GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 110 **NOVEMBER 1926**

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 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 100 to 1. It is also useful in temporary filter set-ups and in tuning circuits of low frequency.

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 $50.00
Ten 0.01 MF steps.
Ten 0.1 MF steps.
Dimensions 9½"x5"x5¾". Weight 6½ lbs.
Code Word "COVER."

Type 219G Condenser ..... Price $75.00
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."

Type 236 Filter Condenser ..... Price $1.00
Dimensions 4"x1⅛"x1⅛". Weight 5 oz.
Code Word "PECAN."

(This Bulletin replaces Bulletin 108)

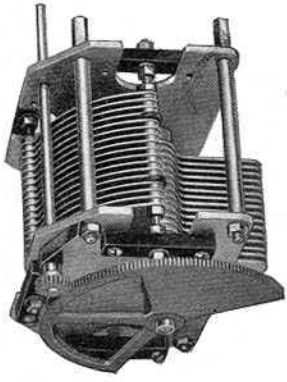
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 112 **NOVEMBER 1926**



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.....$15.50
Dimensions 6" x 6" x 7". Weight 4½ lbs.
Code Word "BABEL."

Type 239E. 1000 MMF. Mounted. With gear..... 19.00
Dimensions 6" x 6" x 7". Weight 4½ lbs.
Code Word "BANDY."

Type 239E. 1000 MMF. Mounted. With gear. Calibrated..... 20.50
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..... 18.50
Dimensions 6" x 6" x 9". Weight 6 lbs.
Code Word "BASIN."

Type 239J. 2000 MMF. Mounted. With gear..... 22.00
Dimensions 6" x 6" x 9". Weight 6 lbs.
Code Word "BATTY."

Type 239J. 2000 MMF. Mounted. With gear. Calibrated..... 23.50
Dimensions 6" x 6" x 9". Weight 6 lbs.
Code Word "BATON."

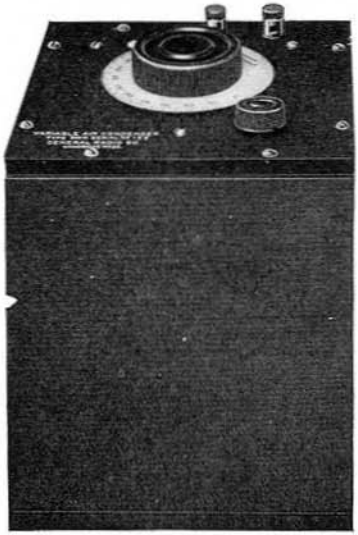
Type 239M. 2000 MMF. Unmounted. Without gear..... 13.00
Dimensions 4½" x 4¾" x 6". Weight 3 lbs.
Code Word "BAYAN."

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

Calibrations can be supplied as follows:

10 calibration points.....$ 1.50

Mounted curve 3.50



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 $28.00
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. Information and bulletins of special apparatus will be sent on request. Our line includes the following: Variable Air Condensers, Standard Condensers, Decade Condensers, Variometers, Standards of Inductance, Standards of Resistance, Decade Resistance Boxes, Wavemeters, Decade Bridge, Capacity Bridge, Audibility Meter, Hot Wire Meters, Galvanometers, Thermo-Couple, Miscellaneous Transformers, Vacuum Tube Oscillator, Oscillograph, Piezo Oscillator, Miscellaneous Apparatus.

All prices in this bulletin are strictly net, subject to change without notice. F. O. B. Cambridge, Mass. Cash should accompany orders from persons or firms with whom we have not already opened accounts. Unless otherwise instructed, we shall use our own judgment regarding method of shipment.

(This Bulletin replaces Bulletin 111)

GENERAL RADIO COMPANY

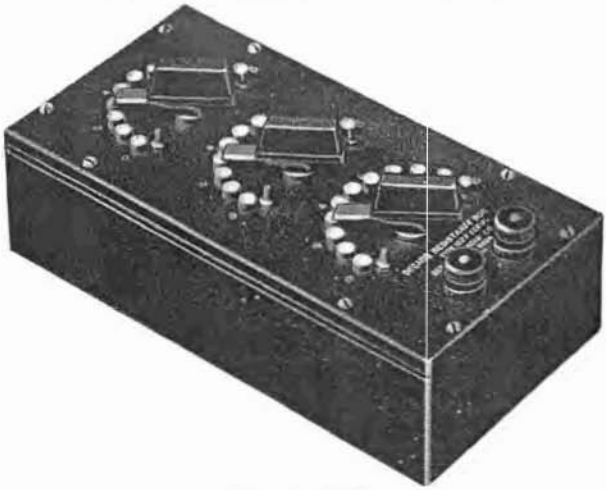
MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 211 NOVEMBER 1926

STANDARDS OF RESISTANCE AND DECADE RESISTANCE BOXES



Type 102F
DECADE RESISTANCE

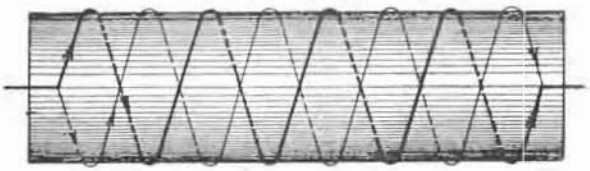
The first requisite for standards of all sorts is, of course, permanence; they must be unaffected by time and temperature.

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 coil 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	$24.00
102E	10 one ohm coils 10 ten ohm coils	DECRY	25.00
102H	10 ten ohm coils 10 one hundred ohm coils	DIVAN	28.00
102F	10 one-tenth ohm coils 10 one ohm coils 10 ten ohm coils	DELTA	32.00
102G	10 one ohm coils 10 ten ohm coils 10 one hundred ohm coils	DIGIT	35.00
102K	10 one-tenth ohm coils 10 one ohm coils 10 ten ohm coils 10 one hundred ohm coils	DEFER	47.00
102J	10 one ohm coils 10 ten ohm coils 10 one hundred ohm coils 10 one thousand ohm coils	DEBIT	53.00
102L	10 ten ohm coils 10 one hundred ohm coils 10 one thousand ohm coils 10 ten thousand ohm coils	DECAY	95.00

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.

Dimensions 3¾" x 2½". Weight 12 oz.

