than 2%, and at 4000 kc., it is less than 4%.

*Waveform Error:*

The instrument is calibrated in terms of r.m.s. values of a pure sinusoidal wave. Since most thermionic voltmeters read average rather than r.m.s. values, any de-

parture from a sinusoidal wave due to the presence of harmonics will introduce an appreciable error.

*Input Impedance:*

10 megohms. No external direct-current path is required.

*Ground:*

It is desirable to ground the low potential input terminal.

*Mounting:*

Aluminum panel, polished walnut case.

*Accessories:*

A six-foot attachment cord and the three tubes are supplied with the instrument.

*Dimensions:*

11 (length) x 8½ (width) x 8¾ (height), overall.

*Weight:*

14½ pounds.

<i>Type</i>	<i>Range</i>	<i>Code Word</i>	<i>Price</i>
626-A	0-3 volts, r.m.s.	ETHIC	\$100.00

## TYPE 483 OUTPUT METERS

THE success of the TYPE 486 Output Meter introduced about two years ago by the General Radio Company has been such that it appears desirable to extend the line in order that instruments may be available for use in connection with the various types of receivers now commercially available. The TYPE 483 Output Meters as well as the TYPE 486 Output Meters are essentially alternating-current voltmeters of the copper-oxide-rectifier type. The instruments include multiplying networks so arranged that a constant load impedance is presented at the terminals. In the several meters now listed, these impedances have been chosen to have the same order of magnitude as the loads commonly employed with radio-receiving circuits. The output meter, therefore, serves both as a test load and as an instrument for measuring the voltage developed across this load.

Instruments are now available for use with four general types of receiving circuits. These may be listed under their characteristic load impedance as follows:

*4000-Ohm Load:* This is the correct value to use with receivers having a single 245-type vacuum tube or having an output transformer for working into 4000-ohm loudspeakers.

*8000-Ohm Load:* The majority of broadcast receivers now in commercial production employ push-pull 245-type tubes. These should work into a load impedance of 8000 ohms. Output meters designed for this value are, therefore, ideally suited for measurements directly across the plate circuit.

*20,000-Ohm Load:* The advent of the 230- and 231-type tubes has resulted in the design of improved battery-operated receivers. Circuits employing 231-type tubes in push-pull have an output impedance of approximately 18,000 ohms. There is also an ever-growing demand for an output meter to be used in connection with code receivers designed for headphone operation. Both of these above requirements will be met by an output meter having a characteristic impedance of 20,000 ohms.



*Design:*

With each of the various types of receivers, it is desirable that the output meter have sufficient sensitivity to permit measurements of hum voltage. By incorporating the latest improvements in methods of meter construction, it has been possible to obtain a full-scale sensitivity of 2 volts even at a characteristic impedance of 20,000 ohms. This sensitivity has been obtained without loss of mechanical ruggedness.

In order to increase the utility of these output meters, seven multiplying steps have been provided. In this way the total range has been increased and at the same time the interval between steps has been decreased as compared with previous designs.

*Characteristic Impedance:*

See price list for values. When the multiplier is set at one, the impedance is that due to the meter alone, and hence varies with voltage as in the case of the TYPE 488 Alternating-Current Voltmeters. With increase in multiplying setting the impedance approaches a pure resistance of the characteristic value and is accurate to  $\pm 2\%$ .

*Sensitivity:*

All have a full-scale sensitivity of 2 volts. See price list.

*Accuracy of Calibration:*

With the multiplier at one, the accuracy of calibration depends entirely on the properties of the copper-oxide-rectifier meter. These are such that the instrument is accurate to within 2% of its full-scale reading at frequencies up to 2000 cycles, within 5% to 5000 cycles and within 10% to 10,000 cycles. At a multiplier setting of two, there is an additional error in the indicated voltage due to the variation in meter impedance with voltage. For the 4000- and 8000-ohm meters, this error is 5% at one volt and 10% at 0.5 volt. For the 20,000-ohm meter this error is 3% at one volt and 6% at 0.5 volt. The network error at a multiplier setting of



TYPE 486-C Output Meter  
(Patent applied for)

two is greater than at any other setting and decreases rapidly as the multiplier ratio is increased.

*Scale Length:*  
2½ inches.

*Mounting:*

The copper-oxide-rectifier voltmeter and the multiplier switch are mounted on a bakelite panel which, in turn, is mounted in a polished walnut case.

*Dimensions:*  
9 x 4¼ x 4¾ inches.

*Weight:*  
3 pounds.

Type	Range	Characteristic Impedance	Maximum Power	Code Word	Price
483-A	0-2-4-10-20-40- 100-200 volts	4000 ohms	10 watts	AVAST	\$42.00
483-B	0-2-4-10-20-40- 100-200 volts	8000 ohms	5 watts	AVERT	50.00
483-C	0-2-4-10-20-40- 100-200 volts	20,000 ohms	2 watts	AVOID	54.00

## TYPE 586-B POWER-LEVEL INDICATOR

(RELAY-RACK MODEL)

THE demand for this instrument equipped with an extra pair of terminals for connecting an auxiliary indicating meter located at a distance has not been sufficient to justify our carrying it in stock. We are, therefore, discontinuing this item as well as the TYPE 586-P3 Meter.

## TYPE 586-CM AND TYPE 586-CR POWER-LEVEL INDICATORS

(CABINET MODEL)

THE new instruments are identical in appearance and operating principles with, and differ only in their greater sensitivity from, the earlier models previously described (pages 106 and 154). The new ones contain more sensitive indicating elements having a mid-scale deflection at a power level 10 decibels below the standard reference level of 6 milliwatts into a load of 500 ohms. They are, so to speak, 10 decibels more sensitive than the older ones. Their calibration is also arranged so that the power level at the instrument terminals is obtained by taking the sum of the meter and "multiplier network" readings.

