GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 1050 **JULY 1927**

Type 219F.
DECADE CONDENSER

Every college and research laboratory has need of a variable condenser of large capacity and reasonable accuracy for temporary set-ups where it is inexpedient to use the precision types. For maximum utility this unit should have the same flexibility as the familiar dial decade type of resistance box.

The knife-blade switch and plug connector types of box do not possess this flexibility.

In the Type 219 Decade Condenser this highly desirable feature is obtained by means of a cam switch which makes a definite contact with the successive units, determined by a ball and socket locking combination. This permits the construction of a unit possessing the same characteristics as the standard dial-decade type of resistance box. The capacitance in microfarads is read directly opposite the end of the switch pointer. The complete unit is mounted in a walnut case with bakelite panel.

The condensers used in the 0.001 steps are the mica type. Rolled, paraffin impregnated paper condensers are used in the higher capacity steps. While this type of condenser is inferior to that using mica dielectric, a well built paper condenser is so satisfactory for a wide variety of laboratory uses that the expense of the mica type in the larger capacities is frequently unjustified. These units are supplied adjusted to 5 percent in the .001 and 2 percent in the 0.01 MF and 0.1 MF steps, which is a fair indication of their constancy under various conditions of temperature and frequency.

The rolled paper condensers used in the type 219 unit represent the best of their type. The paper and foil are fed from the rolls through an impregnating bath of molten paraffin. The thorough impregnation thus obtained not only increases the dielectric strength, but also makes the unit more consistent in its behavior, due to its greater homogeneity. Sufficient overlap is allowed on the foil so that the successive layers of each plate may be bent over for contact with each other. Connection is made to the side of the plate, that is, to all layers in the roll. This method of assembly is much superior for laboratory and filter work to that which makes use of a connection at the ends of the plates only. A condenser of the former type has a materially lower resistance than one of the latter type. The side connection also avoids the increase of phase angle with frequency which occurs with the end connection. The phase angle of these condensers at 1000 cycles is approximately .25%.

The completed condenser units are sealed in metal cans when finally mounted. A rigid moisture proof assembly is thus assured.

The voltage rating of all units is 300 R. M. S.

The paper condensers are available in single units where a permanent installation is to be made. The units are supplied in capacitances of 0.1, 0.2, 0.3, 0.4, 0.5 MF.

USES. The type 219 decade condenser is extremely useful in vacuum tube oscillators of variable frequency. It provides the large capacity required for low frequency, and provides convenient variation over a capacity range of 1000 to 1. It is also useful in temporary filter set-ups and in tuning circuits to low frequencies.

The type 236 condenser is useful in more permanent set-ups in constant capacity circuits, such as filters and artificial net-works.

Type 219F Decade Condenser.....Price $40.00

Ten 0.01 MF steps.
Ten 0.1 MF steps.
Dimensions 9½"x5"x5¾". Weight 6½ lbs.
Code Word "COVER."

Type 219G Condenser.....Price $60.00

Ten 0.001 MF steps.
Ten 0.01 MF steps.
Ten 0.1 MF steps.
Dimensions 12¾" x 5" x 6". Weight 6¾ lbs.
Code Word "BRIAR."

(This Bulletin replaces Bulletin 110)

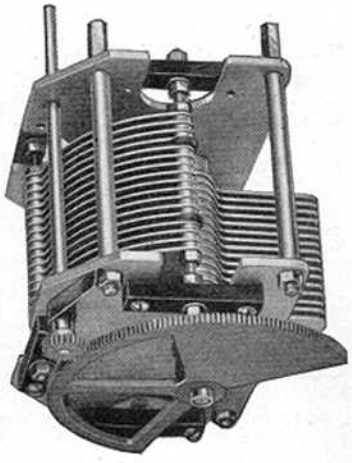
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 1100 **JULY 1927**



Type 239
VARIABLE AIR CONDENSERS

Variable air condensers are generally used as secondary standards for all laboratory purposes for capacitances up to several hundredths microfarad. Condensers for this purpose must first of all be of such rugged mechanical construction as to withstand the handling of ordinary laboratory use, without suffering changes in calibration. It is also important that the phase angle be as low as is consistent with physical strength and that the field through the dielectric remain substantially constant with changes in capacity.

Realizing that there is an economic as well as a physical problem involved, the General Radio Company has divided its laboratory air condensers into three classes, designed to meet different requirements of precision and constancy. The Type 222 is designed for use as a laboratory standard and in precision wavemeters. Where laboratory work of less exacting character is planned, the Type 239 or the Type 246 will be found satisfactory. All three types are alike in general electrical design.

The Type 239 condenser has end plates and condenser plates of aluminum. The rotor plates are so shaped as to give a nearly constant relation between wavelength and angular variation. The rotor bearings are in direct contact with the end plates. The stator is supported from

strips of hard rubber, so placed that the field through them is weak, and practically unvarying for different capacity settings. The rotor turns in locked cone bearings and is counterweighted. A slow motion gear is supplied when desired.

The Type 239 condenser is supplied either unmounted or in a walnut case with bakelite panel.

The equivalent series resistance of the Type 239 condenser is 12 ohms at 1000 cycles at the 1000 MMF. setting.

USES. The Type 239 condenser may be used in tuned circuits, in wavemeters and in bridge work.

Type 239F. 1000 MMF. Mounted. Without gear.....$14.00
Dimensions 6" x 6" x 7". Weight 4½ lbs.
Code Word "BABEL."

Type 239E. 1000 MMF. Mounted. With gear..... 17.00
Dimensions 6" x 6" x 7". Weight 4½ lbs.
Code Word "BANDY."

Type 239E. 1000 MMF. Mounted. With gear. Calibrated..... 18.50
Dimensions 6" x 6" x 7". Weight 4½ lbs.
Code Word "BANJO."

Type 239H. 1000 MMF. Unmounted. Without gear..... 10.00
Dimensions 4½" x 4¾" x 6". Weight 2 lbs.
Code Word "BARON."

Type 239G. 1000 MMF. Unmounted. With gear..... 13.50
Dimensions 9½" x 4¾" x 6". Weight 2 lbs.
Code Word "BASAL."

Type 239K. 2000 MMF. Mounted. Without gear..... 17.00
Dimensions 6" x 6" x 9". Weight 6 lbs.
Code Word "BASIN."

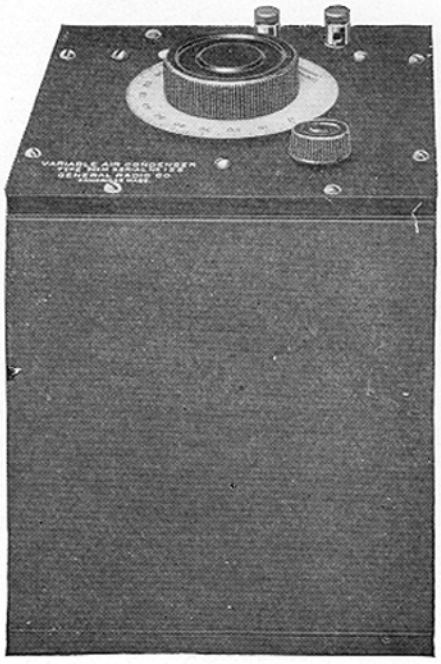
Type 239J. 2000 MMF. Mounted. With gear..... 20.00
Dimensions 6" x 6" x 9". Weight 6 lbs.
Code Word "BATTY."

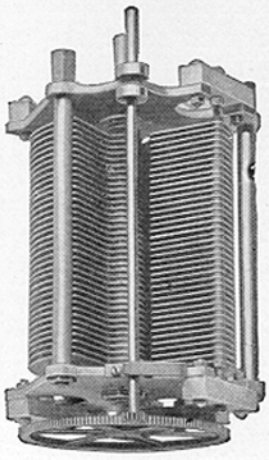
Type 239J. 2000 MMF. Mounted With gear. Calibrated..... 21.50
Dimensions 6" x 6" x 9". Weight 6 lbs.
Code Word "BATON."

Type 239M. 2000 MMF. Unmounted. Without gear..... 13.00
Dimensions 4½" x 4¾" x 6". Weight 3 lbs.
Code Word "BAYAN."

Type 239L. 2000 MMF. Unmounted. With gear..... 16.50
Dimensions 4½" x 4¾" x 6". Weight 3 lbs.
Code Word "BEFIT."

In place of the 10 point calibration supplied on the 239E and 239J models, a mounted calibration curve can be supplied for $2.00 additional.





Type 246
VARIABLE AIR CONDENSERS

The Type 246 is similar in construction to the Type 239, but is heavier and more rugged throughout. It is better adapted to use as a secondary standard than the Type 239 and, in fact, is satisfactory for many uses where the greater precision of setting of the Type 222 is not required.

There is no change in capacity with frequency. The temperature co-efficient is practically zero. The dielectric is isolantite, whose dielectric properties are superior to porcelain and which is, in addition, non-absorbent. The dielectric is of small volume and placed in a weak and practically constant field. As the field through the dielectric does not vary with the position of the plates, the condenser may be assumed to be equivalent to two parallel condensers, one a fixed condenser of small capacity, with all the power loss, the other a perfect variable condenser. This fact is very important when the condenser is used in measuring dielectric losses in connection with our Type 216 Capacity Bridge.

A reduction gearing is provided for ease in making accurate capacity adjustments. As the rotor of the condenser is grounded to the frame, which effectively shields the stator, there is no difficulty due to stray capacities.

USES. The Type 246 condenser meets the wide demand in radio and general laboratory work for a variable condenser of considerable range, low power factor and constant capacity. It is useful as a laboratory standard of capacity in bridge measurements of condenser resistance in tuned circuits and in radio frequency resistance measurements.

LOSSES. The power factor of the Type 246 condensers at 1500 MMF. is about .005%, and the resistance at 1000 cycles is about 12 ohms, and at 300 kilocycles the resistance is approximately .018 ohms.

CONSTRUCTION. The illustration shows the general construction. The plates are heavy aluminum, accurately spaced. The main shaft is fitted between cone bearings, so that there is practically no end-play. These bearings are ground in before their final adjustment. In the reduction gearing, mentioned above, a small fibroil pinion is pressed against the large gear by a phosphor bronze spring so that there is no backlash. Heavy cast bronze end plates separated by large brass spacing pillars make a very rigid assembly.

CALIBRATION. The minimum and maximum capacity of each condenser is marked on the bottom of the case. The average capacities for each of the three sizes of this type of condenser follow:

Type	*Min. Cap.*	*Max. Cap.*	*Voltage (Peak)*
246L	55 MMF.	1500 MMF.	800
246M	70 MMF.	3000 MMF.	800
246P	72 MMF.	5000 MMF.	550

If desired, a celluloid protected calibration curve, accuracy to .5%, is supplied at an extra charge of $4.00.

FINISH. The condenser is mounted in an attractive walnut case with engraved hard rubber panel. A four-inch silvered dial, divided into one hundred divisions, is securely fastened to the main shaft.

Type 246L. Condenser, 1500 MMF. capacity $30.00
Dimensions 7½" x 7½" x 8¼". Weight 9 lbs.
Code Word "CEDAR."

Type 246M. Condenser, 3000 MMF. capacity $34.00
Dimensions 7½" x 7½" x 11½". Weight 12 lbs.
Code Word "CHAOS."

Type 246P. Condenser, 5000 MMF. capacity $38.00
Dimensions 7½" x 7½" x 11½". Weight 12½ lbs.
Code Word "CHARY."

Mounted Calibration Curve, for any of above condensers ..... $ 4.00

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. Our line includes the following:

Standards of Inductance
Standards of Resistance
Standard Condensers
Precision Condensers and Wavemeters
Variable Air Condensers
Decade Resistance Boxes
Telephone Transformers
Vacuum Tube Oscillator
Radio Frequency Oscillator
Tuning Fork Oscillator
Thermo-Couples
Hot Wire Meters
Galvanometers
Galvanometer Shunt
Vernier Condenser
Audibility Meters
Wavemeters
Oscillograph
Vibration Galvanometer
Variometers
Capacity Bridges
Impedance Bridge
Vacuum Tube Bridge
Bridge Circuits for Cable Testing and Other Purposes
Decade Condensers
Miscellaneous Apparatus
Piezo Oscillator
Artificial Telephone Lines
Artificial Cable Units
Attenuation Networks
Lab. Potentiometers
Ohmmeters
Amplification Test Set
Beat Frequency Oscillator
Laboratory Amplifier
Transformers, Fixed and Adjustable

Information and quotations on special apparatus will be sent on request.

(This Bulletin replaces Bulletin 112)

Type 133

STANDARDS OF RESISTANCE

Resistance Standards, wound by the method previously described, are available in the sizes listed below. The accuracy of adjustment is 0.1% for all values.

The case is of moulded bakelite.

Type	Resistance	Current	Code Word	Price
133A	1 Ohm	250MA	RECUR	$6.00
133B	5 Ohm	100MA	REFER	6.00
133C	10 Ohm	100MA	REGAL	6.00
133D	50 Ohm	50MA	RELAX	6.00
133E	100 Ohm	50MA	RELIC	6.00
133F	500 Ohm	50MA	REPAY	6.00
133G	1000 Ohm	50MA	REPEL	7.00
133H	10,000 Ohm	15MA	PASTY	10.00
133K	25000 Ohm	15MA	PASHA	20.00

The type 133K tapped resistance will be found particularly useful in amplification measurements, as it covers the range of usual tube impedances.

The total resistance is 25,000 ohms, tapped at 5,000 ohm steps.

The following resistances may be obtained by suitable series and parallel connections:

1000	2500	5833	8750	15000
1250	3333	6750	10000	17500
1444	3750	6677	11667	20000
1677	4000	7000	12500	25000
2000	4167	7500	13333	
2143	5000	8333	13750	

Dimensions 3¾" x 2½". Weight 12 oz.

(This Bulletin replaces Bulletin 211)

GENERAL RADIO COMPANY

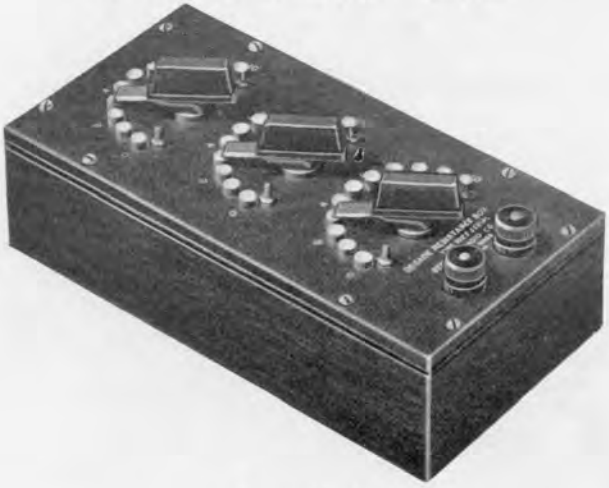
MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 2050 **JULY 1927**

STANDARDS OF RESISTANCE AND DECADE RESISTANCE BOXES



Type 102F

DECADE RESISTANCE

The first requisite for standards of all sorts is, of course, permanence; they must be unaffected by time and temperature.

A satisfactory resistance for alternating current work must not only maintain constant resistance with changes in temperature, but also with changes in frequency.

Long experience has shown that the alloy known as manganin does not change in resistance with age. It is essential that the form on which the resistance is wound does not change so as to introduce stresses in the wire. Care in soldering insures freedom from corrosion. After being wound, the resistance cards are aged for about six months before being adjusted to their final values. This ageing process is to permit the metal to reach a state of rest following the stress incident to winding with the wire necessarily under tension. The observance of these precautions insures a coil whose resistance is unchanging with time.