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	$7.00
133B	5 Ohm	100MA	REFER	7.00
133C	10 Ohm	100MA	REGAL	7.00
133D	50 Ohm	50MA	RELAX	7.00
133E	100 Ohm	50MA	RELIC	7.00
133F	500 Ohm	50MA	REPAY	8.00
133G	1000 Ohm	50MA	REPEL	8.00
133H	10,000 Ohm	15MA	PASTY	12.00
133K	25000 Ohm	15MA	PASHA	25.00

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 208)

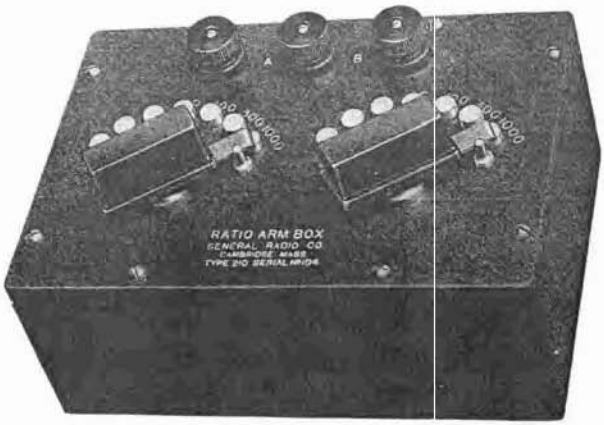
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 212 **NOVEMBER 1926**



Type 210
RADIO 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 211. 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.....$36.00

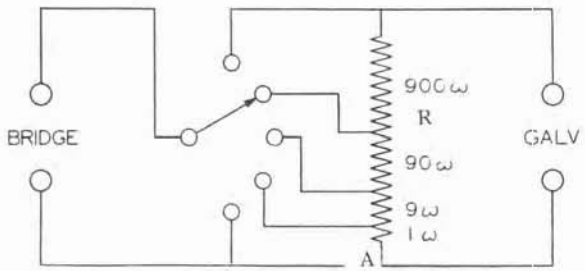
Dimensions 7½"x5"x4". Weight 2¼ lbs.

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 useful. 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 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..... $18.00

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. It 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.....$32.00

Dimensions 10¾" x 7⅝" x 5½". Weight 7 lbs.

Code Word "REBEL."

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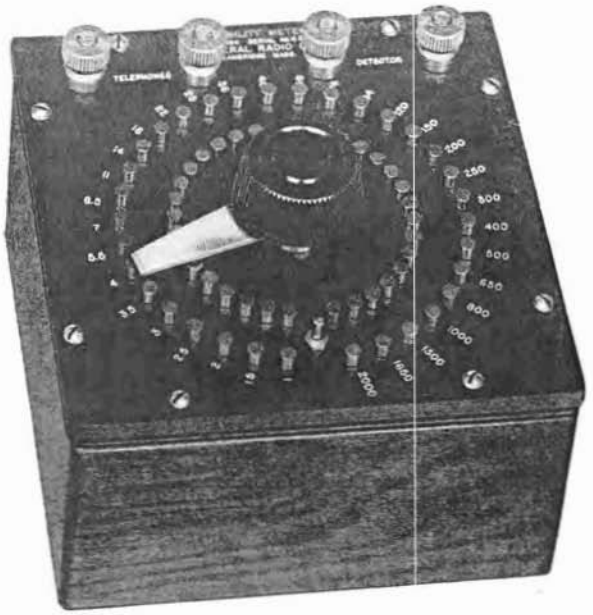
CAMBRIDGE, MASSACHUSETTS

BULLETIN 214 NOVEMBER 1926



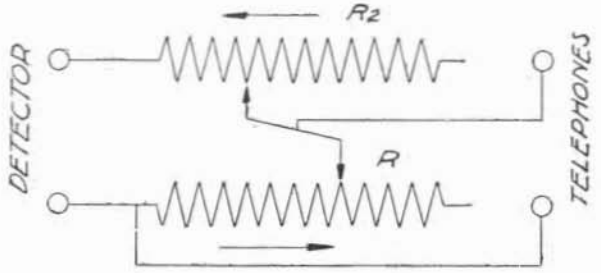
Type 164

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.



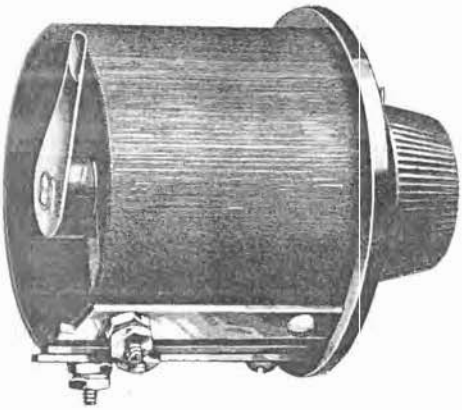
The Type 164 Audibility Meter is designed to keep the impedance of the oscillating circuit practically constant when used at 1000 cycles. It is adapted for use with any good 2000 ohm telephone receiver. This meter consists of two sets of resistance units with thirty-two taps and reads directly in audibilities 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.....$36.00

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 having a rating of 40 watts permits the combination of a high resistance with an unusually large current carrying capacity.

The Type 371 Potentiometer is made in the following ratings:

Res.	*Current*	*Code Word*
5 Ohms	2.8 Amp.	RELAY
900	21.0 MA	REDAN
2500	125 MA	REFIT
5000	90 MA	ROTOR
10000	65 MA	ROWDY
18000	50 MA	RULER

Type 371 Potentiometer..... $6.00

Dimensions 3½" x 3½", Weight 4½ oz.

In ordering, be sure to specify resistance desired.

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Standards of Inductance	Thermo-Couples	Variometers
Standards of Resistance	Hot Wire Meters	Capacity Bridge
Standard Condensers	Galvanometers	Decade Bridge
Variable Air Condensers	Vernier Condenser	Decade Condensers
Decade Resistance Boxes	Audibility Meters	Miscellaneous
Telephone Transformer	Wavemeters	Apparatus

All prices in this bulletin are strictly net, subject to change without notice, F. O. B. Cambridge, Mass. Cash should accompany orders from persons or firms with whom we have not already opened accounts. Unless otherwise instructed we shall use our own judgment regarding method of shipment.

(This Bulletin replaces Bulletin 213)

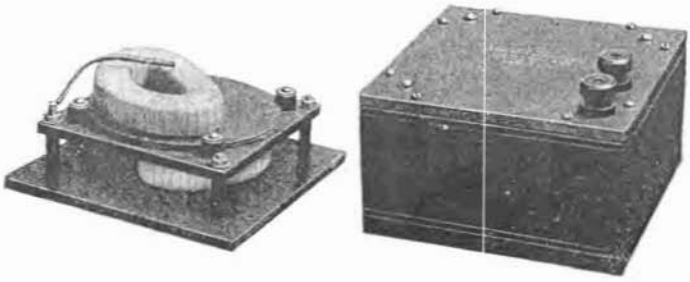
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 307 NOVEMBER 1926



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.

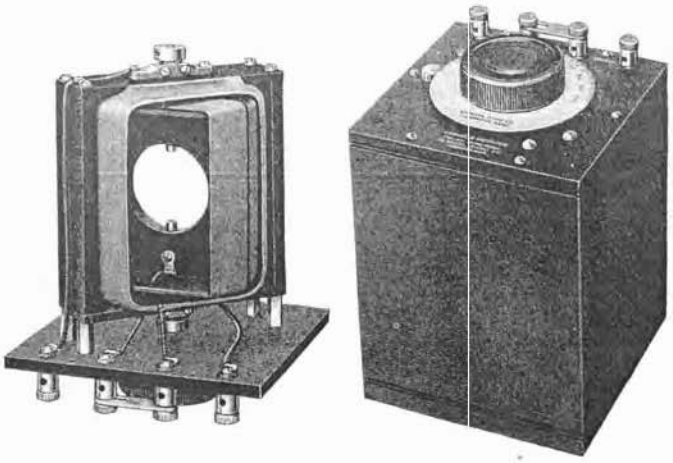
The Type 107 Variometer consists of two coils which are both sections of cylinders, one of which is slightly smaller than the other. The smaller coil is mounted within the larger in such a manner that it may be rotated about its vertical diameter. The connections of each coil are brought out separately 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. $24.00

Carries 3 amperes continuously.

