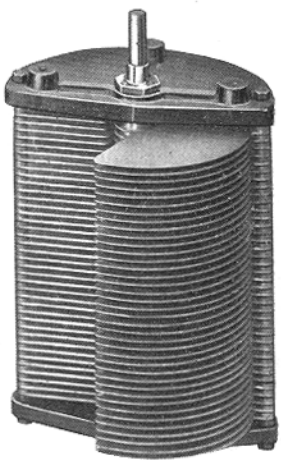
GENERAL RADIO COMPANY

MANUFACTURERS OF

HIGH GRADE RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 101 **JUNE 1920**



VARIABLE AIR CONDENSER
Type 101

For laboratory research work, particularly with circuits carrying currents of radio frequency, it is often desirable to have a variable condenser whose quality is above that of the usual radio experimental type. The losses should be small, and there should be but little change in capacitance with age and with the moderately severe handling to which an experimental condenser is subjected. The Type 101 condensers are built to meet this general laboratory service. These condensers have been manufactured in large quantities for several years and may be found in nearly all of the more important electrical laboratories in this country.

This condenser consists of a set of fixed and a set of rotary plates, both of which are semi-circular. These plates are of heavy aluminum and are spaced sufficiently far apart to prevent short circuiting or appreciable changes in capacitance with age. The end pieces are of heavy moulded bakelite. The shaft is of steel and has large 45 degree angle cone bearings, accurately machined after the assembly of the moving unit. This assures perfect alignment. The bearings

which support the steel shaft are of brass, positively locked in place. When the condenser is completely assembled the moving plates are given a rotation test to insure that the bearings are completely worn in, thus eliminating the chance of any future changing, sticking or binding.

A silvered etched dial with black filled lines and figures is fastened directly to the handle and shaft, rotating with them. The case is of heavy brass with a permanent black crystaline finish. Care is taken to have low resistance connections from both the moving and stationary plates to the binding posts which are mounted on the bakelite top.

Since this condenser is rugged, has low dielectric losses and retains its calibration, it is very useful as a variable standard of capacitance.

All condensers are provided with a label giving maximum and minimum capacitance readings. When so desired, a calibration curve for the entire condenser may be furnished. This calibration is made at 1,000 cycles with an accuracy of .5%. The calibrated condensers are fitted with an 8-inch extension handle for accurate setting. If so desired, however, the extension handle may be furnished with the uncalibrated condensers.

Type 101L Capacitance 1,500 Micromicrofarads $24.00
Dimensions 7″d x 7″. Weight 5¼ lbs.
Code Word "CABIN."

Type 101M Capacitance 3,000 Micromicrofarads $29.00
Dimensions 7″d x 10″. Weight 9 lbs.
Code Word "CADET."

Type 101P Capacitance 5,000 Micromicrofarads $35.00
Dimensions 7″d x 10″. Weight 10 lbs.
Code Word "CANAL."

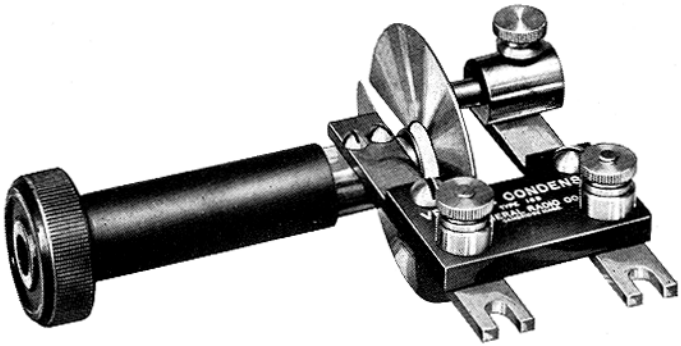
Calibration curve and extension handle with any of the above condensers $5.50

Extension handle $1.50

MICA CONDENSERS

Because of the large size which would be required, it is impractical to build air condensers larger than 5000 micromicrofarads. Above this size mica condensers are preferable. Our line includes two types of mica condensers, the Type 221 which are single unit secondary standards adjusted to better than .5%, and the Type 219 decade condenser adjusted to approximately 1%.

The decade condenser consists of one ten section unit with a total capacitance of .1 microfarad, and one ten section unit with a total capacitance of 1.0 microfarad. The capacitance of the decade units is controlled by a rotary switch, thus permitting the obtaining of any capacitance from .01 microfarad to 1.1 microfarads by changes of .01 microfarad. These condensers will stand 1000 volts and are mounted in polished oak cases. They are described in detail in Bulletin 102.



VERNIER CONDENSER
Type 169

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.

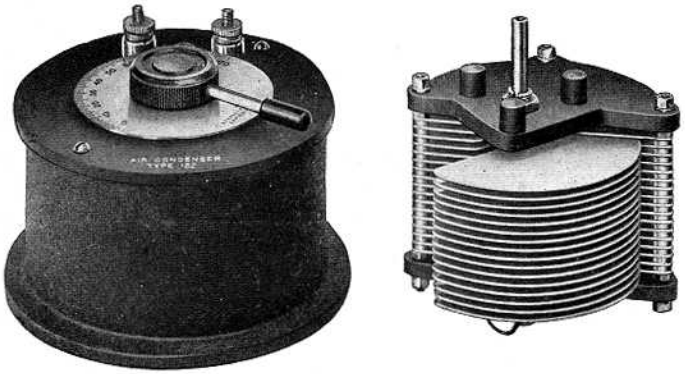
This condenser is also useful in making measurements of very small capacitances, such as are possible with our Type 216 Capacity Bridge.

Type 169 Vernier Condenser $8.00
Dimensions 5½" x 4¼" x 2¾". Weight ¾ lbs.
Code Word "CUBBY."

PRECISION CONDENSER
Type 222

Where great accuracy is desired we recommend the use of our Type 222 Precision Condenser. The construction throughout is unusually heavy and rugged. Dielectric losses are kept at a minimum by the use of a very small amount of low loss solid dielectric which is all placed in a very weak field. The movement of the rotary plates is controlled by a worm and gear. By the use of a primary and of a sub-scale direct readings to one part in 2500 are obtained. This condenser is fully described in Bulletin 702.

Type 222L Capacitance 1500 Micromicrofarads $90.00
Dimensions 8¼" x 8¼" x 9". Weight 16 lbs.
Code Word "COPAL."



VARIABLE AIR CONDENSER
Type 182

This condenser embodies many of the desirable features found in the Type 101 condenser. It is, however, smaller and of lower capacitance, being particularly adapted for use in radio receiving sets and wavemeters. The moving plates are so shaped as to obtain a nearly uniform wave-length variation throughout the entire range of the condenser. The case is of heavy brass with a permanent black crystaline finish. This condenser is made in two capacitances, 700 and 1000 micromicrofarads, and is fully described and priced in Bulletin 901.

The products of the General Radio Company cover a complete line of high frequency radio 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, Slide Wire-Bridge, Audibility Meters, Hot Wire Meters, Galvanometers, Thermo-Couples, Telephone Transformer, 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.

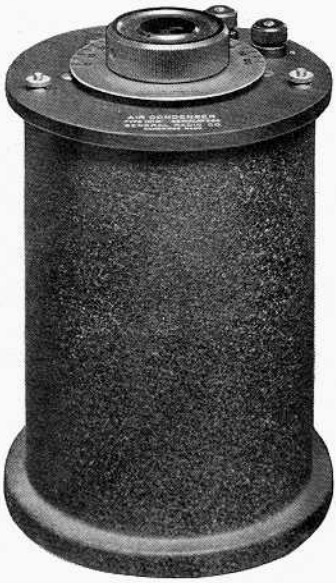
GENERAL RADIO COMPANY

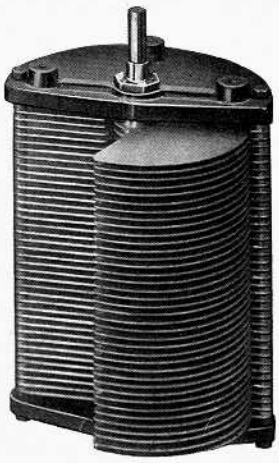
MANUFACTURERS OF

HIGH GRADE RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 102 **JANUARY 1921**





VARIABLE AIR CONDENSER
Type 101

For laboratory research work, particularly with circuits carrying currents of radio frequency, it is often desirable to have a variable condenser whose quality is above that of the usual radio experimental type. The losses should be small, and there should be but little change in capacitance with age and with the moderately severe handling to which an experimental condenser is subjected. The Type 101 condensers are built to meet this general laboratory service. These condensers have been manufactured in large quantities for several years and may be found in nearly all of the more important electrical laboratories in this country.

This condenser consists of a set of fixed and a set of rotary plates, both of which are semi-circular. These plates are of heavy aluminum and are spaced sufficiently far apart to prevent short circuiting or appreciable changes in capacitance with age. The end pieces are of heavy moulded bakelite. The shaft is of steel and has large 45 degree angle cone bearings, accurately machined after the assembly of the moving unit. This assures perfect alignment. The bearings

which support the steel shaft are of brass, positively locked in place. When the condenser is completely assembled the moving plates are given a rotation test to insure that the bearings are completely worn in, thus eliminating the chance of any future changing, sticking or binding.

A silvered etched dial with black filled lines and figures is fastened directly to the handle and shaft, rotating with them. The case is of heavy brass with a permanent black crystalline finish. Care is taken to have low resistance connections from both the moving and stationary plates to the binding posts which are mounted on the bakelite top.

Since this condenser is rugged, has low dielectric losses and retains its calibration, it is very useful as a variable standard of capacitance.

All condensers are provided with a label giving maximum and minimum capacitance readings. When so desired, a calibration curve for the entire condenser may be furnished. This calibration is made at 1,000 cycles with an accuracy of .5%. The calibrated condensers are fitted with an 8-inch extension handle for accurate setting. If so desired, however, the extension handle may be furnished with the uncalibrated condensers.

Type 101L Capacitance 1,500 Micromicrofarads $24.00
Dimensions 7″d x 7″. Weight 5¼ lbs.
Code Word "CABIN"

Type 101M Capacitance 3,000 Micromicrofarads $29.00
Dimensions 7″d x 10″. Weight 9 lbs.
Code Word "CADET"

Type 101P Capacitance 5,000 Micromicrofarads $35.00
Dimensions 7″d x 10″. Weight 10 lbs.
Code Word "CANAL"

Calibration curve and extension handle with any of the above condensers $5.50

Extension handle $1.50

These condensers may also be supplied unmounted. Handle, scale, and indicator button are included but no case, top, or binding posts.

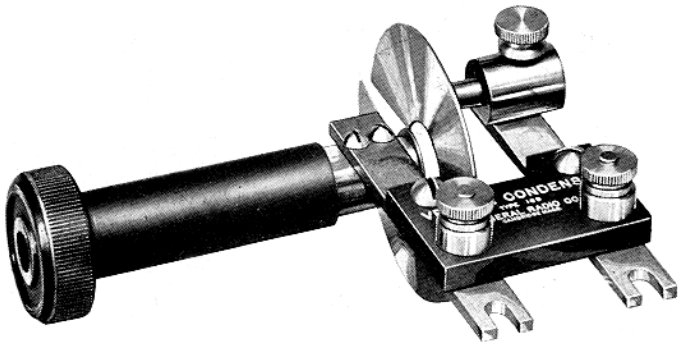
Type 101L Unmounted $18.00
Code Word "CAMEL"

Type 101M Unmounted $21.50
Code Word "CANNY"

Type 101P Unmounted $27.50
Code Word "CANOE"

MICA AND PAPER CONDENSERS

Because of the large size which would be required, it is impractical to build air condensers larger than 5,000 micro-farads. Above this size mica or low loss paper condensers are preferable. Our line includes both of these types of condensers, special information regarding which will be sent on request.



VERNIER CONDENSER
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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.

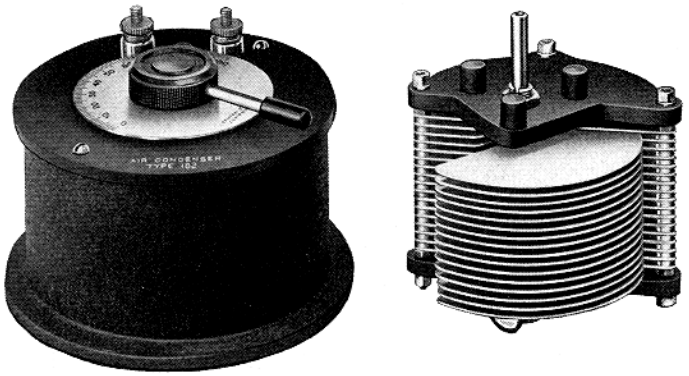
This condenser is also useful in making measurements of very small capacitances, such as are possible with our Type 216 Capacity Bridge.

Type 169 Vernier Condenser $8.00
Dimensions 5½" x 4¼" x 2¾". Weight ¾ lbs.
Code Word "CUBBY"

PRECISION CONDENSER
Type 222

Where great accuracy is desired we recommend the use of our Type 222 Precision Condenser. The construction throughout is unusually heavy and rugged. Dielectric losses are kept at a minimum by the use of a very small amount of low loss solid dielectric which is all placed in a very weak field. The movement of the rotary plates is controlled by a worm and gear. By the use of a primary and of a sub-scale direct readings to one part in 2500 are obtained. This condenser is fully described in Bulletin 702.

Type 222L Capacitance 1,500 Micromicrofarads $90.00
Dimensions 8¼" x 8¼" x 9". Weight 16 lbs.
Code Word "COPAL"



VARIABLE AIR CONDENSER
Type 182

This condenser embodies many of the desirable features found in the Type 101 condenser. It is, however, smaller and of lower capacitance, being particularly adapted for use in radio receiving sets and wavemeters. The moving plates are so shaped as to obtain a nearly uniform wave-length variation throughout the entire range of the condenser. The case is of heavy brass with a permanent black crystalline finish. This condenser is made in two capacitances, 700 and 1000 micromicrofarads, and is fully described and priced in Bulletin 904.

Type 182A Capacitance 700 Micromicrofarads $12.00
Dimensions 5½"d x 4⅛". Weight 2 lbs.
Code Word "CUDDY"

Type 182E Capacitance 1000 Micromicrofarads $13.50
Dimensions 5½"d x 5⅛". Weight 2½ lbs.
Code Word "CANDY"

The products of the General Radio Company cover a complete line of high frequency radio 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, Slide Wire Bridge, Audibility Meters, Hot Wire Meters, Galvanometers, Thermo-Couples, Telephone Transformer, 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.