*Range:*

-20 db to +36 db for standard zero level of 6 milliwatts into a 500-ohm line. Lines of other impedance may be used however. See *Correction Term* below.

*Multiplier Network:*

A constant-impedance network, having a total attenuation of 40 db adjustable in 2 db steps, acts as a "multiplier" for the indicating meter. Its scale reads from -10 db through 0 db to +30 db. Marking the point of zero attenuation "-10 db" permits marking mid-scale deflection of the meter "0 db."

*Indicating Element:*

Copper-oxide rectifier voltmeter having full-scale deflection of 1.10 volts and a mid-scale deflection of 0.548 volt. These correspond, respectively, to power levels of -4 db and -10 db for the standard reference level.

The moving element is slightly damped to prevent undue overthrow on sudden surges. The amount of damping is the same to which operators on monitoring circuits are accustomed.

*Meter Scale:*

Graduated at  $\infty$ , -10, -6, -4, 0, +2, +4, and +6 db to cover total range of 16 db. Marking mid-scale deflection "0 db" instead of "-10 db" is a distinct convenience

in monitoring where power-level differences are observed.

*Accuracy:*

At small meter deflections there may be an error of 0.5 db depending upon the attenuator setting due to impedance changes in the rectifier circuit. The average error is less than 0.2 db. The error due to frequency is negligible below 10,000 cps.

*Impedance:*

5000 ohms. (Note that this is the internal resistance of the instrument and has exactly the same significance as the "resistance" of a voltmeter.)

*Distortion:*

Due to the highly resistive impedance characteristics and the absence of iron, no detectable distortion is introduced into the monitored circuits by these power-level indicators.

*Correction Term:*

When used across loads of other than 500 ohms impedance the correct power level may be obtained by adding to or subtracting from the instrument indications a constant correction term taken from a chart furnished with each instrument.

*Mounting:*

In the TYPE 586-CM Power-Level Indicator meter and multiplier network are

carried on a bakelite panel mounted on a hand-rubbed walnut case. For mounting details of the TYPE 586-CR Power-Level Indicator, see "Relay-Rack Model" below.

*Dimensions:*

10 (length) x 5 (width) x 5 inches (height), overall.

*Weight:*

3 pounds.

<i>Type</i>	<i>Range</i>	<i>Code Word</i>	<i>Price</i>
586-CM	—20 db to +36 db with zero level at 0.006 watt into a 500-ohm line.	HONEY	\$75.00

## RELAY-RACK MODEL

THE TYPE 586-CR Power-Level Indicator is supplied on a 19-inch panel provided with a metal dust cover so that the instrument may be mounted on a standard relay rack. Terminals are provided at the back of the panel for permanent connection.

*Dimensions:*

19 (length) x 5 (height) x 3¼ inches (back-of-panel depth), overall. Panel thickness, ¼ inch.

*Weight:*

4 pounds.

<i>Type</i>	<i>Range</i>	<i>Code Word</i>	<i>Price</i>
586-CR	—20 db to +36 db with zero level at 0.006 watt into a 500-ohm line.	HONOR	\$80.00

## TYPE 488 ALTERNATING-CURRENT METERS

## (VOLTMETER MODELS)

SINCE the description on page 101 was first published, several additional TYPE 488 Voltmeters have been made available. Like the original meters, these consist of a copper-oxide-rectifier element used in conjunction with a micro-ammeter. The newer instruments have a full-scale sensitivity of 2 volts, and a considerably higher resistance per volt than the original TYPE 488-A Alternating-Current Voltmeter. The new instruments are identical with the TYPE 488-A Alternating-Current Voltmeter in mechanical appearance. Catalog specifications covering the complete line are given below.

These specifications replace those on page 101, the TYPE 488-A Alternating-Current Voltmeter having been discontinued.

*Range:*

See price list.

*Impedance:*

See price list. Referred to full-scale value, the impedance changes with applied voltage, the 4000- and 8000-ohm instruments increasing approximately 50% in value at ¼ full-scale voltage; the 20,000-ohm instrument increases approximately 30% at ¼ full-scale voltage.

*Length of Scale:*

2½ inches.

*Accuracy of Calibration:*

Within 2% of its full-scale reading at frequencies up to 2000 cps. Within 5% to 5000 cps. Within 10% to 10,000 cps.

*Mounting:*

Each meter is supplied mounted in a TYPE 298-A Meter Mounting.

*Dimensions:*

Diameter, 3½ ins; depth, 2¼ ins, overall. Mounting hole diameter, 2<sup>7</sup>/<sub>32</sub> ins.

*Weight:*

12 ounces.

<i>Type</i>	<i>Range</i>	<i>Impedance</i>	<i>Code Word</i>	<i>Price</i>
488-BM	0-2 volts, r.m.s.	4000 ohms	OURMETGOAT	\$20.00
488-DM	0-2 volts, r.m.s.	20000 ohms	OURMETSHOE	35.00

SQUARE-LAW GALVANOMETER MODEL

THE usual rectifier-type voltmeter has a nearly linear characteristic and is subject to large waveform errors. By carefully redesigning the rectifier circuit it has been found possible to produce a meter practically free from this defect. The TYPE 488-HM Alternating-Current Galvanometer was developed for use with the TYPE 536-A Distortion-Factor Meter to replace the less rugged thermocouple instrument usually employed for such work. Since it is used for a comparison instrument no calibration is required.

*Range:*

0 to approximately 600 millivolts full scale.

*Resistance:*

Approximately 700 ohms.

*Scale:*

The 2.5-inch scale is divided into fifty equal divisions marked 0—100.

*Calibration:*

The meter is adjusted so that full-scale deflection is obtained at approximately 600 millivolts.

