GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 6050 **JULY 1927**

Type 213

AUDIO OSCILLATOR

A multitude of Bridge measurements require a dependable source of alternating current of low power. The frequency must remain constant. The supply source should also be simple in its operation, rugged and reliable. It was to meet these requirements that the General Radio Type 213 Audio Oscillator was designed.

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

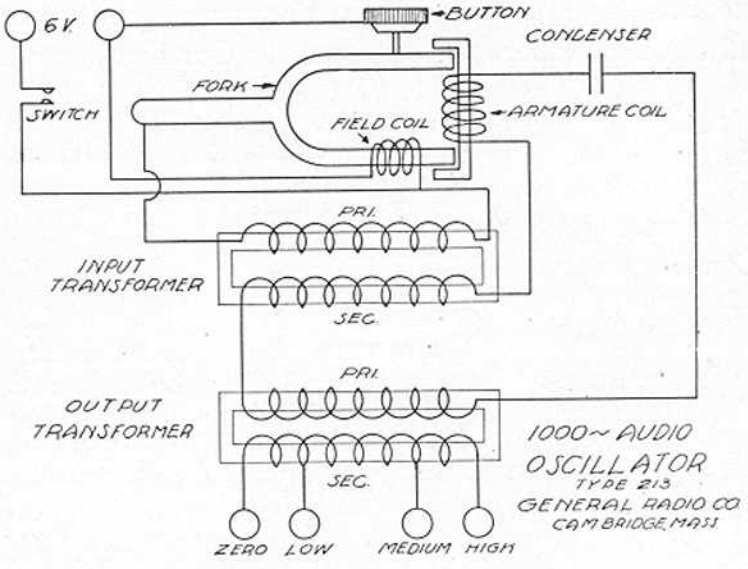
Point	Voltage	Current
Low	0.5 volts	100 milliamperes
Medium	1.5 volts	40 milliamperes
High	5.0 volts	12 milliamperes

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

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

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

Success or failure in the operation of a hummer, or audio oscillator, lies very largely in the microphone button. If the button heats so that the oscillator cannot be run indefinitely, if the adjustment of the button is not permanent, or if slight mechanical shocks change its operating characteristics, the oscillator has little commercial value. A distortion of as small an amount as one five-hundredth of an inch from normal position of the mica will destroy the perfect operation of the button. In order that the button may be insensitive to mechanical shocks and yet operate properly at 1000 cycles, use is made of its high inertia effect at the latter frequency. One side of the button is attached to the tuning fork by means of a short, flat spring. The other side, which has a projecting mounting post, is held in position by a specially designed self-centering spring. This combination of springs enables the button to withstand severe shocks, yet it has sufficient inertia so that perfect operation is obtained. The adjustment of the button is permanent and needs no further attention after leaving our laboratory. This type



of mounting, together with the fact that the electrical constants of the circuits have been adjusted to their optimum values, insures the continuous operation of the oscillator without heating.

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

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

Type 213 Audio Oscillator.....$32.00

Dimensions 6″x4¾″x5″. Weight 4½ lbs.

Code Word "AUGER."

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

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

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

(This Bulletin replaces Bulletin 720)

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 6100 **JULY 1927**

TYPE 377

LOW FREQUENCY OSCILLATOR

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

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

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

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

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

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

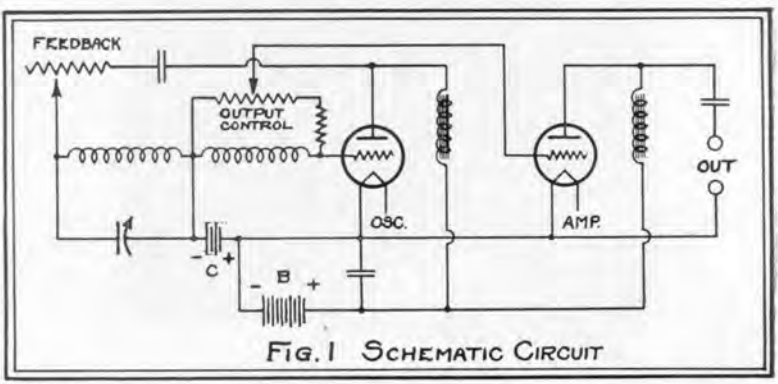


FIG. 1 SCHEMATIC CIRCUIT

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

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

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

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

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

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

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

INSIDE VIEW OF LOW FREQUENCY OSCILLATOR

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

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

USES

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

Other vacuum tube oscillators are under development.

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

Type 377 Low Frequency Oscillator.....$350.00

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

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

Code Word: "OMEGA."