The temperature coefficient of the manganin wire used is so small that the resistance may be considered constant with changes in temperature in ordinary engineering work. As the coefficient is constant over a considerable range it is a simple matter to calculate the correction for more precise work.

In order to meet the third requirement, independence from frequency changes, a special form of winding must be resorted to in order to eliminate inductance and capacity effects. In the General Radio coils, the Ayrton-Perry method, illustrated in the diagram, is used. A thin bakelite form is used. A single wire is first wound on

with a space left between turns equal to the diameter of the wire. A second wire, connected so as to be in parallel with the first, is then wound on the form in the spaces between the turns of the first wire. The direction of rotation of the second winding is opposite that of the first, so that the currents in the two portions of the winding flow in opposite directions. This arrangement also keeps adjacent wires at nearly equal potential, unlike the usual type of bifilar winding which makes the ends of the winding adjacent. Thus both inductance and capacity effects are kept at a minimum.

For coils in excess of 1000 ohms, resistance tape is used. This is tape in which the warp is the resistance wire, and the woof cotton threads which hold the tape together. This type of winding is, of course, non-inductive and very compact where a high current carrying capacity is not essential.

The current carrying capacity of the one-tenth ohm units is one ampere, that of the one ohm units 250 milliamperes, that of the ten ohm units 100 milliamperes, and that of the one hundred and one thousand ohm units 50 milliamperes. The coils above 1000 ohms will carry about 1 watt.

Type 102

DECADE RESISTANCE BOXES

For general laboratory use the most convenient resistance arrangement is that of decade units. By such a method it is possible to get nearly any value of resistance desired. Such units are compact and rugged. With the use of multiple-leaf contact brushes with each leaf making independent contact, and with the ends of these brushes so cut that they are not tangent to the path of travel, thereby preventing the cutting of grooves in the contact studs, the dial method of mounting decade resistance units is fast replacing the older and less satisfactory plug method of connection. This newer method eliminates the inconvenience of the shifting of plugs, and also their high contact resistance.

The General Radio Type 102 decade units are mounted on bakelite panels with engraved lettering, and are enclosed in walnut boxes. The exposed metal parts are finished in polished nickel.

Attention is called to the fact that each decade dial has eleven contact studs, a zero and ten steps. This feature is especially important when working at the upper or lower ends of a dial.

These decade boxes are made in three general types, two, three and four dials. These general types, however, may cover different ranges.

The accuracy of the 0.1 ohm units, including switch contact resistance, is 1%, that of the 1 to 5 ohm units .25%, and that of the larger units .1% on direct current. At 1,500,000 cycles the accuracy is 5%. The wire used has a practically nil temperature coefficient of resistance and contains no iron.

Type	*Units*	*Code Word*	*Price*
102D	10 one-tenth ohm coils 10 one ohm coils	DECOY	$22.00
102E	10 one ohm coils 10 ten ohm coils	DECRY	24.00
102H	10 ten ohm coils 10 one hundred ohm coils	DIVAN	25.00
102F	10 one-tenth ohm coils 10 one ohm coils 10 ten ohm coils	DELTA	30.00
102G	10 one ohm coils 10 ten ohm coils 10 one hundred ohm coils	DIGIT	32.00
102K	10 one-tenth ohm coils 10 one ohm coils 10 ten ohm coils 10 one hundred ohm coils	DEFER	42.00
102J	10 one ohm coils 10 ten ohm coils 10 one hundred ohm coils 10 one thousand ohm coils	DEBIT	50.00
102L	10 ten ohm coils 10 one hundred ohm coils 10 one thousand ohm coils 10 ten thousand ohm coils	DECAY	85.00

The above Decade Resistance Boxes have the following weights and dimensions:

Number of Dials	*Dimensions*	*Weight*
2	7⅜" x 5" x 4¼"	2½ lbs.
3	10" x 5" x 4¼"	4 lbs.
4	12⅝" x 5¼" x 5½"	5 lbs.

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 2100 **JULY 1927**

Type 210
RATIO ARM BOX

For the small laboratory where there is infrequent occasion for bridge measurements the expense of a permanent bridge set up is often unjustified. Where no bridge is available, one may be quickly assembled by combining the ratio arm box with suitable elements for the other arm. A Wheatstone bridge may be put together, using the ratio arm and a standard resistance, or a decade box. An inductance or capacity bridge may be similarly assembled.

The type 210 Ratio Arm Box consists of two similar arms, each with 1000 ohms total resistance, and with intermediate taps at 1-3-10-30-100-300 ohms. The resistances are the Ayrton-Perry type, described in our Bulletin 2050. They are non-inductive and have very low distributed capacitance. The current carrying capacity is five-hundredths of an ampere. The accuracy of adjustment is 0.1%. These resistance units are mounted in a polished walnut box fitted with an engraved bakelite panel. The dial switches are our standard bridge type and have a low and constant resistance.

Type 210 Ratio Arm Box $28.00

Dimensions 7½"x5"x4". Weight 2¼ lbs.

Code Word "RABID."

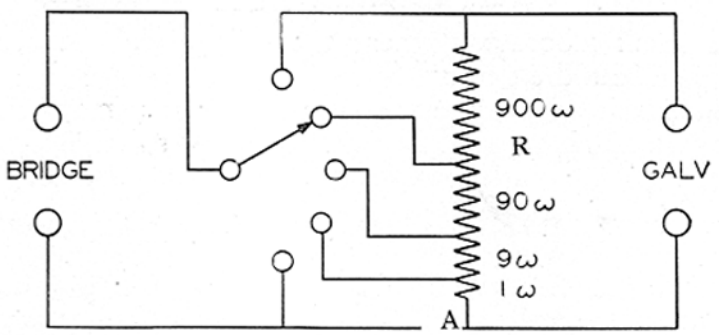
A galvanometer shunt has two general uses, as a means of protecting the galvanometer from injury while adjustments are being made, and to extend its range. For the latter use the so-called "Universal" type of shunt is useful. This type of shunt may be calibrated directly in ratios, as the relative multiplying power is the same for all galvan-

Type 229

GALVANOMETER SHUNT

ometers, regardless of the galvanometer resistance. This feature is best understood by reference to the diagram. The tapped resistance (R) is connected directly across the galvanometer. The bridge connects to one side of the galvanometer and to the tap switch. Solution of the circuit gives the following equation:

$$I_B = I_G \frac{(R_G + R)}{R} N$$



N is the ratio of the total resistance R to the resistance, between the tap and A. This is, of course, independent of the galvanometer resistance, and the shunt may be calibrated in turns of this ratio. It is the constancy of this "relative" multiplying power that gives the name "Universal" to this type of shunt. The multiplying power of the shunt with the tap switch on unity is $\frac{R_G + R.}{R}$ It is therefore important that R should be large compared to Rg for maximum sensitivity.

When used in connection with the ballastic galvanometer method of comparing capacities, the constant resistance across the galvanometer terminals is a distinct advantage, as it insures constant damping for all shunt settings.

The General Radio Type 229 shunt is of the Ayrton-Mather Universal type described above. The total resistance is 1000 ohms.

Taps are provided for ratios of 0.001 — 0.01 — 0.1. A short circuit point is also provided to give complete protection to the galvanometer when so desired. The control is by means of dial switch.

The shunt is mounted in a polished walnut box with engraved bakelite panel. Separate pairs of binding posts are provided for the bridge and galvanometer connection.

Type 229 Universal Galvanometer Shunt..... $25.00

Dimensions 5″x3½″x3″½. Weight 1 lb.

Code Word "GAVOT."

Type 125

PHANTOM ANTENNA RESISTOR

For many tests of transmitting apparatus, it is desirable to replace the antenna by a local circuit, the constants of which are more easily and accurately determined. This also prevents interference with neighboring stations. The Type 125 Phantom Antenna Resistor is provided for this purpose.

This resistor finds many other uses about the laboratory, wherever an accurate resistance of high current-carrying capacity is required.

These units are wound on asbestos-board forms, mounted vertically, an arrangement which insures a good circulation of air. The resistance material is in the form of a ribbon, and has a very low temperature co-efficient of resistance and a constant resistance up to very high frequencies. The inductance is very low and the resistance is accurately adjusted to the stated values.

The resistor is made in two sizes, Type 125A of 4 units of 4 ohms each, and Type 125G of 2 units of 2 ohms each. The separate units of Type 125A have a carrying capacity of 5 amperes and those of Type

125G 15 amperes. It is possible to connect these units so as to obtain the following combinations of resistance and carrying capacity:

Type 125A		Type 125G	
Resistance	Carrying Capacity	Resistance	Carrying Capacity
2 ohms	10 amperes	1 ohms	30 amperes
4 "	5 "	2 "	15 "
8 "	5 "	4 "	15 "
12 "	5 "		
16 "	5 "		

Type 125A Phantom Antenna Resistor..... $15.00
Dimensions 7¾" x 6" x 4¼". Weight 3¼ lbs.
Code Word "RAVEN."

Type 125G. Phantom Antenna Resistor..... $28.00
Dimensions 10¾" x 7⅝" x 5½". Weight 7 lbs.
Code Word "REBEL."

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. Our line includes the following:

Standards of Inductance
Standards of Resistance
Standard Condensers
Precision Condensers and Wavemeters
Variable Air Condensers
Decade Resistance Boxes
Telephone Transformers
Vacuum Tube Oscillator
Radio Frequency Oscillator
Tuning Fork Oscillator
Thermo-Couples
Hot Wire Meters
Galvanometers
Galvanometer Shunt
Vernier Condenser
Audibility Meters
Wavemeters
Oscillograph
Vibration Variometers
Galvanometer Capacity Bridges
Impedance Bridge
Vacuum Tube Bridge
Bridge Circuits for Cable Testing and Other Purposes
Decade Condensers
Miscellaneous Apparatus
Piezo Oscillator
Artificial Telephone Lines
Artificial Cable Units
Attenuation Networks
Lab. Potentiometers
Ohmmeters
Amplification Test Set
Beat Frequency Oscillator
Laboratory Amplifier
Transformers, Fixed and Adjustable

Information and quotations on special apparatus will be sent on request.

Send for Laboratory Catalog "X"

GENERAL RADIO COMPANY

Manufacturers of

Radio and Electrical Laboratory Apparatus

Thirty State Street Cambridge, Massachusetts

(This Bulletin replaces Bulletin 212)

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 2101 **APRIL 1928**

Type 210
RATIO ARM BOX

For the small laboratory where there is infrequent occasion for bridge measurements the expense of a permanent bridge set up is often not justified. Where no bridge is available, one may be assembled quickly by combining the ratio arm box with suitable elements for the other arm. A Wheatstone bridge may be put together, using the ratio arm and a standard resistance, or a decade box. An inductance or capacity bridge may be similarly assembled.

The type 210 Ratio Arm Box consists of two similar arms, each with 1000 ohms total resistance, and with intermediate taps at 1-3-10-30-100-300 ohms. The resistances are the Ayrton-Perry type, described in our Bulletin 2050. They are non-inductive and have very low distributed capacitance. The current carrying capacity is 50 milliamperes. The accuracy of adjustment is 0.1%. These resistance units are mounted in a polished walnut box fitted with an engraved bakelite panel. The dial switches are our standard bridge type and have a low and constant resistance.

Type 210 Ratio Arm Box $28.00

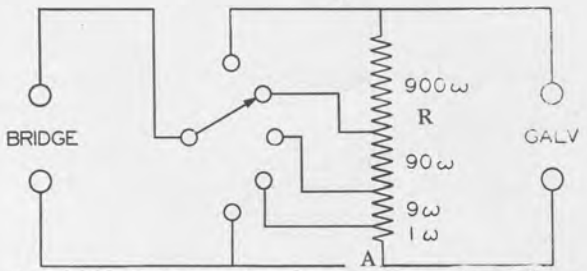
Dimensions 7½"x5"x4". Weight 2¼ lbs.

Code Word "RABID."

Type 229
GALVANOMETER SHUNT

A galvanometer shunt has two general uses, as a means of protecting the galvanometer from injury while adjustments are being made, and to extend its range. For the latter use the so-called "Universal" type of shunt is most convenient. This type of shunt may be calibrated directly in ratios, as the relative multiplying power is the same for all galvanometers, regardless of the galvanometer resistance. This feature is best understood by reference to the diagram. The tapped resistance (R) is connected directly across the galvanometer. The bridge connects to one side of the galvanometer and to the tap switch. Solution of the circuit gives the following equation:

$$I_B = I_G \frac{(R_G + R)}{R} N$$



N is the ratio of the total resistance R to the resistance, between the tap and A. This is, of course, independent of the galvanometer resistance, and the shunt may be calibrated in turns of this ratio. It is the constancy of this "relative" multiplying power that gives the name "Universal" to this type of shunt. The multiplying power of the shunt with the tap switch on unity is $\frac{R_G + R.}{R}$ It is therefore important that R should be large compared to Rg for maximum sensitivity.

When used in connection with the ballastic galvanometer method of comparing capacitance, the constant resistance across the galvanometer terminals is a distinct advantage, as it insures constant damping for all shunt settings.

The General Radio Type 229 shunt is of the Ayrton-Mather Universal type described above. The total resistance is 1000 ohms. Taps are provided for ratios of 0.001 — 0.01 — 0.1. A short circuit point is also provided to give complete protection to the galvanometer when so desired. The control is by means of dial switch.

The shunt is mounted in a polished walnut box with engraved bakelite panel. Separate pairs of binding posts are provided for the bridge and galvanometer connection.

Type 229 Universal Galvanometer Shunt $15.00

Dimensions 5″x3½″x3″½. Weight 1 lb.

Code Word "GAVOT."

Type 125

PHANTOM ANTENNA RESISTOR

For many tests of transmitting apparatus, it is desirable to replace the antenna by a local circuit, the constants of which are more easily and accurately determined. This also prevents interference with neighboring stations. The Type 125 Phantom Antenna Resistor is provided for this purpose.

This resistor finds many other uses about the laboratory, wherever an accurate resistance of high current-carrying capacity is required.

These units are wound on asbestos-board forms, mounted vertically, an arrangement which insures a good circulation of air. The resistance material is in the form of a ribbon, and has a very low temperature co-efficient of resistance and a constant resistance up to very high frequencies. The inductance is very low and the resistance is adjusted accurately to the stated values.

The resistor is made in two sizes, Type 125A of 4 units of 4 ohms each, and Type 125G of 2 units of 2 ohms each. The separate units of Type 125A have a carrying capacity of 5 amperes and those of Type

125G 15 amperes. It is possible to connect these units so as to obtain the following combinations of resistance and carrying capacity:

Type 125A		Type 125G	
Resistance	Carrying Capacity	Resistance	Carrying Capacity
2 ohms	10 amperes	1 ohms	30 amperes
4 "	5 "	2 "	15 "
8 "	5 "	4 "	15 "
12 "	5 "		
16 "	5 "		

Type 125A Phantom Antenna Resistor.....$15.00
Dimensions 7¾" x 6" x 4¼". Weight 3¼ lbs.
Code Word "RAVEN."

Type 125G. Phantom Antenna Resistor.....$28.00
Dimensions 10¾" x 7⅝" x 5½". Weight 7 lbs.
Code Word "REBEL."