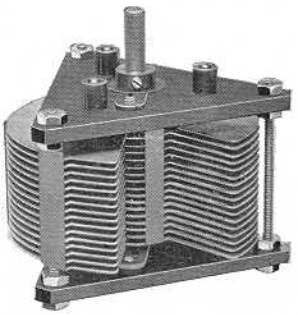
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 103 **JANUARY 1922**



Type 247
VARIABLE AIR CONDENSER

Experimental radio receiving sets require condensers whose quality is high and whose price is reasonable. It is easy to manufacture low-priced condensers as is evidenced by the large number now available. It is more difficult, however, to construct a condenser which is electrically and mechanically good, and yet at the same time to keep the cost of construction low.

For many years the subject of dielectric losses and condenser design has been studied in the Research Laboratory of the General Radio Company. This study has been carried on primarily in order to obtain data for the design of special condensers built to the exacting standards of scientific research work. With this information available, and with our experience in the design of laboratory instruments, we have been able to design a condenser of unusual merit for radio work and, at the same time, to keep its cost of construction remarkably low.

The value of a good condenser in a receiving set is not always fully appreciated. The dielectric losses of the condenser are equivalent to adding a series resistance in the oscillating circuit. To add a series resistance in the oscillating circuit means loss of energy which, in turn, means broad tuning and diminished signal strength. It is thus important that the dielectric losses in condensers be kept low. In this condenser these losses are kept low by using only a high-grade hard rubber for the solid dielectric. They are further kept low by using only a small quantity of this dielectric and so placing it with respect to the electrostatic field that the dielectric hysteresis losses are kept a minimum.

This is just one of the points which have received careful attention in the design of this condenser. Other important features include the following:

CAPACITY SCALE: In addition to the regular degree graduations of the etched metal dial, this dial has marked on it a scale showing capacities in micromicrofarads. This is a unique and valuable feature for radio receiving condensers, and it enables the operator to know at all times just what capacity he is using.

PLATES SOLDERED TOGETHER: In order that the plate resistance may be kept constant, and that the capacity always will remain the same, the plates of the rotary unit and the plates of the stator unit are all soldered together.

HEAVY ZINC PLATES: The plates are of heavy sheet zinc adequately spaced to prevent short-circuiting. Rugged plates of good conductivity are very desirable features in condenser construction.

BEARINGS: A special type spring bearing is used to insure good contact being made with the rotary plates. With this special type of bearing the tension always remains the same, and there is no chance for the rotary plate unit to loosen as the bearing wears. These bearings are so arranged that all the thrust is on one bearing, so that there is no danger of the condenser short-circuiting or changing its capacity if the distance between the bearings becomes changed.

LOW ZERO CAPACITY: The zero capacity of this condenser is approximately 20 micromicrofarads. This low value makes a wide range of wavelengths possible. The maximum capacity is 1000 micromicrofarads.

METAL CASE GROUNDED TO ROTARY PLATES: The condenser is mounted in a metal case finished with our black crystalline finish, the same as is used on our most expensive laboratory instruments. This case is grounded to the rotary plates, thus shielding the condenser and eliminating many of the disturbing effects due to bringing the hand near the condenser.

Do not deny your receiving set the advantages of a scientifically designed condenser.

Type 247A Condenser, completely mounted.....$5.50
Dimensions 4½"D x 3½". Weight 1¾ lb.
Code Word "CRONY."

This condenser may also be supplied without case, panel, knob, dial or binding posts, suitable for back of panel mounting.

Type 247B Condenser, unmounted $3.25
Dimensions 3¾" x 3¾" x 3½". Weight 1 lb.
Code Word "CRUEL."

Knob and dial, without capacity graduations, for use with Type 247B Condenser .....$ .50

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GENERAL RADIO COMPANY

MANUFACTURERS OF
ELECTRICAL AND RADIO LABORATORY APPARATUS
CAMBRIDGE, MASSACHUSETTS

BULLETIN 105 **AUGUST 1922**

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 microfarad 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 a hard-wood block, they cannot become loose or damaged. They will stand potentials of 300 volts. The complete unit is mounted in an attractive oak case with bakelite panel.

This condenser is particularly useful in filter or oscillating circuits. It is, in fact, an excellent all-around 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 micromicrofarads. This is of the order of about a tenth of what is usually obtained in good variable air condensers. This very low loss enables oscillating circuits to be turned very sharply. This condenser will stand potentials up to 500 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.

Type 239
VARIABLE AIR CONDENSER

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 oak case and engraved bakelite panel. All condensers, whether mounted or unmounted, are equipped with a three inch silvered dial divided into one hundred divisions.

Type 239E 1000MMF. Mounted. Without gear.....$15.50
Dimensions 6″ x 6″ x 7″. Weight 4½ lbs.
Code Word "BABEL."

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

Type 239E 1000MMF. Mounted. With gear. Calibrated..$20.50
Dimensions 6″ x 6″ x 7″. Weight 4½ lbs.
Code Word "BANJO."

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

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

Type 239J 2000MMF. Mounted. Without gear.....$18.50
Dimensions 6″ x 6″ x 9″. Weight 6 lbs.
Code Word "BASIN."

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

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

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

Type 239L 2000MMF. 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 104]

Standardize on General Radio Apparatus Throughout.

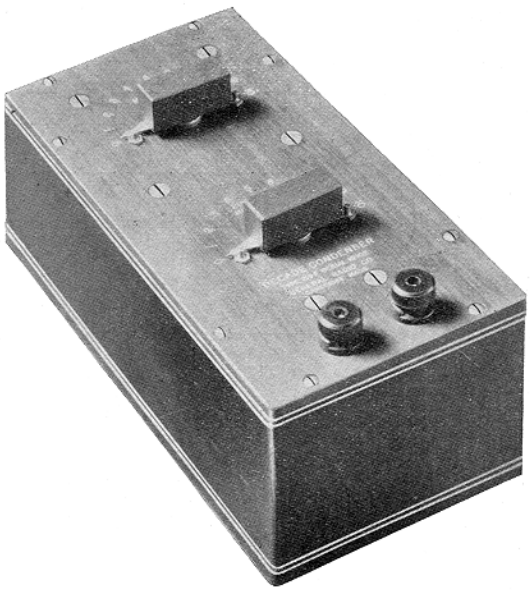
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 107 **NOVEMBER 1923**



Type 219F
DECADE CONDENSER

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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 a hard-wood block, they cannot become loose or damaged. They will stand potentials of 300 volts. The complete unit is mounted in an attractive oak case with bakelite panel.

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

Type 219F Decade Condenser $50.00

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

Code Word " COVER."

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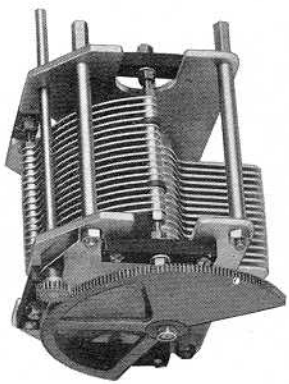
placed in a weak and uniform electrostatic field. This enables us to keep the losses at a minimum. The equivalent series resistance is but 12 ohms at a frequency of 1000 cycles and a capacitance of 1000 micro-microfarads. This is of the order of about a tenth of what is usually obtained in good variable air condensers. This very low loss enables oscillating circuits to be turned 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 oak case and engraved bakelite panel. All condensers, whether mounted or unmounted, are equipped with 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 9½″ 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 105]

Standardize on General Radio Apparatus Throughout.

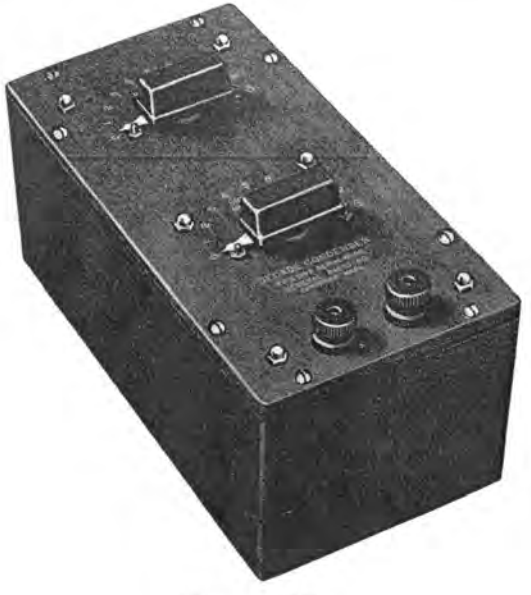
GENERAL RADIO COMPANY

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 9½″ 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."

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 Meter, Hot Wire Meters, Galvanometers, Thermo-Couple, Telephone Transformer, Miscellaneous Apparatus.

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[This Bulletin Replaces Bulletin 107]

Standardize on General Radio Apparatus Throughout.

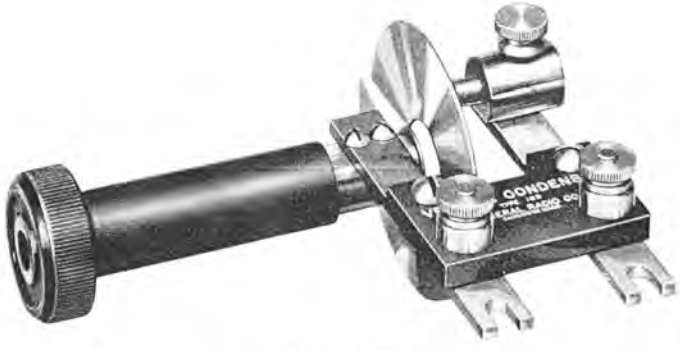
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 108 **NOVEMBER 1923**



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 $5\frac{1}{2}''$ x $4\frac{1}{4}''$ x $2\frac{3}{4}''$. Weight $\frac{3}{4}$ 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 permanency 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.

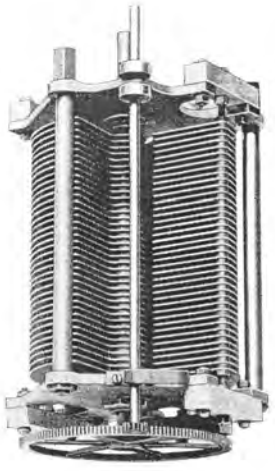
There is no change in capacity with frequency. The temperature coefficient is practically zero. The solid dielectric in this condenser is not only of small volume, and carefully selected, but is placed in a weak electrostatic field. Since this field does not vary with the position of the rotating plates, 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 ratio 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 .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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(This Bulletin replaces Bulletin 106)

Standardize on General Radio Apparatus Throughout.

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 109 **JANUARY 1925**

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, 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)

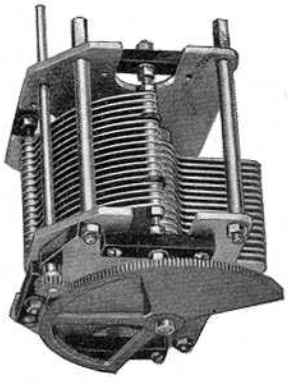
GENERAL RADIO COMPANY

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."

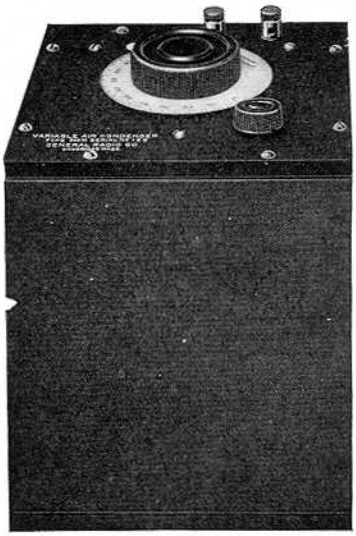
Type 239M. 2000 MMF. Unmounted. Without gear..... 13.00
Dimensions 4½" x 4¾" x 6". Weight 3 lbs.
Code Word "BAYAN."

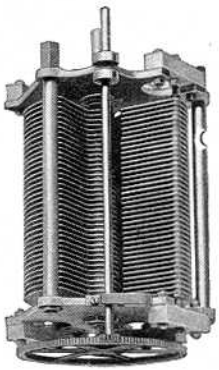
Type 239L. 2000 MMF. Unmounted. With gear..... 16.50
Dimensions 4½" x 4¾" x 6". Weight 3 lbs.
Code Word "BEFIT."

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

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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 111)

GENERAL RADIO COMPANY

MANUFACTURERS OF
HIGH GRADE RADIO LABORATORY APPARATUS
CAMBRIDGE, MASSACHUSETTS

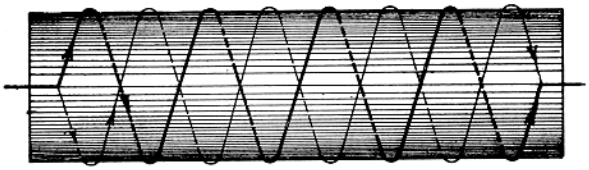
BULLETIN 201 **APRIL 1920**

STANDARDS OF RESISTANCE AND DECADE RESISTANCE BOXES

The ideal standard of resistance for alternating current measurements, and particularly for those at radio frequencies, is one which has zero change of resistance with age, changes of temperature or frequency, and which has a zero phase angle for all frequencies. By selecting carefully the material on which the resistance coil is wound, the kind of wire used, and taking care that in soldering the terminals the connections are permanent and free from corrosion, there will be no appreciable change in resistance with age. As there are several alloys now available whose temperature co-efficient is very small and is constant over a wide range, it is a simple matter to determine with high accuracy the change of resistance of a coil for any ordinary work-

ing temperature. To obtain zero change of resistance with frequency and to obtain 100% power factor is a much more difficult proposition. A change in resistance with frequency is due largely to skin effect and to the distributed capacitance of the coil. The phase angle change with frequency depends only on the inductance and capacitance.

Several methods have been used to reduce the inductance and distributed capacitance of resistance units. The Aryton-Perry method used in our coils is not only satisfactory electrically, but also mechanically. This method is illustrated by the diagram. The winding is



placed on a thin bakelite form. 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 from that of the first, thus making two crossings with the first wire in each complete turn. This arrangement keeps the currents in the two wires flowing in opposite directions and at the same time keeps adjacent wires at nearly equal potentials. This type of winding has the lowest distributed capacitance and inductance of any of the commercially used windings.

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 and one thousand ohm units five-hundredths ampere. The accuracy of these coils is .1% on direct current and about 5% at 1,500,000 cycles (200 meter wave length). The wire used has a practically nil temperature co-efficient of resistance and contains no iron. These resistance units are furnished in two styles of mountings, as single unit standards of resistance and as decade resistance boxes.

DECADE RESISTANCE BOXES
Type 102

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 possible loss.

The General Radio Co. Type 102 decade units are mounted on bakelite panels with engraved lettering, and are enclosed in oak 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 complete lists of these decade boxes is as follows:

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

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.