Code Word "HAPPY."

Type 107G. About .10 to 4 M. H. $24.00

Carries ¾ ampere continuously.

Code Word "HARDY."

Type107H. About .4 to 18 M. H. $24.00

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. Information and bulletins of special apparatus will be sent on request. Our line includes the following: Variable Air Condensers, Standard Condensers, Decade Condensers, Variometers, Standards of Inductance, Standards of Resistance, Decade Resistance Boxes, Wavemeters, Decade Bridge, Capacity Bridge, Audibility Meter, Hot Wire Meters, Galvanometers, Thermo-Couple, Miscellaneous Transformers, Vacuum Tube Oscillator, Oscillograph, Piezo Oscillator, Miscellaneous Apparatus.

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(This Bulletin replaces Bulletin 306)

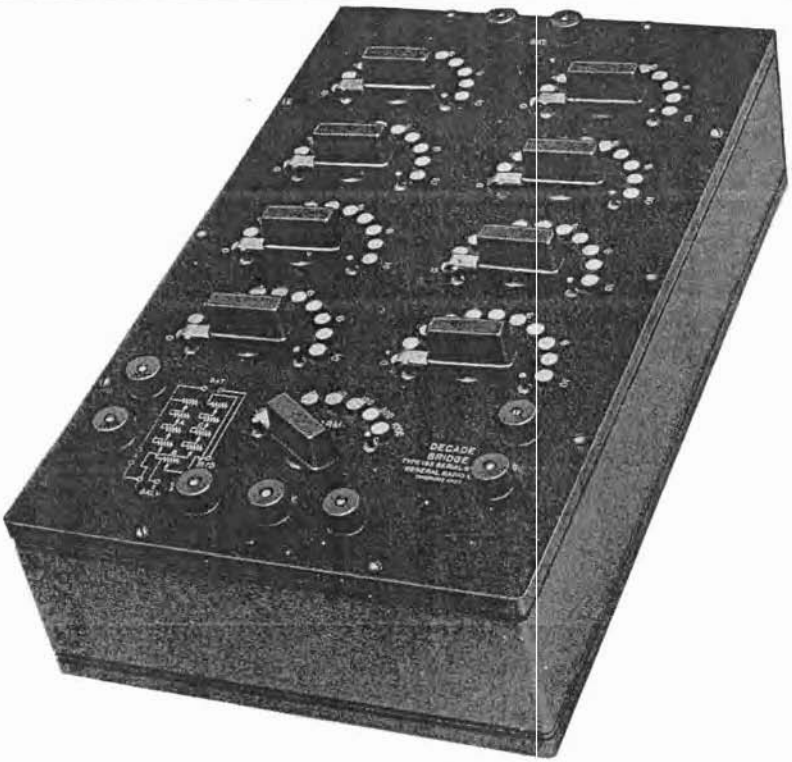
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 411 **NOVEMBER 1926**



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 211.

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:

$$Rx = R_A\, Rc/R_B$$

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:

$$Lx = R_A\, Ls/R_B$$

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

$$Rx = R_A\, (Rs + Rc)/R_B$$

if Rc was connected in the unknown arm or

$$Rx = R_A\, Rs/R_B - Rc$$

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:

$$Lx = R_A\, Rc\, C$$

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:

$$Cx = R_B C_S / R_A$$

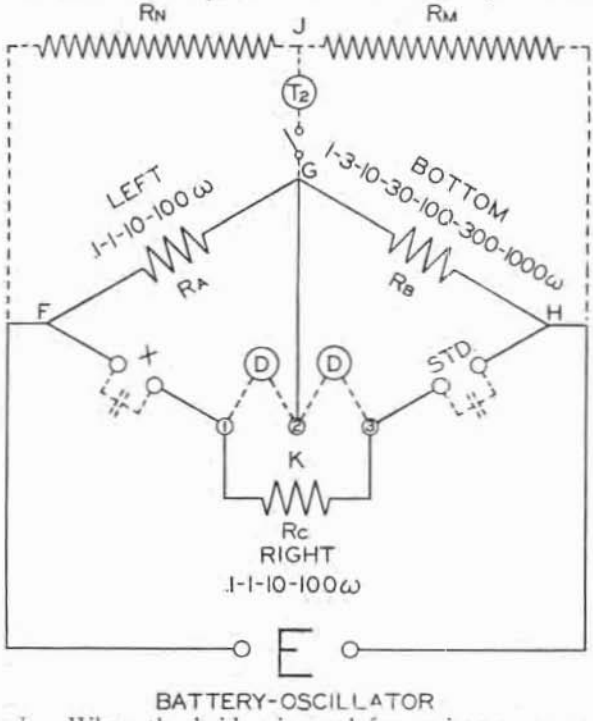
As before, the resistance balance gives the equation:

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

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

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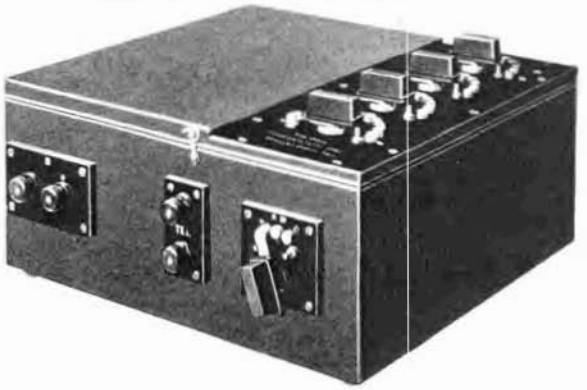


Type 216
CAPACITY BRIDGE

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.

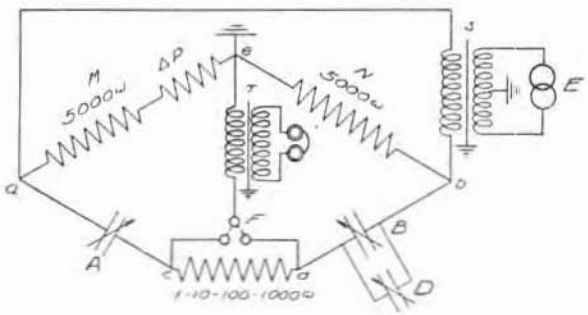
In order to isolate the bridge from stray capacity effects transformers with grounded shields between primary and secondary are used both at the input to the bridge and at the null detector.

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 $160.00
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 ..... $ 90.00
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. Information and bulletins of special apparatus will be sent on request. Our line includes the following: Variable Air Condensers, Standard Condensers, Decade Condensers, Variometers, Standards of Inductance, Standards of Resistance, Decade Resistance Boxes, Wavemeters, Decade Bridge, Capacity Bridge, Audibility Meter, Hot Wire Meters, Galvanometers, Thermo-Couple, Miscellaneous Transformers, Vacuum Tube Oscillator, Oscillograph, Piezo Oscillator, Miscellaneous Apparatus.

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(This Bulletin replaces Bulletin 409)

Standardize on General Radio Apparatus Throughout.