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. This apparatus includes the following:

Standards of Inductance
Standards of Resistance
Standard Condensers
Precision Condensers and Wavemeters
Variable Air Condensers
Decade Resistance Boxes
Telephone Transformers
Vacuum Tube Oscillator
Radio Frequency Oscillator
Tuning Fork Oscillator
Thermo-Couples
Hot Wire Meters
Galvanometers
Galvanometer Shunt
Vernier Condenser
Audibility Meters
Wavemeters
Oscillograph
Vibration
Variometers
Galvanometer
Capacity Bridges
Impedance Bridge
Vacuum Tube Bridge
Bridge Circuits for Cable Testing and Other Purposes
Decade Condensers
Miscellaneous Apparatus
Piezo Oscillator
Artificial Telephone Lines
Artificial Cable Units
Attenuation Networks
Lab. Potentiometers
Ohmmeters
Amplification Test Set
Beat Frequency Oscillator
Laboratory Amplifier
Transformers, Fixed and Adjustable

Information and quotations on special apparatus will be sent on request.

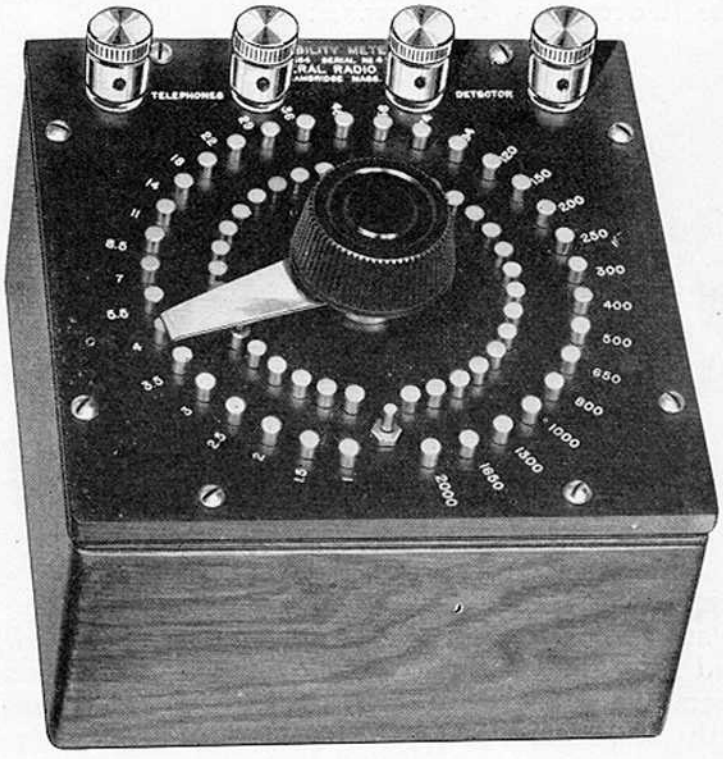
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 2150 **JULY 1927**

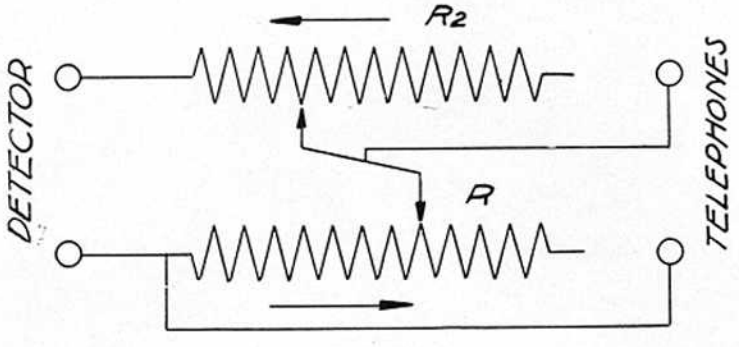


Type 164
AUDIBILITY METER

If a telephone receiver in which signals are being received is shunted by a resistance until the signals are just audible, the ratio of the current in the telephone to the current in the shunt is an indication of the strength of the signals. For instance, if the signal is just audible when 99% of the detector current flows through the shunt and 1% through the telephone receivers, the signal is said to have an audibility of 100. If S is the impedance of the shunt and T the impedance of the telephone receivers the audibility constant is given by the equation:

$$K=\frac{S+T}{S}$$

The increasing use of oscillating circuits for vacuum tube detectors has necessitated the development of a special type of meter for comparing the audibilities of signals. This is because the oscillating circuits are affected by changes in their constants, very slight changes often causing variations of telephone current quite out of proportion to the changes introduced. A series resistance must be added in the plate circuit to compensate for the reduction in resistance of that circuit caused by the shunting of the telephone receivers. The elementary connections of this meter are shown in the diagram. R is the resistance used to shunt the telephone receivers and R^2 is the compensating resistance. As R decreases, R^2 increases.



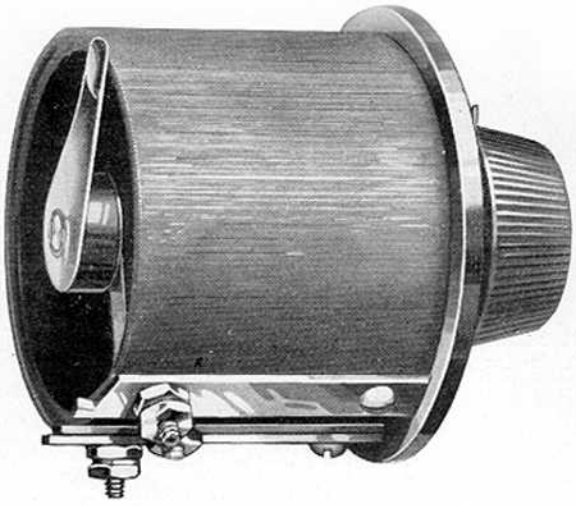
The Type 164 Audibility Meter is designed to keep the impedance of the oscillating circuit practically constant when used at 1000 cycles. It is adapted for use with any good 2000 ohm telephone receiver. This meter consists of two sets of resistance units with thirty-two taps and reads directly in audibilities from 1 to 2000 by approximately 25% steps. As the first step has no resistance in shunt with the telephone receivers, the audibility meter may be left permanently connected in the circuit.

This instrument is mounted in a polished walnut case with engraved bakelite panel. The metal parts are finished in polished nickel. The contact arm is of laminated phosphor bronze and insures perfect contact.

Type 164 Audibility Meter.....$32.00

Dimensions 8" x 8" x 4". Weight 3 lbs.

Code Word "AWAKE."



Type 371

POTENTIOMETER

Experience has shown that the only thoroughly satisfactory variable high resistance for large current is the wire wound type.

The Type 371 Potentiometer has a rating of 22 watts with current in the entire winding.

The Type 371 Potentiometer is made in the following ratings:

Resistance	*Current*	*Code Word*
5 Ohms	2.1 Amp.	RELAY
900	150 MA	REDAN
2,500	90 MA	REFIT
5,000	65 MA	ROTOR
10,000	45 MA	ROWDY
18,000	35 MA	RULER

Type 371 Potentiometer..... $5.00

Dimensions 3½" x 3½". Weight 4½ oz.

In ordering, be sure to specify resistance desired.

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. Our line includes the following:

Standards of Inductance
Standards of Resistance
Standard Condensers
Precision Condensers and Wavemeters
Variable Air Condensers
Decade Resistance Boxes
Telephone Transformers
Vacuum Tube Oscillator
Radio Frequency Oscillator
Tuning Fork Oscillator
Thermo-Couples
Hot Wire Meters
Galvanometers
Galvanometer Shunt
Vernier Condenser
Audibility Meters
Wavemeters
Oscillograph
Vibration Galvanometer
Variometers
Capacity Bridges
Impedance Bridge
Vacuum Tube Bridge
Bridge Circuits for Cable Testing and Other Purposes
Decade Condensers
Miscellaneous Apparatus
Piezo Oscillator
Artificial Telephone Lines
Artificial Cable Units
Attenuation Networks
Lab. Potentiometers
Ohmmeters
Amplification Test Set
Beat Frequency Oscillator
Laboratory Amplifier
Transformers, Fixed and Adjustable

Information and quotations on special apparatus will be sent on request.

(This Bulletin replaces Bulletin 215)

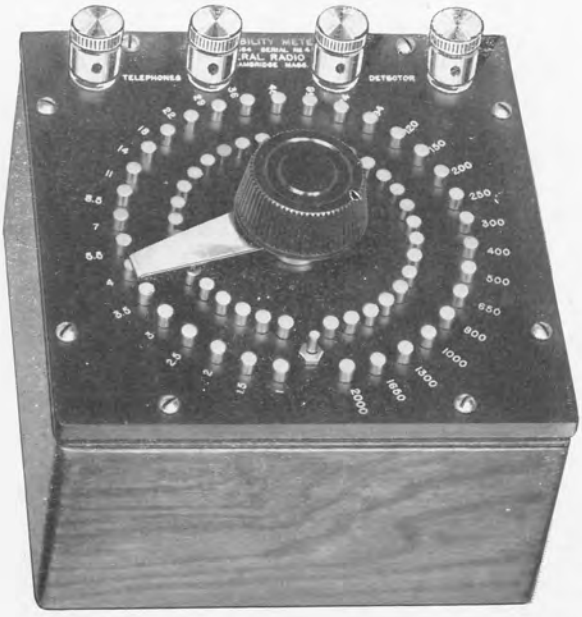
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 2151 **APRIL 1928**



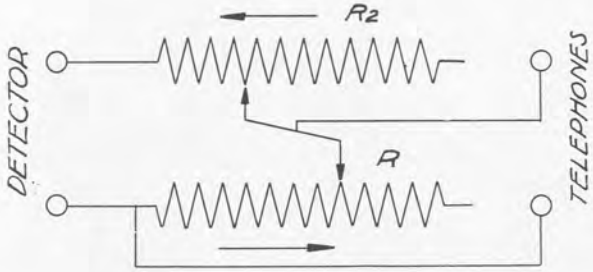
Type 164

AUDIBILITY METER

If a telephone receiver in which signals are being received is shunted by a resistance until the signals are just audible, the ratio of the current in the telephone to the current in the shunt is an indication of the strength of the signals. For instance, if the signal is just audible when 99% of the detector current flows through the shunt and 1% through the telephone receivers, the signal is said to have an audibility of 100. If S is the impedance of the shunt and T the impedance of the telephone receivers the audibility constant is given by the equation:

$$K = \frac{S+T}{S}$$

The increasing use of oscillating circuits for vacuum tube detectors has necessitated the development of a special type of meter for comparing the audibilities of signals. This is because the oscillating circuits are affected by changes in their constants, very slight changes often causing variations of telephone current quite out of proportion to the changes introduced. A series resistance must be added in the plate circuit to compensate for the reduction in resistance of that circuit caused by the shunting of the telephone receivers. The elementary connections of this meter are shown in the diagram. R is the resistance used to shunt the telephone receivers and R^2 is the compensating resistance. As R decreases, R^2 increases.



The Type 164 Audibility Meter is designed to keep the impedance of the oscillating circuit practically constant when used at 1000 cycles. It is adapted for use with any good 2000 ohm telephone receiver. This meter consists of two sets of resistance units with thirty-two taps and reads directly in audibilities from 1 to 2000 by approximately 25% steps. As the first step has no resistance in shunt with the telephone receivers, the audibility meter may be left permanently connected in the circuit.

This instrument is mounted in a polished walnut case with engraved bakelite panel. The metal parts are finished in polished nickel. The contact arm is of laminated phosphor bronze and insures perfect contact.

Type 164 Audibility Meter.....$32.00

Dimensions 8" x 8" x 4". Weight 3 lbs.

Code Word "AWAKE."

Type 371

POTENTIOMETER

Experience has shown that the only thoroughly satisfactory variable high resistor for large current is the wire wound type.

The large wattage rating of the Type 371 Potentiometer permits the use of a high resistance with a large current carrying capacity. There are also available units of low resistance for large current.

The Type 371-T Tapered Potentiometers provide a variation in the change of resistance over the range of the instrument. This feature permits close adjustment when even a small portion of a high resistance unit is in circuit.

The Type 371 Potentiometers are wound on bakelite impregnated duck, formed on moulded bakelite. They are supplied for panel mounting.

The rating of the Type 371 form is 25 watts with current in the entire winding.

The Type 371 Potentiometer is made in the following ratings:

Resistance	*Current*	*Code Word*
5 ohms	2.1 amperes	RELAY
900 ohms	150 milliamperes	REDAN
2,500 ohms	90 "	REFIT
5,000 ohms	65 "	ROTOR
9,000 ohms	45 "	ROWDY
18,000 ohms	35 "	RULER

Type 371 Potentiometer ..... Price $5.00

Dimensions 3½" x 3½". Weight 4¼ oz.

The Type 371-T Tapered Potentiometer is supplied in the 9,000 ohm range only.

Type 371-T ..... Price $6.00

Quotations will be gladly submitted for special units.

In ordering be sure to specify the resistance required.

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. This apparatus includes the following:

Standards of Inductance
Standards of Resistance
Standard Condensers
Precision Condensers and Wavemeters
Variable Air Condensers
Decade Resistance Boxes
Telephone Transformers
Vacuum Tube Oscillator
Radio Frequency Oscillator
Tuning Fork Oscillator
Thermo-Couples
Hot Wire Meters
Galvanometers
Galvanometer Shunt
Vernier Condenser
Audibility Meters
Wavemeters
Oscillograph
Vibration Galvanometer
Variometers
Capacity Bridges
Impedance Bridge
Vacuum Tube Bridge
Bridge Circuits for Cable Testing and Other Purposes
Decade Condensers
Miscellaneous Apparatus
Piezo Oscillator
Artificial Telephone Lines
Artificial Cable Units
Attenuation Networks
Lab. Potentiometers
Ohmmeters
Amplification Test Set
Beat Frequency Oscillator
Laboratory Amplifier
Transformers, Fixed and Adjustable

Information and quotations on special apparatus will be sent on request.

(This Bulletin replaces Bulletin 2150)

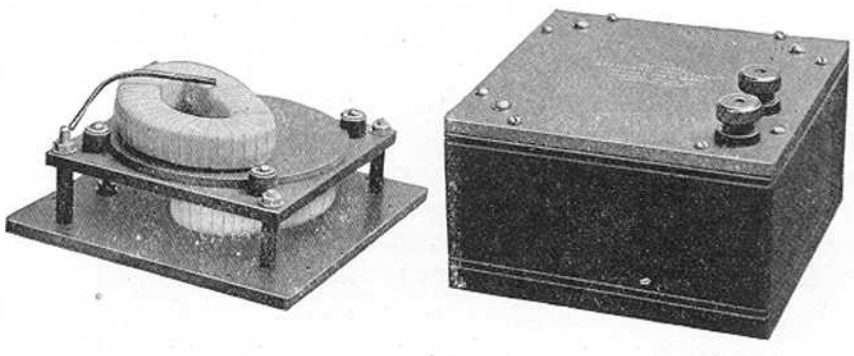
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 3050 **JULY 1927**



Type 106

STANDARDS OF INDUCTANCE

Suitable standards of inductance are a necessary accessory to bridge measurements of inductance. The resistance should be constant for changes in frequency, since its value must be known in computing the resistance of the unknown inductance. It is also desirable that the inductance have no outside field of its own, and be unaffected by neighboring fields.

The type 106 standards are wound with stranded wire, having the strands insulated from each other, the resistance of which is nearly constant over a wide frequency range. Both the effect of the standard on surrounding instruments, and the effect of external fields on it are practically eliminated by the use of the astatic form of winding. In this, the coil is wound in two sections, which are so assembled that their external fields neutralize.

The coils are form wound, firmly bound, and securely fastened to bakelite plates. As the final adjustment is accomplished by rotating one of the coils, it is possible to adjust these standards accurately to their specified values. There is no metal in the field of the coils, in fact only a very small amount of metal, which is all non-magnetic, is used in the entire assembly of this instrument. The accuracy of this adjustment is one-tenth of one per cent. The current carrying capacity of the millihenry and smaller size coils is 2 amperes, that of the 5 and 10 millihenry sizes 1 ampere, and that of the 100 millihenry coil ½ ampere.