*Waveform Error:*

The approach to a square-law characteristic is sufficiently close so that even when two equal voltages of different frequencies are simultaneously applied the waveform error is less than 3%. This means that the effective value of the composite voltage causing a certain deflection will be within

3% of the single frequency voltage causing the same deflection.

*Frequency Characteristic:*

The meter will give the same deflection to within 2% for alternating-current voltages up to 2000 cps., to within 5% up to 5000 cps., and within 10% up to 10,000 cps.

*Adjustment:*

A screw is provided under the glass face for making the zero adjustment. The glass may be removed by unscrewing the bezel.

*Mounting:*

The meter is supplied mounted in a TYPE 298-A Meter Mounting.

*Dimensions:*

Flange diameter, 3½ inches; back-of-panel depth, 2¼ inches, overall; body diameter, 2<sup>27</sup>/<sub>32</sub> inches.

*Weight:*

12 ounces.

<i>Type</i>	<i>Range</i>	<i>Code Word</i>	<i>Price</i>
488-HM	0-600 millivolts, square law.....	OURMETHEAD	\$30.00

TYPE 588-AM DIRECT-CURRENT METER

THIS is a direct-current galvanometer having full-scale sensitivity of 500 micro-amperes and a resistance of 10.0 ohms (5 millivolts) which adapts it for use in conjunction with TYPE 493 Thermocouples. Since each thermocouple must be individually calibrated, the scale is laid out with 50 equal divisions marked from 0 to 50, thus making easy the preparation and reading of calibration curves. The meter is in a TYPE 298-B Meter Mounting which has jacks for plugging in the thermocouple.

This meter may also be used with the TYPE 492-A Oxide Rectifier.

*Range:*

0 to 500 micro-amperes full scale.

*Resistance:*

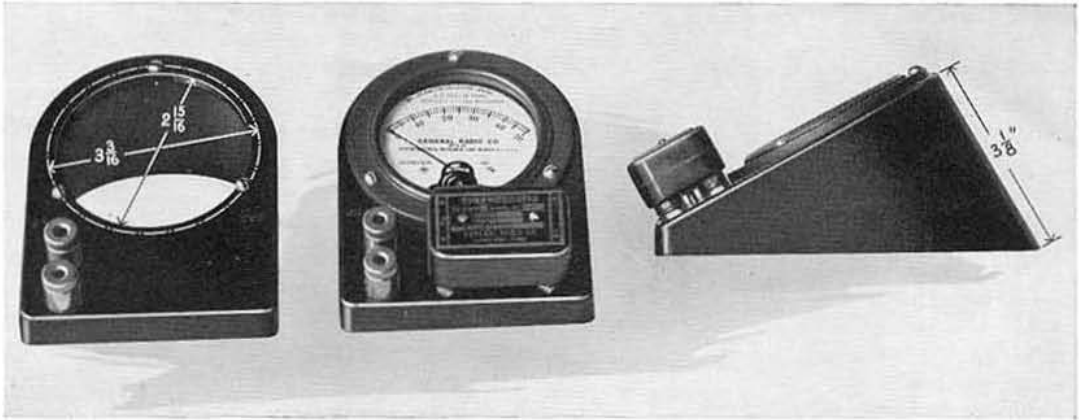
Approximately 10.0 ohms.

*Scale:*

The 2½-inch scale is divided into 50 equal divisions marked 0 to 50.

*Calibration:*

Full-scale deflection is adjusted to within 2% of the specified value of 500 micro-amperes. Other points are not calibrated but deflection is approximately proportional to current over the entire range.



TYPE 298 Meter Mountings. *Left:* TYPE 298-A Meter Mounting. *Center and right:* TYPE 588-AM Direct-Current Meter showing its use with a TYPE 493 Thermocouple. The TYPE 588-AM Direct-Current Meter is supplied mounted in a TYPE 298-B Meter Mounting

*Adjustment:*

A screw is provided in the glass face for making the zero adjustment.

*Weight:*

1 3/4 pounds.

*Dimensions:*

See above photograph.

Type	Range	Code Word	Price
588-AM	0-500 micro-amperes	OURMETMUSH	\$21.00

TYPE 298 METER MOUNTINGS

**D**URING the last few years, the General Radio Company has made extensive use of flush-type meters mounted in the standard 3 1/2-inch navy-type bakelite case. These have been developed for use in power-level indicators, in output meters, and as galvanometers associated with rectifier elements and with thermocouples.

To meet the growing demand for individual meters used apart from complete instruments, the General Radio Company has developed the TYPE 298 Meter Mounting. This is a moulded bakelite case supporting the meter at an angle of approximately 30° from the horizontal. Two of our TYPE 138-V Jack-Top Binding Posts are mounted at the lower left-hand corner. In the TYPE 298-B model, four TYPE 274-J Jacks are mounted in accordance with standard spacing. These jacks, therefore, permit the use of the TYPE 492 Rectifiers or of the TYPE 493 Thermocouples with the meter. It is also possible to use multipliers or attenuation networks mounted in the same kind of bakelite cases.

This unit fits all navy-type meters having short studs. Dimensions are given on the accompanying photograph.