GENERAL RADIO COMPANY

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ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 414 **NOVEMBER 1926**

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

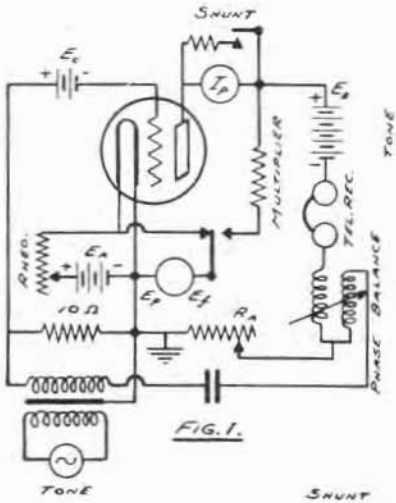


FIG. 1.

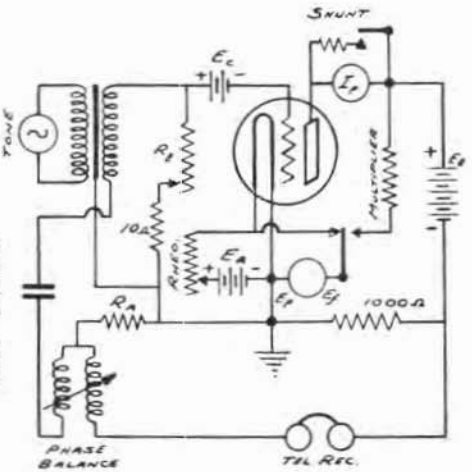


FIG. 2.

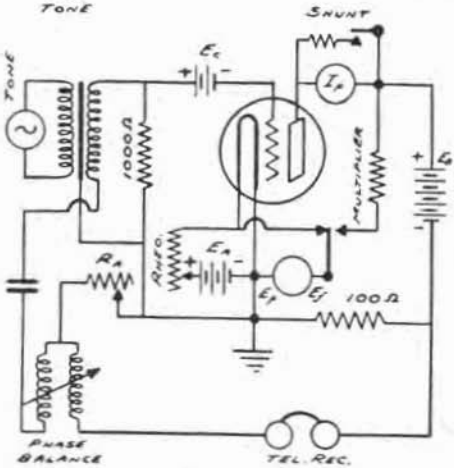


FIG. 3.

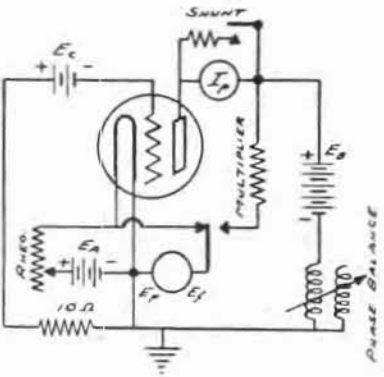


FIG. 4.

(UEg) resulting in the plate circuit from voltage (Eg) impressed on the grid. Minimum tone in the telephones indicates the balance point. Eg 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 $\times 10^{-4}$.

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.

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 $250.00

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 506 **NOVEMBER 1926**

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	$24.00
250 M. A.	6.8 "	EVOKE	Portable	22.00
500 M. A.	3.4 "	EXACT	Portable	22.00
1 amp.	1.2 "	EXCEL	Portable	22.00
2 amp.	.55 "	EXERT	Portable	22.00
3 amp.	.3 "	EXILE	Portable	22.00
5 amp.	.16 "	EXIST	Portable	22.00
10 amp.	.08 "	EXPEL	Portable	22.00
20 amp.	.04 "	EXTRA	Portable	22.00
Galvanometer	4.4 "	ETHER	Portable	21.00

Dimensions 4¾"x5"x3½". Weight 16 oz.

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. The quality and standards of Weston meters are so high and so well known that it is unnecessary to describe them in further detail.

Model 301
DIRECT-CURRENT VOLTMETERS

These meters are made for two general classes of service—low range, for determining the filament potential of vacuum tubes, and high range, for determining plate potentials. The most popular sizes are:

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

Plate and filament current measurements are as necessary as the corresponding voltage measurements. For this service the Model 301 direct-current ammeters are to be recommended. The most useful ranges are:

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. The Weston Model 425 thermo-ammeter has the same overall dimensions as the Model 301 direct-current meters. This unity in size and appearance greatly adds to the attractiveness of a completely equipped control panel. The Model 425 meters are made in the following sizes:

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

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. Information and bulletins of special apparatus will be sent on request. Our line includes the following: Variable Air Condensers, Standard Condensers, Decade Condensers, Variometers, Standards of Inductance, Standards of Resistance, Decade Resistance Boxes, Wavemeters, Decade Bridge, Capacity Bridge, Audibility Meter, Hot Wire Meters, Galvanometers, Thermo-Couple, Miscellaneous Transformers, Vacuum Tube Oscillator, Oscillograph, Piezo Oscillator, Miscellaneous Apparatus.

(This Bulletin replaces Bulletin 505)

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 507 **NOVEMBER 1926**

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

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE 39, MASSACHUSETTS

BULLETIN 716 **MARCH 1926**

TYPE 332

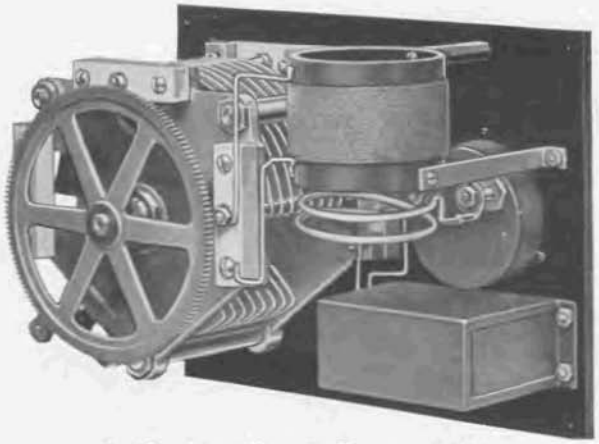
STATION FREQUENCY METER

Transmitting stations, such as broadcast stations, operating at a fixed frequency require a frequency meter of great precision at a fixed point.

The General Radio Type 332 Station Frequency Meter was developed for use by this class of station. It is not a fixed frequency indicator, but a frequency meter covering a limited band on each side of the station frequency. This type of meter offers considerable advantage over those having a single point indication in that it is possible to tell at any time how far off its frequency the station is operating, and whether it is above

or below its proper frequency. This greatly facilitates adjustment of the transmitter.

The instrument is of the usual wavemeter design, except that the range is small, extending about 5% of the station frequency on each side of the calibration point. A variable condenser of small maximum is shunted by a fixed condenser to get the required capacity. This device permits the use of an air condenser with very wide spacing without making the instrument bulky. Increasing the condenser spacing lessens the change in capacity under temperature variations.



Inside view of Station Frequency Meter

As a range of but 10% of the operating frequency is spread over the entire scale of the Type 332 Meter, the scale may be read directly to .1%. The station frequency is at the middle of the scale and is accurately set at our laboratory. The Bureau of Standards will also supply calibration on these meters if desired. The meter must be sent to the Bureau by the purchaser for this check.

When the meter is coupled to the oscillating circuit the resonance point is indicated by means of a thermo-ammeter.