By the proper choice of inductance standard and bridge ratio the type 193 bridge may be made direct reading by the use of these inductances.

Type	Inductance		Code Word	Price
106L	.10	Millihenry	INNER	$24.00
106G	1.0	Millihenry	INERT	24.00
106J	10.0	Millihenrys	IRATE	24.00
106K	100.0	Millihenrys	ISLET	24.00

Type 107
VARIOMETER

For general laboratory work a properly designed variometer has a great variety of uses. In addition to serving as a variable standard of self or mutual inductance, these instruments have many uses such as in filter circuits, radio frequency oscillating circuits and similar work.

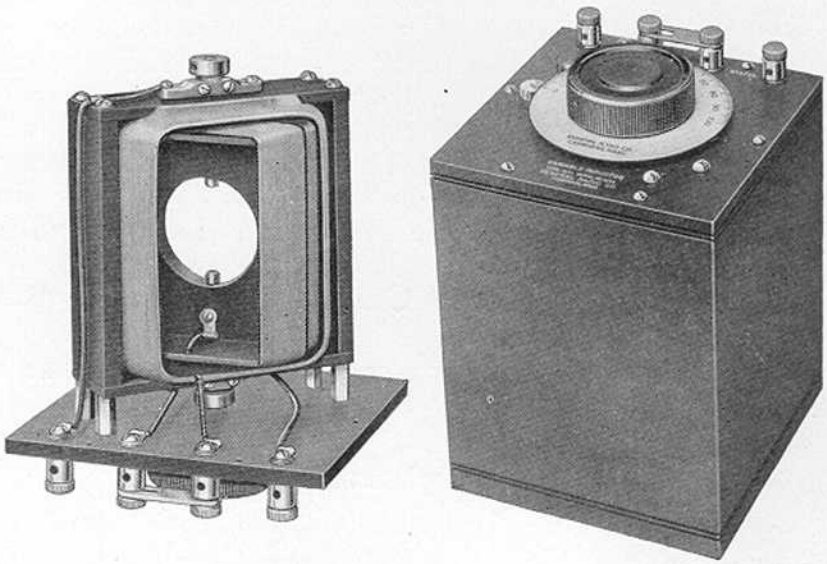
The Type 107 Variometer consists of two coils which are both sections of cylinders, one of which is slightly smaller than the other. The smaller coil is mounted within the larger in such a manner that it may be rotated about its vertical diameter. The connections of each coil are brought out separately in order that the coils may be connected in series, parallel, or used separately. This arrangement not only increases the range through which the inductance may be varied, but also increases the usefulness of the instrument.

A silver etched dial with black filled lines and figures indicates the relative position of the coils. When the dial reading is zero, the currents in the two coils are circulating in opposite directions and the inductance is a minimum. When the dial reading is 50, corresponding to a rotation of 90°, the coils are at right angles and the total inductance is the sum of the self-inductances of the two coils for the series connection, and approximately one-half the inductance of a single coil for the parallel connection. At the 100 reading the currents in the coils are flowing in the same direction and the total inductance becomes the sum of the self-inductances of the coils plus twice their mutual inductance for the series connection, and for the parallel connection approximately one-half of the sum of the mutual inductance and the self-inductance of a single coil.

The connections to the moving coil are made through multiple contacts, giving a low and constant resistance. The coil windings of the smaller inductance sizes are of stranded wire with the separate strands insulated from each other. The field of these coils contains but very little solid dielectric and little metal. This metal is non-magnetic and so placed as to be in a very weak field.

The entire instrument is mounted in a walnut case with engraved bakelite panel. The metal parts are finished in polished nickel.

Attached to the bottom of each variometer case is a certificate giving the maximum and minimum inductance when the coils are connected in series. Calibration curves may also be supplied, for an additional charge of $5.00, giving the inductance throughout the entire range for both the series and parallel connections.



Type 107F. About .02 to .4 M. H. $25.00

Carries 3 amperes continuously.

Code Word "HAPPY."

Type 107G. About .10 to 4 M. H. $25.00

Carries ¾ ampere continuously.

Code Word "HARDY."

Type 107H. About .4 to 18 M. H. $25.00

Carries ½ ampere continuously.

Code Word "HAVEN."

Dimensions 6" x 6" x 8". Weight 4¾ lbs.

We are also prepared to build special inductance coils to specification. Coils for filter circuits a specialty.

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. Our line includes the following:

Standards of Inductance
Standards of Resistance
Standard Condensers
Precision Condensers and Wavemeters
Variable Air Condensers
Decade Resistance Boxes
Telephone Transformers
Vacuum Tube Oscillator
Radio Frequency Oscillator
Tuning Fork Oscillator
Thermo-Couples
Hot Wire Meters
Galvanometers
Galvanometer Shunt
Vernier Condenser
Audibility Meters
Wavemeters
Oscillograph Galvanometer
Vibration Variometers
Capacity Bridges
Impedance Bridge
Vacuum Tube Bridge
Bridge Circuits for Cable Testing and Other Purposes
Decade Condensers
Miscellaneous Apparatus
Piezo Oscillator
Artificial Telephone Lines
Artificial Cable Units
Attenuation Networks
Lab. Potentiometers
Ohmmeters
Amplification Test Set
Beat Frequency Oscillator
Laboratory Amplifier
Transformers, Fixed and Adjustable

Information and quotations on special apparatus will be sent on request.

(This Bulletin replaces Bulletin 307)

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 4050 **JULY 1927**

Type 193

DECADE BRIDGE

Bridge methods have become standard practice for the measurement of inductance, capacity, and resistance. In all bridge circuits the voltage between two points in an electrical network is reduced to zero by balancing the voltage drop across the unknown with that across a standard. The balance or null point is determined by a suitable detector and the value of the unknown computed from the circuit constants. As a large number of bridge circuits have been developed it is desirable that a bridge for general laboratory use should be sufficiently flexible to enable it to be used in as many circuits as possible.

The type 193 decade bridge contains the resistances R_A, R_B, and Rc shown in the diagram. The null point indicator may be connected so as to put Rc in either the unknown, or the standard arm. The

resistances are non-inductive, being our standard decade units, described fully in Bulletin 2050

The cabinet is of polished walnut, fitted with a copper lining to shield the resistance units from outside electrostatic fields. The panel is of polished hard rubber with engraved lettering. A complete wiring diagram is also engraved directly on the panel. The metal parts are finished in bright nickel. Insulated binding posts are used throughout. A wooden dust cover is furnished with each bridge to protect the panel and switches when not in use.

Resistance Measurements. In making measurements of resistances the null indicator is connected between points 2 and 3, and the STD posts connected together. Rc becomes the standard arm. The unknown is connected at X and the bridge balanced. The solution of the network gives the equation:

$$R_X = R_A R_C / R_B$$

This method may be used for either direct or alternating current resistance by connecting a suitable source at E. For resistance measurements the accuracy of the bridge is .2%, if care is taken in balancing.

Inductance Measurements. The bridge is preferably set up with a switch such that the null indicator may be connected either to 1 or 3, placing Rc in either the unknown or standard arm as required. The function of Rc is to balance the bridge for resistance, since resistances as well as inductances must be balanced. Rc is connected in the arm having the lower resistance. As this is not generally known, the switch is convenient. The unknown is connected at X, a suitable standard at STD and the bridge balanced. The solution of the network gives the equation:

$$L_X = R_A L_S / R_B$$

As the bridge is also balanced for resistance, the resistance of the unknown is also indicated:

$$R_X = R_A (R_S + R_C) / R_B$$

if Rc was connected in the unknown arm or

$$R_X = R_A R_S / R_B - R_C$$

An inductance may be compared with a capacity by connecting the capacity across R_A. The unknown inductance is connected at the STD posts, the null indicator to 2 and 3, and the X posts, connected together. The solution of this network gives the equation:

$$L_X = R_A R_C C$$

The accuracy of inductance measurements is about .2% for air core inductances. Owing to the change of inductance with saturation it is impossible to obtain an exact balance with iron core inductances as the degree of saturation changes with every adjustment. The error is consequently greater in this type of measurements. The range for inductance measurement is from about 20 microhenries to several henries.

Capacity measurements. For measurements of capacity the bridge is also set up with a switch for transferring Rc from the unknown to the standard arm. The unknown is connected at X and a suitable standard at STD. With the bridge balanced, the solution of the network gives the equation:

$$C_X = R_B C_S / R_A$$

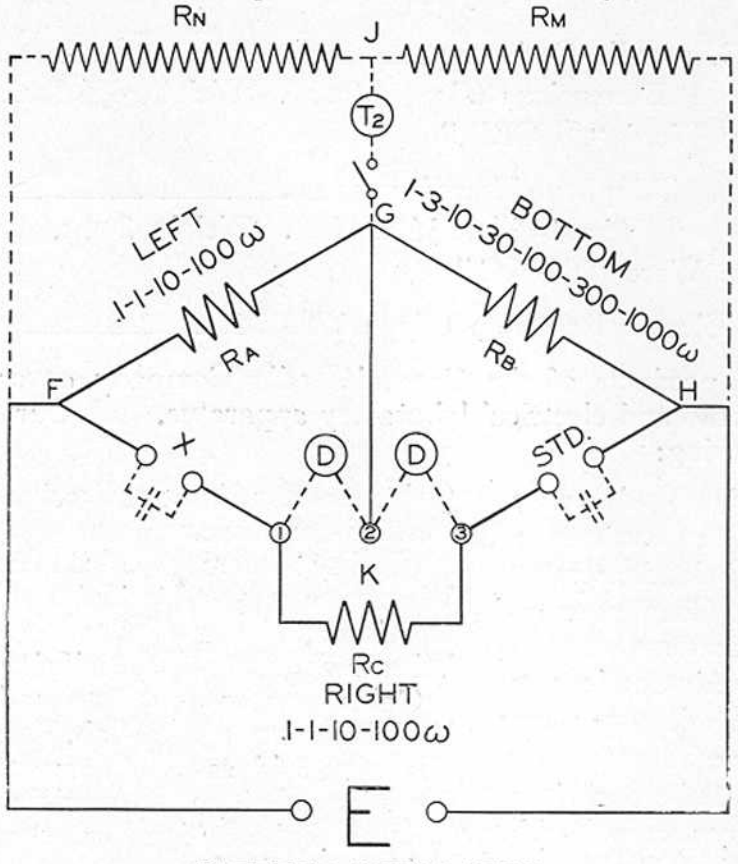
As before, the resistance balance gives the equation:

$$R_X = R_A (R_S + R_C)/R_B \text{ or } R_X = R_A R_S/R_B - R_C$$

depending on the position of Rc.

The accuracy of the bridge for capacity measurements is .2%. Its range is from 0.01 to several microfarads.

Wagner Earth. When a telephone is used as a null indicator, difficulty may arise due to the potential difference between the observer and the telephones. The charging current resulting prevents an exact balance. This difficulty may be overcome by the use of the "Wagner Earth Connection," which brings the telephone to earth potential. This is accomplished by means of the resistances R_M and R_N and the extra telephones T^2 in the figure. The junction of R_N and R_M is grounded at J. With the switch open the bridge is balanced in the usual manner. Closing the switch, the secondary bridge consisting of R_N, R_M, R_A and R_B is balanced, using T^2. All adjustments are of course made at R_N and R_M in order not to upset the balance of the bridge. When no current flows through T^2, D is at ground potential. The switch is opened, and the balance completed. R_M and R_N may be decade boxes.



Standards. When the bridge is used for resistance measurements, Rc is used for the standard. For inductance measurements our type 106 standard is recommended. By proper choice of standards the bridge may be made direct reading.

Sources of EMF. For direct current measurements, a storage battery is of course used. While various forms of interrupters have been developed for making inductance and capacity measurements, modern practice leans to the use of a source of alternating E.M.F. Where one

frequency (1000 cycles) is desired, our type 213 audio oscillator is recommended. Where a variable frequency is required, our vacuum tube oscillator, type 377, may be used to advantage.

Null Point Indicators. For direct current measurements a galvanometer is used. For alternating current a telephone headset or a vibration galvanometer such as our type 338 is used. At 60 cycles particularly telephones are most unsatisfactory and the vibration galvanometer is quite sensitive. A two stage amplifier is very helpful with both types of indicator. When making measurements of small capacitances or large inductances the sensitivity of the bridge may be increased by using in the detector circuit a telephone transformer, such as the General Radio Type 166. The high impedance side, which is marked SEC, is connected across the proper GALV binding posts and the telephone receivers connected across the low impedance side.

Type 193. Decade Bridge $115.00
Size 17″ x 10½″ x 5″. Weight 12¾ lbs.
Code Word "BIGOT."

Type 213. Audio Oscillator $32.00
Dimensions 6″ x 4¾″ x 5″. Weight 4½ lbs.
Code Word "AUGER."

Type 166. Telephone Transformer $7.00
Size 2¾″ x 2½″ x 2¼″. Weight 2 lbs.
Code Word "TOPIC."

Western Electric Receivers (Type 1002C) $12.00

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. Our line includes the following:

Standards of Inductance
Standards of Resistance
Standard Condensers
Precision Condensers and Wavemeters
Variable Air Condensers
Decade Resistance Boxes
Telephone Transformers
Vacuum Tube Oscillator
Radio Frequency Oscillator
Tuning Fork Oscillator
Thermo-Couples
Hot Wire Meters
Galvanometers
Galvanometer Shunt
Vernier Condenser
Audibility Meters
Wavemeters
Oscillograph
Vibration Galvanometer
Variometers
Capacity Bridges
Impedance Bridge
Vacuum Tube Bridge
Bridge Circuits for Cable Testing and Other Purposes
Decade Condensers
Miscellaneous Apparatus
Piezo Oscillator
Artificial Telephone Lines
Artificial Cable Units
Attenuation Networks
Lab. Potentiometers
Ohmmeters
Amplification Test Set
Beat Frequency Oscillator
Laboratory Amplifier
Transformers, Fixed and Adjustable

Information and quotations on special apparatus will be sent on request.

(This Bulletin replaces Bulletin 411)

Standardize on General Radio Apparatus Throughout.

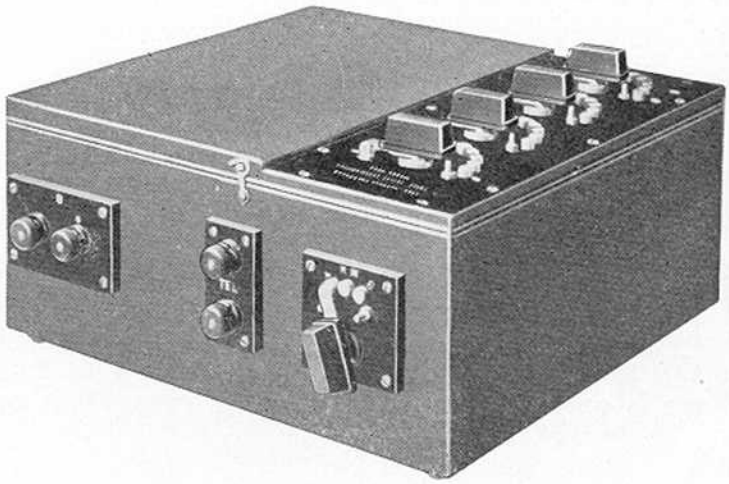
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 4100 **JULY 1927**



Type 216

CAPACITY BRIDGE

Description

For precise measurements of small capacitances or accurate determination of dielectric losses the ordinary type of bridge is unsatisfactory, since the stray capacities in the circuit are of the same order of magnitude as the capacity to be measured. A bridge for the measurement of small capacitances requires complete shielding of all its elements.