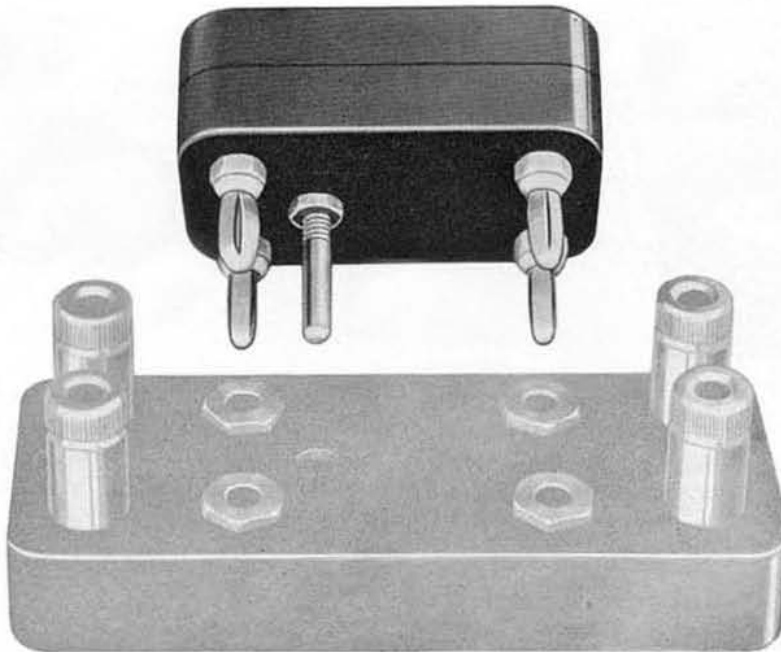
*Dimensions:*

Height, 2 1/2 inches. Width, 3 3/4 inches. Length, 6 inches.

*Weight:*

1 pound.

Type		Code Word	Price
298-A	Without Jacks.....	FABLE	\$2.00
298-B	With Jacks.....	FACET	2.25



Mounting case for TYPE 492-A Oxide Rectifier and TYPE 493 Thermocouples for plugging into a TYPE 274-RJ Mounting Base

**TYPE 492-A OXIDE RECTIFIER\***

**T**HE TYPE 492-A Oxide Rectifier is provided for use with relays and direct-current indicating instruments on alternating-current service. The unit is at present offered primarily for experimental use and the following specifications are indicative rather than positive.

It must be realized that the copper-oxide type of rectifier is subject to changes in both sensitivity and frequency characteristics with output load. The sensitivity also varies with impressed voltage. The values given below approximate those obtained under usual conditions of voltage and load.

This rectifier unit is made for us by the General Electric Company.

*Frequency Error:*

The rectifier may be used without appreciable frequency error at frequencies below 5000 cycles per second.

*Temperature Error:*

Temperature errors of about 5% may be expected between normal extreme temperatures. Maximum sensitivity is obtained with a load of 5000 to 7000 ohms. This value should be used when the instrument is operating a relay. If a 1-milliamper meter of 400 or 500 ohms resistance is used, full-scale deflection will be obtained at about 2 volts across the rectifier input.

The maximum current output from the rectifier should not exceed 15 milliamperes, nor should the impressed voltage exceed 3 volts.

Obviously, the apparent change of impedance with resistance can be greatly reduced by proper use of series and shunt resistance on the input side.

*Dimensions:*

Size of case, exclusive of plugs, 2 1/8 x 1 3/8 x 3/4 inches.

*Weight:*

4 ounces.

<i>Type</i>	<i>Code Word</i>	<i>Price</i>
492-A	FLORA	\$7.00

\*This description supersedes the one on pages 154 and 155.



## TYPE 493 THERMOCOUPLES\*

(CONTACT-TYPE MODELS)

WHILE indicating direct-current instruments can be made for currents as low as a few micro-amperes, dynamometer instruments for the measurement of alternating currents are not available in low ranges due to the inherent low efficiency of this type of instrument.

In the measurement of alternating currents of small magnitudes the heating effect of the current is generally utilized. In the thermocouple the heat caused by the flow of current through a wire is applied to a junction of dissimilar metals. Such a junction sets up a direct-current voltage which actuates a sensitive direct-current indicating meter. This type of instrument is a true integrating ammeter, since the direct-current meter reading is a function of average squared current in the heater. A thermocouple is, therefore, independent of waveform errors. Frequency errors occur only at frequencies so high that the shunting effect of stray capacitances in the couple mounting becomes significant.

In addition to the contact-type couples described in the specifications immediately following this paragraph, separate-heater couples are also available.

### Construction:

The thermo-junctions used in these couples are mounted in an evacuated glass bulb. The vacuum serves to prevent radiation of heat from the couple and also reduces the effect of external temperature variations. The glass bulb is surrounded by felt and mounted in a bakelite container, fitted with plugs for plugging into a TYPE 274-RJ Mounting Base (see page 162). The thermo-junction is in direct contact with the heater wire at one point only.

These contact-type couples are suitable for use on either alternating or direct current and may, of course, be calibrated on direct current. Reversed readings are de-

sirable in making calibrations although reversal will not ordinarily change the indication by more than one per cent.

### Couple Resistance:

10 to 12 ohms, all types.

### Heater Resistance:

Plus or minus 10% of values given in following table.

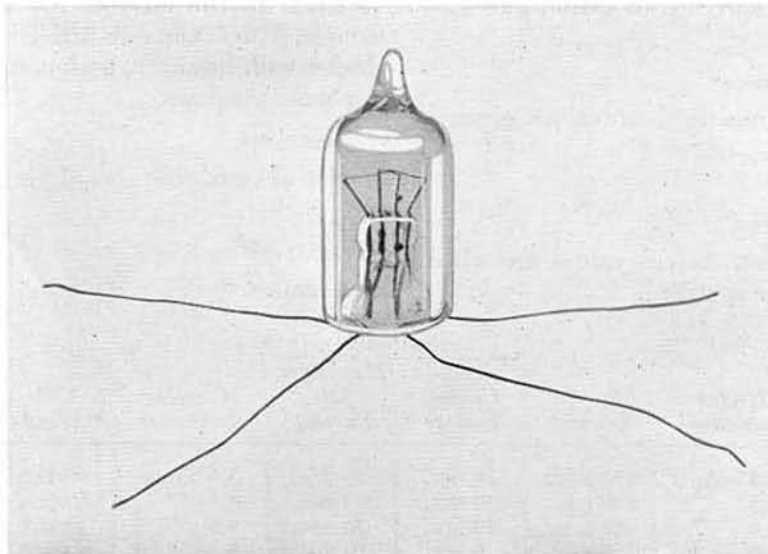
### Electric Sensitivity:

Current for 10 millivolts plus or minus 10% of values given in following table.

