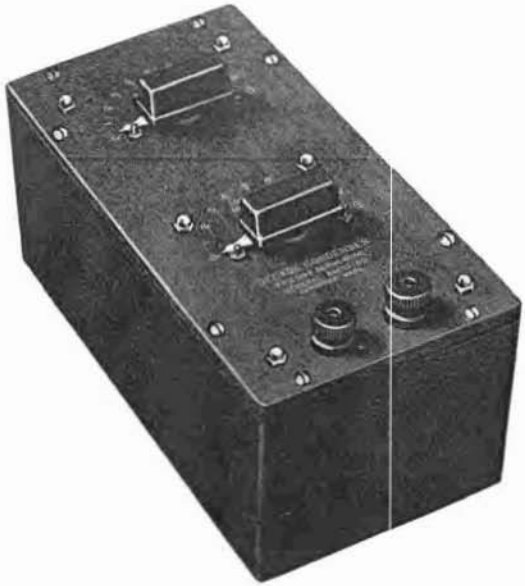
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 108 JANUARY 1925



Type 219F
DECADE CONDENSER

It is often as necessary to have an adjustable decade condenser for laboratory work as it is to have a decade resistance box. The utility of such a condenser is greatly reduced if it is necessary to open and close switches or to remove plugs to vary its capacitance. The condenser should have the same flexibility as a decade resistance box.

This feature of flexibility has been accomplished by the use of a sector switch, thus enabling the capacitance to be varied in the same easy manner as is done in our decade resistance units. The setting of the switch is definite, being determined by a ball and socket locking combination, The capacitance in microfarads is read directly opposite the end of the switch pointer.

In the 219F unit we have a two-dial combination giving a total capacitance of 1.1 microfarads. Each dial has ten steps, the lower dial of .01 microfarad each and the upper dial 0.1 microfarad each. This makes the range of the condenser from .01 microfarad to 1.1 microfarads adjustable in steps of .01 microfarad.

The condenser units are our specially wound, low-loss paper condensers adjusted with an accuracy of 2 per cent. Each condenser is separately mounted and is independent of the others of the unit. As these condensers are sealed in metal cases they cannot become loose or damaged. They will stand potentials of 300 volts. The complete unit is mounted in an attractive walnut case with bakelite panel.

This condenser is particularly useful in filter or oscillating circuits. It is, in fact, an excellent all-round laboratory instrument.

Type 219F Decade Condenser.....$50.00

Dimensions 10" x 5" x 5¾". Weight 6½ lbs.

Code Word "COVER."

Type 239
VARIABLE AIR CONDENSER

The recent studies of dielectric losses have brought out forcibly the necessity for giving much attention to these losses in condenser design. Their importance has been further emphasized by the requirements of vacuum tube oscillating circuits. Such circuits demand for sharp resonance that these losses be kept a minimum. Condensers which might be adequate for crystal receiver circuits would be quite unsatisfactory for use in vacuum tube oscillating circuits.

Where great precision is required, there is available our Type 222 precision condenser. Because of its necessarily elaborate design, however, it is not suitable for installation in radio sets or for general laboratory use. It is a precision standard. In order to have available a condenser which would meet the general laboratory requirements and the rigid requirements of carefully designed radio sets, we have developed the rugged, low-loss condenser shown in the cut. This condenser is similar in general design to our precision condenser. It has metal end plates, locked cone bearings and is rigidly supported. The only solid dielectric material used is in the form of supporting strips for the fixed plates. These strips are of carefully selected hard rubber, and are

placed in a weak and uniform electrostatic field. This enables us to keep the losses at a minimum. The equivalent series resistance is but 12 ohms at a frequency of 1000 cycles and a capacitance of 1000 micro-microfarads. This very low loss enables oscillating circuits to be tuned very sharply. This condenser will stand potentials up to 800 volts.

The rotary plates are grounded in order that capacity effects of the hand when adjusting the condenser may be reduced to a minimum. The plates are of heavy aluminum and are so shaped as to give a nearly uniform wavelength variation. This is particularly important when the condensers are to be used in wavemeters or radio receiving sets.

All types of this condenser are provided with a counterweight and when so desired, may be equipped with a slow-motion gear so that settings to a fraction of a division on the scale may be obtained with ease. This is a distinct advantage when tuning to continuous wave stations.

When mounted, the condenser is provided with walnut case, engraved hard rubber panel and a three inch silvered dial divided into one hundred divisions.

Type 239E 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 239G 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 4½″ x 4¾ ″ x 6″. Weight 2 lbs.
Code Word "BASAL."

Type 239J 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 239L 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."

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[This Bulletin Replaces Bulletin 107]

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GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

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Type 169

VERNIER CONDENSER

The increasing use of vacuum tube oscillating circuits where resonance is very sharply defined has created a demand for a variable condenser of small capacitance. Very often a movement of less than a single division on the ordinary variable air condenser will go beyond the resonance point. The Type 169 Vernier Condenser has been designed to go in parallel with the ordinary variable condenser so as to obtain a very fine adjustment. The spacing of the terminals is so arranged that this condenser may be slipped directly across the binding posts of any of our other condensers, thus permitting a parallel connection without using connecting wires.

The stationary plate may be varied in distance from the moving plate, thus permitting a variation in maximum capacitance from about .5 to 10 micromicrofarads. A hard rubber extension handle is provided to avoid effects from placing the hand too near the condenser.

This condenser is also useful in making measurements of very small capacitances, such as are possible with our Type 216 Capacity Bridge.

Type 169 Vernier Condenser..... $8.00

Dimensions 5½″ x 4¼″ x 2¾″. Weight ¾ lbs.

Code Word "CUBBY"

Type 246
VARIABLE AIR CONDENSER

The condenser shown above meets the need for a laboratory type of condenser less expensive than our Precision Condenser, Type 222, but possessing the same characteristics of premanency of calibration and low power loss, necessary in secondary standards of capacity. The permanency of calibration is assured by the heavy plates, the cone bearings whose adjustment is locked and by the general rugged construction. The low effective resistance is due to advanced engineering design, utilizing rotor plates grounded to the frame and stator plates supported by porcelain insulators. This type of construction is similar to that used in the practically resistanceless variable standards of capacity of the Bureau of Standards.

There is no change in capacity with frequency. The temperature coefficient is practically zero. The solid dielectric in this condenser is not only of small volume, and carefully selected, but is placed in a weak electrostatic field. Since this field does not vary with the position of the rotating plates, it may be assumed that the condenser is the equivalent of two parallel condensers, one being a perfect condenser of variable capacity, the other, a fixed condenser with which is associated all the power loss. This fact is very important when the condenser is used in measuring dielectric losses in connection with our Type 216 Capacity Bridge.

Accurate adjustment of capacity is made easy by the small knob which drives the main shaft through reduction gearing. There is no trouble due to variation of stray capacities by the operator's hand because the rotor plates are grounded to the frame. Laboratories find that this Type 246 Condenser satisfactorily meets the constantly arising demand, in radio and general laboratory work, for a variable condenser of considerable capacity range, low power factor and permanent capacity. Some of its uses are given below.

USES. As a laboratory standard of capacity, in bridge measurements of condenser resistance, in any low resistance tuned circuit, in measuring the resistance of antennas, inductances and condensers at radio frequencies, and in any place where a high grade laboratory condenser can be used.