The Type 216 Capacity Bridge has been designed for this type of measurement. The elementary circuit is similar to that of the Type 193 Bridge, consisting of three resistances, two ratio arms and a power factor resistance. The cabinet containing the bridge is copper lined and divided into several shielded compartments.

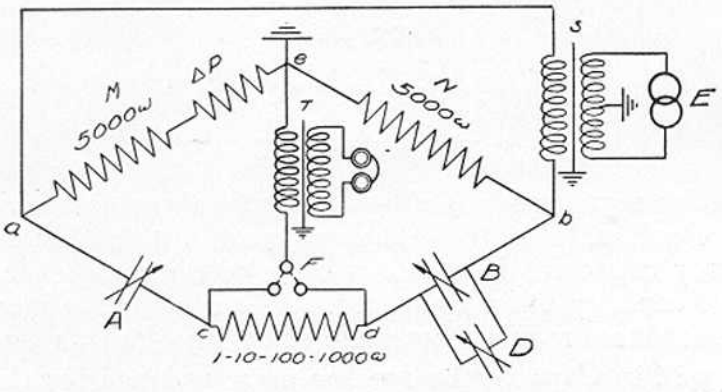
In order to isolate the bridge from stray capacity effects transformers with grounded shields between primary and secondary are used both at the input to the bridge and at the null detector.

As this bridge is designed for the measurement of small capacities, where the substitution method is used with equal total capacities in the bridge arms, the ratio arms are equal resistances. The use of equal arms without switches makes a very accurate adjustment of the resistances possible. As the arms are identical, any slight changes of power factor with frequency will balance and produce no resultant

error. The third resistance arm may be connected in series with either capacity arm as required to balance the bridge. A switch (F) is provided for convenience in making the change. This resistance is one of our standard non-inductively wound decade boxes, mounted in a shielded compartment.

It is very often desirable to calibrate a vernier condenser whose total capacitance is of the order of three or four micromicrofarads. For this work the bridge is first balanced, using capacitances of the order of 1000 micromicrofarads. If one of the resistance ratio arms were to be increased one part in one thousand *i. e.*, from 5000 to 5005 ohms, the ratio of the capacitances would be changed accordingly, which is a change of one micromicrofarad. In order that the ratio arms may be changed in this manner, resistance units are supplied with the bridge. These units may be added to either ratio arm. Although the standard equipment of each bridge includes three of these resistance units so as to give ratios of unbalancing of .001, .01 and .1, they can be furnished to give any ratio desired.

Since the impedance of small capacitances at 1000 cycles is high—that of 1000 micromicrofarads being 160,000 ohms—it is desirable that a high impedance detector be used to denote the balance point of the bridge. As the impedance at 1000 cycles of a pair of sensitive telephone receivers is only of the order of 20,000 ohms, it is evident that



this is too low. For this reason a telephone transformer with a primary impedance of 200,000 ohms and a secondary impedance of 20,000 ohms is used. This arrangement provides the correct impedance in both the bridge and the telephone circuits and makes it possible to detect a very small difference in potential, such as that caused by the unbalancing of the condenser arms to the extent of one hundredth of a micromicrofarad.

In order to prevent errors due to capacity between the observer and the telephones, a grounded shield is used between the primary and secondary of this transformer. The junction of the two resistance arms is also grounded.

The accurately calibrated decade resistance arm provided for power factor measurements is valuable as a means of measuring dielectric losses.

OPERATION: The space available in this booklet is insufficient for printing full operating instructions for the bridge. A complete book of instructions, outlining the procedure for various types of measurement, is supplied with each instrument.

USES: The Type 216 Bridge is adapted to the measurement of capacitances up to about .5 MF. with great accuracy. The bridge is capable of indicating an unbalance of one hundredth of a micromicrofarad. The probable error of measurement using our Type 222 Precision Condenser is about 1 MMF. When greater accuracy is required an accurately calibrated condenser of small capacity should be connected across the Precision. As most errors come from stray fields and moving leads, a permanent and substantial set-up is necessary for accurate work.

The bridge is also suited to the determination of the power factor of dielectrics. The resistance adjustment may be made to one ohm (the impedances measured are often in the neighborhood of 200,000 ohms). This single ohm, however, may be a considerable percentage of the chance of resistance (Rc), and for this reason from 5-10% is a conservative figure for the accuracy of resistance measurements.

The testing of small samples of cable or the study of temperature changes in dielectrics is made easy because of the sensitivity of this instrument. An example of this latter use is a test made on a sample of hard rubber. The sample, which was three inches square and one-half inch thick, was placed between two metal plates. At 54°F. this sample had a capacitance of 11. micromicrofarads and a phase angle of 48′. When heated to 100°F. the capacitance had increased to 12. micromicrofarads and the phase angle to 1°55′.

For the usual run of capacity and power factor measurements, the type 213 Audio Oscillator is suitable as a source. Where measurements are to be made over a wide range of frequencies our Type 377 Vacuum Tube Oscillator is available. This instrument offers a range extending from 50 and 60 cycle commercial frequencies, through the audio carrier frequencies and into the radio frequencies.

Type 216. Capacity Bridge $150.00
Dimensions 15″ x 14″ x 7″. Weight 17 lbs.
Code Word "CIVIC."

Type 213. Audio Oscillator ..... $ 32.00
Dimensions 6″ x 4¾″ x 5″. Weight 4½ lbs.
Code Word "AUGER."

Type 222. Precision Condenser. Max. Cap. 1500 MMF..... $ 80.00
Dimensions 9″ x 8½″ x 10″. Weight 15 lbs.
Code Word "COPAL."

Type 246L. Balancing Condenser. Max. Cap. 1500 MMF.....$ 28.00
Dimensions 7½" x 7½" x 8¼". Weight 9 lbs.
Code Word "CEDAR."

Type 1002C. Western Electric Double Head Receivers.....$ 12.00

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. Our line includes the following:

Standards of Inductance
Standards of Resistance
Standard Condensers
Precision Condensers and Wavemeters
Variable Air Condensers
Decade Resistance Boxes
Telephone Transformers
Vacuum Tube Oscillator
Radio Frequency Oscillator
Tuning Fork Oscillator
Thermo-Couples
Hot Wire Meters
Galvanometers
Galvanometer Shunt
Vernier Condenser
Audibility Meters
Wavemeters
Oscillograph
Vibration Galvanometer
Variometers
Capacity Bridges
Impedance Bridge
Vacuum Tube Bridge
Bridge Circuits for Cable Testing and Other Purposes
Decade Condensers
Miscellaneous Apparatus
Piezo Oscillator
Artificial Telephone Lines
Artificial Cable Units
Attenuation Networks
Lab. Potentiometers
Ohmmeters
Amplification Test Set
Beat Frequency Oscillator
Laboratory Amplifier
Transformers, Fixed and Adjustable

Information and quotations on special apparatus will be sent on request.

(This Bulletin replaces Bulletin 412)

Standardize on General Radio Apparatus Throughout.

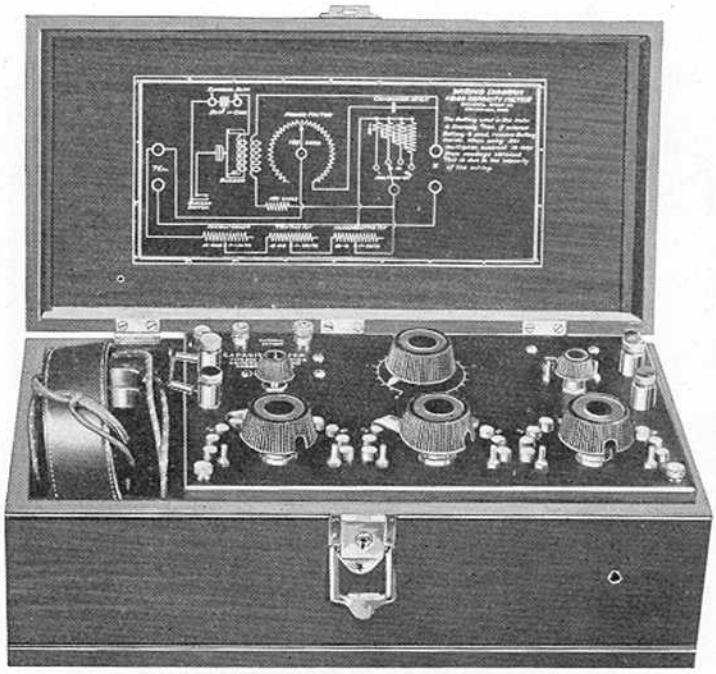
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 4150 **JULY 1927**



Type 240

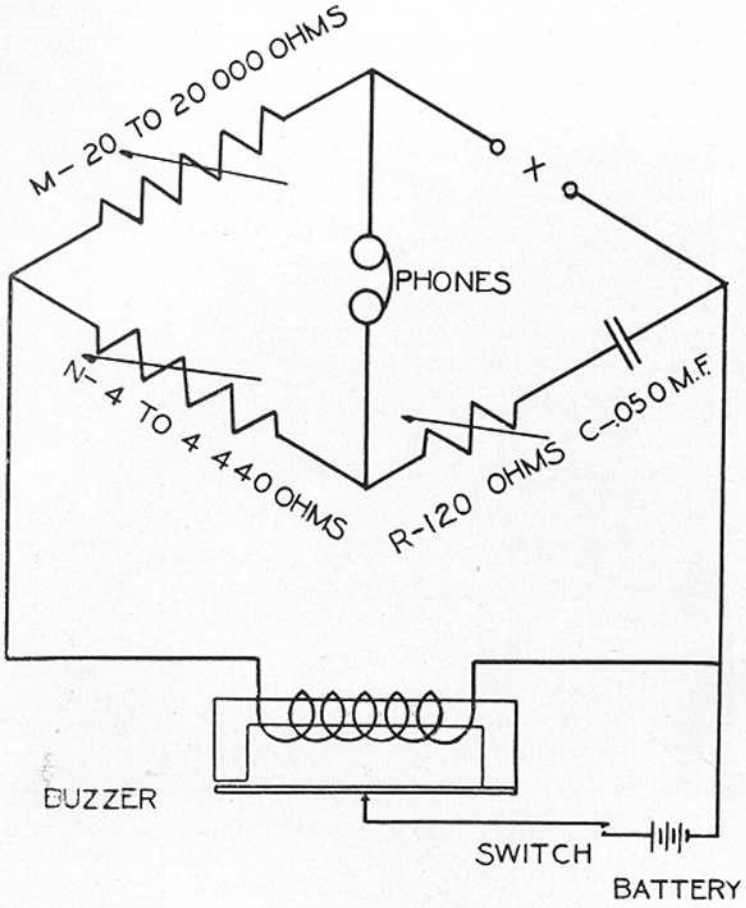
DIRECT READING CAPACITY METER

The Type 240 Capacity Meter meets the demand for a reliable direct reading capacity measuring instrument. It is especially adapted to general laboratory and commercial uses in obtaining capacity measurements ranging from .001 to 10 microfarads with an accuracy to one-half of one per cent. Its simplicity of operation and general dependability make it invaluable in factory inspection work in measuring or comparing capacity values.

The instrument consists of a capacity bridge with variable resistances in the ratio arms and capacitances in the unknown and standard arms. A schematic diagram of the whole assembly is shown on page 453. The input is from a specially designed microphone buzzer supplied from a 4½ volt dry battery contained in the case. Provision is also made for the use of an external battery.

The standard condenser, C, is built up of heavy brass plates interspaced with mica dielectric, assembled under pressure and impregnated with paraffin. It is firmly clamped in a heavy aluminum frame.

The entire assembly is enclosed in a polished walnut cabinet fitted with nickeled lock. A substantial leather handle is provided on the



cover of the cabinet to make it easily portable. The panel is of polished hard rubber 3/8" thick carefully engraved with white enamel lettering. All metal parts are of highly polished nickel finish. The three resistance switches have double leaf blades and are so constructed as to wear the contact surfaces of the switch taps evenly, eliminating the tendency to groove the points. A pair of high resistance phones are furnished with the meter and are contained in a compartment in the cabinet.

OPERATION

Before operating the meter it is necessary to put the battery in place as follows: Remove the four screws at the corners and lift the panel out. The battery is then slipped under the steel holder so that

the terminals make contact with the metal strips on the ends of the buzzer leads. The panel may now be put back in place and the instrument is ready for operation.

The unknown capacity is connected to the two clips (at X in the diagram). The three dials marked "Microfarads," "Tenths," "Hundredths," and the dial marked "Multiply By" are set approximately at the capacity to be measured if it is known. The buzzer switch is turned on and the dials are set, beginning with the dial marked "Microfarads" and adjusting the three lower dials in turn until the minimum sound is heard in the phones, then adjusting the dial marked "Power Factor in Per Cent" until the sound heard in the phones is still further reduced.

The capacity is read on the three lower dials, beginning at the left. The reading of the dials times the multiplier is the capacity in microfarads. The per cent power factor is read from the Power Factor dial. For greater accuracy the multiplier dial should be set as follows: For capacities from:

1	to	10	M.F.	multiply by	1.
0.1	to	1	M.F.	"	" 0.1
0.01	to	.1	M.F.	"	" 0.01
0.001	to	0.01	M.F.	"	" 0.001

If the meter is to be stored or shipped the battery should be removed, otherwise the electrolyte in the battery may run out and damage the meter.

USES

The capacity meter is especially adapted to all uses where a convenient, rugged, and reliable instrument is desired for general laboratory and commercial use in measuring capacities. It is particularly suited to the use of manufacturers of condensers for an inspection instrument whereby condensers may be quickly and accurately tested to a standard of capacity. When a condenser is being tested it is only necessary to vary the setting of one of the capacity switches within the limits of the tolerance allowed. The power factor dial offers a ready means of detecting condensers with high losses. Because of its simplicity of operation this instrument does not require a skilled operator and will not easily get out of order.

Type 240 Capacity Meter..... $80.00

Dimensions 7"x6"14½". Weight 10½ lbs.

Code Word "CYNIC."

The resistances M and N are wound on thin bakelite strips to reduce distributed capacity and inductance. R is a rheostat of 120 ohms resistance.

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. Our line includes the following:

Standards of Inductance
Standards of Resistance
Standard Condensers
Precision Condensers and Wavemeters
Variable Air Condensers
Decade Resistance Boxes
Telephone Transformers
Vacuum Tube Oscillator
Radio Frequency Oscillator
Tuning Fork Oscillator
Thermo-Couples
Hot Wire Meters
Galvanometers
Galvanometer Shunt
Vernier Condenser
Audibility Meters
Wavemeters
Oscillograph
Vibration Galvanometer
Variometers
Capacity Bridges
Impedance Bridge
Vacuum Tube Bridge
Bridge Circuits for Cable Testing and Other Purposes
Decade Condensers
Miscellaneous Apparatus
Piezo Oscillator
Artificial Telephone Lines
Artificial Cable Units
Attenuation Networks
Lab. Potentiometers
Ohmmeters
Amplification Test Set
Beat Frequency Oscillator
Laboratory Amplifier
Transformers, Fixed and Adjustable

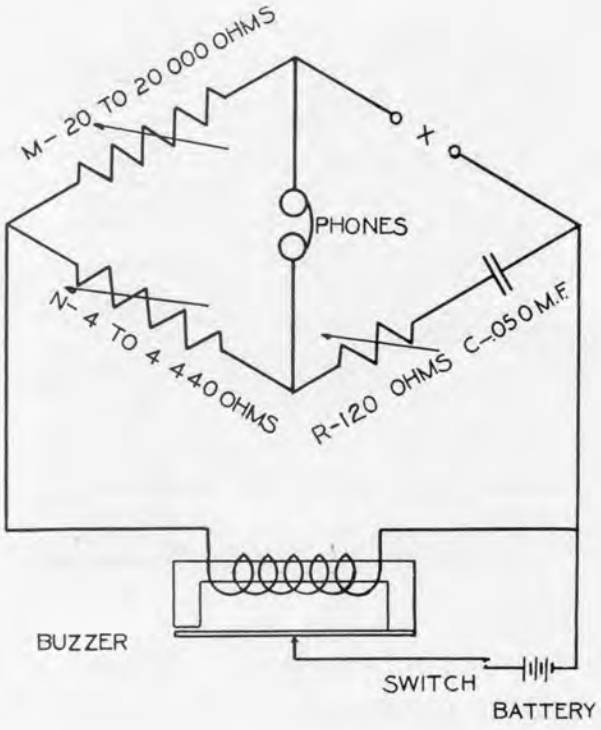
Information and quotations on special apparatus will be sent on request.