### Thermal Sensitivity:

26 microvolts per degree Fahrenheit.

\* This description supersedes the one on pages 155 and 156.



Contact-type vacuum thermocouple as mounted in TYPE 493 Thermocouples

*Coefficient of Resistance:*

Couple elements, 0.00013 per degree Fahrenheit; heater, 0.00009 per degree Fahrenheit.

*Dimensions:*

Size of case, exclusive of plugs,  $2\frac{1}{8}$  x  $1\frac{3}{8}$  x  $\frac{3}{4}$  inches.

*Meter:*

The TYPE 588-A Direct-Current Meter described on page 218 is recommended for use with these couples.

*Weight:*

4 ounces.

Type	Heater Resistance	Current to Give 10 millivolts Open Circuit	Maximum Safe Current		Code Word	Price
493-A	0.5 ohms	275 mla.	415 mla.	.....	FUNNY	\$12.00
493-C	2 "	100 mla.	150 mla.	.....	FOCUS	12.00
493-E	10 "	25 mla.	40 mla.	.....	FOLLY	12.00
493-H	100 "	7 mla.	11 mla.	.....	FORAY	12.00
493-K	450 "	4.5 mla.	7 mla.	.....	FORUM	12.00

## SEPARATE-HEATER MODELS

FOR certain types of measurements at high frequencies it is detrimental to have any electrical contact between the couple and heater of a thermocouple. This difficulty can be avoided by the use of the separate-heater type of thermocouple in which couple and heater are kept in thermal but not electrical contact by means of a small bead of insulating material. We are now pleased to announce that we can supply separate-heater thermocouples mounted in our standard bakelite cases, like the TYPE 493 Thermocouples previously described.

The separate-heater construction completely eliminates reversal and shunting errors. This isolation of meter and couple means that the meter need be used with fewer precautions against stray capacitances to ground at very high frequencies.

*Couple Resistance:*

From 3.5 to 8.0 ohms, approximately, depending on the type. See the price list. Valves are as specified to within  $\pm 10\%$ .

*Meter:*

Ideally, the greatest overall efficiency is obtained when the resistance of the meter is equal to the internal resistance of the couple. The TYPE 588-AM Direct-Current Meter will, however, be found satisfactory for most purposes.

*Heater Resistance:*

Plus or minus 10% of values given in price list.

*Dimensions:*

Size of case, exclusive of plugs,  $2\frac{1}{8}$  x  $1\frac{3}{8}$  x  $\frac{3}{4}$  inches.

*Electric Sensitivity:*

See price list. Actual values are within  $\pm 10\%$  of these specified.

*Weight:*

4 ounces.

Type	Heater Resistance	Current	Sensitivity		Couple Resistance	Code Word	Price
			Open-Circuit Voltage	Maximum Safe Current			
493-HA	0.45 ohms	370 mla.	10 mv.	500 mla.	3.5 ohms	EAGER	\$15.00
493-HB	1.3 "	150 mla.	10 mv.	200 mla.	3.5 "	EAGLE	15.00
493-HE	10.0 "	35 mla.	10 mv.	50 mla.	3.5 "	EARLY	15.00
493-HG	37.0 "	9 mla.	6 mv.	10 mla.	8 "	EARTH	15.00



## CUMULATIVE INDEXES

INDEX BY TYPE NUMBER..... 224

INDEX BY TITLE..... 226

These indexes contain references to all the information published in Catalog F, Part 1 (the original Catalog F), in Catalog F, Part 2, and in Catalog F, Part 3 (this booklet).