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

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

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

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 6150 **JULY 1927**

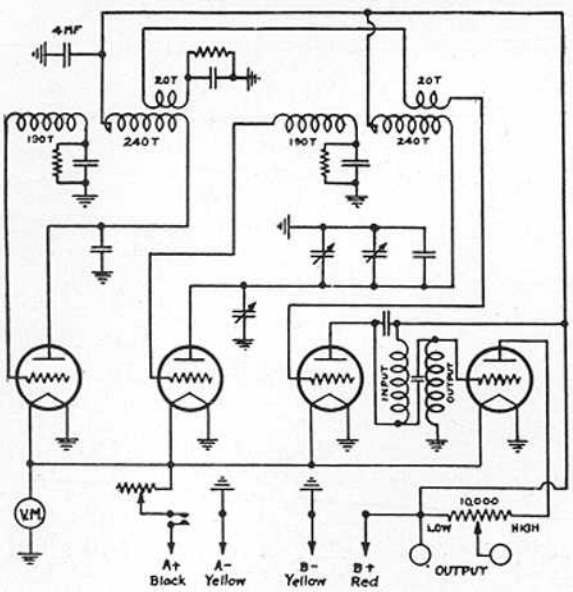
Type 413

BEAT-FREQUENCY OSCILLATOR

In measuring loudspeakers and audio frequency systems, it is often desirable to move through the entire frequency range quickly. The conventional type of vacuum tube oscillator, although it may be so designed as to be continuously variable, requires the adjustment of a number of controls in varying the frequency through the entire audio range. As the change in frequency involved is large, about five hundred to one, it cannot be obtained by the rotation of a single instrument of practicable construction. If, however, the measuring frequency is obtained by beating two oscillators together, a small percentage change in frequency of one of the oscillators will cause a relatively large change in the beat frequency.

Supplementing its oscillators of conventional type, the General Radio Company is manufacturing a beat frequency oscillator with a range of approximately 20 to 9000 cycles. The Type 413 Beat-Frequency Oscillator consists of two oscillator tubes, a detector, and an amplifier tube. The frequency of one of the oscillators is fixed at about 60 kilocycles, while that of the other is variable from approximately 50 kilocycles to 60 kilocycles. Both oscillators are coupled to the grid circuit of the detector tube. The oscillators are so constructed and shielded as to maintain a constant frequency over long periods without adjustment. The system of coupling the oscillators to the detector, supplying it with a low voltage from each oscillator is such that tendency of the two oscillators to pull into synchronism as zero beat is approached is eliminated. The detector output is fed through a Type 373 Double Impedance

Coupler giving nearly constant amplification over the wide range of frequencies used, to an amplifier tube. The output of the oscillator is taken off across a 10,000 ohm resistor used as a voltage divider, permitting the adjustment of the output voltage without changes in the oscillator circuit proper which might affect wave-form or frequency.



Three variable capacities will be seen in the above diagram. One of these is a small compensating condenser mounted inside the instrument. The purpose of this condenser is to correct for any slight inaccuracy in the fixed condenser in this circuit. Slight changes in frequency of either oscillator due to changes in circuit conditions may be compensated for by means of this condenser, which is adjusted so as to bring the two oscillators to zero beat. The frequency is changed by means of two other variable condensers, the main tuning unit of 500 MMF maximum capacity, and a micro-condenser shunted across it for fine adjustment.

The Beat-Frequency Oscillator is designed for use with either WX-12 or UX-199 tubes, space being provided in the cabinet for three one and one-half volt dry cells and three twenty-two volt "B" batteries. UX-201A tubes may be used with an external battery if desired. A five-volt Weston meter on the panel, and a rheostat inside the cabinet permit the adjustment of the filament voltage to the rated value. The Type 413 oscillator has an output of about two and one-half volts. The variation in output voltage over the frequency range is about 10%. The wave-form is satisfactory for most purposes, the total of harmonics being at a maximum but 4% of the wave in voltage.

The Type 413 oscillator is useful in the measurement of all devices intended for operation in the audio frequency range. It is particularly helpful in the study of loudspeaker response curves, as the complete frequency range at practically constant intensity is available by one-half revolution of the main dial so that peaks or hollows in the response of the speaker are immediately evident. Any tendency to blast at particular frequencies is quickly revealed.

The Type 413 Beat-Frequency Oscillator may also be used to modulate the output of the General Radio Type 384 Radio Frequency Oscillator. The modulated radio frequency output thus obtained may be used in testing receiving sets for both radio and audio frequency response. The audio modulating frequency can be quickly compared with the audio frequency output of the receiver with an oscillograph such as the General Radio Type 338.

This instrument is licensed under Patent No. 1113149 by the Radio Corporation of America for experimental laboratory use only where no commercial features are involved.

Type 413 Beat-Frequency Oscillator.....Price $210.00

Without batteries or tubes.

Dimensions 12″ x 8″ x 20″. Weight, 27 pounds; with battery, 40 pounds.

Code Word "ORGAN."

Type 384

RADIO FREQUENCY OSCILLATOR

A small radio frequency oscillator has a wide range of usefulness in the laboratory. For maximum utility such an instrument must have a wide frequency range and be readily portable. The Type 384 Oscillator has been designed to meet these requirements.

The Type 384 Oscillator is of the plug-in coil type. The range may be extended from 15 to 30,000 meters by means of nine coils. A single UX199 tube is used which permits an entirely self-contained instrument. A plate milliammeter is provided to indicate oscillation.