The instrument is completely enclosed in a walnut case with leather carrying-handle. The hinged top is removable, so that the meter may be permanently installed.

USES

The Type 332 Station Frequency Meter is adapted for use as a control frequency meter for transmitting stations operating on a fixed frequency.

Its construction permits its installation on the operating desk, where the operator may have under his observation an indication of the transmitter frequency. When permanently installed the meter deflection will also give an indication of the power being developed in the oscillator.

The meter may be supplied with either wavelength or frequency calibration, but will be calibrated in frequency unless otherwise specified.

Type 332 Station Frequency Meter..... $170.00

Dimensions, 8½" x 10¾" x 8¼". Weight, 13 lbs.

Code Word: "SENNA."

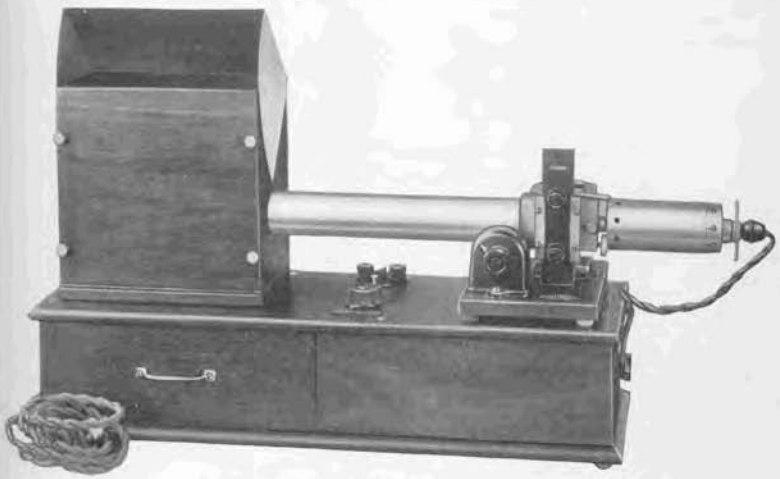
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE 39, MASSACHUSETTS

BULLETIN 717 **MARCH 1926**



TYPE 338
STRING OSCILLOGRAPH

In many lines of work and experimentation with alternating currents the need is frequently felt for a simple, sensitive, portable, and inexpensive oscillograph, with which one may view with ease either sustained wave forms or transient currents and voltages existing at any point in an electrical circuit or network. To meet this requirement the General Radio Company has designed a compact and moderately priced outfit which may be used for two distinct purposes:

1. As a string oscillograph which operates with much less power than is usually required by such instruments, but which affords a satisfactory means for the visual examination of wave forms over a wide range of frequencies. The wave of either current or voltage is traced by the shadow image of a very fine vibrating wire rather than by a spot of light reflected from a mirror attached to a moving system. The vibrating element can, accordingly, be made much lighter, resulting in an increased sensitivity of the instrument. The uses for such an instrument are manifold, as, for example: the observation of large or small alternating currents in the laboratory, power house, or class room; the visual examination of telephonic currents in simple or complicated circuits; the study of mechanical vibrations (when combined with some form of microphone or magnetophone) occurring in moving machinery, or in bridges or other

structures subject to intermittent stresses; etc. For many such lines of work the portable nature of the equipment is of especial value. If the oscillograph is connected in series with the loud speaker of a radio receiving set, an instructive and entertaining result will be obtained.

2. As a reliable vibration galvanometer, the string of which may be tuned to give a good degree of sensitivity at any desired frequency over a considerable range. In this respect the instrument is especially useful as a null point detector in A. C. bridge measurements when using low frequencies at which the telephone receiver becomes insensitive and otherwise unsatisfactory. As the galvanometer has no coil in the magnetic field, its reactance is practically nil when the string is not vibrating, a feature which is desirable for certain applications.

An idea of the sensitivity of the instrument may be obtained from the following data: Using a string of 0.0004 inch tungsten wire, undamped, and tuned to the fundamental of the applied A. C. frequency, the following potentials are required to produce a wave form having an amplitude of one millimeter:

At	60	cycles	0.2 millivolts
At	250	"	1.0 "
At	500	"	2.4 "
At	1000	"	8.5 "

The D. C. sensitivity of the same string when tuned at various frequencies is seen from the following data, which give the D. C. potentials required to give a deflection of one millimeter on the screen:

At	60	cycles	0.0047 volts
At	250	"	0.065 "
At	500	"	0.30 "
At	1000	"	1.31 "

The resistance of the instrument strung with the 0.0004 inch tungsten wire is of the order of 65 ohms.

The complete equipment of the string oscillograph comprises the following items:

1. A galvanometer, Type 338–20.
2. A rotating mirror box, Type 338–21.
3. An oscillograph base cabinet, Type 338–22.
4. A carrying-case, Type 338–12, for readily storing or transporting the instrument.
5. A convenient piece of auxiliary apparatus consists of an adjustable rheostat, Type 340, having a total resistance of 100,000 ohms. This, placed in series with the oscillograph, enables the same to be used with voltages up to 500.
6. Another useful piece of auxiliary equipment consists of a step-down transformer, Type 285-N, to adapt the oscillograph for efficient operation in high impedance circuits.

A motor-driven film camera is being developed to be used with this equipment.

The appearance of the outfit may be seen from photograph. A walnut base cabinet serves to support and properly align the parts. In

the left portion of this is a drawer for holding spare string mountings and other equipment.

The galvanometer is mounted upon the right-hand end of the cabinet. It is sensitized by two permanent magnets, thus eliminating the need of a source of direct current for producing the necessary magnetic field. Two specially shaped pole pieces afford a long, narrow, vertical gap in which the string vibrates, and at the same time serve to support the optical system, which consists of a large and a small condenser lens, together with a microscope objective. The large lens and the standard automobile headlight bulb used are located in the lamp chamber seen on the extreme right, while the two small lenses are located within a tube passing through the pole pieces. All three lenses are adjustable along the optical axis, while the lamp is adjustable in three dimensions. This makes it easy to focus the system to give a uniform field of illumination. A thumb-screw, located on the left end of the lamp chamber, slides the optical system as a whole with reference to the string and thereby focuses the shadow image of the same upon the observing screen.

The string is mounted upon a metal rocker arm, which, in turn, is attached to the rear of a vertical bakelite strip, shown in the photograph. Two adjustment screws will be seen protruding through the front of this strip. One of these varies the tension on the string while the other serves to move the string across the light beam in order to center the image on the screen. Provision is made for damping the vibration of the string, if desired, by means of two drops of oil. The whole string assembly is readily removable, electrical contact being made through two springs on the galvanometer base. Two string mountings are provided with the equipment, one strung with a very fine tungsten wire about .0004 inch in diameter, while the other is strung with a coarser wire. These strings, which are each 4½ inches in length, may be considerably overloaded without damage. As they carry no mirror their replacement, if accidentally broken, is a comparatively simple operation.

On the left of the galvanometer base is mounted an enclosed potentiometer for adjusting the potential applied to the string, and hence controlling the amplitude of vibration.