# INDEX BY TYPE NUMBER

<i>Type</i>	<i>Instrument</i>	<i>Page</i>	<i>Type</i>	<i>Instrument</i>	<i>Page</i>
102	Decade-Resistance Boxes.....	16, 126	338	String Oscillograph and Vibration Galvanometer.....	93
106	Standard Inductances.....	31, 129	338-P	Accessories.....	95
107	Variable Inductors.....	32, 129	339	Switch.....	112, 160
125	Phantom-Antenna Resistors.....	30	340	Rheostat.....	19
127	Hot-Wire Meters.....	103	349	Socket.....	113
133	Standard Resistances.....	18	356	Quartz-Plate Holder.....	63
137	Knobs.....	110, 158	358	Wavemeter.....	69
138	Binding Posts.....	110, 160	359	Variable-Ratio Transformers.....	46
139	Switches.....	112	360-A	Test Oscillator.....	91, 147
156	Socket.....	113	361-B	Vacuum-Tube Bridge.....	81
166	Telephone Transformer.....	47	361-P	Accessories.....	84
174	Direct-Reading Wavemeters.....	70	366	Filter Choke.....	49
189	Galvanometers.....	102	368	Variable Air Condensers.....	12
193	Decade Bridge.....	75	371	Potentiometers.....	27, 126
193-P1	Wagner Ground.....	141	374	Variable Air Condensers.....	11
202	Switch.....	112	375-A	Station Piezo-Electric Oscillator.....	58, 137
210	Ratio-Arm Box.....	87	376	Quartz Plates.....	62, 138
213	Audio Oscillators.....	41	377-B	Low-Frequency Oscillator.....	35
214	Rheostats and Potentiometers.....	28, 126, 179	379	Radio-Frequency Chokes.....	50
216	Capacity Bridge.....	76	380	Decade Switch and Condensers.....	14, 125
219	Decade Condensers.....	14	383	Portable Capacity Bridge.....	78, 142
222	Precision Condensers.....	6, 171	383-P	Accessories.....	80, 142
224	Precision Wavemeters.....	67, 140	384	Portable Radio-Frequency Oscillator.....	38
229	Galvanometer Shunts.....	86	384	Inductors.....	40
239	Variable Air Condensers.....	8, 124	387-A	Speaker Filter.....	47
240	Capacity Meter.....	80, 142	389-B	Magnetostriction Oscillator.....	64
241	Microphone Hummers.....	41	389-P	Inductors and Rod Mountings.....	65, 140
246	Variable Air Condensers.....	7	403-D	Standard-Signal Generator.....	89, 145, 195
247	Variable Air Condensers.....	9	403-P	Output Shunts.....	146
249	Attenuation Boxes.....	22	403-P }	Inductors for TYPE 403-D.....	90, 146
260	Porcelain Insulator.....	114	403-Q }		148
268	Variocoupler.....	33	404	Test-Signal Generator.....	153
269	Variometer.....	33	407	Synchronous Shutter.....	153
274	Plugs, Jacks, and Bases.....	114, 162	407-P	Accessories.....	151
275	Piezo-Electric Oscillator.....	57	408	Oscillograph Camera.....	152
275-P	Inductors.....	58, 137	408-P	Accessories.....	152
276-A	Quartz Plate.....	63	409	Camera Shelf.....	30
280	Porcelain Insulator.....	114	410	Rheostats and Potentiometers.....	37
285	Amplifier Transformers.....	43	413-B	Beat-Frequency Oscillator (Battery Operated).....	66
287	Direct-Reading Ohmmeters.....	104	416	Magnetostriction Rods.....	91, 202
293-A	Universal Bridge.....	191	418	Dummy Antenna.....	188
293-P	Accessories.....	193	419-A	Rectifier-Type Wavemeter.....	40, 132
298	Meter Mountings.....	219	423	Vacuum-Tube Oscillator.....	99
301	Rheostats and Potentiometers.....	29	426-A	Thermionic Voltmeter.....	100
302	Geared Dial.....	109	427-F	A.C. Voltmeter.....	24
303	Geared Dial.....	109	429	Attenuation Box.....	186
309	Socket Cushion.....	113	434-B	Frequency Meter.....	50, 133
310	Dials.....	109, 157	437	Center-Tap Resistance.....	113
317	Dials.....	109, 157	438	Socket.....	50, 133
318	Dial Plate.....	157	439	Center-Tap Resistance.....	83
321	Artificial-Cable Boxes.....	98	443	Mutual-Conductance Meter.....	49, 133
329	Attenuation Boxes.....	23	446	Voltage Divider.....	25
330	Filter Sections.....	97	452-C	Voltage Divider.....	25
334	Variable Air Condensers.....	10			
335-Z	Variable Air Condenser.....	11			
337	Switches.....	112			



<i>Type</i>	<i>Instrument</i>	<i>Page</i>	<i>Type</i>	<i>Instrument</i>	<i>Page</i>
457-A	Modulation Meter.....	143	557	Amateur-Band Condenser.....	12, 124
478-A	Cathode-Ray Oscillograph Tube...	207	558-P	Frequency Meter.....	68
480	Relay Rack.....	55	565	Transformer.....	48
481	Polar Relay.....	108, 157	568	Variable Air Condensers.....	173
483	Output Meters.....	214	573-A	Resistance-Impedance Coupler....	45
486	Output Meter.....	106	574	Wavemeter.....	189
488	Alternating-Current Meters.....	217	575	Piezo-Electric Oscillator.....	134
489-B	Twin Magnetostriction Oscillator..	65	576-A	Quartz Bar (and Holder).....	63, 139
492-A	Oxide Rectifier.....	220	577	Inductors.....	34, 129
493	Thermocouples.....	221	584	Alternating-Current Portable Radio-Frequency Oscillator.....	39
496-A	Power Supply Unit.....	211	585	Amplifier Transformer.....	43, 133
497-A	Tube Mounting.....	209	586	Power-Level Indicator... ..	106, 154, 216
497-P	Accessories.....	211	586-P	Accessories.....	154, 216
500	Resistors.....	177	587	Speaker Filter.....	47
502	Dials.....	158	588-A	Direct-Current Meter.....	218
503	Dials.....	158	590	Piezo-Electric Oscillator.....	59, 137
507	Non-Polar Relay.....	108	591	Temperature-Control Unit.....	61, 138
508-A	Oscillator.....	181	591-P	Accessories and Replacements... ..	61, 138
510	Decade-Resistance Units.....	177	592	Multivibrators.....	56, 134
511	Syncro-Clock.....	71	593	Timing Unit.....	73
511-P	Replacement.....	73, 140	594	Heat-Control Unit.....	62
513-B	Beat-Frequency Oscillator (A.C. Operated).....	130	595	Power-Supply Unit.....	56
514-A	Amplifier.....	183	598-A	Fader.....	26
514-P	Accessories.....	185	600-A	Standard-Signal Generator.....	195
527-A	Rectifier Filter.....	49	601-A	Standard-Signal Generator.....	199
529	Attenuation Box.....	24	601-P	Inductors.....	202
530	Band-Pass Filters.....	207	602	Decade-Resistance Boxes.....	174
536-A	Distortion-Factor Meter.....	204	624	Precision Wavemeter.....	68, 140
539	Variable Air Condensers.....	123, 172	624-P	Inductors.....	68
540	Filament Transformer.....	48	626-A	Vacuum-Tube Voltmeter.....	213
541	Push-Pull Transformer.....	46	638	Sockets.....	160
545	Transformer.....	48	638-P1	Socket-Mounting Ring.....	161
547	Temperature-Control Box.....	59	645	Laboratory Amplifier.....	42
547-P	Accessories and Replacements... ..	60, 138	649	Socket.....	160
547-B	Temperature-Control Unit.....	60	652	Volume Controls.....	179
552	Volume Controls.....	126	656	Socket.....	161
553	Volume Controls.....	128	657	Socket.....	161
554	Voltage Divider.....	25	658	Socket.....	161
556	Amateur-Band Condenser.....	124			