LOSSES. In all Type 246 Condensers at 1500 MMF. the power factor is about .005%; the resistance at 1000 cycles is about 12 ohms and at 300,000 cycles (1000 meters) the resistance is approximately .018 ohm.

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 worn 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 aluminum 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

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GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE 39, MASSACHUSETTS

BULLETIN 209 **JANUARY 1925**

Type 210
RATIO ARM BOX

For many laboratory measurements such as Wheatstone bridge or impedance bridge measurements, when a complete bridge is not available, it is very convenient to have mounted in one unit suitable resistances which may be used as ratio arms. Such an arrangement is also convenient for comparing capacitances, without the use of a compensating resistance, where errors of the order of one or two per cent are permissible.

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 207. 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″ x 5″ x 4″. Weight 2¼ lbs.

Code Word "RABID."

Type 229
UNIVERSAL GALVANOMETER SHUNT

When indicating a bridge balance by means of a galvanometer, it is desirable to have a shunt for protecting the galvanometer during the preliminary adjustments. A calibrated shunt is also desirable for extending galvanometer ranges when used for the measurement of small currents. The most convenient type of a galvanometer shunt for general laboratory use is the Ayrton-Mather Universal type. The relative multiplying factors of this shunt remain constant for any resistance galvanometer.

Our Type 229 Galvanometer Shunt is arranged in accordance with the Ayrton-Mather principle and has a total resistance of 1000 ohms. Taps are arranged to permit a reduction of the galvanometer current to .001-.01-.1 of the maximum. A short circuit point is also provided to give complete protection to the galvanometer when so desired. The control is by means of our standard bridge type of dial switch.

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

Type 229 Universal Galvanometer Shunt.....$18.00

Dimensions 5″ x 3½″ x 3½″. 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 interfering with neighboring stations. The Type 125 Phantom Antenna Resistor is provided for this purpose.

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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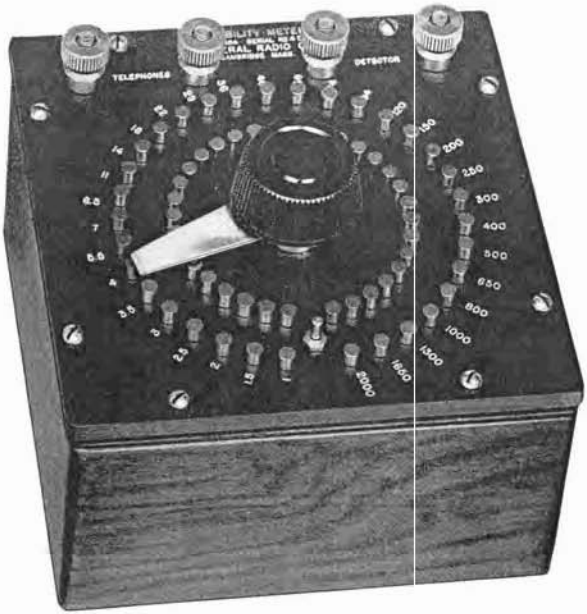
ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE 39, MASSACHUSETTS

BULLETIN 210 JANUARY 1925

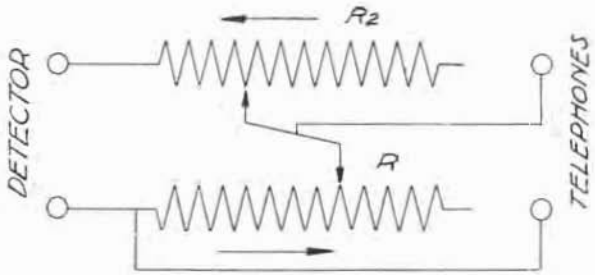


Type 164
AUDIBILITY METER

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 effected 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."

[This Bulletin replaces Bulletin 209]

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GENERAL RADIO COMPANY

MANUFACTURERS OF

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CAMBRIDGE, MASSACHUSETTS

BULLETIN 306 **JANUARY 1925**

Type 106

STANDARDS OF INDUCTANCE

These standards of inductance have been designed for general laboratory use and are suitable for radio frequencies as well as for commercial or audio frequencies. To minimize skin effects and eddy current losses the windings are of stranded wire with the separate strands insulated from each other. 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.

Considerable errors, particularly in bridge measurements, may be introduced if the inductance standards have a large outside field. To minimize this effect these standards are wound astatically, thus making the external field negligible. The use of the astatic winding eliminates the effects of other inductances in the vicinity of the standard.

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. The accuracy of this adjustment is one-tenth of one per cent. The current carrying capacity of the 1 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.

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

Dimensions 6″ x 6″ x 4″. Weight 2¾ lbs.

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.

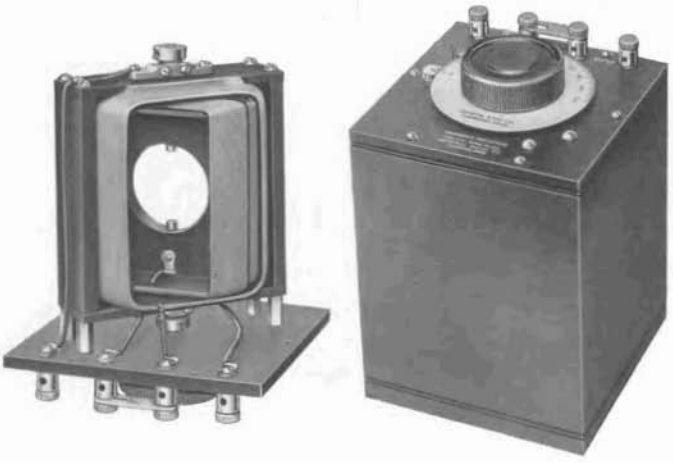
The Type 107 Variometer consists of two coils which are both sections of cylinders one of which is slightly smaller than the other. The smaller coil is mounted within the larger in such a manner that it may be rotated about its vertical diameter. The connections of each coil are brought out separately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

Type 107H 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 and calibrated oscillating circuits a specialty.

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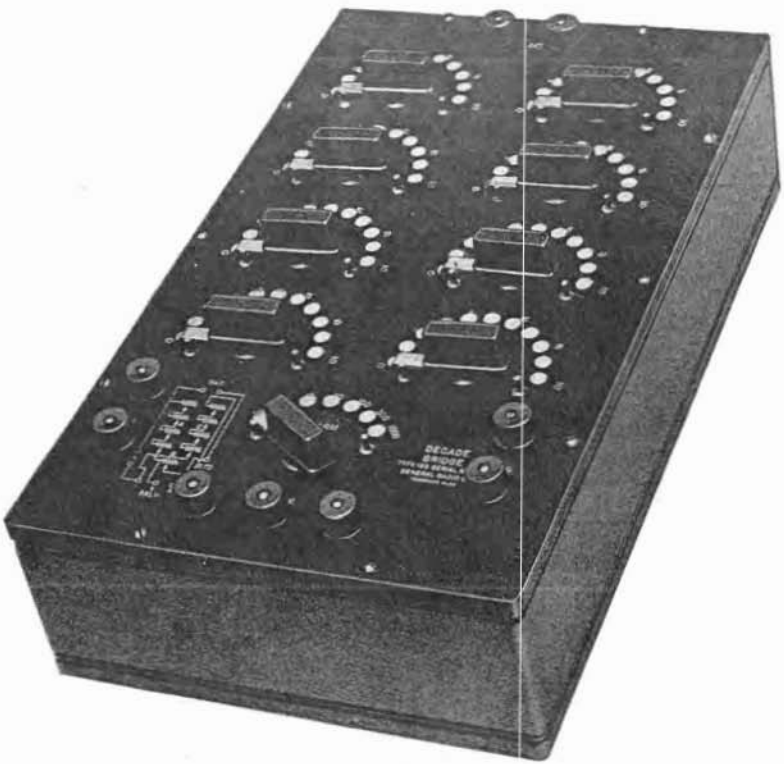
CAMBRIDGE, MASSACHUSETTS

BULLETIN 408 JANUARY 1925



Type 193

DECADE BRIDGE

The Type 193 Decade Bridge is designed to cover the many uses which are required of a laboratory bridge. It is adapted for both direct and alternating current measurements. While it is sufficiently flexible to give the necessary variety of connections demanded in the laboratory, when set up for commercial testing its operation becomes so simple that very little instruction is required by unskilled operators to make routine measurements.