STANDARDS OF RESISTANCE
Type 133

These resistance units are single coils, wound by the method described above, and fitted with a suitable mounting. The case is of metal with black crystalline finish. The panel is of bakelite with engraved lettering. These standards are made in the following seven convenient sizes:

Type	*Resistance*	*Code Word*	*Price*
133A	1 ohm	Recur	$7.00
133B	5 ohms	Refer	7.00
133C	10 ohms	Regal	7.00
133D	50 ohms	Relax	7.00
133E	100 ohms	Relic	7.00
133F	500 ohms	Repay	8.00
133G	1000 ohms	Repel	8.00

Dimensions 3″ d. x 2¼″. Weight 11 oz.

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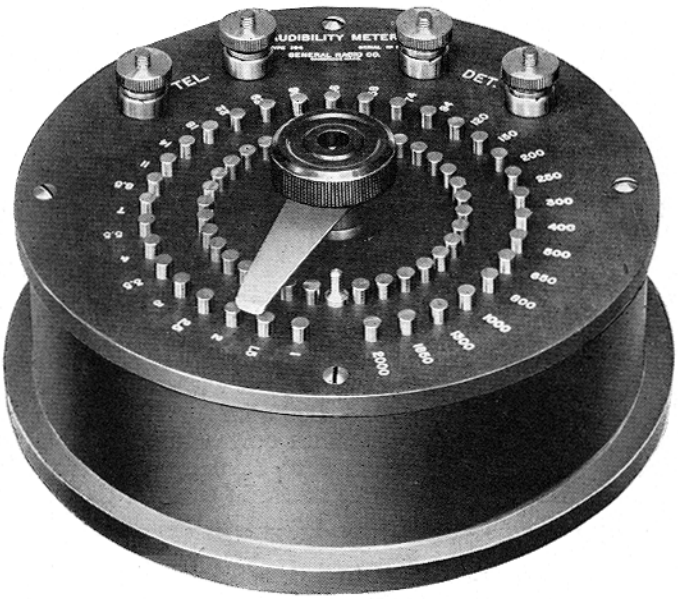
GENERAL RADIO COMPANY

MANUFACTURERS OF

HIGH GRADE RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 202 **APRIL 1920**



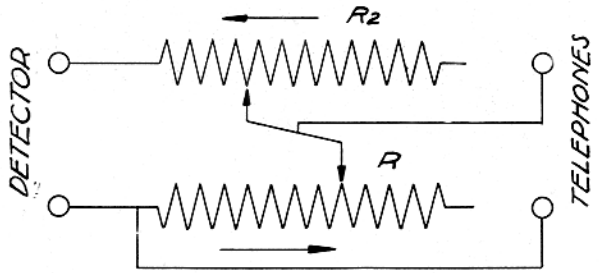
AUDIBILITY METER

Type 164

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 oak 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 $7\frac{5}{16}$" d. x 4". Weight 3 lbs.

Code Word "AWAKE."

PHANTOM ANTENNA RESISTOR

Type 125

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.

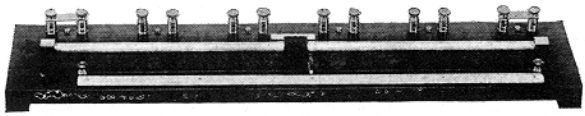
These units are wound on asbestos-board forms, mounted vertically, an arrangement which insures a good circulation of air. The resistance material is in the form of a ribbon, and has a very low temperature co-efficient of resistance and a constant resistance up to very high frequencies. The inductance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

This resistance 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 Resistance.....$15.00
Dimensions 7¾" x 6" x 4¼". Weight 3¼ lbs.
Code Word "RAVEN."

Type 125G Phantom Antenna Resistance.....$32.00
Dimensions 10¾" x 7⅝" x 5½". Weight 7 lbs.
Code Word "REBEL."



SLIDE WIRE BRIDGE
Type 130

The design of this bridge is such as to permit of obtaining all the ordinary measurements made with a bridge and at the same time does not make the instrument bulky or heavy. The bridge is particularly adapted for class-room demonstration or student use where a variety of arrangements such as the Wheatstone, Kelvin, or Carey Foster circuits are required. Great care has been used in the construction of this bridge. The base is of polished oak with engraved box-wood scale. The slider moves on a brass tube one-half inch in diameter, insuring good contact and durability. The slide wire is of manganin, one-half meter long, and has a resistance of approximately 0.9 ohm. Two pairs of binding posts are provided for extension coils to increase the range of the slide wire. Heavy copper connecting bars are used throughout. The metal parts are finished in dull nickel.

Type 130 Slide Wire Bridge.....$18.00

Dimensions 24″ x 4½″ x 2″. Weight 3¾ lbs.

Code Word "SATYR."

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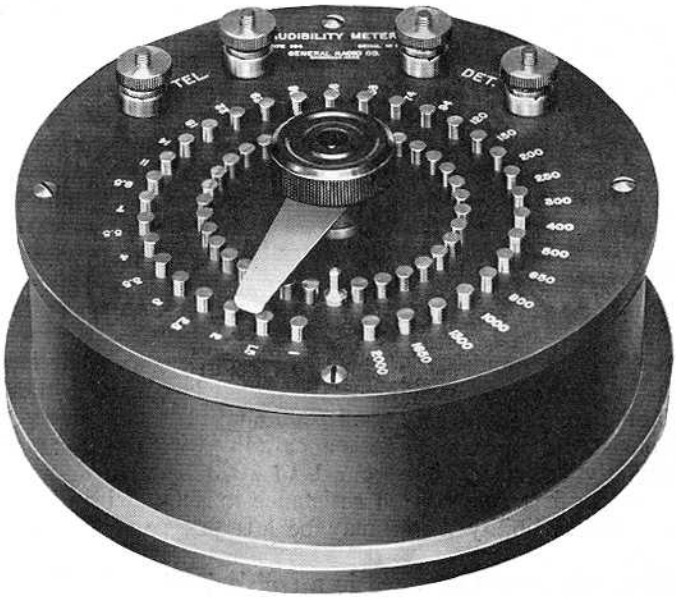
GENERAL RADIO COMPANY

MANUFACTURERS OF
HIGH GRADE RADIO LABORATORY APPARATUS
CAMBRIDGE, MASSACHUSETTS

BULLETIN 203 **NOVEMBER 1920**



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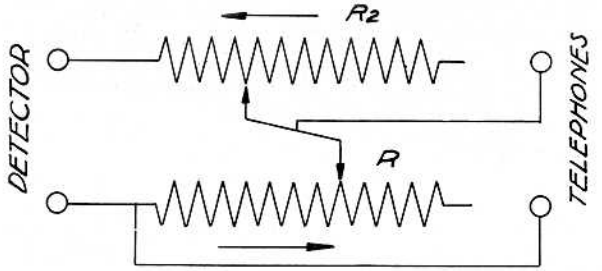

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This instrument is mounted in a polished oak case with engraved bakelite panel. The metal parts are finished in polished nickel. The contact arm is of laminated phosphor bronze and insures perfect contact.

Type 164 Audibility Meter $36.00

Dimensions $7\frac{5}{16}$" d. x 4". Weight 3 lbs.

Code Word "AWAKE."

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The resistor is made in two sizes, Type 125A of 4 units of 4 ohms each, and Type 125 G 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:

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12 "	5 "		
16 "	5 "		

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Type 130

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Code Word "SATYR."

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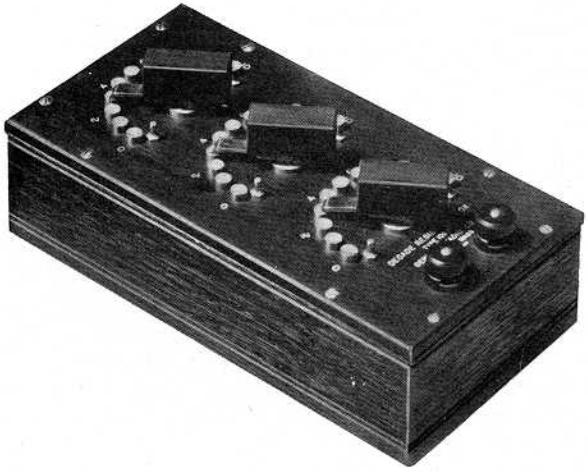
[This Bulletin replaces Bulletin 202]

GENERAL RADIO COMPANY

MANUFACTURERS OF
HIGH GRADE RADIO LABORATORY APPARATUS
CAMBRIDGE, MASSACHUSETTS

BULLETIN 204 **DECEMBER 1920**

STANDARDS OF RESISTANCE AND DECADE RESISTANCE BOXES



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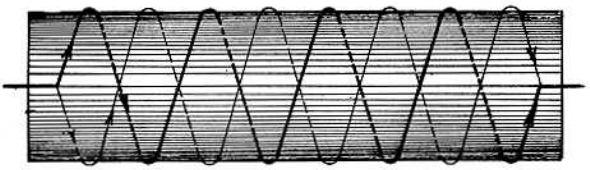

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The current carrying capacity of the one-tenth ohm units is one ampere, that of the one ohm units one-quarter ampere, that of the ten ohm units one-tenth ampere, and that of the one hundred ohm and one thousand ohm units five-hundredths ampere. The accuracy of these coils is .1% on direct current and about .5% at 1,500,000 cycles (200 meter wave length). The wire used has a practically nil temperature co-efficient of resistance and contains no iron. These resistance units are furnished in two styles of mountings, as single unit standards of resistance and as decade resistance boxes.

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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

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Number of Dials	*Dimensions*	*Weight*
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STANDARDS OF RESISTANCE
Type 133

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GENERAL RADIO COMPANY

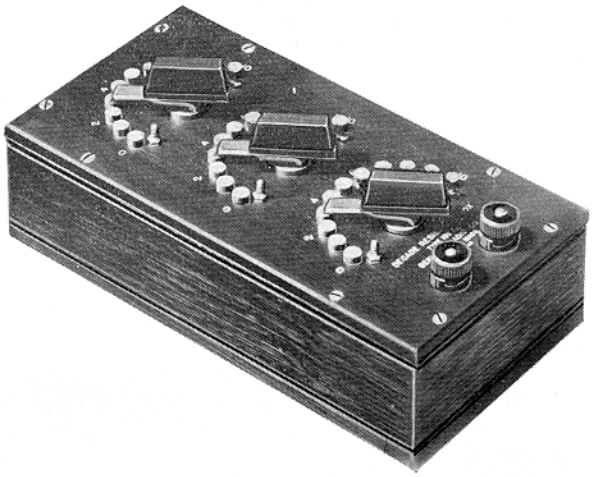
MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 207 **NOVEMBER 1923**

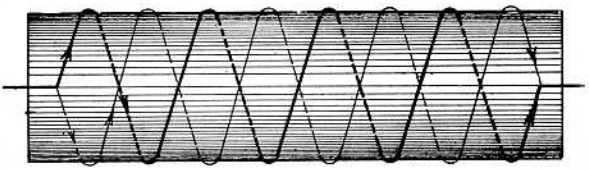
STANDARDS OF RESISTANCE AND DECADE RESISTANCE BOXES



The ideal standard of resistance for alternating current measurements, and particularly for those at radio frequencies, is one which has zero change of resistance with age, changes of temperature or frequency, and which has a zero phase angle for all frequencies. By selecting carefully the material on which the resistance coil is wound, the kind of wire used, and taking care that in soldering the terminals the connections are permanent and free from corrosion, there will be no appreciable change in resistance with age. As there are several alloys now available whose temperature co-efficient is very small and is constant over a wide range, it is a simple matter to determine with high accuracy the change of resistance of a coil for any ordinary work-

ing temperature. To obtain zero change of resistance with frequency and to obtain 100% power factor is a much more difficult proposition. A change in resistance with frequency is due largely to skin effect and to the distributed capacitance of the coil. The phase angle change with frequency depends only on the inductance and capacitance.

Several methods have been used to reduce the inductance and distributed capacitance of resistance units. The Ayrton-Perry method used in our coils is not only satisfactory electrically, but also mechanically. This method is illustrated by the diagram. The winding is placed on a thin bakelite form. 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 from that of the first, thus making two crossings with the first wire in each complete turn. This arrangements keeps the currents in the two wires flowing in opposite directions and at the same time keeps adjacent wires at nearly equal potentials. This type of winding has the lowest distributed capacitance and inductance of any of the commercially used windings.

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 and one thousand ohm units five-hundredths ampere. The accuracy of these coils above one ohm is .1% on direct current and about .5% at 1,500,000 cycles (200 meter wave length). The wire used has a practically nil temperature co-efficient of resistance and contains no iron. These resistance units are furnished in two styles of mountings, as single unit standards of resistance and as decade resistance boxes.

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 mount-

ing 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 possible loss.

The General Radio Co. Type 102 decade units are mounted on bakelite panels with engraved lettering, and are enclosed in oak 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 complete lists of these decade boxes is as follows:

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

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.

Type 133
STANDARDS OF RESISTANCE

These resistance units are single coils, wound by the method described above, and fitted with a suitable mounting. The case is of brass with black crystalline finish. The panel is of bakelite with engraved lettering. The accuracy of adjustment is 0.1%. These standards are made in the following seven convenient sizes:

Type	*Resistance*	*Code Word*	*Price*
133A	1 ohm	Recur	$7.00
133B	5 ohms	Refer	7.00
133C	10 ohms	Regal	7.00
133D	50 ohms	Relax	7.00
133E	100 ohms	Relic	7.00
133F	500 ohms	Repay	8.00
133G	1000 ohms	Repel	8.00

Dimensions 3″ d. x 2¼″. Weight 11 oz.

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, Slide Wire Bridge, Audibility Meters, Hot Wire Meters, Galvanometers, Thermo-Couples, Telephone Transformer, Miscellaneous Apparatus.

[This Bulletin replaces Bulletin 205]

Standardize on General Radio Apparatus Throughout.

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE 39, MASSACHUSETTS

BULLETIN 208 **NOVEMBER 1923**

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 oak 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 oak 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."

Type 130
SLIDE WIRE BRIDGE

The design of this bridge is such as to permit of obtaining all the ordinary measurements made with a bridge and at the same time does not make the instrument bulky or heavy. The bridge is particularly adapted for class-room demonstration or student use where a variety of arrangements such as the Wheatstone, Kelvin, or Carey Foster circuits are required. Great care has been used in the construction of this bridge. The base is of polished oak with engraved box-wood scale. The slider moves on a brass tube one-half inch in diameter, insuring good contact and durability. The slide wire is of manganin, one-half meter long, and has a resistance of approximately 0.9 ohm. Two pairs of binding posts are provided for extension coils to increase the range of the slide wire. Heavy copper connecting bars are used throughout. The metal parts are finished in dull nickel.

Type 130 Slide Wire Bridge. $18.00

Dimensions 24″ x 4½″ x 2″. Weight 3¾ lbs.

Code Word "SATYR."