(This Bulletin replaces Bulletin 413)

The resistances M and N are wound on thin bakelite strips to reduce distributed capacity and inductance. R is a rheostat of 120 ohms resistance.

The standard condenser, C, is built up of heavy brass plates interspaced with mica dielectric, assembled under pressure and impregnated with paraffin. It is firmly clamped in a heavy aluminum frame.

The entire assembly is enclosed in a polished walnut cabinet fitted with nickeled lock. A substantial leather handle is provided on the



cover of the cabinet to make it easily portable. The panel is of polished hard rubber ⅜" thick carefully engraved with white enamel lettering. All metal parts are of highly polished nickel finish. The three resistance switches have double leaf blades and are so constructed as to wear the contact surfaces of the switch taps evenly, eliminating the tendency to groove the points. A pair of high resistance receivers is furnished with the meter, which contains a compartment for them.

OPERATION

Before operating the meter it is necessary to put the battery in place as follows: Remove the four screws at the corners and lift the panel out. The battery is then slipped under the steel holder so that

the terminals make contact with the metal strips on the ends of the buzzer leads. The panel may now be put back in place and the instrument is ready for operation.

The unknown capacity is connected to the two clips (at X in the diagram). The three dials marked "Microfarads," "Tenths," "Hundredths," and the dial marked "Multiply By" are set approximately at the capacitance to be measured if its order of magnitude is known. The buzzer switch is turned on and the dials are set, beginning with the dial marked "Microfarads," and adjusting the three lower dials in turn until the minimum sound is heard in the receivers, then adjusting the dial marked "Power Factor in Per Cent" until the sound heard in the receivers is still further reduced.

The capacitance is read on the three lower dials, beginning at the left. The reading of the dials times the multiplier is the capacitance in microfarads. The per cent. power factor is read from the Power Factor dial. For greater accuracy the multiplier dial should be set as follows: For capacities from:

1	to 10	M.F.	multiply	by	1.
0.1	to 1	M.F.	"	"	0.1
0.01	to .1	M.F.	"	"	0.01
0.001	to 0.01	M.F.	"	"	0.001

If the meter is to be stored or shipped the battery should be removed, otherwise the electrolyte in the battery may seep out and damage the meter.

USES

The capacity meter is especially adapted to all uses where a convenient, rugged, and reliable instrument is desired for general laboratory and commercial use in measuring capacitances. It is particularly suited to the use of manufacturers of condensers for an inspection instrument whereby condensers may be quickly and accurately tested. When condensers of supposedly the same capacitance are necessary to vary the setting of one of the capacity switches within the limits of the tolerance allowed. The power factor dial offers a ready means of detecting condensers with high losses. Because of its simplicity of operation this instrument does not require a skilled operator and will not easily get out of order.

Type 240 Capacity Meter..... $80.00

Dimensions 7"x6"14½". Weight 10½ lbs.

Code Word "CYNIC."

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. This apparatus includes the following:

Standards of Inductance
Standards of Resistance
Standard Condensers
Precision Condensers and Wavemeters
Variable Air Condensers
Decade Resistance Boxes
Telephone Transformers
Vacuum Tube Oscillator
Radio Frequency Oscillator
Tuning Fork Oscillator
Thermo-Couples
Hot Wire Meters
Galvanometers
Galvanometer Shunt
Vernier Condenser
Audibility Meters
Wavemeters
Oscillograph
Vibration Galvanometer
Variometers
Capacity Bridges
Impedance Bridge
Vacuum Tube Bridge
Bridge Circuits for Cable Testing and Other Purposes
Decade Condensers
Miscellaneous Apparatus
Piezo Oscillator
Artificial Telephone Lines
Artificial Cable Units
Attenuation Networks
Lab. Potentiometers
Ohmmeters
Amplification Test Set
Beat Frequency Oscillator
Laboratory Amplifier
Transformers, Fixed and Adjustable

Information and quotations on special apparatus will be sent on request.

(This Bulletin replaces Bulletin 4050)

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 4151 **APRIL 1928**

Type 240

DIRECT READING CAPACITY METER

The Type 240 Capacity Meter meets the demand for a reliable direct reading capacitance measuring instrument. It is especially adapted to general laboratory and commercial uses in obtaining capacitance measurements ranging from .001 to 10 microfarads with an accuracy to one-half of one per cent. Its simplicity of operation and general dependability make it invaluable in factory inspection work in measuring or comparing capacitance values.

The instrument consists of a capacity bridge with variable resistances in the ratio arms and capacitances in the unknown and standard arms. A schematic diagram of the whole assembly is shown on page 453. The input is from a specially designed microphone buzzer supplied from a 4½ volt dry battery contained in the case. Provision is also made for the use of an external battery.

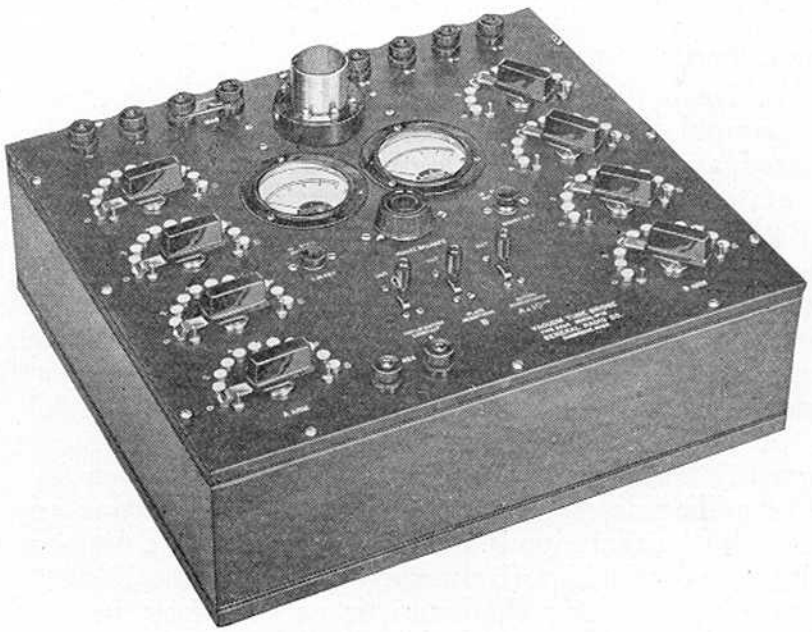
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 4200 **JULY 1927**



Type 361A

VACUUM TUBE BRIDGE

The uses of the three-electrode vacuum tube have become so manifold that the study of its various characteristics is of considerable importance. Several tube-testing devices have been developed and placed on the market. These usually consist of a series of meters and rheostats, with or without enclosed batteries, and are designed to check filament power and to measure certain so-called "static characteristics," such as the joint emission to grid and plate or the steady plate current passing under any particular conditions of filament current or voltage, plate voltage and DC grid bias. From characteristic curves obtained in this manner the "static amplification constant" and other data of value may be determined. Under certain conditions, however, the "dynamic characteristics" of a tube are of more fundamental importance. To obtain such data it is necessary to apply an AC potential to the grid of the tube and to make use of certain balanced-bridge measurements.

The General Radio Type 361-A Bridge was developed to furnish an instrument which would not only provide for the easy and rapid measurement of filament emission and certain so-called "static characteristics," but would also act as a direct-reading bridge giving three fundamental "dynamic characteristics" of the tube, namely: the Amplification Constant, the Plate Resistance and the Mutual Conductance. To measure these dynamic constants the bridge must be supplied with current from an audio-frequency tone source, preferably sinusoidal in character, and then be balanced for a null setting in the telephone head-set after the manner of the ordinary impedance bridge. The General Radio Type 213 Tuning Fork Oscillator makes an excellent tone source for this purpose.

The bridge is designed to combine accuracy with great ease and speed of manipulation. All changes in the bridge to obtain the different circuits used are made by means of throw switches. The balancing adjustments are on a dial decade scheme. There is no necessity for removing plugs or changing connections.

The tube to be measured is inserted in a detachable UV type socket, mounted externally on the panel of the bridge and fitted with an adapter for the small base tubes such as the UX-199, etc. A ten-volt Weston meter is provided for measuring the voltage directly across the filament terminals and, by means of a multiplier, the "B" battery voltage. A Weston five-milliampere meter is used for measuring the plate current. This is equipped with a shunt extending its range to twenty-five milliamperes. Provision is made for inserting any desired "C" battery in the grid circuit. Thus, by varying the filament voltage, plate voltage and grid bias (by means external to the bridge) the data for the customary "static characteristic curves" may be conveniently read on the bridge meters. Routine inspection tests at definite voltages are, of course, quickly and easily performed.

The bridge is equipped with three telephone keys and two four-dial resistance arms, the proper manipulation of which enables the operator to determine quickly the three dynamic characteristics mentioned above for any particular specifications of filament voltage, plate voltage and grid bias. Thus, in a similar manner, the "dynamic characteristic curves" of a particular tube may be easily and rapidly obtained and research or routine inspection work greatly facilitated.

The resistances are of the non-inductive low distributed capacity type, and the bridge is adequately shielded. The input transformer has a shield between its two windings.

The units constituting the bridge may be arranged in any of the accompanying circuits by manipulation of the key switches.

The circuit of figure 1, obtained by throwing in the key marked "AMPLIFICATION CONSTANT" provides for the direct measurement of the voltage amplification constant of the tube under test. The resistance R_A (the four dial A-arm of the bridge) is adjusted until the drop through it due to current from the tone source balances the potential (UEg) resulting in the plate circuit from voltage (Eg) impressed on the grid. Minimum tone in the telephones indicates the balance point. Eg

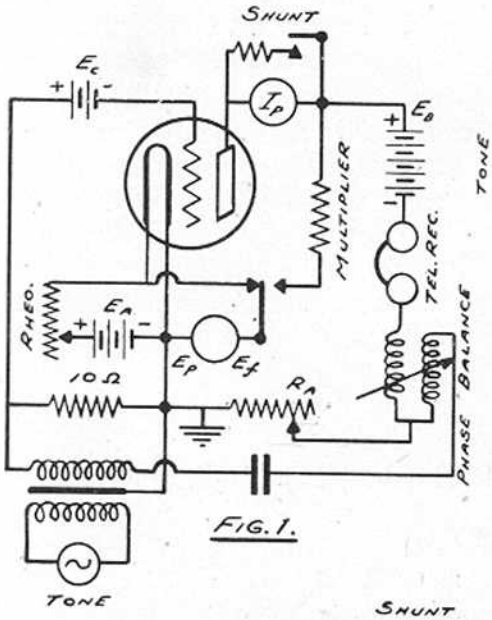


FIG. 1.

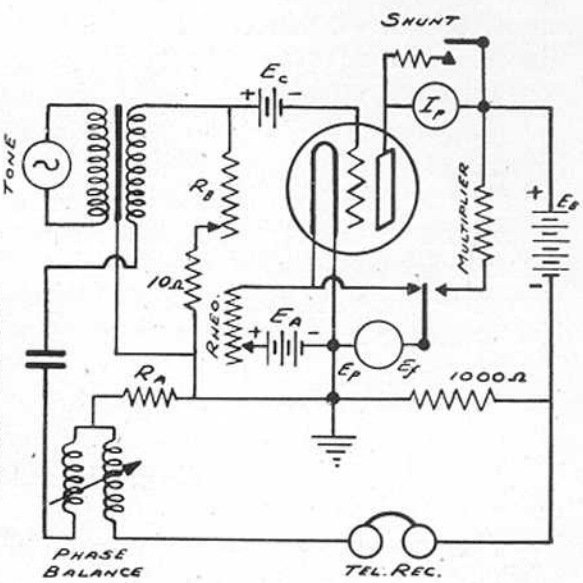


FIG. 2.

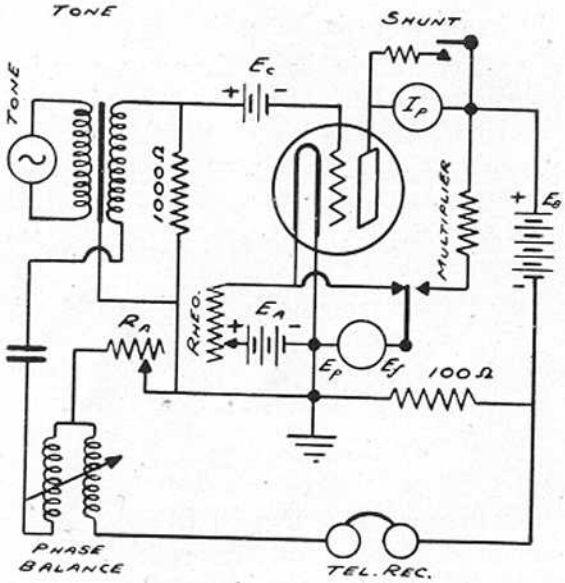


FIG. 3.

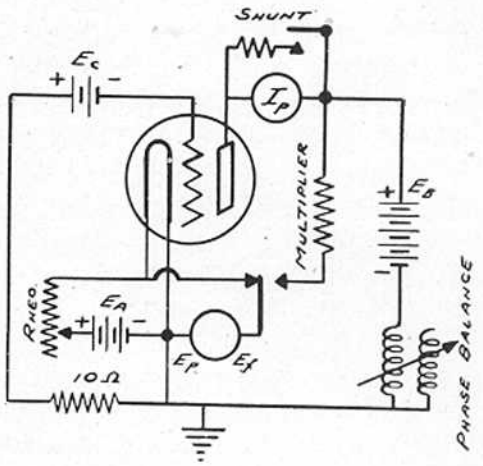


FIG. 4.

results from the flow of the current from the tone source through the 10 ohm resistance in series with R_A.

In order for no current to flow:

$$Ep = UEg = R_A I_T$$

Where I_T is the current from the tone source

UEg is opposite in phase to $R_A I_T$

$$Eg = 10 I_T$$

$$U = R_A/10$$

The resistance (R_A) is numerically equal to 10 U, and the decade resistance system is calibrated directly in terms of amplification constant.

A variometer, by means of which the quadrature component of e.m.f. introduced by the tube capacity may be balanced out, greatly

facilitates the balance. The constant may be read to two decimal places. The resistance provides for the measurement of amplification constants up to 100.00.

To measure plate resistance the bridge is set for the circuit of Fig. 2. The value of amplification constant just determined is set on the A arm, and the bridge is balanced by adjusting the four dial B arm. It will be noted that R_A has been switched to the grid circuit and replaced by the 1000 ohm resistance. R_B has been added in the grid circuit. The condition of balance requires that the drops across the 1000 ohm plate resistance and R_A be equal.