The general arrangement of this bridge consists of three resistance arms, two of which are four dial decades each having a range of from 0.1 ohm to 1111 ohms. The third arm is a single dial having

a resistance tapped at 1-3-10-30-100-300 and 1000 ohms. In order to adapt this bridge for use with frequencies up to 10,000 cycles all resistance units are wound non-inductively and have very low distributed capacitance. This is accomplished by using the Ayrton-Perry Method of winding described in our Bulletin No. 208.

The accuracy of adjustment of these coils is 0.1% on direct current and about 0.5% at 1,500,000 cycles. The wire used has a practically nil temperature co-efficient of resistance and contains no iron. The current carrying capacity of the one-tenth ohm units is one ampere, that of the one ohm units one-quarter ampere, that of the ten ohm units one-tenth ampere, and that of the one hundred ohm units five-hundredths ampere.

Dial switches are used in place of the older and less satisfactory plug method of connection. This eliminates the inconvenience of the shifting of plugs, and also their possible loss. These switches have multiple-leaf contact brushes with each leaf making independent contact. The ends of the contact leaves are so cut that they are not tangent to the path of travel, thereby preventing the cutting of grooves in the contact studs. These switches have a low and constant resistance, even after long use. 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.

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 tight fitting wooden dust cover is furnished with each bridge to protect the panel and switches when not in use.

Operation

The three general classes of measurements to which this bridge is adapted are direct current resistance by the Wheatstone method, inductance, and capacitance. For inductance and capacitance measurements an external standard is employed, while for resistance measurements one of the bridge arms is used as a standard. The circuits of the bridge are shown in the diagram.

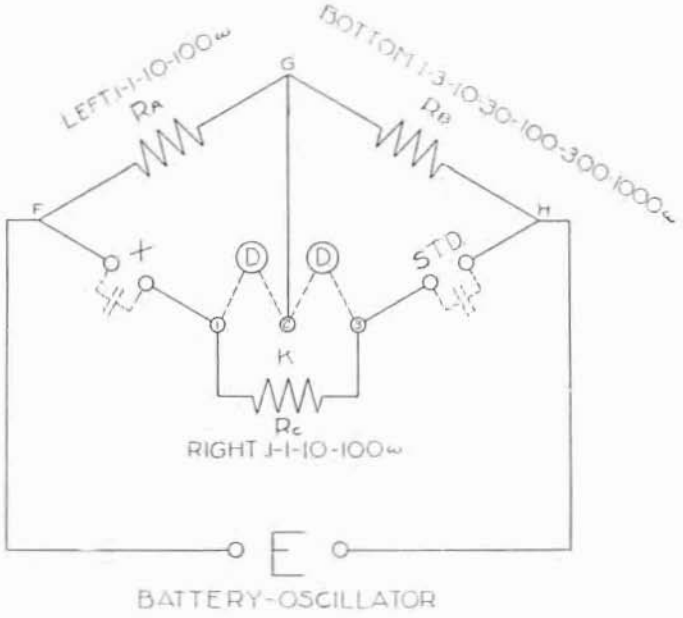
The power source supplied to the bridge is connected to the binding posts marked BAT. For direct current resistance measurements this source is one or two cells of a battery, while for capacitance and inductance measurements an alternating current source must be used. The alternating current should be of known and constant frequency and free from harmonics. The General Radio Co. Type 213 Audio Oscillator was designed for this work.

For direct current resistance measurements a sensitive galvanometer should be used to indicate the balance point. This galvanometer is connected between the GALV binding posts 1 and 2. When an alternating current source is supplied to the bridge in capacitance and inductance measurements, a sensitive telephone receiver or vibration galvanometer is used to detect the balance point. This detector will be connected to either the GALV binding posts 1 and 2, or 2 and 3 depending on the conditions of balance.

To make a direct current resistance measurement by the Wheatstone method the resistance to be measured is connected to the binding posts marked X. A short circuit bar is placed between the STD binding posts. Arms A and B are used as ratio arms and Arm C adjusted to obtain a balance. The unknown resistance is then given by the expression

$$R_X = \frac{R_A}{R_B} R_C$$

For inductance and capacitance measurements the bridge is used as an impedance bridge, that is, the bridge is simultaneously balanced for resistance and reactance. The inductance or capacitance to be measured is connected at X and the inductance or capacitance standard at STD. In this case Arms A and B are used as ratio arms and Arm C is a compensating resistance in order that the bridge may be in balance



for resistance as well as for reactance. When the telephones, or vibration galvanometer, are connected between GALV binding posts 1 and 2, this compensating resistance is in series with the standard, and when the telephones are connected to binding posts 2 and 3 this compensating resistance is in series with the unknown impedance. The compensating resistance should be connected so as to be in series with the impedance having the lower resistance. At the balance point the following relationships exist between the unknown and the standard impedance.

Inductance measurements $L_X = \frac{R_A}{R_B} L_S$

Capacitance measurements $C_X = \frac{R_B}{R_A} C_S$

Uses

The Type 193 Decade Bridge is designed for general laboratory use. For direct current measurements its principle use is as a Wheatstone bridge. The connections are such, however, that the different arms may be used independently as standard decade resistance units. When used as an impedance bridge the range for capacitance measurements is from 0.003 to several microfarads, and for inductance measurements from about 20 microhenrys to several henrys. When making measurements of small capacitances or large inductances the sensitivity of the bridge may be increased by using in the detector circuit a telephone transformer, such as the General Radio Co. Type 166. The high impedance side, which is marked SEC, is connected across the proper GALV binding posts and the telephone receivers connected across the low impedance side. Since all of the resistance units are wound non-inductively and to have very low distributed capacitance they are adapted for use at radio frequencies.

Since the bridge is so arranged that the individual arms are accessible, use may be made of the principle that in diagonal arms a capacitance will balance an inductance. By the correct choice of the inductance or capacitance standard, the bridge may be made direct reading in either capacitance or inductance. The precision of such measurements is that of the adjustment of the bridge, namely 0.1%.

Type 193 Decade Bridge $125.00
Size 17" x 10½" x 5". Weight 12¾ lbs.
Code Word "BIGOT."

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

Type 166 Telephone Transformer $9.00
Size 2¾" x 2½" x 2¼". Weight 2 lbs.
Code Word "TOPIC."