The products of the General Radio Company cover a complete line of high frequency radio 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, Decade Resistance Boxes, Wavemeters, Decade Bridge, Capacity Bridge, Slide Wire Bridge, Audibility Meters, Hot Wire Meters, Galvanometers, Thermo-Couple, Telephone Transformer, 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 206]

Standardize on General Radio Apparatus Throughout

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."

The products of the General Radio Company cover a complete line of high frequency radio 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, Decade Resistance Boxes, Wavemeters, Decade Bridge, Capacity Bridge, Audibility Meters, Hot Wire Meters, Galvanometers, Thermo-Couple, Telephone Transformer, 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 208]

Standardize on General Radio Apparatus Throughout.

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE 39, MASSACHUSETTS

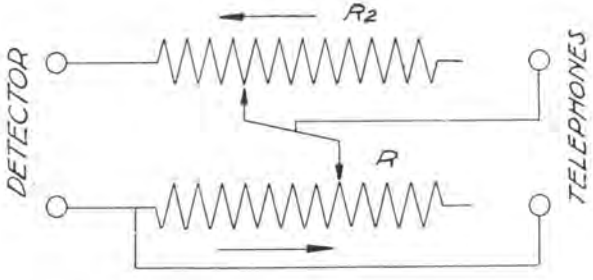
BULLETIN 210 **JANUARY 1925**

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]

Standardize on General Radio Apparatus Throughout.

GENERAL RADIO COMPANY

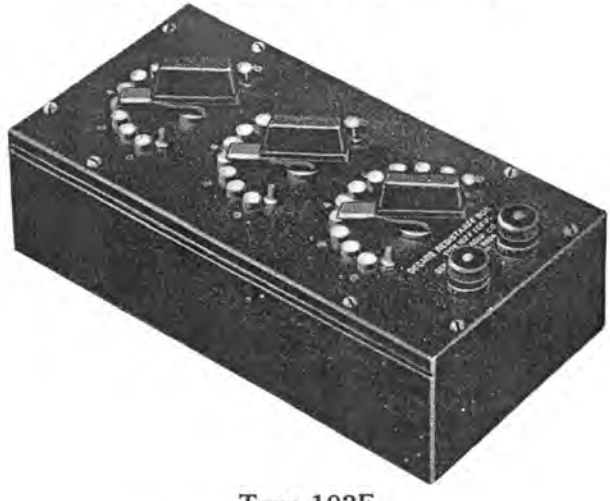
MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 211 **NOVEMBER 1926**

STANDARDS OF RESISTANCE AND DECADE RESISTANCE BOXES



Type 102F
DECADE RESISTANCE

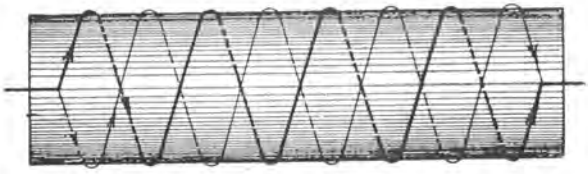
The first requisite for standards of all sorts is, of course, permanence; they must be unaffected by time and temperature.

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)

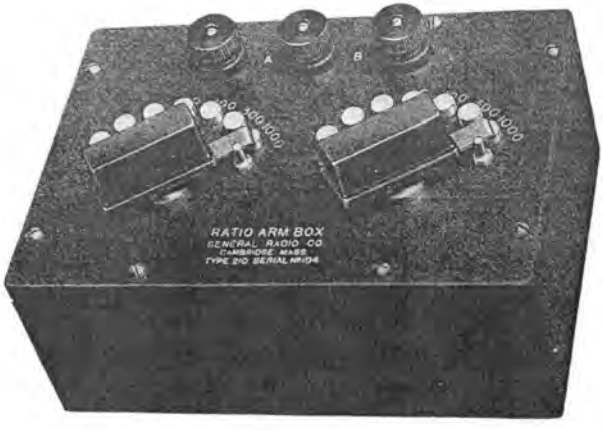
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 212 **NOVEMBER 1926**



Type 210
RADIO ARM BOX

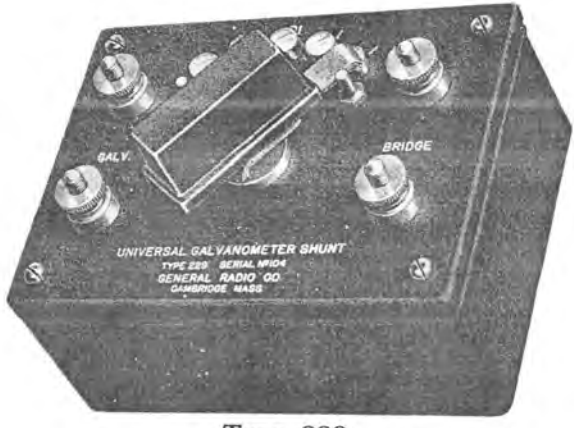
For the small laboratory where there is infrequent occasion for bridge measurements the expense of a permanent bridge set up is often unjustified. Where no bridge is available, one may be quickly assembled by combining the ratio arm box with suitable elements for the other arm. A Wheatstone bridge may 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.

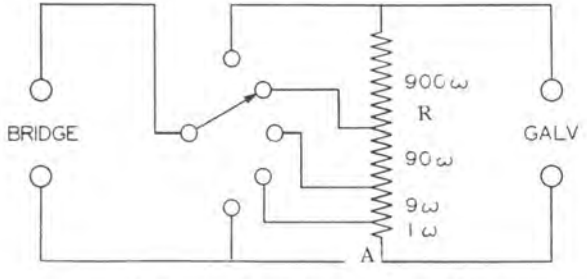
Code Word "RABID."



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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(This Bulletin replaces Bulletin 209)

208

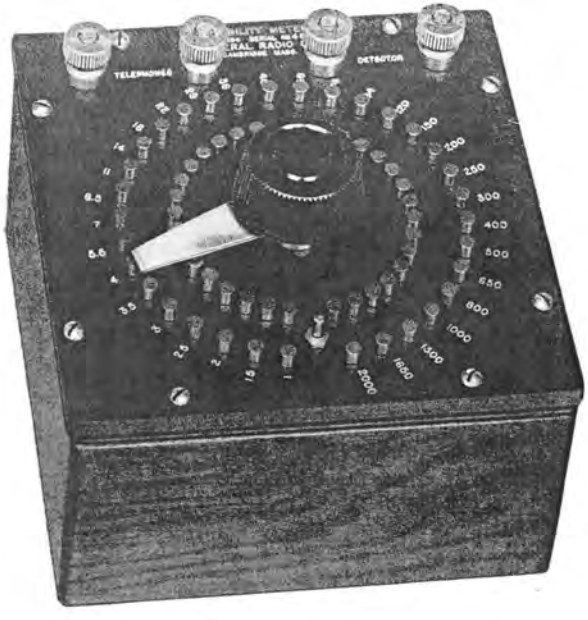
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 214 NOVEMBER 1926



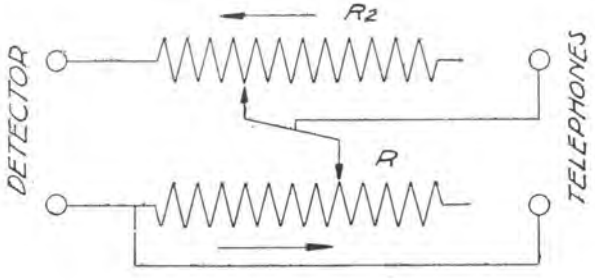
Type 164

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.



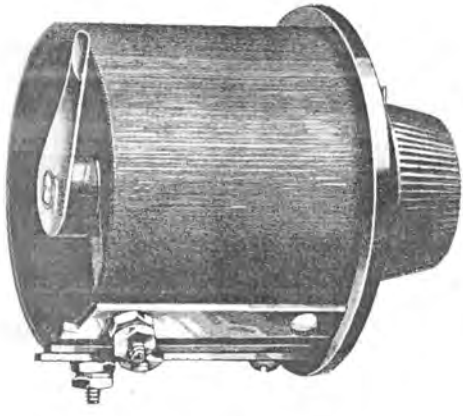
The Type 164 Audibility Meter is designed to keep the impedance of the oscillating circuit practically constant when used at 1000 cycles. It is adapted for use with any good 2000 ohm telephone receiver. This meter consists of two sets of resistance units with thirty-two taps and reads directly in audibilities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

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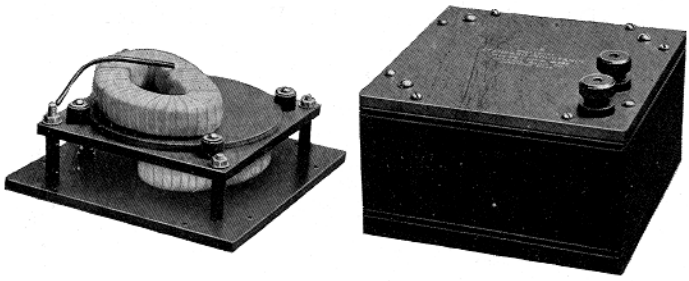
(This Bulletin replaces Bulletin 213)

GENERAL RADIO COMPANY

MANUFACTURERS OF
HIGH GRADE RADIO LABORATORY APPARATUS
CAMBRIDGE, MASSACHUSETTS

BULLETIN 301 **JUNE 1920**



STANDARDS OF INDUCTANCE
Type 106

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. The 1.0 Millihenry and smaller coils have twelve strand windings while seven strands are used on the larger coils. 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 prevent the possibility of this outside field 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 percent. The .05 and .20 Millihenry coils will carry 2.5 amperes indefinitely, the 1 Millihenry coil 2 amperes, and the 5.0 Millihenry coil 1 ampere.

These inductance standards are mounted in polished oak cases with engraved bakelite panels fitted with insulated binding posts.

Type	Inductance	Code Word	Price
106E	.05 Millihenry	INCUR	$24.00
106F	.20 Millihenry	INEPT	24.00
106G	1.0 Millihenry	INERT	24.00
106H	5.0 Millihenrys	INFIX	24.00

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

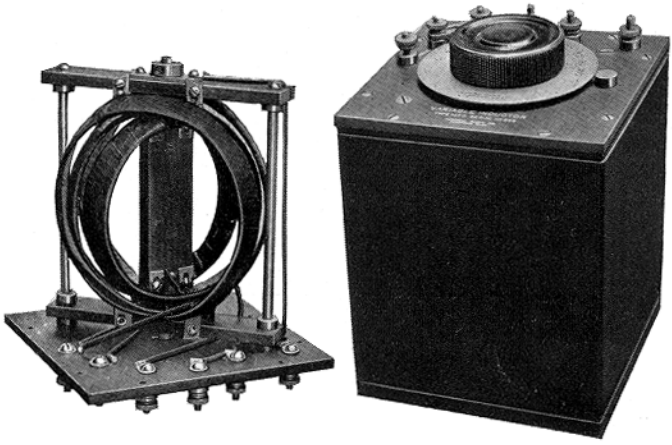
VARIOMETER

Type 107

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 spheres 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, but by a simple arrangement of connecting bars these 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 cur-



rents 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 an oak 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 for the coils both for the series and for the parallel connections. Calibration curves may also be supplied, for an additional charge of $5.00, giving the inductance throughout the entire range for both and series and parallel connections. Ranges other than those listed below can be constructed for a slightly increased cost.

Type 107C About .008 to .4 M.H. $24.00
Carries 3 amperes continuously.
Code Word "HAPPY."

Type 107D About .12 to 6 M.H. $24.00
Carries 1 ampere continuously.
Code Word "HARDY."

Type 107E About .4 to 20 M.H. $24.00
Carries ½ ampere continuously.
Code Word "HAVEN."

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

The products of the General Radio Company cover a complete line of high frequency radio 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, Slide Wire-Bridge, Audibility Meters, Hot Wire Meters, Galvanometers, Thermo-Couples, Telephone Transformer, Miscellaneous Apparatus.

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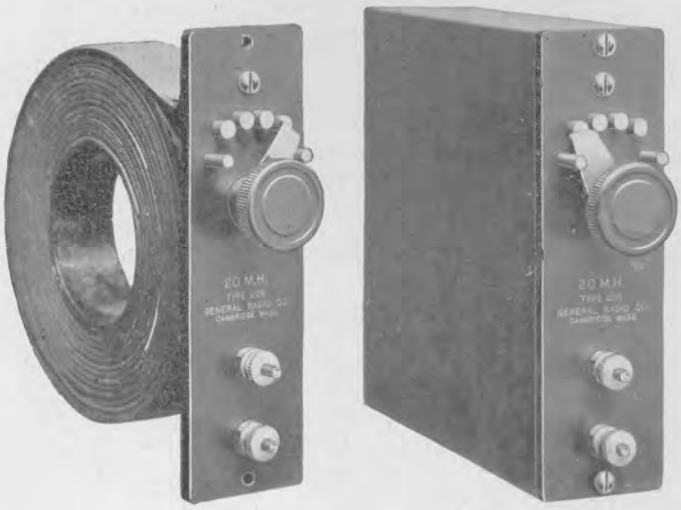
GENERAL RADIO COMPANY

MANUFACTURERS OF
HIGH GRADE RADIO LABORATORY APPARATUS
CAMBRIDGE, MASSACHUSETTS

BULLETIN 302 **AUGUST 1920**



FOUR STEP INDUCTOR
Type 226

The tuned circuits of an experimental radio receiving station must be capable of operating over a wide range. They should extend from 150 meters to above 20,000 meters. It is impractical to construct a single coil, even when equipped with a slider and sectionalizing switches to cover this entire range. It has become common practice to employ several sets of coils to cover this range. If coils without taps are used, the number required is so large that it is inconvenient to make the many changes required when working at a variety of wavelengths.

We have designed a set of four coils, each with four taps, which are particularly adapted for use in radio receiving sets. Although built with four different values of inductance they have the same physical dimensions thus permitting two or more circuits to be coupled together. By working at the extreme limits of each coil it would be possible to cover the range referred to above with three sizes instead of four. The four sizes, however, give a much greater flexibility than do three.

The coils are approximately of Maxwellian shape. The winding is such as to keep the distributed capacitance a minimum. This is a particularly important feature in that it increases the range over which any one coil may be used, and what is more important, it increases the efficiency of the coil by keeping the dielectric losses a minimum. These coils are rugged in construction and attractive in appearance. The case is of polished oak with engraved bakelite panel. The metal parts are finished in polished nickel.

One very distinctive feature about these coils is that they are self-supporting and, accordingly, do not require any auxiliary mounting. Coupling between coils is varied by simply changing the distance between coils or by turning through any desired angle. The arrangement of taps is such as to give values of approximately 20%, 45%, 75% and 100% of the maximum inductance.