On the left of the cabinet is mounted the mirror box, which is likewise made of walnut. This contains a rotating octagonal metallic mirror which affords the necessary time element of linear motion perpendicular to the vibration. The mirror is mounted on the shaft of a small induction motor and is provided with jewelled bearings. This motor is of simple construction, consisting of a circular disc, the periphery of which passes through a gap in a rectangular, laminated core. The core is energized by a high impedance coil carrying a 60-cycle current and is surrounded by two copper rings acting as "shading coils" around one half of the cross section of each pole. The unsymmetrical distortion of the resulting field affords the driving torque. This motor is not inherently synchronous, as its speed may be controlled over a wide range merely by varying the voltage impressed on the energizing coil. This is done by means of a potentiometer, the knob of which is seen in the center of the cabinet. A very constant speed of any desired value may be maintained

in this manner, which makes it easy to synchronize the motor to any frequency impressed on the string, producing thereby a stationary wave pattern. For observing transient phenomena of some duration, it is desirable to have the mirror run quite slowly, while the maximum speed of the motor is necessary to separate the individual wave forms at the higher frequencies. The 60-cycle wavelength at maximum speed is from 2½ to 3 inches, giving a wavelength of about 1/16 inch at 3000 cycles.

A screen bent on the arc of a circle is seen by looking down into the box, which is provided with an adjustable metallic cover that serves as a hood for shielding the screen when desired. The observer may stand at some distance from the screen and still watch the wave form while manipulating other apparatus. This is a convenient feature. A cylindrical lens is mounted in the mirror box for concentrating the light beam into a narrow line. This sharpens and intensifies the image considerably. The front vertical wall of the mirror box is easily removable for inspection and adjustment of the enclosed parts.

Terminal posts, together with a cord and plug, are provided for attaching the equipment to a source of 60-cycle, 110-volt current which may conveniently be turned on or off by a small plunger switch mounted on the center portion of the cabinet. This is the only source of power required, as the lamp is lit through a step-down transformer mounted in the cabinet. The whole outfit takes about 40 watts.

The cabinet contains a 3 MF. paper condenser which is frequently useful for eliminating a D. C. component from the string.

An aluminum tube connecting the galvanometer with the mirror box is sometimes a help in reducing extraneous illumination of the screen.

When the outfit is desired for use only as a vibration galvanometer it may be procured without the mirror box, but provided with a longer tube having a small translucent screen for observing the image of the vibrating string. In front of this is a small cylindrical lens for concentrating the light beam and intensifying the image. A metallic support is provided for the outer end of this tube.

Galvanometer, Type 338–20	$80.00
Mirror Box, Type 338–21	60.00
Cabinet, Type 338–22	40.00
Carrying-Case	20.00
Type 338 Oscillograph, with Carrying-Case	$200.00

Dimensions, 30″ x 11″ x 17″. Weight, 61 lbs.

Code Word: "OFFER"

Type 338–20 Vibration Galvanometer Equipment, with Carrying-Case	$140.00

Dimensions, 30″ x 11″ x 17″. Weight, 53 lbs.

Code Word: "OFTEN"

Rheostat, Type 340	$14.00
Transformer, Type 285-N	10.00

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE 39, MASSACHUSETTS

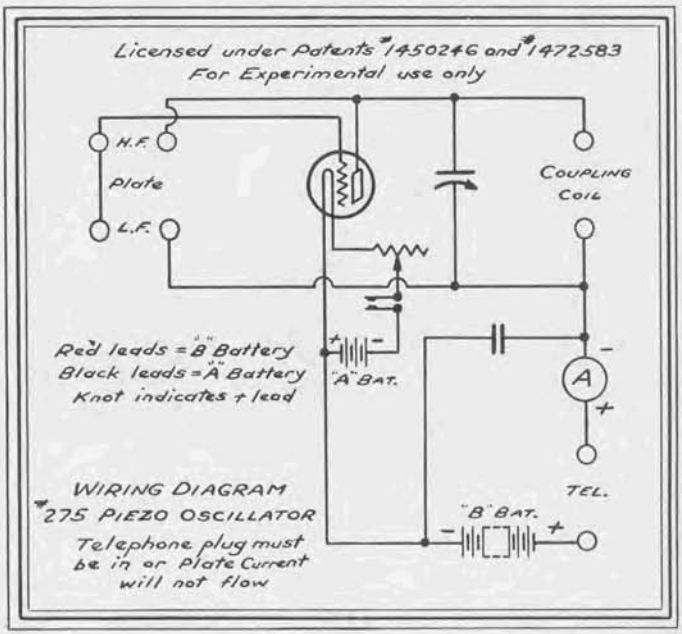
BULLETIN 718 **MARCH 1926**

TYPE 275
PIEZO ELECTRIC OSCILLATOR
TYPE 276—QUARTZ PLATE

The piezo electric properties of crystalline quartz make it particularly well adapted for use as a frequency standard. Plates of this material when properly prepared, and placed in the circuit shown on page 768, will hold the frequency to extremely minute variations. The oscillating frequency is independent of the electrical constants of the circuit. The frequency is entirely dependent on the physical dimensions of the quartz plate which may be ground very closely to specifications. The frequency is practically unvarying with temperature and is not affected by any mechanical shock which does not fracture the plate.

The General Radio Company, working in conjunction with Dr. W. G. Cady and Dr. G. W. Pierce, has developed a commercial application of this principle.

The instrument is entirely self-contained and consists of the components shown in the wiring diagram below, mounted in a suitable cabinet which includes all necessary batteries. As the plate mounts on the front of the panel with a plug-in arrangement, plates may be readily exchanged in order to extend the frequency range. The tuned circuit must be adjusted approximately to the frequency of the quartz plate, or the system will not oscillate. The system will oscillate only at the frequency determined by the plate, and not at the frequency of the tuned circuit. The coil is mounted externally and is suitable for coupling to other apparatus.



The oscillator circuit is shown above. A UX-199 tube is used as an oscillator. The meter, mounted on the front of the panel, indicates when the circuit is oscillating. A pair of telephones or similar high impedance must be connected at the plugs marked "TEL." The Quartz Plate is plugged in, either at H.F. or L.F., depending on the frequency at which it is to oscillate. In general, plates for frequencies higher than 500 K.C. should be used in the H.F. mounting. Reasonable care should be taken in handling the plates, as they will fracture if subjected to too great a mechanical shock.

Limits are imposed on the fundamental frequencies for which it is possible to provide plates by physical conditions. The lower frequencies require a very large plate, while for the higher frequencies the plates

become very thin, difficult to handle, and fragile. The practical limits at present are about 100 and 1500 kilocycles. Lower and higher frequencies are readily obtained from these fundamentals, as the oscillator output is rich in harmonics.

Where it is desired to use the weaker harmonics of the plate, an oscillating vacuum tube is coupled to the oscillator output. The auxiliary oscillator may then be tuned to the harmonics of the quartz-controlled tube by the beat method. Harmonics as high as the thirtieth may be made use of by this method. Lower frequencies than the fundamental may also be obtained by means of the auxiliary tube. The auxiliary tube is adjusted to the lower frequency by tuning it for dead beat between its harmonic of the desired order and the quartz-controlled oscillator. By means of this device, a single plate may be used to obtain a great number of frequencies.