At balance: $R_A I_T = 1000 I_P$

$I_P = UE_g/(R_p + 1000)$

$E_g = I_T (R_B + 10)$

Substituting and dividing: $R_A = 1000 (R_B + 10) U (R_p + 1000)$

But: $U = R_A/10$

Hence: $100 (R_B + 10)/(R_p + 1000) = 1$

Giving: $R_p = 100 R_B$

R_B is calibrated to read directly in plate resistance.

As before use is made of the variometer in balancing out quadrature component in accurate adjustment of the bridge. Measurement may be made of plate resistances up to 100,000 ohms in 10 ohm steps.

For measurement of mutual conductance, the bridge circuit is transformed to that of Fig. 3 (the 1000 ohm plate resistance of Fig. 2 is reduced to 100 and the grid resistance becomes 1000). Balance is obtained by adjusting R_A and the variometer.

At balance: $R_A I_T = 100 I_P = 100 UE_g/(R_p + 100)$

$E_g = 1000 I_T$

$R_A = 100{,}000 U/R_p$ (R_p is large compared to 100).

$U = R_A R_P/100{,}000$

Mutual Conductance $= U/R_P = R_A/100{,}000$

Since the A arm is marked with 1/10 of its true resistance:

Mutual conductance in mhos = reading of A arm x 10^{-4}.

Values up to 0.01 mho may be read in steps of one micromho.

Fig. 4 is the circuit for taking the static characteristics. The voltmeter is normally connected across the filament. Depressing a switch connects it across the plate battery, and throws in a multiplier. The maximum reading is 200 volts. The ammeter is provided with a shunt, reading 5 or 25 milliamperes maximum. A button type of switch controls the shunt.

The Type 361-A Vacuum Tube Bridge recommends itself to the use of laboratories of radio manufacturers where an accurate knowledge of tube characteristics is required, for intelligent design either of tubes or of sets. It is also particularly well adapted to the work of college laboratories, being sufficiently simple in operation and rugged for class work, and sufficient accurate for more advanced research.

A pamphlet of instructions is supplied with the bridge.

Type 361-A. Vacuum Tube Bridge, price $220.00

Code Word "BIBLE."

Dimensions 16″ x 14″ x 8″. Weight 21 lbs.

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 4201 **MARCH 1928**

Type 361B

VACUUM TUBE BRIDGE

The uses of the three-electrode vacuum tube have become so manifold that the study of its various characteristics is of considerable importance. Several tube-testing devices have been developed and placed on the market. These usually consist of a series of meters and rheostats, with or without enclosed batteries, and are designed to check filament power and to measure certain so-called "static characteristics," such as the joint emission to grid and plate or the steady plate current passing under any particular conditions of filament current or voltage, plate voltage and DC grid bias. From characteristic curves obtained in this manner the "static amplification constant" and other data of value may be determined. Under certain conditions, however, the "dynamic characteristics" of a tube are of more fundamental importance. To obtain such data it is necessary to apply an AC potential to the grid of the tube and to make use of certain balanced-bridge measurements.

The General Radio Type 361-A Bridge was developed to furnish an instrument which would not only provide for the easy and rapid measurement of filament emission and certain so-called "static characteristics," but would also act as a direct-reading bridge giving three fundamental "dynamic characteristics" of the tube, namely: the Amplification Constant, the Plate Resistance and the Mutual Conductance. To measure these dynamic constants the bridge must be supplied with current from an audio-frequency tone source, preferably sinusoidal in character, and then be balanced for a null setting in the telephone head-set in the manner of the ordinary impedance bridge. The Type 213 Tuning Fork Oscillator makes an excellent tone source for this purpose.

The bridge is designed to combine accuracy with great ease and speed of manipulation. All changes in the bridge to obtain the different circuits used are made by means of throw switches. The balancing adjustments are on a dial decade scheme.

The tube to be measured is inserted in a detachable UV type socket, mounted externally on the panel of the bridge and fitted with an adapter for the small base tubes such as the UX-199, etc. A ten-volt Weston meter is provided for measuring the voltage directly across the filament terminals and, by means of a multiplier, the "B" battery voltage. A Weston five-milliampere meter is used for measuring the plate current. This is equipped with a shunt extending its range to twenty-five milliamperes. Provision is made for inserting any desired "C" battery in the grid circuit. Thus, by varying the filament voltage, plate voltage and grid bias (by means external to the bridge) the data for the customary "static characteristic curves" may be read conveniently on the bridge meters. Routine inspection tests at definite voltages are, of course, quickly and easily performed.

The bridge is equipped with three telephone keys and two four-dial resistance arms, the proper manipulation of which enables the operator to determine quickly the three dynamic characteristics mentioned above for any particular specifications of filament voltage, plate voltage and grid bias. Thus, in a similar manner, the "dynamic characteristic curves" of a particular tube may be easily and rapidly obtained and research or routine inspection work greatly facilitated.

The resistances are of the non-inductive low distributed capacity type, and the bridge is adequately shielded. The input transformer has a shield between its two windings.

The units constituting the bridge may be arranged in any of the accompanying circuits by manipulation of the key switches.

The Type 361B Bridge is a modification of the Type 361A, and is designed to measure A. C. as well as D. C. tubes.

The circuit of figure 1, obtained by throwing in the key marked "AMPLIFICATION CONSTANT" provides for the direct measurement of the voltage amplification constant of the tube under test. The resistance R_A (the four dial A-arm of the bridge) is adjusted until the drop through it due to current from the tone source balances the potential (UEg) resulting in the plate circuit from voltage (Eg) impressed on the grid. Minimum tone in the telephones indicates the balance point. Eg

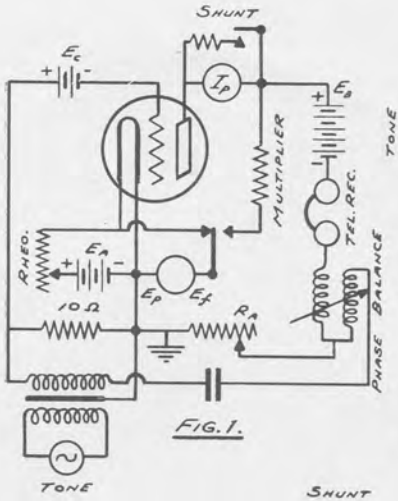


FIG. 1.

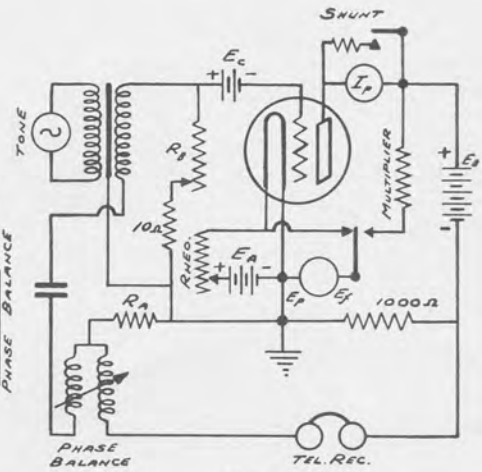


FIG. 2.

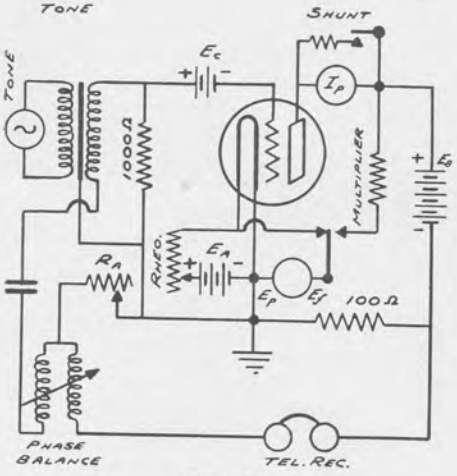


FIG. 3.

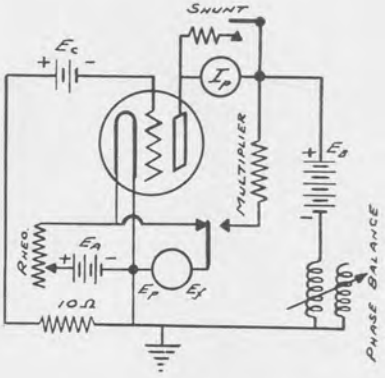


FIG. 4.

results from the flow of the current from the tone source through the 10 ohm resistance in series with R_A.

In order for no current to flow:

$$E_p = \mu E_g = R_A I_T$$

Where I_T is the current from the tone source

μE_g is opposite in phase to $R_A I_T$

$$E_g = 10 I_T$$

$$\mu = R_A/10$$

The resistance (R_A) is numerically equal to 10μ, and the decade resistance system is calibrated directly in terms of amplification constant.

A variometer, by means of which the quadrature component of e.m.f. introduced by the tube capacity may be balanced out, greatly

facilitates the balance. The constant may be read to two decimal places. The resistance provides for the measurement of amplification constants up to 100.00.

To measure plate resistance the bridge is set for the circuit of Fig. 2. The value of amplification constant just determined is set on the A arm, and the bridge is balanced by adjusting the four dial B arm. It will be noted that R_A has been switched to the grid circuit and replaced by the 1000 ohm resistance. R_B has been added in the grid circuit. The condition of balance requires that the drops across the 1000 ohm plate resistance and R_A be equal.

At balance: $R_A I_T = 1000 I_P$

$I_P = \mu E_g/(R_p + 1000)$

$E_g = I_T (R_B + 10)$

Substituting and dividing: $R_A = 1000 (R_B + 10) \mu (R_p + 1000)$

But: $\mu = R_A/10$

Hence: $100 (R_B + 10)/(R_p + 1000) = 1$

Giving: $R_p = 100 R_B$

R_B is calibrated to read directly in plate resistance.

As before use is made of the variometer in balancing out quadrature component in accurate adjustment of the bridge. Measurement may be made of plate resistances up to 100,000 ohms in 10 ohm steps.

For measurement of mutual conductance, the bridge circuit is transformed to that of Fig. 3 (the 1000 ohm plate resistance of Fig. 2 is reduced to 100 and the grid resistance becomes 1000). Balance is obtained by adjusting R_A and the variometer.

At balance: $R_A I_T = 100 I_P = 100 \mu E_g/(R_p + 100)$

$E_g = 1000 I_T$

$R_A = 100{,}000 \mu/R_p$ (R_p is large compared to 100).

$\mu = R_A R_P/100{,}000$

Mutual Conductance $= \mu/R_P = R_A/100{,}000$

Since the A arm is marked with 1/10 of its true resistance:

Mutual conductance in mhos = reading of A arm $\times 10^{-4}$.

Values up to 0.01 mho may be read in steps of one micromho.

Fig. 4 is the circuit for taking the static characteristics. The voltmeter is normally connected across the filament. Depressing a switch connects it across the plate battery, and throws in a multiplier. The maximum reading is 200 volts. The ammeter is provided with a shunt, reading 5 or 25 milliamperes maximum. A button type of switch controls the shunt.

A pamphlet of instructions is supplied with the bridge.

Type 361-B. Vacuum Tube Bridge, price $220.00

Code Word "BIBLE."

Dimensions 16" x 14" x 8". Weight 21 lbs.

The bridge is supplied with adapters for both D. C. and A. C. tubes with the UX base, and for tubes with the UY base. Other adapters may be obtained as follows:

Type 361-40 For use with large UV base

Type 361-41 For use with small UV base

Price, either type $3.00

(This Bulletin replaces Bulletin 4200)

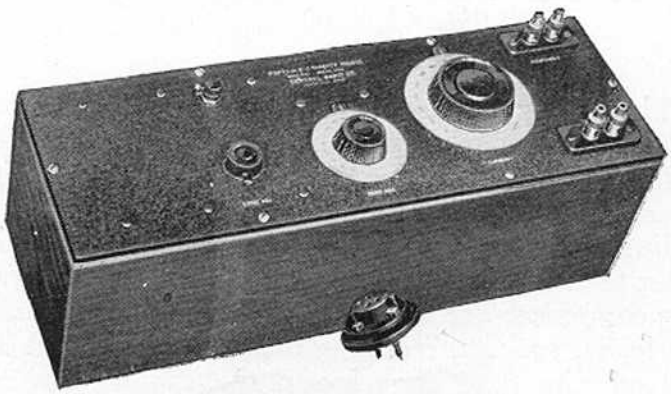
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 4250 **JULY 1927**

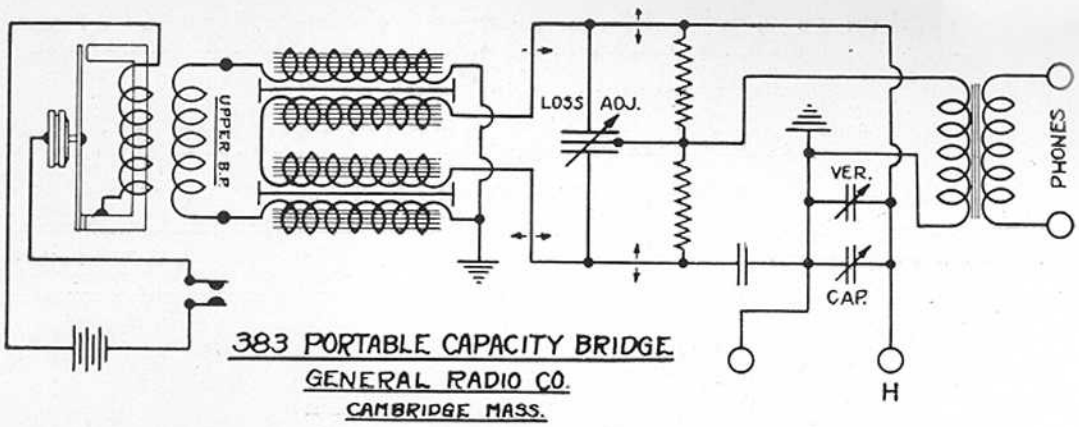


Type 383

PORTABLE CAPACITY BRIDGE

The measurement of small capacities is of great importance in several branches of radio work. In the design of delicately adjusted receivers it is necessary to give considerable attention to the inter-electrode (grid filament, plate-filament, and grid-plate) capacities of vacuum tubes. For this reason, the measurement of these capacities is of particular interest both to tube and to receiver manufacturers. The very small capacities involved (about 5 micromicrofarads) render the usual type of bridge measurement not very satisfactory for this use. The Type 383 Portable Capacity Bridge is particularly designed for this type of work.

A conventional type of bridge circuit, as shown on the next page, is used, consisting of two resistance and two capacity arms. It is actuated by a self-contained microphone hummer supplied from a 4½-volt dry battery. The output from the hummer, of about 800 cycles frequency, is fed through a transformer to the bridge circuit. The transformer has shielding between its primary and secondary, and is in addition wound in two sections so as to reduce capacity effects. The phones are supplied from another transformer, its primary connected across the bridge, the secondary brought to the lower terminals in the photograph. Three adjustments appear on the bridge panel, marked LOSS ADJ., ZERO ADJ., and CAPACITY. These correspond to the condensers labelled LOSS ADJ., VER., and CAP., respectively in the diagram. The LOSS ADJ. condenser, shunted across the resistance arms of the bridge, compensates for the variation from zero of the power factor of the unknown



capacity. This adjustment is not calibrated as it is not intended for use as a means of measuring power factor. It is intended merely to compensate for loss current in the condenser arm which might otherwise render a balance of the bridge impossible. It is generally necessary to make this adjustment only when rather high loss is associated with the capacity under test. The ZERO ADJUST condenser is included across the balancing condenser and the unknown in order to balance out stray capacities of leads, sockets, etc. As the ratio arms and standard condenser are fixed, the total capacity in the fourth arm of the bridge, which includes the unknown with its leads, the zero adjusting and the measuring condenser must be constant for balance. In making measurements the leads, sockets, or other apparatus associated are connected to the terminals and the capacity of the ZERO ADJ. condenser reduced sufficiently to balance the bridge with the CAPACITY condenser set at maximum capacity. The dial on this condenser is set to read 180 degrees out of phase with the capacity, i.e., the dial is set at 0 for maximum capacity.