These coils are adapted for general laboratory use as well as for radio receiving sets. It is seldom necessary to use a complete set of twelve coils to cover all ranges from 150 to above 20,000 meters. A satisfactory arrangement for this range is the following selection:

3 A Coils, 2 C Coils and 3 D Coils.

The ranges covered by these coils when used with one of our type 182E Condensers, which has a maximum capacitance of 1000 micromicrofards, are shown in the following table:

Type	Max. Ind.	Resistance	Approximate Range	Code Word	Price
226A	0.3 M.H.	0.8 Ohm	140- 1000 meters	IMAGE	$6.00
226B	3.0 M.H.	0.9 Ohm	400- 3000 meters	IMBED	$6.00
226C	20.0 M.H.	2.5 Ohms	1100- 8000 meters	IMBUE	$6.00
226D	125.0 M.H.	30.0 Ohms	3000-22000 meters	IMPEL	$6.00

Dimensions 5″ x 6″ x 1½″. Weight 2½ lbs.

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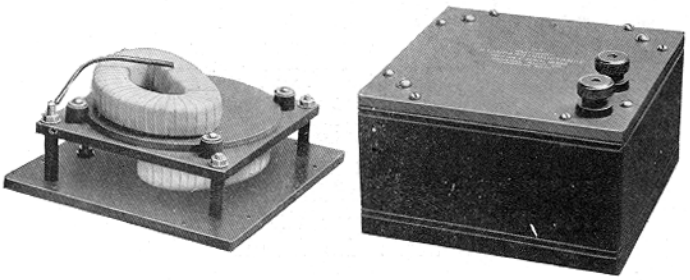
GENERAL RADIO COMPANY

MANUFACTURERS OF
ELECTRICAL AND RADIO LABORATORY APPARATUS
CAMBRIDGE, MASSACHUSETTS

BULLETIN 303 **JANUARY 1921**



STANDARDS OF INDUCTANCE
Type 106

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. The 1.0 Millihenry and smaller coils have twelve strand windings while seven strands are used on the larger coils. 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 accurancy of this adjustment is one tenth of one percent. The .05 and .20 Millihenry coils will carry 2.5 amperes indefinitely, the 1 Millihenry coil 2 amperes, and the 5.0 Millihenry coil 1 ampere.

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106G	1.0 Millihenry	INERT	24.00
106H	5.0 Millihenrys	INFIX	24.00

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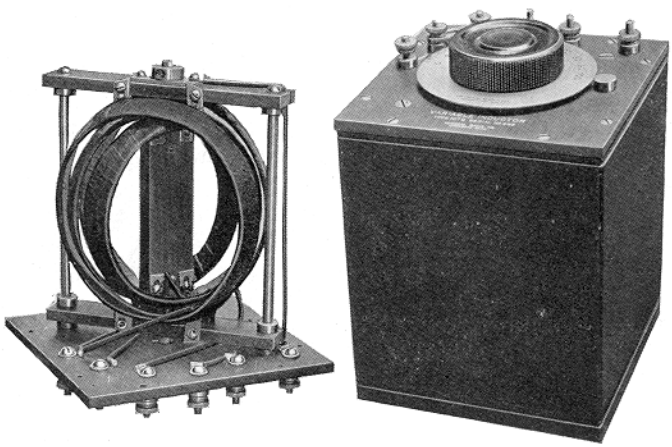

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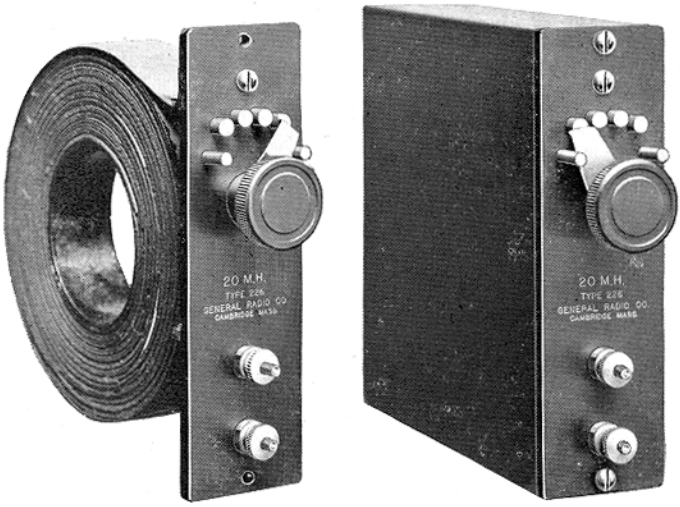
[This Bulletin replaces Bulletin 301]

GENERAL RADIO COMPANY

MANUFACTURERS OF
ELECTRICAL AND RADIO LABORATORY APPARATUS
CAMBRIDGE, MASSACHUSETTS

BULLETIN 304 **APRIL 1921**



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(This Bulletin replaces Bulletin 302)

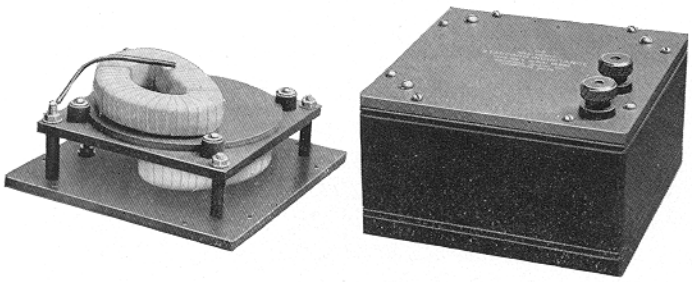
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 305 **NOVEMBER 1923**



Type 106

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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*
102L	.10	Millihenry	INNER	$24.00
106G	1.0	Millihenry	INERT	24.00
102J	10.0	Millihenrys	IRATE	24.00
102K	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.

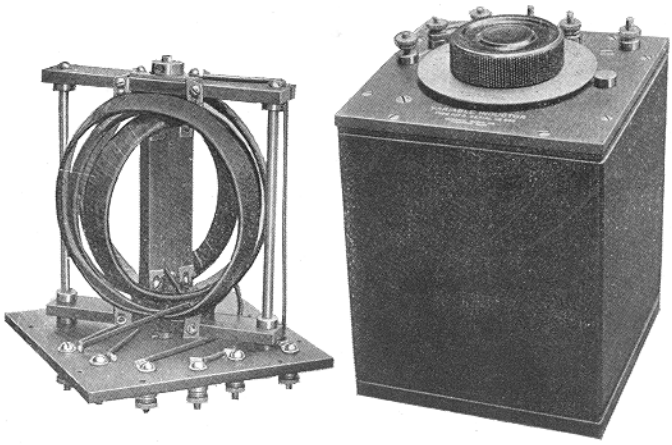
The Type 107 Variometer consists of two coils which are both sections of cylinders one of which is slightly smaller than the other. The smaller coil is mounted within the larger in such a manner that it may be rotated about its vertical diameter. The connections of each coil are brought out separately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

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, Slide Wire Bridge, Audibility Meter, Hot Wire Meters, Galvanometers, Thermo-Couples, Telephone Transformer, 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 304**)

Standardize on General Radio Apparatus Throughout.

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

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.

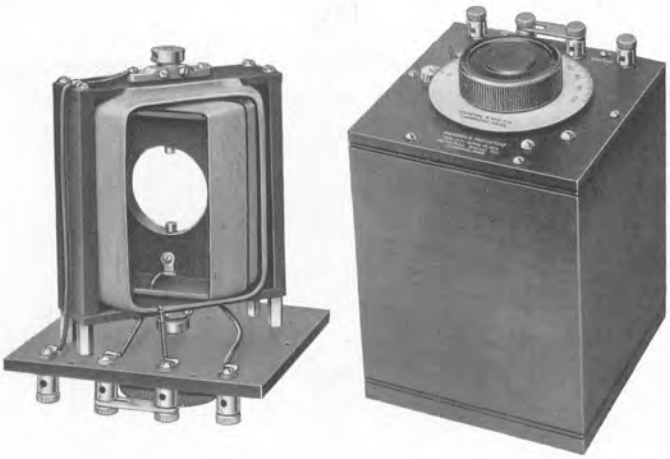
The Type 107 Variometer consists of two coils which are both sections of cylinders one of which is slightly smaller than the other. The smaller coil is mounted within the larger in such a manner that it may be rotated about its vertical diameter. The connections of each coil are brought out separately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

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 Meter, Hot Wire Meters, Galvanometers, Thermo-Couples, Telephone Transformer, Miscellaneous Apparatus.

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(This Bulletin replaces Bulletin 305)

Standardize on General Radio Apparatus Throughout.

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.

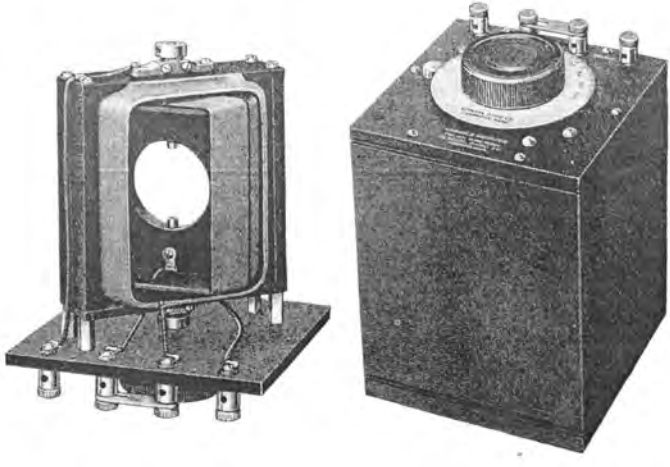
The Type 107 Variometer consists of two coils which are both sections of cylinders, one of which is slightly smaller than the other. The smaller coil is mounted within the larger in such a manner that it may be rotated about its vertical diameter. The connections of each coil are brought out separately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

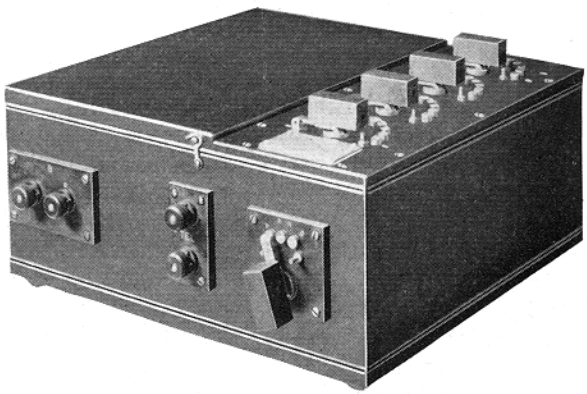
GENERAL RADIO COMPANY

MANUFACTURERS OF

HIGH GRADE RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 401 **MARCH 1920**



CAPACITY BRIDGE

Type 216

Description

There has long been a need for some simple yet reliable method of measuring capacitances as low as a few micro-microfarads with a precision of at least one-tenth of one percent. 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 accompanying diagram.

The input source E is the General Radio Co. Type 213 1000-cycle Audio Oscillator, described in Bulletin 701. 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 midpoint. The primary and secondary windings of this transformer are shielded from each other.

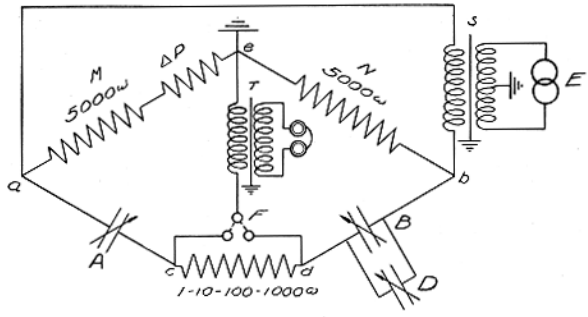
The bridge circuit consists of the two ratio arms M and N, and the arms A and B in which the standard and the unknown condensers are placed. The junction point of the two ratio arms is

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 our standard 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 oak. 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.

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 the maximum of results. 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 we recommend our Type No. 213 Audio Oscillator 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 micro-microfarads being 160,000 ohms—it is desirable that the detector used to denote the balance point of the bridge have a high impedance. As the impedance at the above frequency 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 micro-microfarad. 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 micro-microfarads. For this work the bridge is first balanced, using capacitances in the order of 1000 micro-microfarads. 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 micro-microfarad. 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.

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 micro-microfarads to a precision of one hundredth of a micro-microfarad. 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 micro-microfarads and a phase angle of 48′. When heated to 100° F. the capacitance had increased to 12.25 micro-microfarads 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 M. M. F.... $90.00
Dimensions 9″ x 8½″ x 10″. Weight 15 lbs.
Code Word "COPAL"

Type 169 Vernier Condenser $8.00
Dimensions 5½″ x 4¼″ x 2¾″. Weight ¾ lbs.
Code Word "CUBBY"

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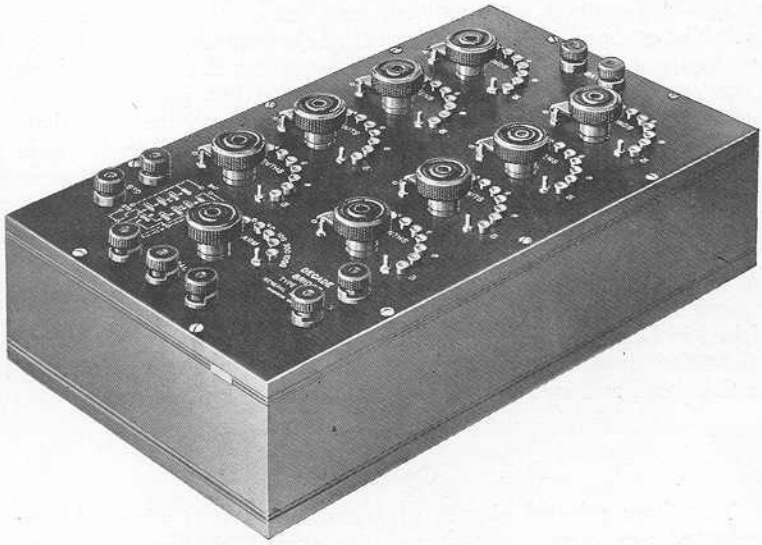
GENERAL RADIO COMPANY

MANUFACTURERS OF

HIGH GRADE RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 402 **AUGUST 1920**



DECADE BRIDGE
Type 193
Description

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 resistance combinations of 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 Aryton-Perry Method of winding described in our Bulletin No. 201.

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 oak, 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.