QUARTZ PLATES

Three classes of plates are provided. Where a wavemeter standard is desired, and the exact points of calibration are immaterial, a plate can be provided without grinding. Plates of this class are provided with the usual mounting, and the fundamental frequency measured to 0.1%, engraved on the cover. They can usually be supplied within 25% of any specified frequency within the above range. By making use of harmonics, one plate may be used for a number of calibration points. Where a closer approximation to a specified frequency is desired, plates may be provided within 5% of the required frequency. Where the requirements are still more rigid, plates may be ground to within 0.1% of the specified frequency.

The entire instrument is enclosed in a walnut cabinet, containing all batteries. The price includes batteries and tubes, coupling coil, and one plate.

USES

In the General Radio Type 275 Oscillator the principle of frequency control by the use of quartz crystals has been made available for general experimental use. The 275 Oscillator is intended primarily as a frequency standard. As such it offers numerous advantages over the ordinary standard wavemeter as a primary standard. The entire equipment is considerably less bulky than the wavemeter, and the essential standard of frequency, the quartz plate, is of vest-pocket dimensions. The frequency is affected only by some change in the physical dimensions of the plate or in the holder clearances. The development of a small, reliable frequency standard suggests the possibility of uniform frequency standards, provided by a central laboratory, ending the present interference between stations due to a difference in standards.

Licensed under U. S. Pats. Nos. 1450246 and 1472583 for experimental use only.

Dimensions, 10″ x 11″ x 8″. Weight complete, 19 lbs.

Prices:

Oscillator complete with one plate	$115.00
Oscillator complete with one plate ground to specified frequency	145.00
Plates, mounted, each	30.00
Plates, mounted ground within 5% of specified frequency	40.00
Plates, mounted ground to specified frequency	60.00

This Bulletin replaces Bulletin No. 715.

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 803 **NOVEMBER 1926**

TYPE 377

LOW FREQUENCY OSCILLATOR

Many forms of electrical and physical research problems require a source of alternating current of good wave form and variable over a wide range of frequencies. The properties of the oscillating vacuum tube make it inherently adapted for use as such a source.

In consequence of a licensing agreement with the Radio Corporation of America, the General Radio Company is now able to supply such an oscillator for laboratory use.

The Type 377 Vacuum Tube Oscillator has a frequency range of from 60 to 75,000 cycles, extending through the audio and carrier frequency ranges into the lower radio frequencies. The simplified circuit of the oscillator is shown in Fig. 1. The frequency of the oscillating tube (left) is controlled by tuning the plate circuit. The output of the oscillating tube is fed through a coupling potentiometer to the amplifier tube (right). The plate of the amplifier tube connects direct to the output terminals. The parallel feed system of plate supply is used on both tubes.

The front panel assembly of the oscillator is shown on the first page of this bulletin. The meters are so equipped with switching arrangements that filament or plate voltage and oscillator or amplifier plate current may be read. The two switches directly under the meters are the transfer switches.

The output of the oscillator is adjustable and may be held constant over the frequency range by means of the potentiometer coupling to the amplifier tube. The resistance marked FEEDBACK is in the plate of the oscillator tube, and controls oscillation. For most satisfactory wave form the feedback control should be set at the point at which the tube just begins to oscillate.

The frequency is continuously variable by means of the seven controls on the lower part of the panel. There are three coils so tapped as to give six switch positions, and a decade capacity system extending from .001 MF. to 10 MF. An air condenser with maximum of 0.0011 MF. makes the capacity system continuously variable.

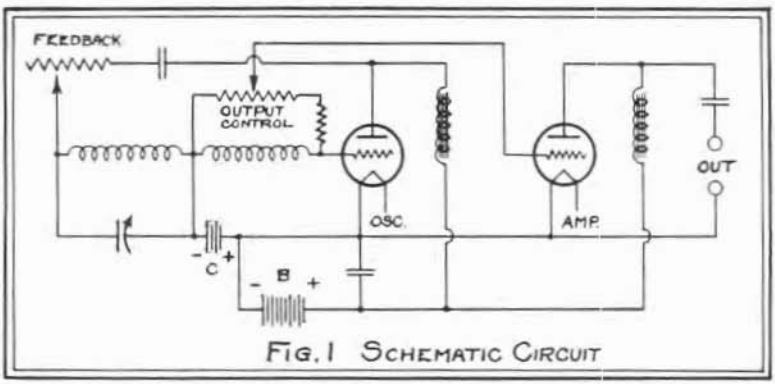


FIG. 1 SCHEMATIC CIRCUIT

An approximate calibration giving the settings of the controls at frequency intervals of about ten per cent for the entire frequency range is provided with each instrument.

The oscillator is intended to be used with either UV-201A, UX-112 or UX-210 tubes. For average use the UX-112 type will be found satisfactory.

The wave form of the oscillator output is very closely sinusoidal. The largest single harmonic component in the voltage wave is of the order of two per cent. Where particularly good wave form is required, it is advisable to use tubes of the UX-210 type. Load does not affect wave form unless the amplifier tube is overloaded. The load will not affect the frequency, as it is not applied directly to the oscillating tube.

Frequency does not vary more than one per cent under ordinary variations in tube conditions.

The power output of the instrument will vary with the plate voltage and the type of tube. With a UX-210 tube, the output is about .2 watt with 120 volts on the plate and about .5 watt with 220 volts on the plate.

The entire oscillator is mounted in a sturdy oak cabinet with sub-

stantial brass carrying-handles and clasp. The panel swings outward, giving easy access to the instruments, all of which are mounted on the back of the panel.

INSIDE VIEW OF LOW FREQUENCY OSCILLATOR

Battery and output connections are carried through holes in the cabinet and made to the back of the panel. No external binding posts appear. The cabinet is strong enough so that the oscillator may be hung from a wall by means of bolts through the back of the cabinet if desired.

Space sufficient for five blocks of plate batteries of the 3¼" x 2¾" x 5⅝" size is provided in the cabinet, providing 112.5 volts.

USES

The low-frequency oscillator will be found of great use in all measurement work at audio, carrier and low radio frequencies. Among its uses are bridge measurements of all kinds, studies of the response curves of transformers and loudspeakers, and the study of filter characteristics, and studies of cable and other dielectric behavior.

Other vacuum tube oscillators are under development.

Oscillators for special ranges and single frequencies (for laboratory use only) will be provided to the customer's order.

Type 377 Low Frequency Oscillator $400.00

Licensed under Pat. No. 1113149, for radio laboratory experimental use only where no business features are involved.

Dimensions, 19⅛" x 18" x 10½". Weight, 50 lbs.

Code Word: "OMEGA."

The products of the General Radio Company cover a complete line of radio and electrical laboratory apparatus. Information and bulletins of special apparatus will be sent on request. Our line includes the following:

Standards of Inductance	Thermo-Couples	Variometers
Standards of Resistance	Hot Wire Meters	Capacity Bridge
Variable Air Condensers	Galvanometers	Decade Bridge
Decade Resistance Boxes	Oscillograph	Decade Condensers
Telephone Transformer	Audibility Meters	Vacuum Tube Oscillators
	Wavemeters	

All prices in this bulletin are strictly net, subject to change without notice, F. O. B. Cambridge, Mass. Cash should accompany orders from persons or firms with whom we have not already opened accounts. Unless otherwise instructed we shall use our own judgment regarding method of shipment.