Western Electric Receivers (Type 1002C) $12.00

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

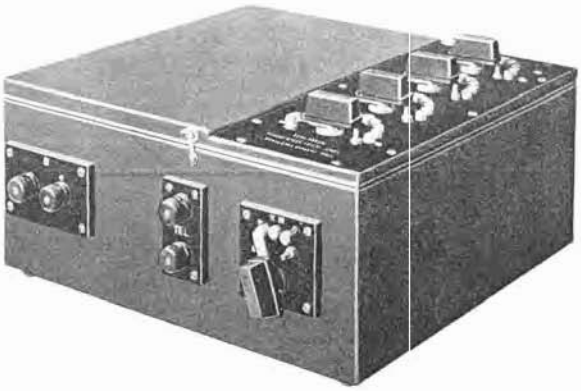
[This Bulletin Replaces Bulletin 407]

Standardize on General Radio Apparatus Throughout.

GENERAL RADIO COMPANY

MANUFACTURERS OF
ELECTRICAL AND RADIO LABORATORY APPARATUS
CAMBRIDGE, MASSACHUSETTS

BULLETIN 409 JANUARY 1925



Type 216
CAPACITY BRIDGE

Description

There has long been a need for some simple yet reliable method of measuring capacitances as low as a few micromicrofarads with a precision of at least one-tenth of one per cent. The desirability of a convenient, reliable, and accurate method of comparing the losses in small samples of dielectrics has also long been recognized. It was to meet these needs that the General Radio Co. Type 216 Capacity Bridge was designed.

Reduced to its simplest form, this bridge consists of a Wheatstone Bridge circuit with resistances in the ratio arms and capacitances in the unknown and standard arms. The complete arrangement is shown by the diagram on Page 437.

The input source E is the General Radio Co. Type 213 1000-cycle Audio Oscillator, described in Bulletin 712. This oscillator is connected to the input terminals "AC" of the bridge. These terminals lead to a shielded compartment containing an input transformer whose primary is grounded at its mid-point. The primary and secondary windings of this transformer are shielded from each other.

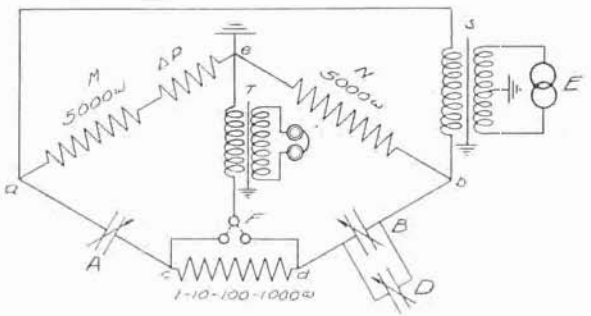
The bridge circuit consists of the two ratio arms M and N, and the arms A and B in which the standard and the unknown condensers are placed. The junction point of the two ratio arms is grounded.

These ratio arms are made up of equal resistance units wound on thin cards to reduce the inductance and the distributed capacitance. A method, however, is provided for adding resistance units to either the M or N arm in order to get small amounts of unbalancing. A four dial decade resistance box, the units of which are Ayrton-Perry non-inductive low distributed capacitance coils, is arranged so that it may be connected in either the A or B arm by means of the switch F. A sensitive telephone receiver, or a vibration galvanometer, is used to detect the point of balance. This detector is connected to the bridge through a transformer which has a grounded shield between the primary and secondary windings.

The cabinet containing the bridge units is of polished walnut. All panels are of polished hard rubber with engraved lettering. The metal parts are finished in bright nickel. The interior of the cabinet is lined with copper, lacquered to retain its polished finish. The wiring, as well as the separate units of the bridge, is thoroughly shielded. Complete instructions accompany each bridge.

Operation

Since it is desired to detect minute changes in resistance and capacitance with this bridge it is very essential that each unit of the bridge be constructed to give a resultant maximum sensitivity. It is also very important that the supply source be of constant frequency and



free from harmonics. Reliable readings for very small changes of capacitance cannot be obtained unless the supply source has a pure tone. It is for this reason that the Type No. 213 Audio Oscillator is recommended for use with this bridge.

The use of a supply transformer, instead of connecting the audio oscillator directly across the ratio arms, aids in the proper operation of the bridge. A shield, placed between the primary and secondary winding of this input transformer, prevents errors which would be caused by capacitance to earth of the supply source. In order that the potentials impressed across each of the ratio arms of the bridge shall be equal, the junction point of these arms and also the mid-point of

the input transformer primary is grounded. The use of an input transformer increases the voltage applied to the bridge arms, a very desirable feature in the measurement of small capacitances.

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. A shield similar to that of the input transformer is placed between the primary and secondary windings to prevent the introduction of errors caused by outside capacitances to earth.

As the bridge is designed primarily for the comparison of equal capacitances, the ratio arms are made equal. A variable standard low loss condenser such as the General Radio Co. Type 222 precision condenser is particularly adapted for use in the standard arm of the bridge. The use of equal ratio arms without any switches makes it possible to adjust these arms very accurately, and insures that their resistance will always be constant. Since these ratio arms are exactly alike, any change in inductance or capacitance with frequency will be the same in each arm, and will have no resultant effect on the balance of the bridge.

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.

In order to obtain a balance with a bridge of this type, the resistance as well as the reactance must be balanced. To provide this resistance balance a four dial decade resistance unit may be placed in either the A or B arm. The shift is made by means of a single switch located on the side of the cabinet. The use of this decade resistance provides a convenient and accurate means of measuring dielectric losses.

A set of operating instructions covering in detail its uses and operation is supplied with each bridge.

Uses

The Type 216 Capacity Bridge is an instrument by means of which capacitances up to several microfarads can be measured quickly and accurately. It provides also a means of measuring capacitances as small as a few micromicrofarads to a precision of one hundredth of a micromicrofarad. Since the dielectric loss equivalent resistance at 1000 cycles can be measured to an ohm with this bridge, it is possible to obtain the phase angle of condensers or to compare different dielectrics. 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 3 inches square and one-half inch thick was placed between two metal plates. At 54° F. this sample had a capacitance of 11.20 micromicrofarads and a phase angle of 48′. When heated to 100° F. the capacitance had increased to 12.25 micromicrofarads and the phase angle to 1° 55′.

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 169 Vernier Condenser $8.00
Dimensions 5½″ x 4¾″ x 2¾″. Weight ¾ lbs.
Code Word "CUBBY"

Type 1002C Western Electric Double Head Receivers $12.00

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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 408]

Standardize on General Radio Apparatus Throughout.