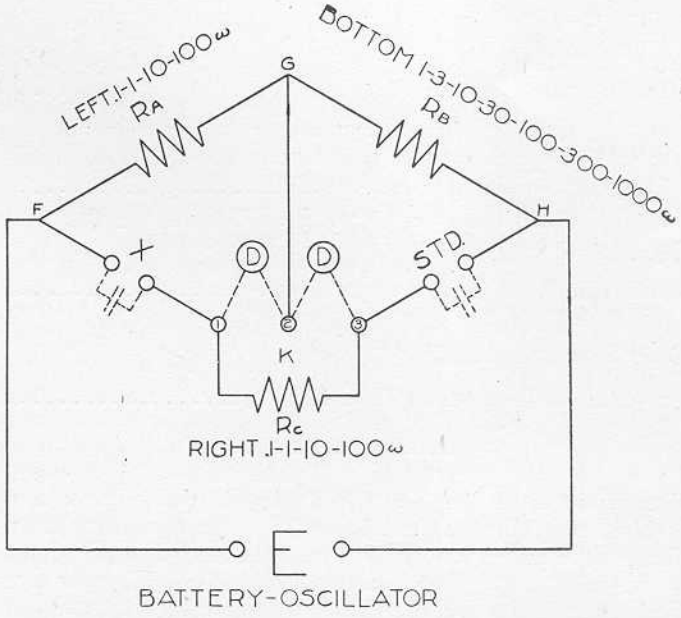
The power source supplied to the bridge is connected to the binding posts marked BAT. For direct current resistance measurements this source is one or two cells of a battery, while for capacitance and inductance measurements an alternating current source must be used. The alternating current should be 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

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

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 as 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 $L_X = \frac{R_A}{R_B} \cdot L_S$

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

Uses

The Type 193 Decade Bridge is designed for general laboratory use. For direct current measurements its principal 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 microhenries 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.

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 1002A)..... $13.00

The products of the General Radio Company cover a complete line of high frequency radio 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, Slide Wire-Bridge, Audibility Meters, Hot Wire Meters, Galvanometers, Thermo-Couples, Telephone Transformer, 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.

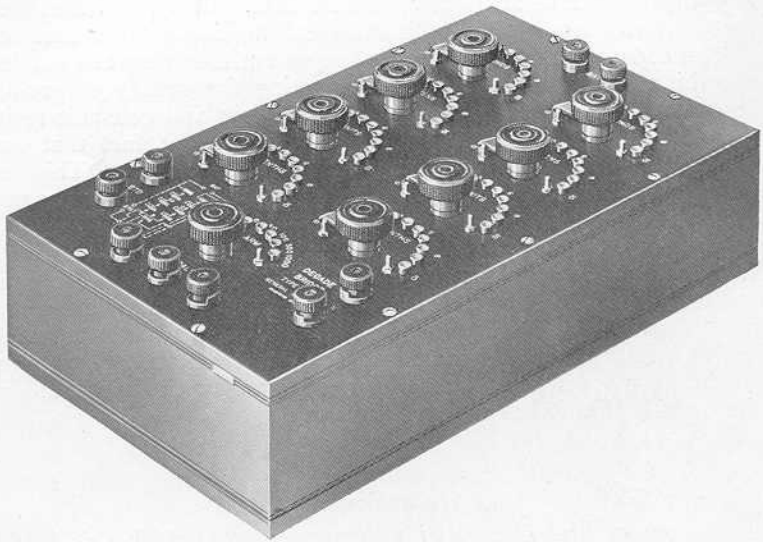
GENERAL RADIO COMPANY

MANUFACTURERS OF

HIGH GRADE RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 403 **DECEMBER 1920**



DECADE BRIDGE
Type 193
Description

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 resistance combinations of 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. 204.

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 oak, 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.

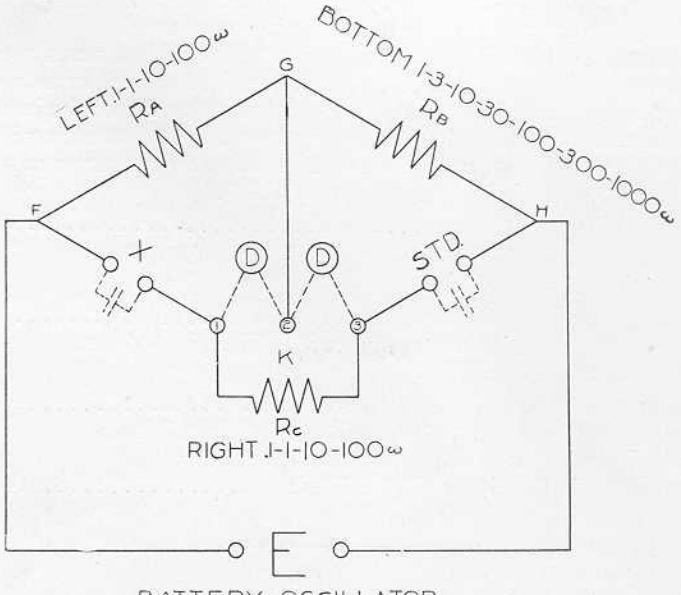
The power source supplied to the bridge is connected to the binding posts marked BAT. For direct current resistance measurements this source is one or two cells of a battery, while for capacitance and inductance measurements an alternating current source must be used. The alternating current should be 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

$$Rx = \frac{R_A}{R_B} . R_C$$

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.

$$\text{Inductance measurements } Lx = \frac{R_A}{R_B} . Ls$$

$$\text{Capacitance measurements } Cx = \frac{R_B}{R_A} . Cs$$

Uses

The Type 193 Decade Bridge is designed for general laboratory use. For direct current measurements its principal 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 microhenries 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%.

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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 1002A) $15.00

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[This Bulletin replaces Bulletin 402]

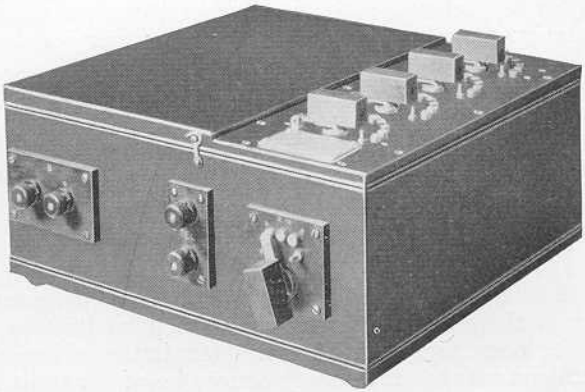
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 404 **JANUARY 1921**



CAPACITY BRIDGE
Type 216

Description

There has long been a need for some simple yet reliable method of measuring capacitances as low as a few micro-microfarads with a precision of at least one-tenth of one percent. 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 accompanying diagram.

The input source E is the General Radio Co. Type 213 1000-cycle Audio Oscillator, described in Bulletin 703. 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 midpoint. The primary and secondary windings of this transformer are shielded from each other.

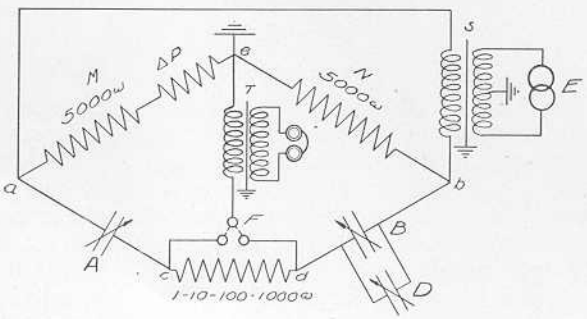
The bridge circuit consists of the two ratio arms M and N, and the arms A and B in which the standard and the unknown condensers are placed. The junction point of the two ratio arms is

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 our standard 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 oak. 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.

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 the maximum of results. 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 we recommend our Type No. 213 Audio Oscillator 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 micro-microfarads being 160,000 ohms—it is desirable that the detector used to denote the balance point of the bridge have a high impedance. As the impedance at the above frequency 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 micro-microfarad. 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 micro-microfarads. For this work the bridge is first balanced, using capacitances of the order of 1000 micro-microfarads. 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 micro-microfarad. 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.

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 micro-microfarads to a precision of one hundredth of a micro-microfarad. 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 micro-microfarads and a phase angle of 48′. When heated to 100° F. the capacitance had increased to 12.25 micro-microfarads 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 M. M. F.....$90.00
Dimensions 9″ x 8½″ x 10″. Weight 15 lbs.
Code Word "COPAL"

Type 169 Vernier Condenser $8.00
Dimensions 5½″ x 4¼″ x 2¾″. Weight ¾ lbs.
Code Word "CUBBY"

Type 1002A Western Electric Double Head Receivers.....$15.00

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[This Bulletin replaces Bulletin 401]

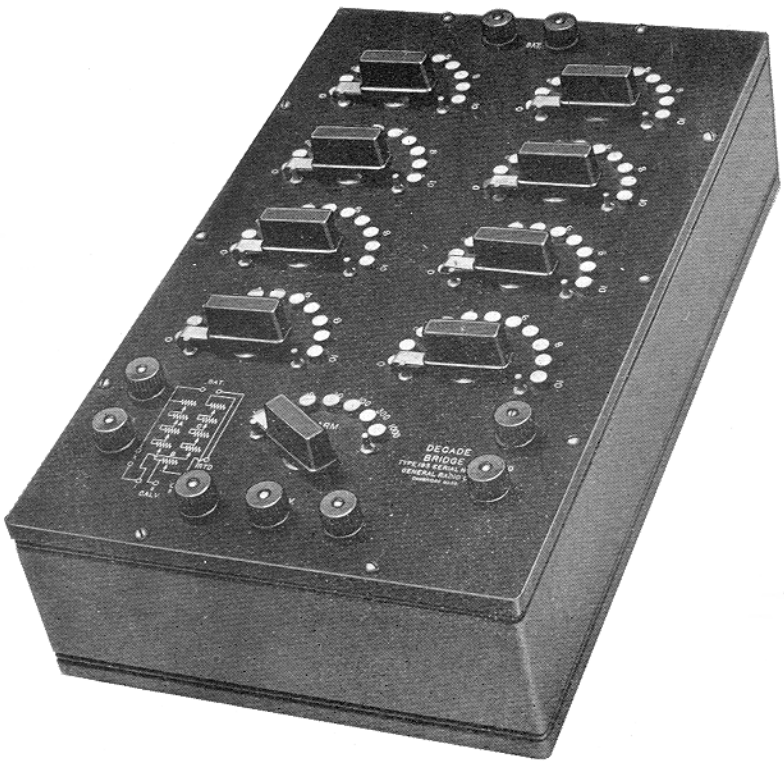
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 407 **NOVEMBER 1923**



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

resistance combinations of 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. 207.

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.

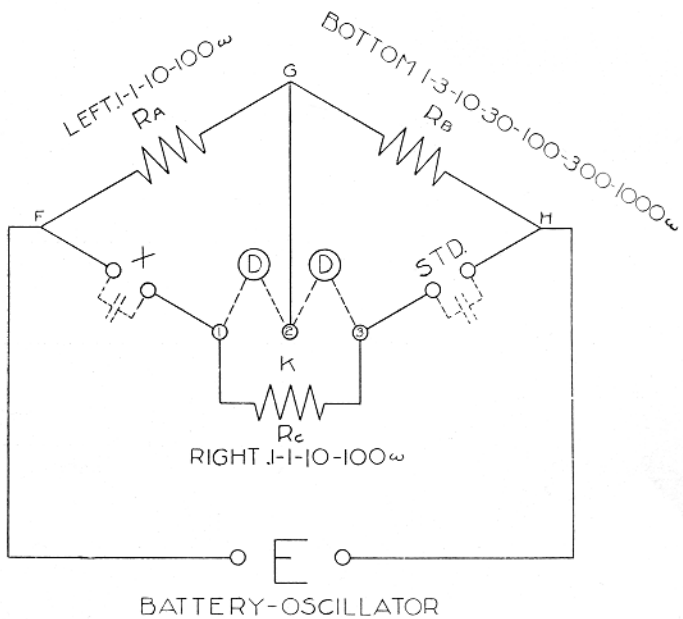
The power source supplied to the bridge is connected to the binding posts marked BAT. For direct current resistance measurements this source is one or two cells of a battery, while for capacitance and inductance measurements an alternating current source must be used. The alternating current should be 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 principal 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%.

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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

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[This Bulletin Replaces Bulletin 405]

Standardize on General Radio Apparatus Throughout.

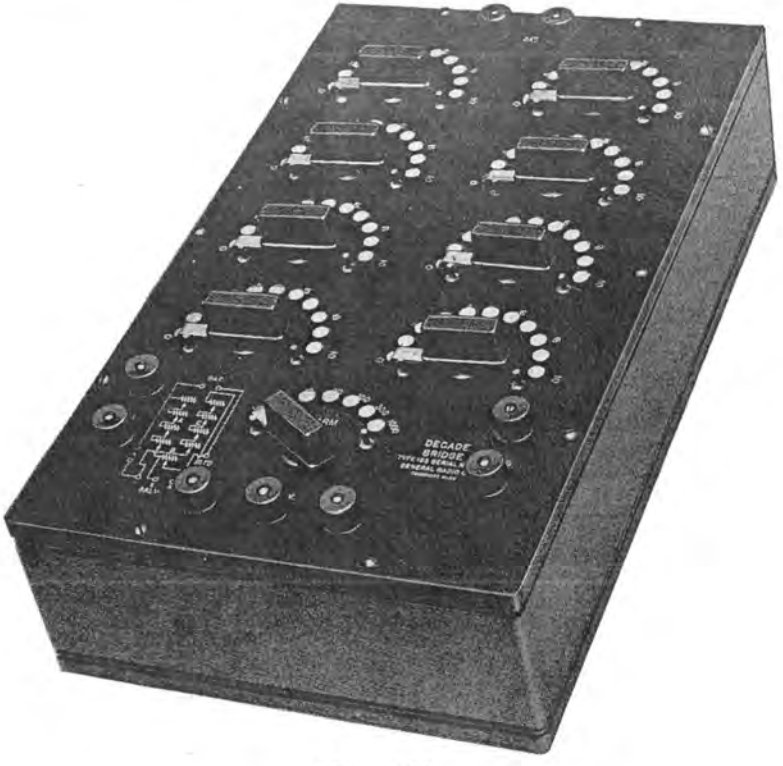
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 408 JANUARY 1925



Type 193
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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.