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 804 **DECEMBER 1926**

MISCELLANEOUS TRANSFORMERS

There are many instances in radio and telephone work where circuits of different impedances are coupled together, requiring some form of impedance adjusting device.

The General Radio Company manufactures an extensive line of impedance adjusting units for various requirements. These include both fixed ratio transformers for specific needs and variable ratio transformers for laboratory use which may be adapted to a wide range of circuit impedances.

VARIABLE RATIO TRANSFORMERS

For general laboratory purposes a transformer of variable ratio is frequently convenient. Such a transformer may be connected in circuit and the ratio adjusted until the maximum energy transfer is obtained.

The Type 359 Transformers are provided in several models, each having a power rating of 25 watts. The ratio is varied on all types by means of the switch, as illustrated. The primary coil in each case is fixed, while the secondary may be adjusted to step down (ratios less than unity) or to step up (ratios greater than unity) the impedance.

Types 359A to 359D inclusive are adapted for working out of circuits having impedances of from 6000 to 20,000 ohms, at frequencies above 60 cycles. Types 359E to 359H inclusive are designed to give the same variable ratios with the primary working out of circuits having an impedance of the order of 600 ohms. Types 359C, D, G and H are auto transformers, while Types 359B, E and F have separate primary and secondary windings. They are provided with terminals to fit the Type 274 plug, a convenient feature which facilitates circuit changes.

Type 359A Transformer
Turns ratio (sec. to pri.) 0.025, 0.35, 0.5, 0.7, 1.0, 1.4.
Type 359B Transformer
Turns ratio (sec. to pri.) 0.06, 0.09, 0.13, 0.18, 0.25, 0.35.
Type 359C Auto Transformer
Turns ratio (sec. to pri.) 0.025, 0.35, 0.5, 0.7, 1.0, 1.4.
Type 359D Auto Transformer
Turns ratio (sec. to pri.) 0.06, 0.09, 0.13, 0.18, 0.25, 0.35.

Types 359A to D inclusive are designed to work out of circuits having impedances of from 6,000 to 20,000 ohms.

Type 359E Transformer
Turns ratio (sec. to pri.) 0.025, 0.35, 0.5, 0.7, 1.0, 1.4.
Type 359F Transformer
Turns ratio (sec. to pri.) 0.025, 0.35, 0.5, 0.7, 1.0, 1.4.
Type 359G Auto Transformer
Turns ratio (sec. to pri.) 0.025, 0.35, 0.5, 0.7, 1.4.
Type 359H Auto Transformer
Turns ratio (sec. to pri.) 0.06, 0.09, 0.13, 0.18, 0.23, 0.35.

Types 359E to H inclusive are designed to work out of circuits having impedances of 500 to 600 ohms.

Direct current (primary) resistance all types 400 ohms.

Type 359 Transformers..... Price $15.00

Dimensions 4¼" x 3⅝" x 4½".

The Type 284 transformers are designed for remote control and line amplifier work. Their power rating is 20 watts.

Type 284C Double or Single Microphone to Grid Coupling Transformer.

This transformer is designed for coupling a microphone of either the single or double button type to the grid of the modulator tube.

Type 284D Plate to Telephone Line Coupling Transformer.

A transformer designed to work out of the plate of a vacuum tube into the standard telephone line (500-600 ohms impedance).

Type 284E Telephone Line to Grid Coupling Transformer.

A coupling unit for working out of the low impedance of a telephone line into the high impedance grid circuit of a vacuum tube.

Type 284F Plate to Grid Coupling Transformer.

An interstage coupling transformer for use where good quality is essential. The power rating is double that of our standard Type 285.

Type	Turns Ratio	Impedance Ratio	Resistance (ohms) Pri.	Sec.
284C	1:104	1:10,600	4	14,000
284D	6.3:1	40:1	340	18
284E	1:41	1:1700	18	14,000
284F	1:6.5	1:42.5	340	14,000

Type 284 Transformers ..... Price $12.00

Dimensions 4½" x 3½" x 2¾". Weight 2¼ lbs.

Type 285M Single Microphone to Grid Coupling Transformer.

Similar to the type 284C, but designed for use with a single bottom microphone. The power rating is 10 watts.

Turns ratio 1:44.5. Impedance 1:2000.

Dimensions 3½" x 3¼" x 2½". Weight 1½ lbs.

Type 285M ..... Price $7.00

Type 285T is designed for use between circuits having approximately the same impedance, in the neighborhood of 500 to 600 ohms where it is desired to insulate such circuits from each other, as when direct current flows in one, and is undesirable in the other.

Impedance Ratio 1:1.

Dimensions 3½" x 3¼" x 2½". Weight 1½ lbs.

Type 285T ..... Price $7.00

The Type 285N is designed to adapt the elements of the Type 338 Oscillograph to bridge circuits.

Ratio—Turns 18:1; Impedance 325:1.

Dimensions 3½" x 3¼" x 2½". Weight 1½ lbs.

Type 285N ..... Price $10.00

POWER TRANSFORMERS

Small power transformers are frequently required about the laboratory. The following types are available. The power rating of all types is 60 watts:

Type 273 Transformers ..... Price $12.00

Type 273K.	Pri. 110	Sec. 200—6.5—5	volts
Type 273M.	Pri. 110	Sec. 480—7.5—7.5	volts
Type 273L.	Pri. 110	Sec. 150—7.5—6	volts

Dimensions 3¼" x 3¾" x 3½". Weight 3¾ lbs.

Type 285 0. 110—9.6 volts (10 watts) ..... Price $7.00

Dimensions 3½" x 3½" x 2½". Weight 1½ lbs.

A number of other transformers will be found listed in Bulletin No. 926. They include small power transformers, iron cored chokes, coupling transformers, and filters for use between the plate of various types of vacuum tubes and loudspeakers.

Special transformers, both power and impedance adjusting, may be made to order along the lines of those listed above. The usual price for such special transformers is $15.00 each net.

The Engineering Department of the General Radio Company would be glad to determine specifications for any such transformers designed to serve any particular purpose.

Type 166

TELEPHONE TRANSFORMERS

For many purposes in a laboratory a small iron core transformer of high and adjustable impedance is extremely useful. It may be used to advantage in impedance bridges employing a telephone receiver to detect the balance point. With this transformer it is possible to adjust the impedance of the telephone circuit to the most satisfactory value for the bridge circuit, independent of the telephone receiver impedance.

The winding is all on one leg of the core, but is in two separate parts so as to be used as a primary and secondary. These windings, however, may be connected in series should it be desired to use an auto transformer connection. Taps are brought out on both the primary and secondary windings so that it is possible to vary the impedance and the ratio of transformation. A small air gap is left in the iron core to prevent any possible distortion of wave form due to saturation of the iron. The panel is of bakelite with engraved lettering. Nickel plated binding posts are used as terminals for the taps. The following table shows the number of turns between each set of binding posts:

PRIMARY		SECONDARY	
1-2	150 Turns	5-6	1200 Turns
2-3	300 Turns	6-7	2400 Turns
3-4	600 Turns	7-8	4800 Turns

Type 166 Telephone Transformer $9.00

Dimensions 2¾" x 2½" x 2¼". Weight 2 lbs.

Code Word "TOPIC."