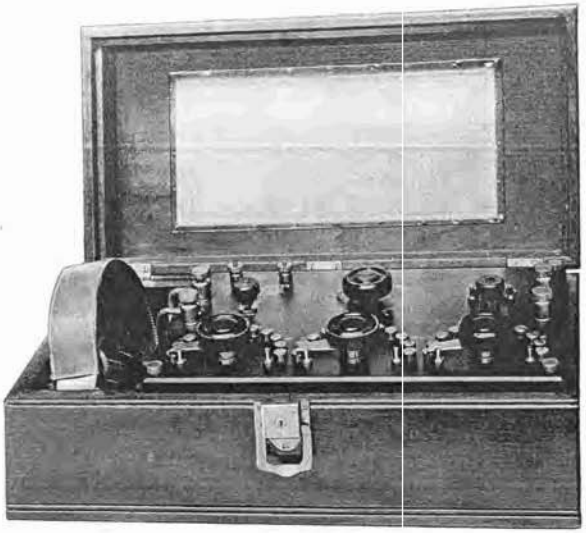
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE 39, MASSACHUSETTS

BULLETIN 410 JANUARY 1925



TYPE 240

DIRECT READING CAPACITY METER

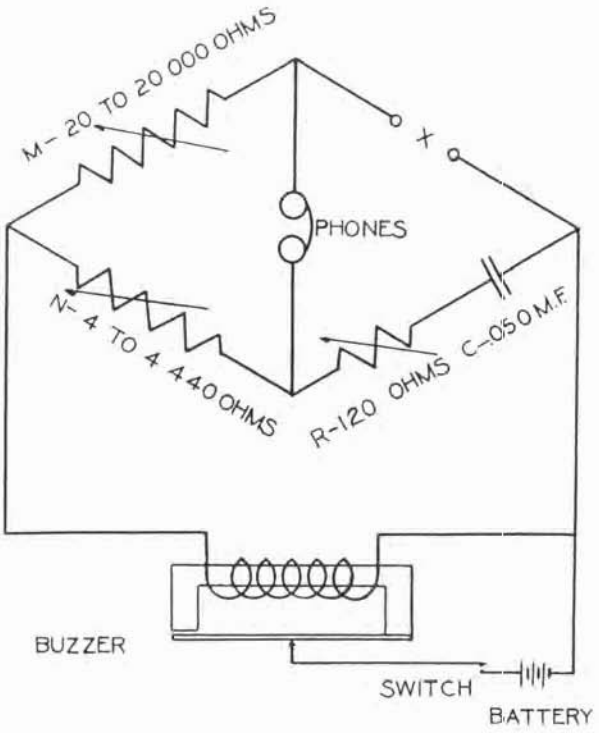
The Type 240 Capacity Meter meets the demand for a reliable direct reading capacity measuring instrument. It is especially adapted to general laboratory and commercial uses in obtaining capacity measurements ranging from .001 to 10 microfarads with an accuracy to one half of one per cent. Its simplicity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

The instrument consists of a capacity bridge with variable resistances in the ratio arms and capacitances in the unknown and standard arms. A schematic diagram of the whole assembly is shown on page 441. The input is from a specially designed microphone buzzer supplied from a 4½ volt dry battery contained in the case. Provision is also made for the use of an external battery.

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

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

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



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

OPERATION

Before operating the meter it is necessary to put the battery in place as follows: Remove the four screws at the corners and lift the panel out. The battery is then slipped under the steel holder so that the terminals make contact with the metal strips on the ends of the buzzer leads. The panel may now be put back in place and the instrument is ready for operation.

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

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

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

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

USES

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

Type 290 Capacity Meter..... $80.00
Dimensions 7" x 6" x 14½". Weight 10½ lbs.
Code Word: "CYNIC."

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
Standard Condensers	Galvanometers	Decade Bridge
Variable Air Condensers	Vernier Condenser	Decade Condensers
Decade Resistance Boxes	Audibility Meters	Miscellaneous
Telephone Transformer	Wavemeters	Apparatus

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GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 505 **JANUARY 1925**

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 milli-

ampere 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 919.

TYPE 170

Range	*Code Word*	*Case*	*Price*
100 M. A.	EXULT	Portable	$24.00
250 M. A.	EVOKE	Portable	22.00
500 M. A.	EXACT	Portable	22.00
1 amp.	EXCEL	Portable	22.00
2 amp.	EXERT	Portable	22.00
3 amp.	EXILE	Portable	22.00
5 amp.	EXIST	Portable	22.00
10 amp.	EXPEL	Portable	22.00
20 amp.	EXTRA	Portable	22.00
Galvanometer	ETHER	Portable	21.00

Dimensions 4¾" x 5" x 3½". 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

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[This Bulletin replaces Bulletin 504]

Standardize on General Radio Apparatus Throughout

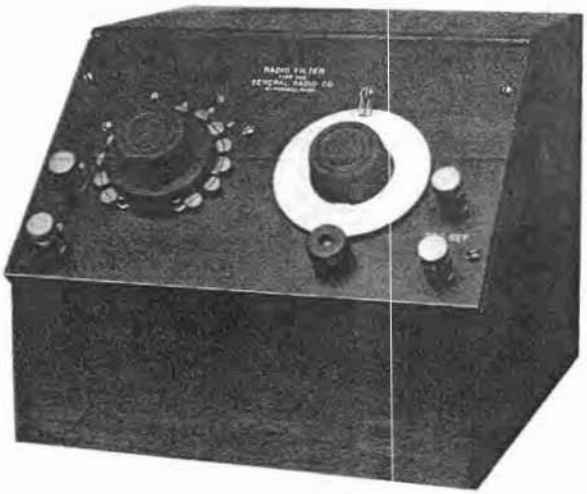
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 711 **JANUARY 1925**



Type 305

COMBINATION WAVEMETER AND FILTER

With the large number of broadcasting stations operating there are few locations where it is not often desirable to eliminate some interfering station. Unless the wave length separation is large this elimination can seldom be obtained by the usual tuning methods. Oftentimes there is general interference which it is desired to reduce. These results may be accomplished by the use of the Type 305 Radio Filter. This instrument consists of a tuned circuit inductively coupled to a coil placed in the antenna circuit. To use this filter it is necessary only to connect the antenna and ground wires to two binding posts on the input side of the filter and the receiving set to two binding posts on the output side. All necessary changes in connections are made by a single selector switch. As this switch is provided with an off position the filter may be left permanently connected and used only when desired. This selector switch enables the filter to be used as either a rejector or acceptor without the necessity of changing a single external connection. The condenser is a special model of our low loss, gear controlled Type 247 with plates shaped so as to give a nearly uniform wave length scale. The coils are wound

with sufficiently large wire to give the circuit a low decrement, and the number of turns of the antenna coil are controlled by the selector switch. One of the valuable features of the instrument is the wave length scale marked directly on the condenser dial. This scale, calibrated to within 2%, not only aids in the setting of the filter, but also enables the filter to be used as a wavemeter. The scale is calibrated from 150 to 500 meters, which is the working range of the filter. The entire equipment is mounted on a bakelite panel and enclosed in a polished walnut cabinet. The metal parts are finished in polished nickel.