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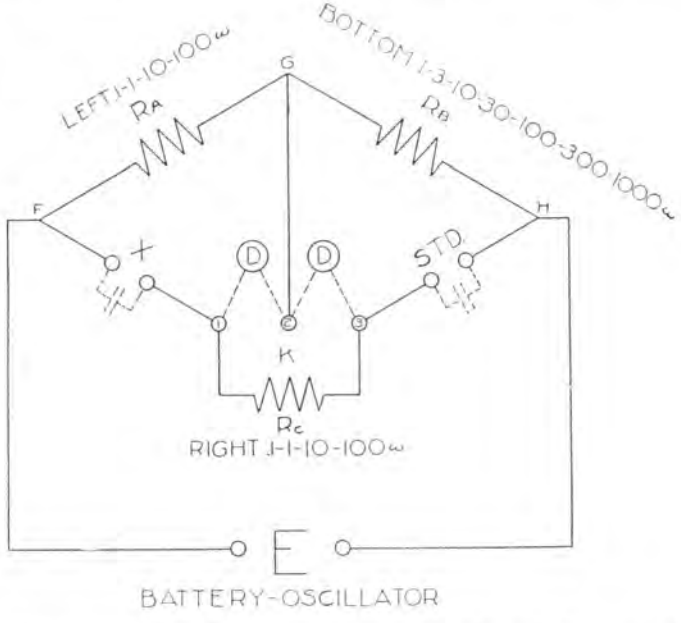

for resistance as well as for reactance. When the telephones, or vibration galvanometer, are connected between GALV binding posts 1 and 2, this compensating resistance is in series with the standard, and when the telephones are connected to binding posts 2 and 3 this compensating resistance is in series 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

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[This Bulletin Replaces Bulletin 407]

Standardize on General Radio Apparatus Throughout.

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 408 NOVEMBER 1923

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 percent. 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 433.

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.

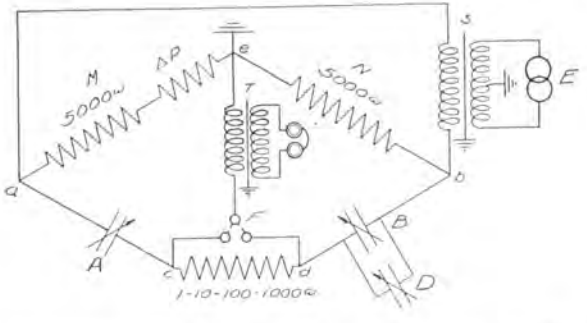
The bridge circuit consists of the two ratio arms M and N, and the arms A and B in which the standard and the unknown condensers are placed. The junction point of the two ratio arms is grounded.

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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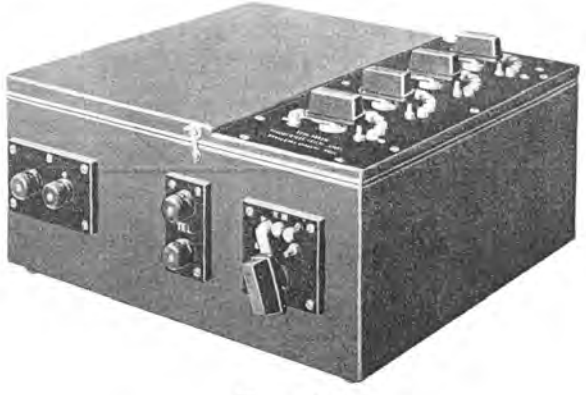
[This Bulletin replaces Bulletin 406]

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

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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.

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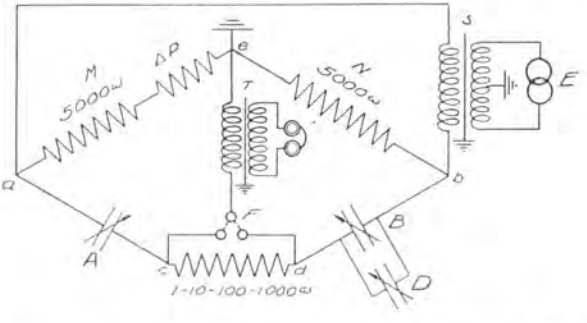
Since it is desired to detect minute changes in resistance and capacitance with this bridge it is very essential that each unit of the bridge be constructed to give a resultant maximum sensitivity. It is also very important that the supply source be of constant frequency and



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

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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.
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Code Word "COPAL"

Type 246L Balancing Condenser. Max. Cap. 1500 MMF $28.00
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Type 169 Vernier Condenser $8.00
Dimensions 5½″ x 4¾″ x 2¾″. Weight ¾ lbs.
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[This Bulletin replaces Bulletin 408]

Standardize on General Radio Apparatus Throughout.

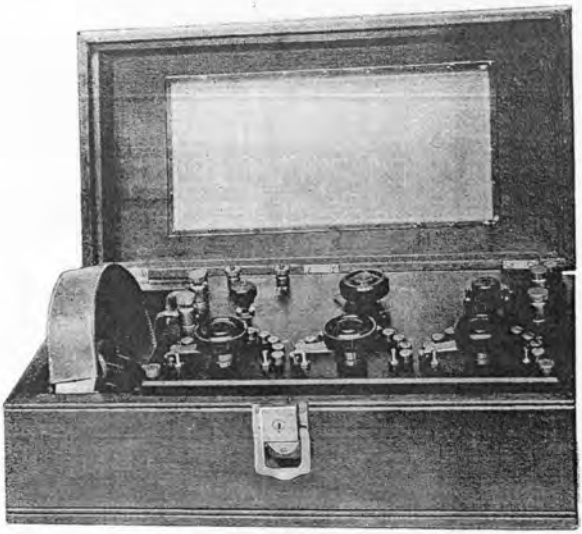
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE 39, MASSACHUSETTS

BULLETIN 409 **AUGUST, 1924**



TYPE 240

DIRECT READING CAPACITY METER

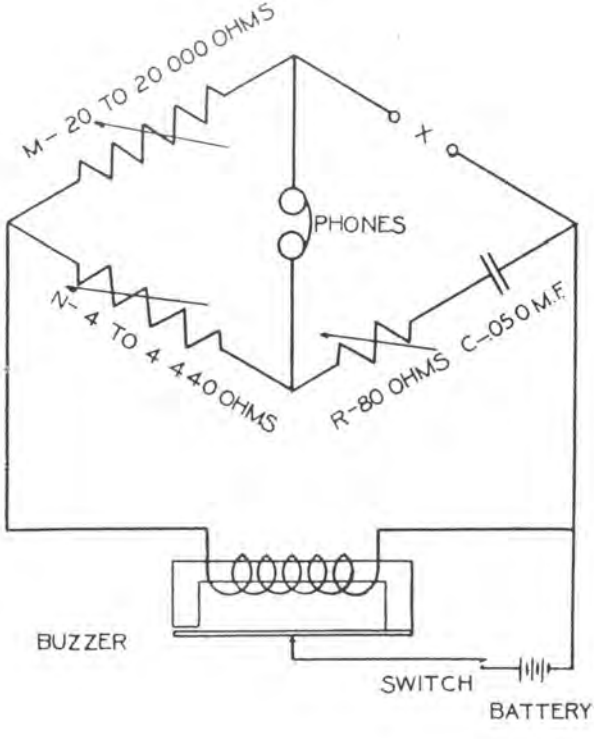
The Type 240 Capacity Meter meets the demand for a reliable direct reading capacity measuring instrument. It is especially adapted to general laboratory and commercial uses in obtaining capacity measurements ranging from .001 to 10 microfarads with an accuracy to one half of one per cent. Its simplicity 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 437. 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 80 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 $\frac{3}{8}$" 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 "Micofarads," "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 manufactures 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	Slide Wire Bridge
Variable Air Condensers	Vernier Condenser	Decade Bridge
Decade Resistance Boxes	Audibility Meters	Decade Condensers
Telephone Transformer	Wavemeters	Miscellaneous Apparatus

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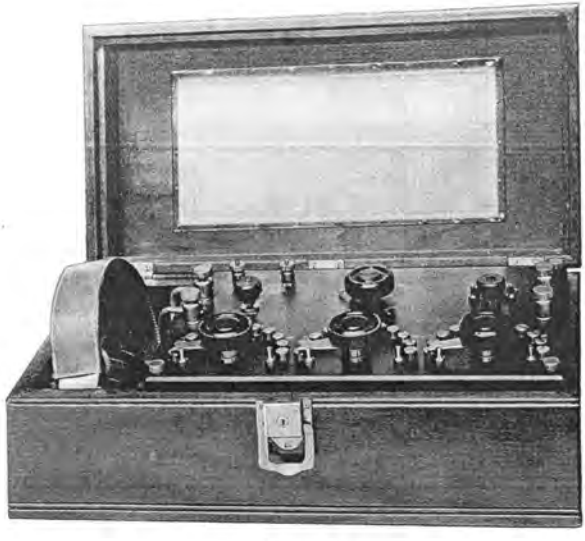
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE 39, MASSACHUSETTS

BULLETIN 410 JANUARY 1925



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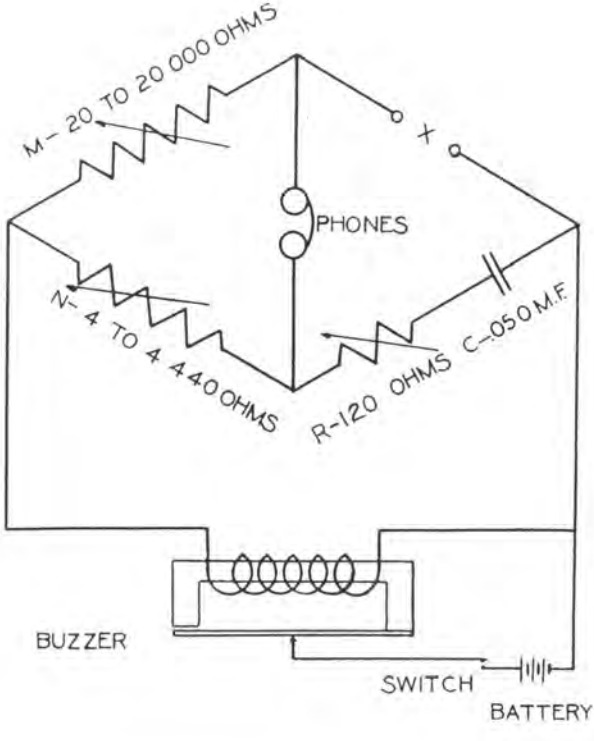
The instrument consists of a capacity bridge with variable resistances in the ratio arms and capacitances in the unknown and standard arms. A schematic diagram of the whole assembly is shown on page 441. The input is from a specially designed microphone buzzer supplied from a 4½ volt dry battery contained 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 $\frac{3}{8}$" 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.

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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.

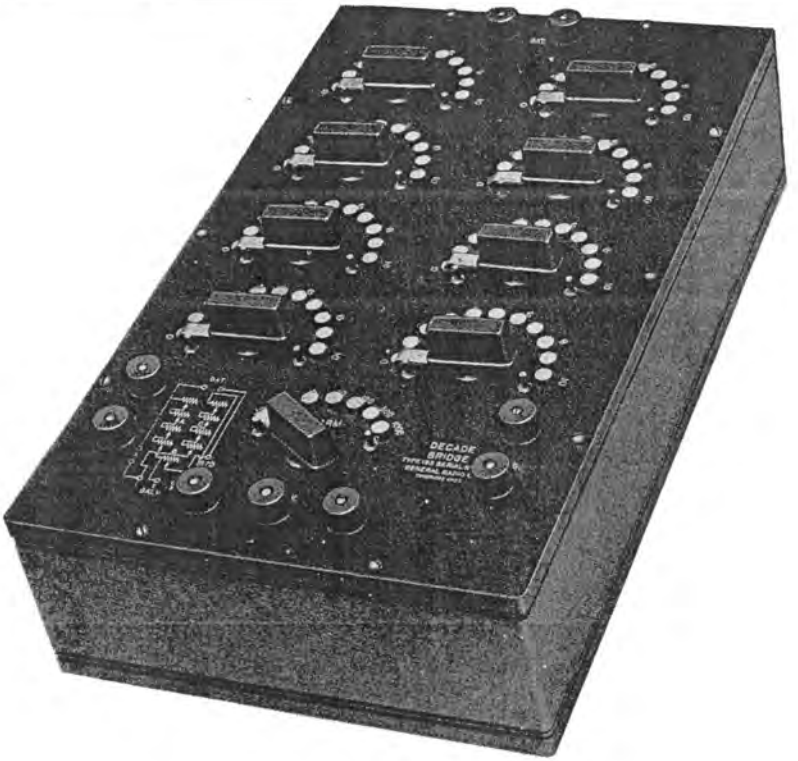
GENERAL RADIO COMPANY

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:

$$C_X = R_B C_S / R_A$$

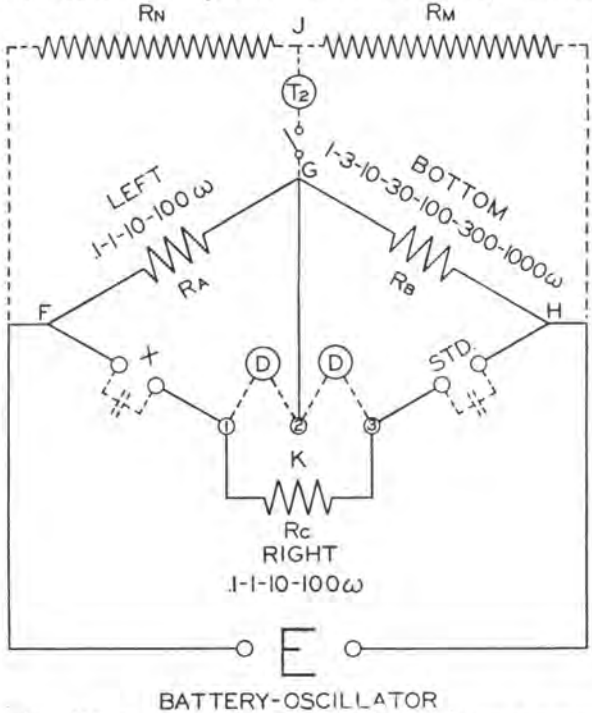
As before, the resistance balance gives the equation:

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

depending on the position of Rc.

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

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



Standards. When the bridge is used for resistance measurements, Rc is used for the standard. For inductance measurements our type

GENERAL RADIO COMPANY

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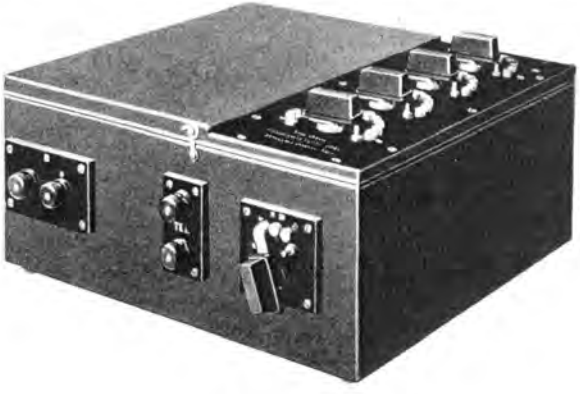
CAMBRIDGE, MASSACHUSETTS

BULLETIN 412 **NOVEMBER 1926**



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.