# INDEX BY TITLE

- Air condensers, *see* *Condensers*  
Ammeters, d'Arsonval, 102  
    direct-current, 218  
    hot-wire, 103-104  
    thermocouple, 221  
Amplifier, coupling devices, 43-47, 133  
    laboratory, 42, 183  
    transformers, 43-46, 133  
Antenna, dummy, 30, 91, 202  
    phantom, resistor, 30  
Anti-capacity switches, 112-113, 160  
Artificial cable box, 19, 98  
    lines, 19, 98  
Assemblies, binding-post, 114  
    standard-frequency, 51  
Attenuation boxes, 19-25, 126, 179  
    networks, 19-25, 126, 179  
Audibility meter, *see* TYPE 529, 24  
Audio oscillator, 41, 130, 181  
Ayrton-Perry resistors, 15-16, 174-178  
Bar, quartz, 63, 139  
Bases, mounting, 114, 162  
Beat-frequency oscillator, 37-38, 130  
Binding-post assemblies, 114  
Binding posts, 110  
Bridge, accessories, 84-87, 141-142, 193  
    capacity, 76-77, 78-79, 80-81, 191  
    decade, 75-76, 141, 191  
    frequency, 186  
    impedance, 75-76, 191  
    inductance, 74-76, 191  
    mutual-conductance, 83-84  
    resonance, 74, 191  
    universal, 191  
    vacuum-tube, 81-84  
    Wheatstone, 75, 191  
    Wien, 186  
Cable, artificial, 19, 98  
Calibrated condensers, 5-9, 13-14, 123-125  
    inductors, 31-32, 129  
    resistors, 15-19, 174-178  
Camera, oscillograph, 150-153  
Capacitance, *see* *Capacity*  
Capacitors, *see* *Condensers*  
Capacity bridges, 76-77, 78-79, 80-81, 141-142  
    meter, 80-81, 142, 191  
Cathode-ray oscillograph, 203, 207-212  
Center-tap resistors, 50, 133  
Charger, battery, 56  
Choke, filter, 49  
    radio-frequency, 50  
Clock, *see* *Syncro-Clock*  
Condensers, amateur-band, 12, 124, 173  
    calibrated, 5-9, 13-14, 123-125  
    decade, 14, 125  
    high-voltage, 10-11  
    loss-measurement, 76-77, 171  
    mica-dielectric, 13-14, 125  
Condensers (continued)  
    micro, 12, 173  
    paper-dielectric, 13-14, 125  
    precision, 6-7  
    short-wave, 9-12, 124, 173  
    straight-line frequency, 11, 124, 172  
Connector plate, 59-60  
Contact-type thermocouples, 221  
Contacts, switch, 110  
Control, heat, 62  
    temperature, 59-62  
    volume, 25-26, 126-128, 179  
Copper-oxide-rectifier, 220  
    voltmeter, 100-101, 105-107, 154, 214-218  
Coupler, resistance-impedance, 45  
Coupling devices, 43-47, 133  
Cushion, socket, 113  
Decade bridge, 75-76, 141, 191  
    condensers, 14, 125  
    resistance boxes, 16-18, 126, 174  
    resistance units, 177  
    switch and condensers, 14, 125  
Dial, friction-drive, 158  
    geared, 109  
    plain, 109, 157  
    plate, 157  
    vernier, 109, 158  
Dielectric loss measurement, 76-77  
Direct-reading wavemeter, 70, 189  
Distortion-factor meter, 204  
Divider, voltage, 25, 27-30, 49, 133  
Dummy antenna, 30, 91, 202  
Dynatron oscillator, 40, 132  
Eliminator, plate-battery, 56  
Experimental inductors, 33-34, 129  
    wavemeters, 68-70, 188-190  
Fader, 25-26, 128, 179  
Field-strength measurement, 145-147, 195, 199  
Filament transformer, 48  
Filter choke, 49  
    electric wave, 97, 207  
    rectifier, 49  
    sections, 97, 207  
    speaker, 47  
Frequency measurement, 51-73, 134-140,  
    186-190  
    meter, amateur-band, 68-69  
    meter (audio), 186  
    *see* *Wavemeter*  
    standards, 51-73  
Friction-drive dials, 158  
Galvanometer, d'Arsonval, 102  
    direct-current, 218  
    hot-wire, 103  
    pointer, 102  
    square-law, 218  
    string, 93-96  
    vibration, 93-96