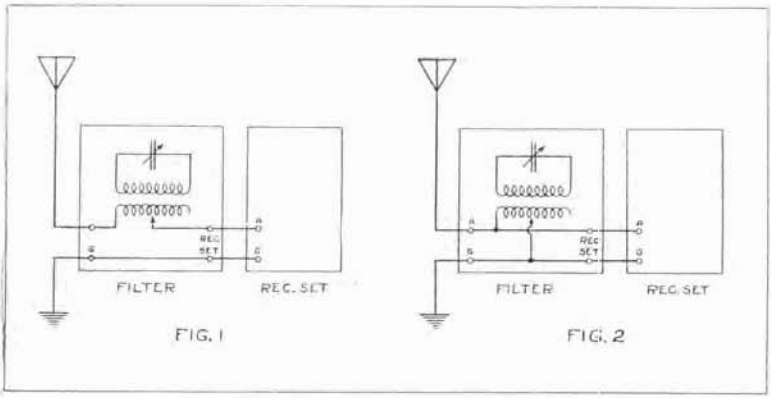


FIG. 1 FIG. 2

OPERATION

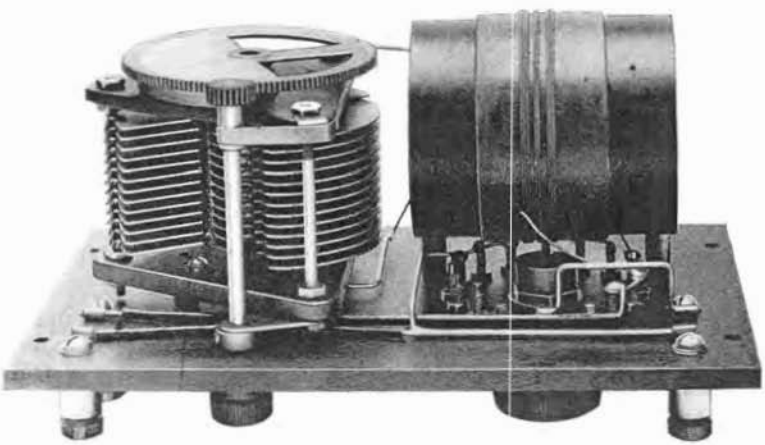
The filter can be used with any antenna connected receiving set to improve the selectivity; the improvement being more noticeable when used with the single circuit type than with the inductively coupled type of receiver. When used with a crystal receiver the operation of the filter is quite simple, but some practice is necessary to get the best results when using it with a regenerative tube set, especially when the Parallel Filter is used. The external connections are the same for all uses of the filter. The antenna is connected to the binding post marked A and the ground to G. The binding posts of the receiving set that ordinarily would be connected to antenna and ground should be connected to the two filter binding posts marked REC. SET. When the white indicator line of the filter selector switch is set opposite the contact marked O the filter is disconnected and the receiving set may be used just as if the filter were not present.

1. THE SERIES FILTER. When the selector switch is set opposite the contacts marked 8 or 5 of the SER side, the connections are as shown in Fig. 1. It will be seen that the filter is connected in series with the antenna. If the wave length scale of the filter condenser is then set at some point such as 360 meters any incoming signal of this wave length will be prevented from reaching the receiving set. This is due to the counter-electromotive force set up in the

resonance circuit of the filter. The effectiveness of the filter in cutting out a station depends on the sharpness of the tuning of the station. For this reason spark stations cannot be eliminated effectively by the series filter. The parallel filter must be used for such cases.

When it is desired to eliminate a single broadcasting or other continuous wave station set the filter switch at 0 and tune the receiving set until the undesired station is received with maximum intensity. Then set the filter switch on point 8 of the SER (series) side and turn the wave length scale slowly until the station disappears and comes back again. Rotate the dial back and forth, using the vernier knob, until the point of minimum intensity is found. Leaving the filter set at this point the receiving set may be re-tuned to whatever wave length is desired. If this wave length is more than 10 meters away from that of the interfering station usually no interference will be experienced.

If the interfering station signal intensity is small compared with that of the desired station the filter switch may be set on point 5 instead of 8. These numbers refer to turns on the coupling coil. The more turns used the more effective the filtering action, but a broader neutralized band is obtained.



When cutting out an interfering station by the series connection, there will be no reduction of signals on wave lengths differing by a few meters from the filter setting. The wave length of the interfering station may be read from the setting of the filter condenser dial.

2. THE PARALLEL FILTER. When the selector switch is set on the PAR (parallel) side the connections are as shown in Fig. 2. It will be seen that the filter is connected in parallel with the receiving set and forms a short circuit between the antenna and ground. Incoming signals of the same wave length as that for which the filter is set build up a voltage across the terminals of the filter which is

impressed on the input of the receiver. Signals of all other wave lengths are not in resonance with the filter and pass to the ground as if short circuited. It will thus be seen that when set for the parallel position the filter will permit only signals of one wave length to reach the receiving set. These signals, however, will be reduced somewhat in strength, due to unavoidable losses in the filter circuit, so that it is possible to use the parallel connection only with signals of at least moderate intensity.

When it is desired to receive from a single station only set the filter switch at O and tune the receiving set so as to receive the desired station at maximum intensity. Set the filter switch on 5 of the PAR side and carefully turn the wave length dial until the signals are again heard with maximum intensity. Further improvement will be obtained by re-tuning the receiving set and making any further readjustment necessary on the filter. The best results will be obtained using the parallel connection after experience is obtained in the re-tuning adjustments. The tuning of the filter is very critical and care must be taken in making settings.

The parallel connection will be found particularly helpful when it is desired to listen to a broadcast program without the annoyance of radio telegraph interference.

3. USE AS WAVEMETER. Wave lengths of received signals may be measured directly with an accuracy of 2%. To do this set the filter switch on O and tune the receiving set to the desired station; then set the filter switch on 5 of the SER side and turn the wave length scale until the signal disappears. The reading on the wave length dial is that of the incoming signal.

Type 305. Combination Wavemeter and Filter $25.00
Dimensions 8″ x 9¼″ x 7½″. Weight 7 lbs.
Code Word "FAIRY."

The products of the General Radio Company include not only those listed in this bulletin, but also radio and electrical laboratory apparatus. Information and bulletins of special apparatus will be sent on request. These instruments include: Low Loss Variable Air Condensers, Precision Condenser, Vernier Condenser, Decade Condenser, Variometers, Standards of Inductance, Standards of Resistance, Decade Resistance Boxes, Impedance Bridge, Capacity Bridge, Audibility Meter, Wavemeters, Ratio Arm Box, Galvanometer Shunt, Hot Wire Ammeters, Recorders, Amplifiers and Miscellaneous Apparatus.

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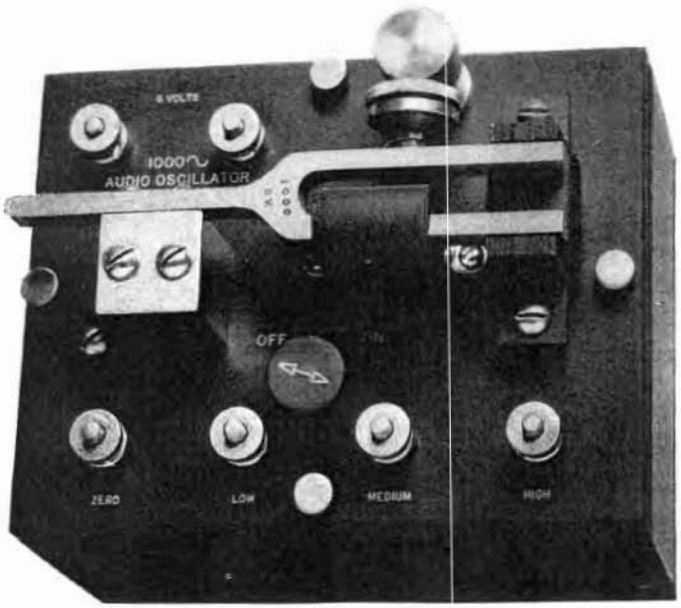
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 713 JANUARY 1925



AUDIO OSCILLATOR

Type 213

The precision of most alternating current bridge measurements is in no small measure dependent on the source of power supplied to the bridge. The waveform should be practically free from harmonics. Where a balance is indicated by means of the null method with a telephone receiver, the presence of harmonics of even very small magnitude will prevent the accurate determination of the balance point for the fundamental. The frequency must remain constant. The supply source should also be simple in its operation, rugged and reliable. It was to meet these requirements that the General Radio Co. Type 213 Audio Oscillator was designed.