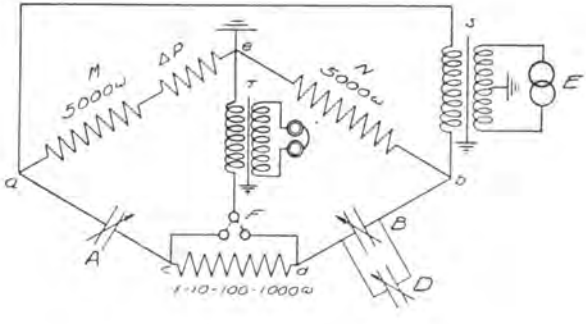
In order to isolate the bridge from stray capacity effects transformers with grounded shields between primary and secondary are used both at the input to the bridge and at the null detector.

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

MANUFACTURERS OF

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

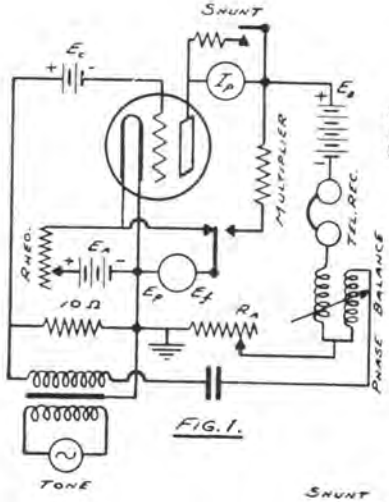

FIG. 1.

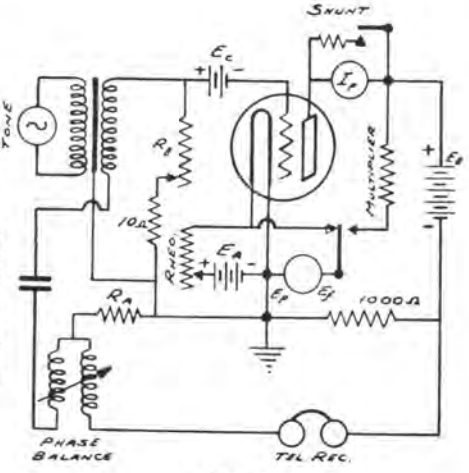

FIG. 2.

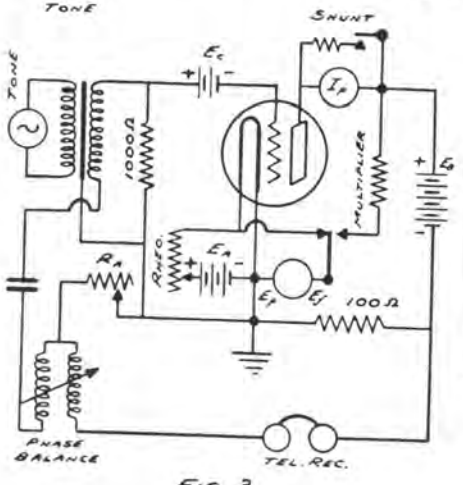

FIG. 3.

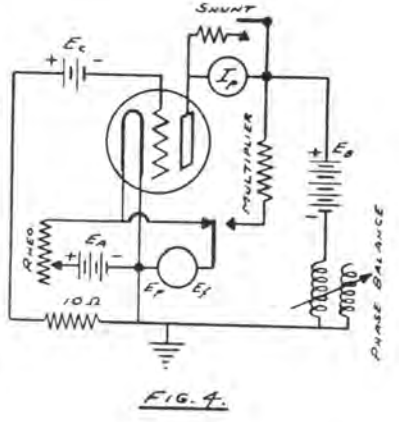

FIG. 4.

(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

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HIGH GRADE RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 501 **JUNE 1920**

HOT WIRE METER
Type 170

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 currents at high frequencies. In our types 127 and 170 Hot Wire Ammeters careful design and good workmanship are co-ordinated to produce 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 ex-

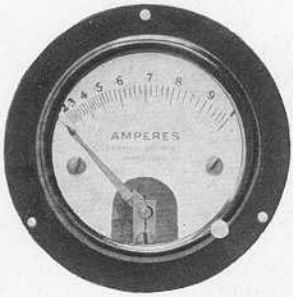
tensively in wavemeters and similar oscillating circuits for determining the resonance point. The Type 170 meters have found a wide use outside of the radio field. They are used as transfer instruments in generator testing and similar work.

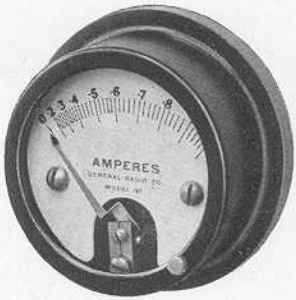
The expanding strip in these meters is of thin platinum, so as to prevent oxidation. It is so proportioned that it works at a low temperature and is of low resistance. These are two highly desirable features, since the former permits reasonable overloading without burning out, and the latter minimizes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

The type of multiplying action is such that a more uniform scale is obtained than with many hot wire meters. The bearings which support the steel shaft are the best grade jewel sapphire. 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.

The Type 127 front-of-board and flush mounting meters are mounted in metal cases finished in black japan. The Type 127 portable meters are mounted in moulded bakelite cases. The binding posts are finished in polished nickel. In mounting the flush type of meter an opening in the panel 2⅝″ in diameter should be provided. In mounting the front-of-board type allowance should be made for a case 3″ in diameter. The Type 170 meters are mounted in polished walnut cases and are fitted with insulated binding posts.





Type 127

Range	Code Word	Case	Price
100 Milli-Amps.	MAYOR	Front of Board	$15.00
¼ amp.	MADAM	Front of Board	11.00
½ amp.	MAJOR	Front of Board	10.00
1 amp.	MANOR	Front of Board	10.00
2 amps.	MARRY	Front of Board	10.00
3 amps.	MASON	Front of Board	10.00
5 amps.	MATIN	Front of Board	10.00
10 amps.	MAXIM	Front of Board	10.00
Galvanometer	MAGIC	Front of Board	9.00

Dimensions 3″ d. x 1½″. Weight 9 oz.

100 Milli-Amps.	MEDAL	Flash Mounting	$15.00
¼ amp.	MERCY	Flush Mounting	11.00
½ amp.	MERIT	Flush Mounting	10.00
1 amp.	MERRY	Flush Mounting	10.00
2 amps.	METAL	Flush Mounting	10.00
3 amps.	MIMIC	Flush Mounting	10.00
5 amps.	MINIM	Flush Mounting	10.00
10 amps.	MINNY	Flush Mounting	10.00
Galvanometer	MITER	Flush Mounting	9.00

Dimensions 3″ x 1½″. Weight 9½ oz.

100 Milli-Amps.	MUGGY	Portable	$16.00
¼ amp.	MOCHA	Portable	12.00
½ amp.	MOGUL	Portable	11.00
1 amp.	MOLAR	Portable	11.00
2 amps.	MONAD	Portable	11.00
3 amps.	MORAL	Portable	11.00
5 amps.	MUMMY	Portable	11.00
10 amps.	MUSTY	Portable	11.00
Galvanometer	MOTTO	Portable	10.00

Dimensions 3″ x 4″ x 1½″. Weight 10½ oz.

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	22.00

Dimensions 4¾″ x 5 x 3½″. Weight 16 oz.

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GENERAL RADIO COMPANY

MANUFACTURERS OF
HIGH GRADE RADIO LABORATORY APPARATUS
CAMBRIDGE, MASSACHUSETTS

BULLETIN 502 **DECEMBER 1920**

HOT WIRE METER
Type 170

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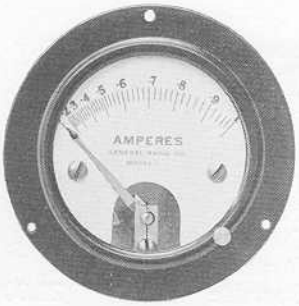
oscillating circuits for determining the resonance point. The Type 127 meters are used extensively for measuring the radiation, filament and plate currents in experimental continuous wave transmitting stations. The Type 170 meters have found a wide use outside of the radio field. They are used as transfer instruments in generator testing and similar work.

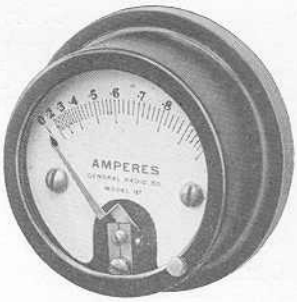
The expanding strip in these meters is of thin platinum, so as to prevent oxidation. It is so proportioned that it works at a low temperature and is of low resistance. These are two highly desirable features, since the former permits reasonable overloading without burning out, and the latter minimizes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

The Type 127 flush mounting meters are mounted in metal cases finished in black japan, while the front-of-board and portable types have cases of moulded bakelite. In mounting the flush type of meter an opening in the panel 2⅝″ in diameter should be provided. In mounting the front-of-board type allowance should be made for a case 3″ in diameter. The Type 170 meters are mounted in polished walnut cases and are fitted with insulated binding posts.





TYPE 127A

Range		Code Word	Case	Price
100	Milli-Amps.	MEDAL	Flush Mounting	$9.00
¼	Amp.	MERCY	Flush Mounting	7.75
½	Amp.	MERIT	Flush Mounting	7.75
1	Amp.	MERRY	Flush Mounting	7.75
2.5	Amps.	MINOR	Flush Mounting	7.75
5	Amps.	MINIM	Flush Mounting	7.75
10	Amps.	MINNY	Flush Mounting	7.75
	Galvanometer	MITER	Flush Mounting	7.25

Dimensions 3 in. x 1½ in. Weight 9½ oz.

TYPE 127B

100	Milli-Amps.	MAYOR	Front of Board	9.00
¼	Amp.	MADAM	Front of Board	7.75
½	Amp.	MAJOR	Front of Board	7.75
1	Amp.	MANOR	Front of Board	7.75
2.5	Amps.	MAPLE	Front of Board	7.75
5	Amps.	MATIN	Front of Board	7.75
10	Amps.	MAXIM	Front of Board	7.75
	Galvanometer	MAGIC	Front of Board	7.25

Dimensions 3 in. d. x 1½ in. Weight 9 oz.

TYPE 127C

100	Milli-Amps.	MUGGY	Portable	10.00
¼	Amp.	MOCHA	Portable	9.00
½	Amp.	MOGUL	Portable	9.00
1	Amp.	MOLAR	Portable	9.00
2.5	Amps.	MOTOR	Portable	9.00
5	Amps.	MUMMY	Portable	9.00
10	Amps.	MUSTY	Portable	9.00
	Galvanometer	MOTTO	Portable	8.50

Dimensions 3 in. x 4 in. x 1½ in. Weight 10½ oz.

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.

POINTER GALVANOMETER

Type 189

This is a portable instrument of the same general size as the Type 170 hot wire ammeter and is designed for use with direct currents of small magnitude. It is of the D'Arsonval type, has a double suspension and is well damped. It is made with a resistance of either 10 or 100 ohms and with scales having either zero left or zero center. The 100 ohm type requires approximately 25 microamperes for a full scale deflection—50 divisions from center to either side—while the 10 ohm type requires approximately 75 microamperes. The zero left instruments require twice these currents for full scale deflections of 100 divisions. When used with our Type 134 Thermo Couple, these galvanometers may be used to measure currents too small to give satisfactory readings on a 100 milliampere hot wire ammeter.

Price, any type $32.00
Size 4¾″ x 5″ x 3½″. Weight 2½ lbs.

Type 134 Thermo Couple $6.00
Size 2½″ x 1¼″ x 2″. Weight 4 oz.

While the meters of our own manufacture are limited to our Types 127 and 170 hot wire ammeters and our Type 189 D'Arsonval portable galvanometer, we can also supply Weston meters of all types.

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 501]

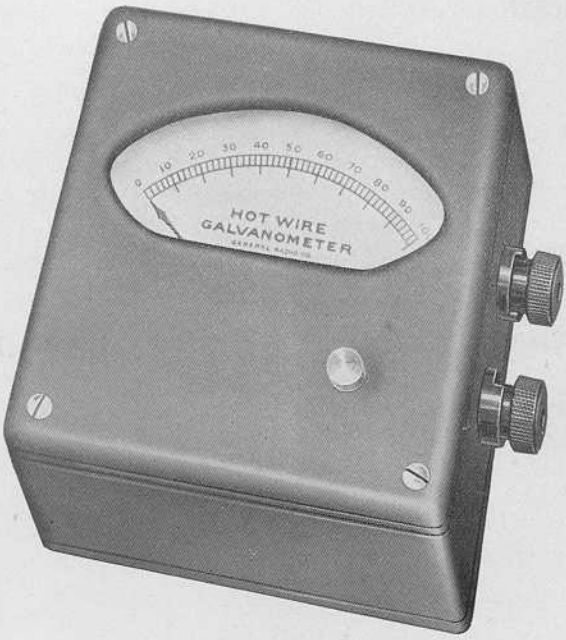
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 504 **NOVEMBER 1923**



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.

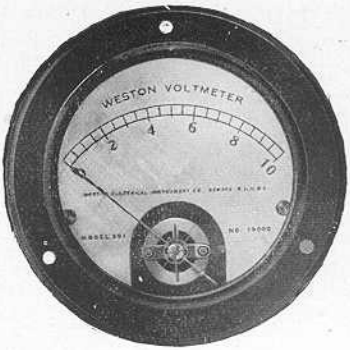
These instruments are made in two general sizes. Type 127 is the smaller, or three-inch size, and is made in three types, portable, front-of-board mounting and flush mounting. Type 170 is the large size and is made only in the portable type. It is mounted in a polished, walnut case and fitted with carrying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

The Type 170 meters are made in the sizes listed below. The Type 127 meters are illustrated and listed in Bulletin 916.

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:

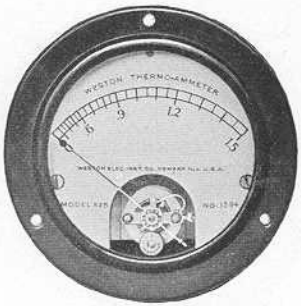
Range	*Code Word*	*Price*
10 volts	Autobath	$8.00
15 volts	Autobasket	8.00
50 volts	Autobattle	8.00
100 volts	Autobat	13.00

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 electrical and radio 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, Slide Wire Bridge, Audibility Meters, Hot Wire Meters, Galvanometers, Thermo-Couple, Telephone Transformer, Miscellaneous Apparatus.

[This Bulletin replaces Bulletin 503]

Standardize on General Radio Apparatus Throughout

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

The products of the General Radio Company cover a complete line of electrical and radio 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-Couple, Telephone Transformer, Miscellaneous Apparatus.

[This Bulletin replaces Bulletin 504]

Standardize on General Radio Apparatus Throughout

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