- Geared dials, 109  
Generator, standard-signal, 89, 145-149, 194-202  
    test-signal, 148  
    see *Oscillators*  
Heat-control unit, 62  
Holder, quartz-plate, 62-63  
Hot-wire meters, 103  
Hum-balancing resistors, 50, 133  
Hummer, microphone, 41  
Impedance-resistance coupler, 45  
Indicators, power-level, 105-107, 216  
Inductance, standards of, 31-32, 129  
Inductors, 31-34, 129  
    fixed, 31, 34, 129  
    variable, 32-33, 129  
Insulators, porcelain, 113-114  
Jacks, 114  
Knobs, moulded, 110  
Laboratory amplifier, 42, 183  
Line, artificial, 19, 98  
Low-frequency oscillator, 35-36, 130, 181  
Magnetostriction oscillator, 64-66  
    rods, 66, 139  
Meter mountings, 219  
Meters, ammeters, 102-104  
    audibility, see *Audibility*  
    capacity, 80, 142  
    distortion-factor, 204  
    frequency, 186, also see *Wavemeters*  
    hot-wire, 103-104  
    modulation, 143-145  
    mutual-conductance, 83-84  
    ohmmeters, 104-105  
    output, 105-107  
    oxide-rectifier, 100-101, 214-218  
    power-level indicators, 105-107, 216  
    square-law, 218  
    thermocouple, 221  
    voltmeters, 99-101, 105-107, 213-218  
    wave, 66-70, 140, 188-190  
Microphone amplifier, 183  
    hummer, 41  
    mixing controls, 25-26, 27-30, 126-128, 179  
    transformer, 44, 133  
Microvolter, 88-91, 145-147, 194-202  
Mixing controls, 25-26, 27-30, 126-128, 179  
Modulation meter, 143  
Monitor, frequency, 58-59, 134-138  
Moulded knobs, 109, 110  
Mounting bases, 114, 162  
    meter, 219  
Multivibrators, 56, 134  
Mutual-conductance meter, 83-84  
Networks, attenuation, 19-25, 126-128, 179  
Non-polar relay, 108-109  
Ohmmeters, 104-105  
Oscillators, audio, 37-38, 41, 130, 181  
    beat-frequency, 37-38, 130  
    dynatron, 40, 132  
    low-frequency, 35-36, 130, 181  
Oscillators (continued)  
    magnetostriction, 64-66  
    microphone-button, 41  
    microphone-hummer, 41  
    piezo-electric, 57-63, 134-139  
    portable radio-frequency, 38-40  
    reed-type, 41  
    standard-signal, 88-91, 145-147, 194-202  
    station piezo-electric, 58-59, 134, 137  
    test, 91-92, 147-149  
    tuning-fork, 41  
Oscillograph, string, 93-96  
    camera, 150-153  
    cathode-ray, 203-212  
Output meter, 105-107, 214  
Oxide-rectifier, 220  
    voltmeters, 100-101, 105-107, 214-218  
Phantom antenna, 91, 202  
    resistor, 30  
Photocell amplifier, 183  
Pierce magnetostriction oscillator, 64-66  
Piezo-electric oscillator, 57-63, 134-139  
Plate, quartz, 62-63, 138  
Plugs, 114  
Polar relay, 108, 157  
Porcelain insulators, 113-114  
Portable capacity bridges, 78-81, 142  
    radio-frequency oscillators, 38-40  
Potentiometers, 25, 27-30, 49, 126, 179  
Power, factor measurement, 76-77  
    level indicator, 105-107, 216  
    supply unit, 56  
Precision condenser, 6-7, 171  
    wavemeters, 66-68, 140, 188-190  
Push-pull transformers, 46  
Quartz bar, 63, 139  
    plate, 62-63, 138  
    plate holder, 62-63  
Rack, relay, 55  
Radio-frequency chokes, 50  
    oscillators, 35-40, 132  
Ratio-arm box, 87  
Rectifier filter, 49  
    oxide, 220  
Relaxation oscillator, see *Multivibrator*  
Relay, low-current, 108, 157  
    non-polar, 108-109  
    polar, 108, 157  
    rack, 55  
Resistance-impedance coupler, 45  
    standard, 18, 126  
    unit, center-tap, 50, 133  
Resistors, Ayrton-Perry, 15-16, 174-178  
    calibrated, 15-19, 126, 174-178  
    decade, 174-177  
    phantom-antenna, 30  
Rheostats, 27-30, 126, 179  
Rods, magnetostriction-oscillator, 66, 139  
Sections, filter, 97, 207  
Separate-heater thermocouples, 222

- Service-testing equipment, 80-81, 83-84, 91-92,  
104-105, 105-107, 147-149
- Shunts, galvanometer, 86-87
- Shutter, synchronous, 153
- Socket cushion, 113  
vacuum-tube, 113, 160-161
- Speaker, filters, 47
- Standard-frequency assembly, 51-56
- Standard inductance, 31-32, 129  
resistances, 18, 126, 174-179  
signal generator, 88-91, 146-147, 194-202
- Station piezo-electric oscillator, 58-59
- Strain insulators, 113-114
- String-holders, 95-96  
oscillograph, 93-96
- Supply, power, 56
- Switch contacts, 110, 160  
stops, 110, 160
- Switches, 112, 160
- Synchronous, motor, 71-73  
shutter, 153
- Syncro-Clocks, 71-73
- Telephone transformer, 47
- Temperature-control boxes, 59-62, 134-138
- Test oscillator, 91-92, 147
- Test-signal generator, 148
- Thermionic voltmeter, 99-100, 213
- Thermocouples, 221-222
- Thermometer, 60-61
- Thermo-regulator, see *Temperature-control boxes*
- Thermostat, 60-61
- Time measurement, 51-73
- Timing unit, 73
- Transformers, amplifier, 43-46  
filament-heating, 48
- Transformers (continued)  
mounting bases, 114, 162  
plate-supply, 48  
power-supply, 48  
push-pull, 46  
telephone, 47  
variable ratio, 46-47
- Tube, cathode-ray oscillograph, 207  
vacuum, bridge, 81-84  
vacuum, voltmeter, 213
- Vacuum-tube bridge, 81-84  
oscillators, 35-40, 130-132  
voltmeter, 99-100, 213
- Variable air condensers, 5-12, 123-125, 171-173  
inductors, 32, 33, 129  
ratio transformer, 46-47
- Variocoupler, 33
- Variometer, 32, 33
- Vernier condenser, 12, 173  
dial, 109, 158
- Vibration galvanometer, 93-96
- Voltage divider, 25, 27-30, 49, 133, 179
- Voltmeter, oxide-rectifier, 100-101, 105-107,  
214-218  
thermionic, 99-100, 213  
vacuum-tube, 99-100, 213
- Volume controls, 25-26, 27-30, 126-128, 179
- Wall insulators, 113-114
- Wave filters, 97, 207
- Waveform measurement, 205
- Wavemeter, 66-70, 140, 188-190  
direct-reading, 70, 189  
experimental, 68-70, 188-190  
precision, 66-68, 140  
rectifier-type, 188

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