The output of this oscillator is about 0.06 watt at 1000 cycles. External binding posts are so arranged that three output voltages may be obtained. The outputs obtainable with these three different connections are as follows:

Point	*Voltage*	*Current*
Low	0.5 volts	100 milliamperes
Medium	1.5 volts	40 milliamperes
High	5.0 volts	12 milliamperes

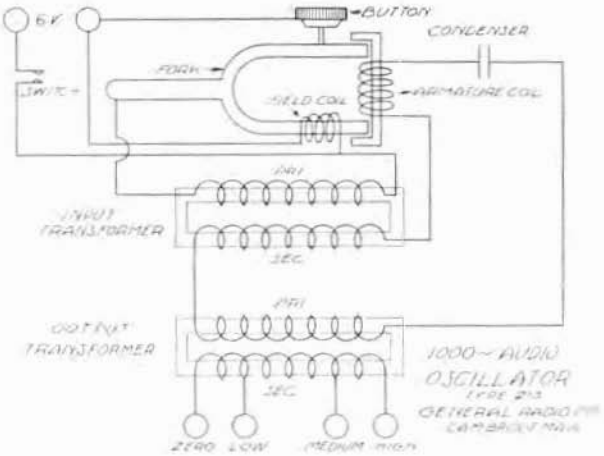
For some capacitance measurements it is desirable to use a high voltage. This increased voltage may be obtained by connecting an inductance and capacitance in series across the high voltage output terminals of the oscillator. By adjusting this circuit to resonance, voltages as high as 50 or 100 may be obtained by connecting output leads across the condenser. This instrument will operate satisfactorily on from four to eight volts. The input current is approximately 0.13 ampere. When running, the oscillator may be heard for a distance of approximately twenty-five feet, or may be made silent by enclosing in a sound-proof box.

The circuits of this oscillator are shown in the diagram. The closing of the switch places the field magnetizing coil directly across the battery. Also across the battery is the primary of the input transformer in series with the microphone button. The resonance circuit consists of the secondary of the input transformer, the primary of the output transformer, the armature coil and the condenser. The output transformer secondary has three taps to permit the obtaining of three different output voltages. The use of the two transformers prevents the output wave from containing any direct current component. Each transformer core has a small air gap to prevent distortion of the wave form. Since, however, the magnetic circuits are all nearly closed iron paths there is very little outside field. This feature is particularly important where the oscillator is being used in close proximity to the bridge. The tuning fork insures that the frequency be kept constant and at 1000 cycles. The resonance circuit is carefully adjusted to this value. Since the oscillator is self-starting it may be located at a point distant from the bridge and operated by a switch placed at the bridge.

By the use of the field magnetizing coil on one tine of the vibrating fork, instead of relying on its permanent magnetism, the polarity and intensity of the magnetization of the fork with respect to the armature are permanently maintained.

Success or failure in the operation of a hummer, or audio oscillator, lies very largely in the microphone button. If the button heats so that the oscillator cannot be run indefinitely, if the adjustment of the button is not permanent, or if slight mechanical shocks change its operating characteristics the oscillator has little commercial value. A distortion of as small an amount as one five-hundredth of an inch from normal mica will destroy the perfect operation of the button. In

order that the button may be insensitive to mechanical shocks and yet operate properly at 1000 cycles, use is made of its high inertia effect at the latter frequency. One side of the button is attached to the tuning fork by means of a short, flat spring. The other side, which has a



projecting mounting post, is held in position by a specially designed self-centering spring. This combination of springs enables the button to withstand severe shocks, yet it has sufficient inertia so that perfect operation is obtained. The adjustment of the button is permanent and needs no further attention after leaving our laboratory. This type of mounting, together with the fact that the electrical constants of the circuits have been adjusted to their optimum values, insures the continuous operation of the oscillator without heating.

It should, of course, be understood that this oscillator is not intended to displace the larger types of oscillators used where several watts of output are required. It is intended rather for general laboratory use where power of good waveform is desired for a single bridge. As the pureness of waveform is dependent on the load on the oscillator, whenever a pure waveform is essential the oscillator should not be overloaded. This oscillator is adapted for the usual alternating current measurements of inductance and capacitance.

The oscillator is mounted in a polished walnut box and has an engraved bakelite panel. The exposed metal parts are finished in polished nickel. The control switch is easily accessible and is of the convenient lock button design.

Type 213 Audio Oscillator..... $32.00

Dimensions 6" x 4¾" x 5". Weight 4½ lbs.

Code Word "AUGER"

Type 166
TELEPHONE TRANSFORMER

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"

(This Bulletin replaces Bulletin 712)

Standardize on General Radio Apparatus Throughout.

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 714 **JANUARY 1925**

TYPE 174

DIRECT READING WAVEMETER

The Type 174 Wavemeter is designed for general use in commercial and experimental radio stations. Its equipment is such that it is adapted for use with receiving or transmitting sets, employing either damped or undamped waves. Its self-contained, direct-reading features make this instrument particularly valuable for commercial work.

A hot wire galvanometer is used for indicating resonance of transmitted signals of average intensity, while for weak signals a crystal detector and binding posts for telephones are provided. For producing damped oscillations of known wavelengths, the wavemeter is equipped with a high frequency buzzer operating on a battery mounted within the wavemeter case. The oscillating circuit consists of three coils with a selector switch and a variable air condenser. This combination gives a wavelength range of 130 to 3000 meters. The inductance coils are bank-wound in order to keep the distributed capacity a minimum. The condenser is our low loss Type 239, equipped with slow-motion gear.

Particular care has been given to the mechanical construction and to the appearance of this instrument. All of the equipment is mounted on a hard rubber panel and enclosed in a polished walnut carrying case fitted with lock and key. The metal parts are finished in polished nickel.

OPERATION

The dial on which are drawn the three wavelength scales corresponding to the three inductance coils is mounted directly above the variable condenser and is fastened to the rotor plate shaft. The scales are indicated by the numbers 1, 2 and 3 engraved on the panel. Above the galvanometer is a switch engraved RANGE, with points numbered 1, 2 and 3. These three points correspond respectively to the three wavelength scales. Thus, when the wavemeter is set say at 360 meters, Scale 1 is used and the range switch set on Point 1. In addition to the three wavelength scales, a scale divided into one hundred equal divisions is provided. This scale is simply placed for reference and is convenient in making certain measurements.