The unknown capacity is then connected and the condenser marked CAPACITY rotated (reducing its capacity) until the bridge is again balanced. The LOSS ADJ. condenser is adjusted as required in each case. The capacity of the unknown condenser is obtained by multiplying the reading of the measuring condenser by a factor appearing on the dial.

A very convenient accessory in making measurements on the interelectrode capacities of vacuum tubes is the socket shown in the foreground. This socket is equipped with three plugs so spaced as to fit the binding posts of the bridge, and connected to grid, plate, and filament. In measuring the tube capacities, this socket is plugged in and the bridge balanced for zero. The tube is then placed in the socket and its capacities measured directly.

Readings can be made to about one-half division on a one hundred-division scale with ear-phones, or somewhat more accurately if an amplifier and vacuum tube voltmeter are used.

The Type 383 Capacity Bridge is made in two models. One, with a range extending to thirty micromicrofarads, is designed for the measurement of small capacities. Another model, its range extending to 600 micromicrofarads, is particularly useful in matching condenser units for

use in single control setups. The accuracy of the instrument makes it very useful for this purpose, as it will show up smaller differences between such units than are permissible in the receiver. Its simplicity in comparison with the quartz-controlled oscillators and other expedients resorted to for condenser matching recommends it strongly.

A very useful adjunct to the capacity bridge is a two-stage amplifier as described below. A vacuum tube voltmeter can then be used to detect balance and a somewhat greater accuracy attained than is possible with ear-phones. Another advantage of the voltmeter is that it permits tolerance limits to be marked on the dial of the voltmeter, a useful practice in factory inspection work.

Type 383 Portable Capacity Bridges:

Type 383-A (30 MMF) ..... Price $80.00
Code Word "BRUIN."

Type 383-B (600 MMF) ..... Price $80.00
Code Word "BUGLE."

Type 415
LABORATORY AMPLIFIER

The sensitivity of a great many laboratory measurements can be increased by the use of a properly designed amplifier. An amplifier also makes possible the substitution of a visual for an auditory balance of bridge circuits operating at 800 to 1000 cycles. This feature is of advantage, for example, in connection with the Type 383 Capacity Bridge. When this instrument is set up for factory test work, a vacuum tube voltmeter may be used as an indicator, which greatly simplifies the setting of tolerances. An amplifier is necessary also in making observation by means of an oscillograph such as the General Radio Type 338, where the circuit conditions must not be disturbed by the measuring equipment.

In the Type 415 Laboratory Amplifier, the necessary equipment and batteries are contained in a single cabinet of stout construction. The audio coupling units are mounted on our Type 274 plugs so that any type of coupling unit desired may be used. This feature makes possible a quick determination of the relative merits of different types of amplifying systems. The output of the second tube may be connected directly to the output terminals or by means of a plug base, to any form of output coupling device desired. Four plug plates may be obtained which may be used for mounting various types of coupling units.

The battery space is sufficient for four 22-volt batteries, one 4.5-volt C battery and three 1.5-volt A cells. The amplifier is designed for use with WX-12 or UX-199 (CX-12 or CX-299) tubes. A voltmeter in the panel provides for proper adjustment of the filament voltages.

The input and output binding posts are our type 138-T permitting connection by means either of wire leads or our Type 274 plugs.

Type 415 Laboratory Amplifier.....Price $40.00

(Without batteries, tubes or transformers.)

Code Word "ACRID."

Weight, 11 lbs.; with batteries and transformers, 34 lbs.

Type 274 Four-Plug Plates ..... $ .75

Type 285-D Transformer 1:2.7 ratio mounted on plug plate..... 7.00

Type 285-H Transformer 1:6 ratio mounted on plug plate..... 7.00

Type 373 Double Impedance Coupler, mounted..... 7.50

Type 285-O Impedance-adjusting transformer for oscillograph element mounted 8.00

Dimensions 6" x 7" x 18". Weight 10 lbs.

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. Our line includes the following:

Standards of Inductance
Standards of Resistance
Standard Condensers
Precision Condensers and Wavemeters
Variable Air Condensers
Decade Resistance Boxes
Telephone Transformers
Vacuum Tube Oscillator
Radio Frequency Oscillator
Tuning Fork Oscillator
Thermo-Couples
Hot Wire Meters
Galvanometers
Galvanometer Shunt
Vernier Condenser
Audibility Meters
Wavemeters
Oscillograph
Vibration Galvanometer
Variometers
Capacity Bridges
Impedance Bridge
Vacuum Tube Bridge
Bridge Circuits for Cable Testing and Other Purposes
Decade Condensers
Miscellaneous Apparatus
Piezo Oscillator
Artificial Telephone Lines
Artificial Cable Units
Attenuation Networks
Lab. Potentiometers
Ohmmeters
Amplification Test Set
Beat Frequency Oscillator
Laboratory Amplifier
Transformers, Fixed and Adjustable

Information and quotations on special apparatus will be sent on request.

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 5050 **JULY 1927**

Type 170
HOT WIRE METER

An instrument for the measurement of currents at high frequencies must have its inductance and capacitance kept as small as possible. High impedance would cause the readings to vary with frequency. For many radio frequency measurements a suitably designed hot wire ammeter has the necessary characteristics which particularly adapt it to this work. It should, however, be recognized that a hot wire ammeter is inherently a less accurate instrument than those of the moving coil type, which of course are impractical for measuring current at high frequencies. In our types 127 and 170 Hot Wire Ammeters careful design and good workmanship have produced an instrument

which is electrically and mechanically good, rugged and reliable. These meters, particularly the galvanometer type, which is the 250 milliampere size uncalibrated, are used very extensively in wavemeters and similar oscillating circuits for determining the resonance point. The Type 127 meters are used extensively for measuring the radiation, filament and plate currents in experimental continuous wave transmitting stations. The Type 170 meters have found a wide use outside of the radio field. They are used as transfer instruments in generator testing and similar work.

The expanding strip in these meters is of thin platinum, so as to prevent oxidation. It is so proportioned that it works at a low temperature and is of low resistance. These are two highly desirable features, since the former permits reasonable overloading without burning out, and the latter minimizes the losses.

The type of multiplying action is such that a more uniform scale is obtained than with many hot wire meters. These meters have been corrected for temperature so that there is very little shift of zero. Any necessary correction may be made by adjusting a knurled screw. This type of instrument is equally accurate on direct or alternating current of any frequency.

These instruments are made in two general sizes. Type 127 is the smaller, or three-inch size, and is made in three types, portable, front-of-board mounting and flush mounting. Type 170 is the large size and is made only in the portable type. It is mounted in a polished, walnut case and fitted with carrying strap.

The Type 170 meters are made in the sizes listed below. The Type 127 meters are illustrated and listed in Bulletin 925.

Range	Resistance	Code Word	Case	Price
100 M. A.	31.0 ohms	EXULT	Portable	$20.00
250 M. A.	6.8 "	EVOKE	Portable	20.00
500 M. A.	3.4 "	EXACT	Portable	20.00
1 amp.	1.2 "	EXCEL	Portable	20.00
2 amp.	.55 "	EXERT	Portable	20.00
3 amp.	.3 "	EXILE	Portable	20.00
5 amp.	.16 "	EXIST	Portable	20.00
10 amp.	.08 "	EXPEL	Portable	20.00
20 amp.	.04 "	EXTRA	Portable	20.00
Galvanometer	4.4 "	ETHER	Portable	20.00

Dimensions 4¾"x5"x3½". Weight 16 oz.

Type 287
OHMMETER

There are many occasions in laboratories, service stations and factories where an approximate measurement of resistance is required. The type 287 Direct Reading Ohmmeter is designed for the quick determination of resistance where an approximate value is sufficient.

The type 287 Ohmmeter consists of a battery and meter in series with a resistance which protects the meter from damage at short circuit, and provides a zero adjustment. The dial is calibrated directly in ohms. Clip leads are provided for convenience in attaching the instrument.

One of the greatest uses of the Ohmmeter is the checking of apparatus and tracing of circuits. Its indication of the actual resistance of the circuit makes the Ohmmeter useful when the battery and telephone method of tracing circuits is of little use. This feature makes it possible to detect, not only open and short circuits, but also wrong connections, since the resistance between two points will indicate the instruments in circuit.

Before using the Ohmmeter, the zero should be checked by connecting the terminals together. The knob should then be adjusted until the meter needle registers zero resistance (short circuit). The short circuit is then removed from the meter and it is ready for use. If the meter is to be shipped or stored for a considerable length of time the battery should be removed lest the acid injure the cabinet.

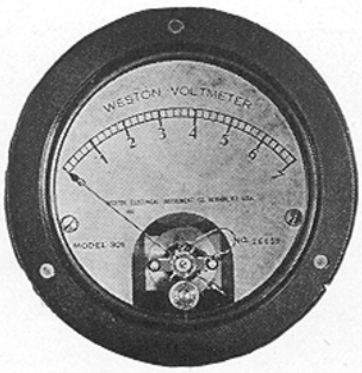
Type 287A. Range 0 to 5000 ohms.....Price $25.00

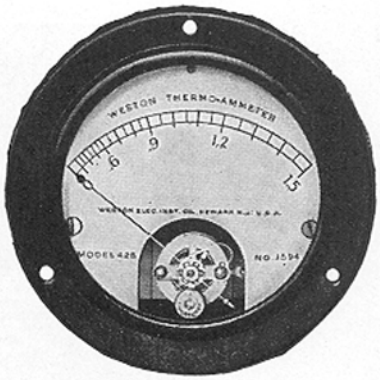
Code Word "ONION"

Type 287B. Range 0 to 2000 ohms.....Price $25.00

Code Word "ORBIT"

Dimensions 6¾"x5¾"x4½". Weight 2½ lbs.





WESTON METERS

Supplementing our own line of hot wire ammeters, we can supply Weston direct-current volt meters, direct-current ammeters and thermo-ammeters. These meters are all the 3″ size, flush mounting with black japan finish. They are similar in appearance and interchangeable with our Type 127-A Hot Wire Ammeters.

Model 301—Direct Current Voltmeters

Range	Code Word	Price
4 volts	AUTOBALANCE	$8.00
10 volts	AUTOBATH	8.00
15 volts	AUTOBASKET	8.00
50 volts	AUTOBATTLE	8.00
100 volts	AUTOBAT	13.00

Higher ranges using external shunts may be supplied, if desired.

Model 301—Direct Current Ammeters

Range	Code Word	Price
5 milliamperes	AUTOGALE	$10.00
100 milliamperes	AUTOGAGE	8.00
200 milliamperes	AUTOGASKET	8.00
1.5 amperes	AUTOCAB	8.00
3 amperes	AUTOCOFFER	8.00
5 amperes	AUTOCOMB	8.00
10 amperes	AUTOCOUPLE	8.00

Model 425—Thermo-Ammeters

Where quickness in movement and low meter energy consumption are important features, we recommend the use of thermo-ammeters in place of hot wire ammeters for measuring antenna currents.

Range	Code Word	Price
1.5 amperes	THIAZIN	$17.00
3 amperes	THIBET	17.00
5 amperes	THICKISH	17.00
10 amperes	THIELT	18.00
20 amperes	THIENYL	18.00
115 milliampere Galvanometer	THIETSEE	18.50

(This Bulletin replaces Bulletin 506)

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 5100 **JULY 1927**

Type 134
THERMO-COUPLE

Due to the comparatively large power drawn by alternating current instruments of the usual type, thermo-couples have been found best adapted to the measurement of small currents.

The action of the thermo-couple depends on the behavior of joints of dissimilar metals when heated. When small joints of unlike metal are welded together and heated, a direct voltage is generated. In the Type 134 Thermo-Couple a junction composed of copper and constantan is placed inside a heater coil. Heat developed by the passage of the alternating current through the heater coil raises the temperature of the junction and generates a direct voltage.

The Type 134 couple is designed for use with our Type 189 and 150 microampere galvanometer. When used with this instrument, a current of 50 milliamperes in the heater coil gives full scale deflection on the meter.

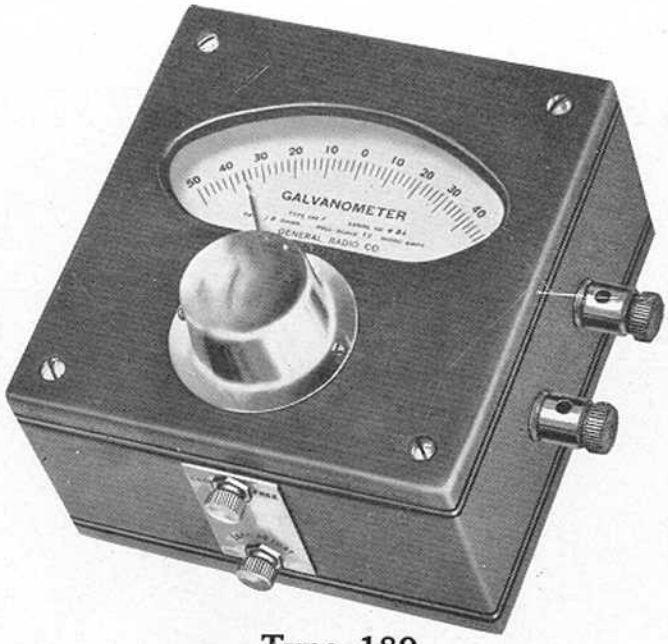
The resistance of the heater coil is about 11 ohms; that of the junction approximately 1 ohm.

The mounting for the couple is supplied with spade terminals, spaced to fit on the binding posts of the 189 galvanometer.

Type 134 Thermo Couple, price $6.00

Dimensions 2″ x 3″ x 1¾″. Weight 4 oz.

Code Word "TABBY."



Type 189
POINTER GALVANOMETER

Most laboratories require a sensitive, portable, instrument for the measurement of currents of the order of 10 to 1000 microamperes. Such an instrument must be both sensitive and rugged. The type 189 galvanometer is adapted for just such service.

This instrument is of the D'Arsonval type, using the strained suspension which permits of greater sensitivity than the pivot type and requires no leveling. The coil is wound on a damping form and adjusted to bring the coil just under critical damping. The construction is such as to allow a safe clearance between the coil and the shoes of the magnet poles, thus preventing interference from chance lint or dust particles.

The suspension is of phosphor bronze rolled into a thin strip. The spring support for the suspension is such as to take up any ordinary shocks without danger of straining or snapping the suspension. This type of construction, together with the natural properties of the phosphor bronze strip, insure a reasonably stable zero. The galvanometer pointer is fitted with a zero adjustment, and a clamp.

Its combination of portability and sensitivity make this instrument available for a wide variety of uses, ranging from indicating a bridge balance to the measurement of radio received signal strength. The clearly drawn three inch scale makes the reading of the instrument very easy.

The case is of polished walnut and the metal parts are finished in polished nickel. A convenient leather carrying strap is provided.

Type	Zero	Approximate Resistance	Approximate Microamperes full scale	Code Word
189E	left	10 ohms	150	GABLE
189F	centre	10 ohms	75	GAILY
189H	left	100 ohms	50	GALOP
189J	centre	100 ohms	25	GAMIN
189L	left	2000 ohms	10	GAZEL

Size 5″x5″x3½″. Weight 2½ lbs.

Price, all types..... $36.00