TRANSMITTING SETS

In determining the wavelength of a transmitting set, the range switch should be set on the point covering the wavelength scale within which the transmitted wavelength should fall. The wavemeter should then be brought near the tuning inductance or the antenna or ground lead of the transmitter. By turning the knurled knob marked INCREASE WAVELENGTH, the variable condenser will be rotated, varying the wavelength of the wavemeter. At resonance—that is, the point where the wavelength of the wavemeter is the same as that of the transmitter—the maximum amount of energy will be transferred from the transmitting set to the wavemeter. This point is indicated by a maximum deflection of the hot wire galvanometer. Care, however, should be taken that the wavemeter is not too near a powerful transmitter because an excess amount of energy may be transferred to the wavemeter, causing the galvanometer to burn out. It will be found that with a sharply tuned transmitter, particularly when using

vacuum tubes, that the resonance point is very sharp. The condenser must be rotated slowly, as the galvanometer needle will swing from zero to nearly full scale and back again over a very small range of wavelengths. If the condenser is rotated too rapidly, the resonance point will be passed through without being noted. In the case of a buzzer or transmitter of small output, sufficient energy may not be radiated to operate the galvanometer. In this case, a pair of telephones should be connected to the binding posts marked TEL. Resonance will then be indicated by maximum intensity of signal in the telephones.

RECEIVING SETS

Two methods of determining the wavelength of a receiving set may be employed. The first, the reaction method, is applicable only to a vacuum tube receiving set, and then only when the set is oscillating. The wavemeter should be brought near the tuning inductance of the receiving set. By tuning the condenser of the wavemeter a sharp click will be heard in the head phones of the receiving set at the point where the condenser passes through the resonance point. The wavelength would then be read on the proper scale. It is usually necessary to have the wavemeter quite close to the receiving set. As the axis of the coils in the wavemeter is parallel to the panel, and extends from front to rear of the case directly beneath the galvanometer, best results are usually obtained by placing the right-hand edge of the wavemeter parallel to the tuning coil of the receiving set.

Where it is desired to set an inductively-coupled receiving set at a definite wavelength, the wavemeter should be set at that wavelength and the antenna circuit of the receiving set opened. The secondary of the receiving set should be adjusted either by means of the inductance or condenser until the reaction click is heard in the head phones of the receiving set. The wavemeter is then removed and the antenna circuit reconnected. The antenna circuit should then be varied until a click is again heard in the head phones. This will indicate that the primary and secondary circuits of the receiving set are both adjusted to the same value and to the value set on the wavemeter. This method requires, of course, that the set be oscillating during adjustment.

Where a single circuit receiving set is used, the antenna and ground connections should be left on. The tuning condenser is varied until the reaction click is heard in the telephone receivers. As with the inductively-coupled receiving set, the vacuum tube must be oscillating while the wavelength adjustments are being made.

A much quicker but slightly less accurate way to adjust the receiver is by means of the buzzer on the wavemeter. The wavemeter is set at the desired wavelength and the buzzer turned on by means of the buzzer switch. The receiving set should then be adjusted until the maximum intensity of buzzer signal is heard in the head phones. This method of adjustment is similar to tuning to an incoming signal.

GENERAL

Because of the sensitive type of buzzer used, it may be found that on turning the buzzer switch no sound can be heard. The buzzer adjusting screw should be turned to the right or left until the buzzer starts to operate. If the buzzer will not operate, make certain that the battery is in good condition. When a wavemeter is shipped, no battery is placed in the wavemeter, but one is shipped separately. This method is used to prevent damage to the wavemeter in case it should remain unused for a long time. Dry cells kept for a long time in an inverted or horizontal position will deteriorate and leak; the wavemeter should, accordingly, always be stored so that the cover is on top, thus keeping the battery in an upright position.

The diagram mounted in the cover should be studied carefully in order to understand the wavemeter circuits. The four panel thumbscrews should be removed and the panel lifted from the case. The inside of the wavemeter should be examined to become familiar with its mechanical operation, but under no circumstances should adjustments be attempted, as they will affect the calibration. The buzzer battery should be put in place before replacing the panel. It will be noted that provision has been made on the panel for an external coil. This arrangement is to enable an additional coil to be used for special work. Under normal conditions the short circuit bar between the two binding posts marked EXT COIL should not be removed. This is true even when the telephone receivers are connected to the telephone binding posts. This bar is removed only when an external coil is used.

Type 174 Direct Reading Wavemeter..... $68.00

Dimensions 9″ x 7″ x 6″. Weight 6¾ lbs.

Code Word: "WITTY."

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, Vernier Condenser, Standard Condensers, Decade Condensers, Variometers, Standards of Inductance, Standards of Resistance, Decade Resistance Boxes, Wavemeters, Decade Bridge, Capacity Bridge, Audibility Meters, Hot Wire Meters, Galvanometers Thermo-Couples, Telephone Transformers, 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 713)

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GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

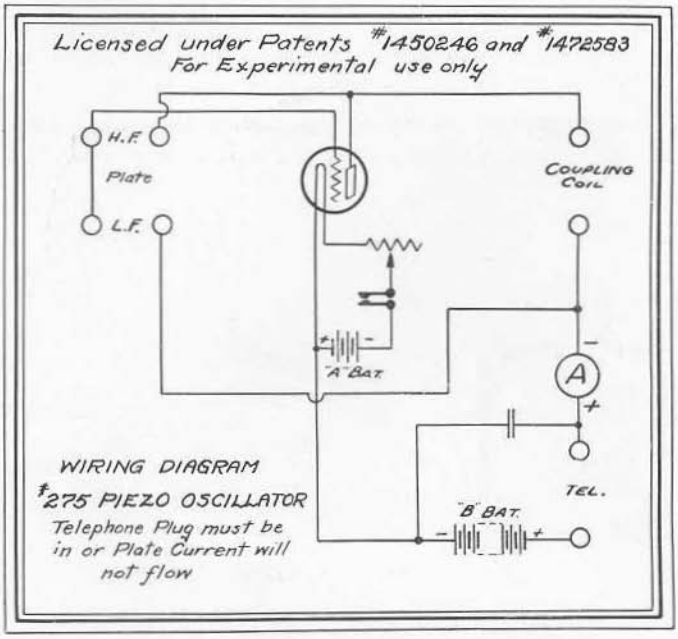
BULLETIN 715 **NOVEMBER 1925**

Type 275
PIEZO ELECTRIC OSCILLATOR
Type 276—QUARTZ PLATE

The piezo electric properties of crystaline 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 758 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 shown 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. A coil is provided for coupling with other apparatus.

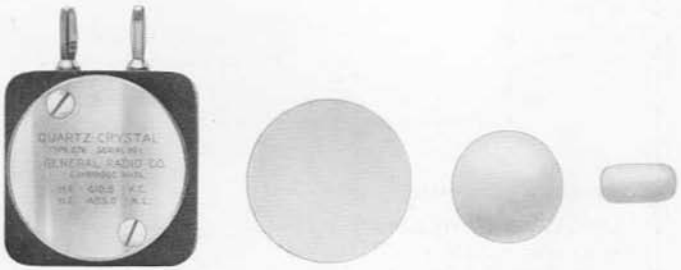


The oscillator circuit is shown above. A UV 199 tube is used as an oscillator. The meter, mounted on the front of the panel, indicates when the circuit is oscillating. A pair of telephones or similar high impedance must be connected at the plugs marked "TEL". The Quartz Plate is plugged in, either at 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 Pats. No. 1450246 and 1472583 for experimental use only.

Weight complete 15 lbs.

Dimensions 12½" x 9 ¾" x 8 ¼".

PRICES—

Oscillator complete with one plate	$110.00
Oscillator complete with one plate ground to specified frequency	135.00
Plates, mounted each	25.00
Plates, mounted ground within 5% of specified frequency	35.00
Plates, mounted ground to specified frequency	50.00

ALL THE ABOVE PRICES ARE NET.