The Type 384 Oscillator may be used as a source in high frequency measurements of coils and condensers, or for the checking of receivers. It is particularly useful for the latter purpose when combined with the Type 384 Beat-Frequency Oscillator. The oscillator is provided with input terminals so that the beat oscillator may be used as a modulator. In this manner the over-all receiver characteristics may be readily checked, both radio frequency and audio frequency tests being made simultaneously.

The Type 384 Oscillator is also readily adapted to use as the auxiliary oscillator in conjunction with the type 275 Piezo Oscillator when using harmonics of the plate frequency for calibration of frequency standards.

Type 384 R. F. Oscillator, without coils.....Price $80.00
Code Word "ODIUM".

The following coils are available for use with the Type 384 R. F. Oscillator:

Type	*Range*	*Code Word*	*Price*
384-A	15-30 meters	HAZEL	$3.00
384-B	30-80 "	HEAVY	3.00
384-C	70-200 "	HELOT	3.00
384-D	190-575 "	HERON	3.00
384-E	565-1,700 "	HILLY	4.00
384-F	1,700-4.400 "	HINNY	4.00
384–G	4,400–12,000 "	HOARY	5.00
384-H	12,000-30,000 "	HOLLY	8.00
384-D 8	200-600 "	HOBBY	4.00

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

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(This Bulletin replaces Bulletin 726)

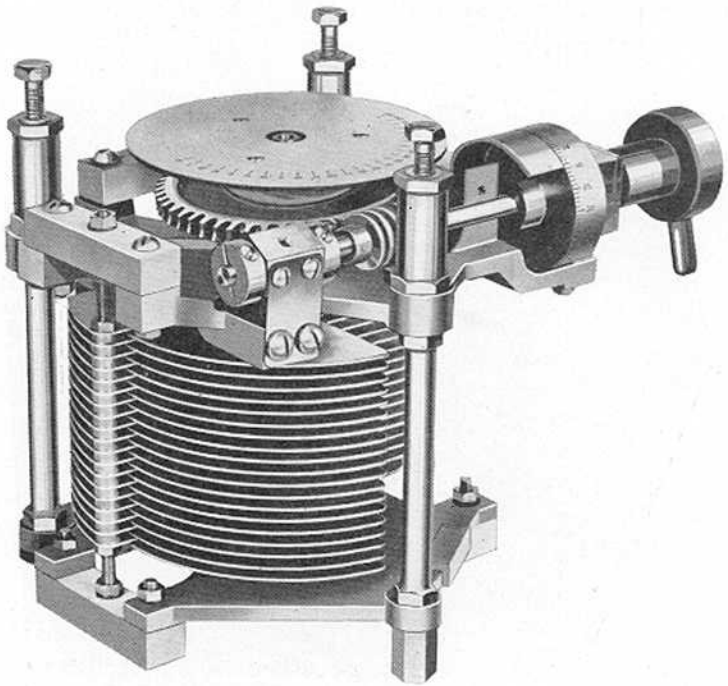
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 706C **JULY 1927**



Type 222

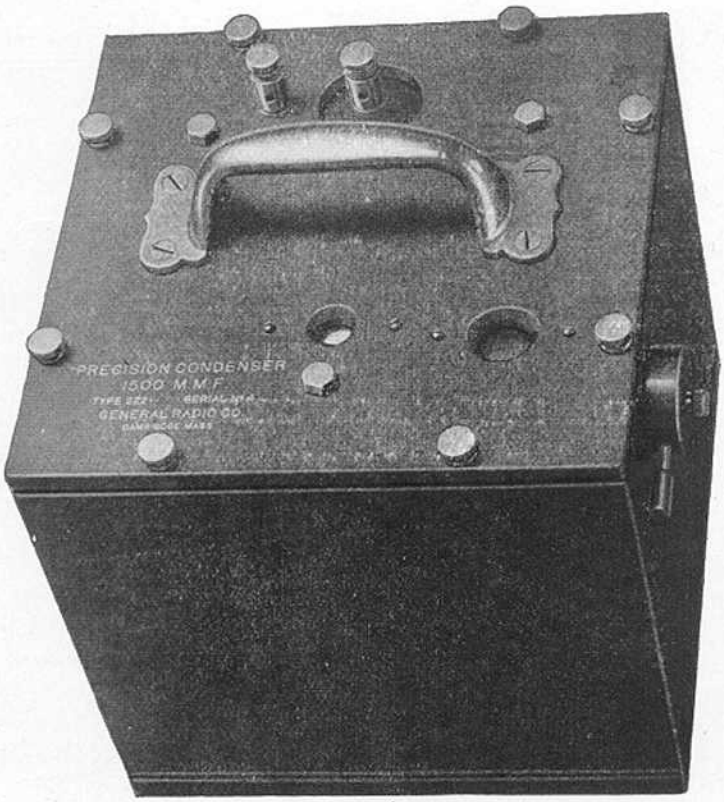
PRECISION CONDENSER

Condensers used as standards and for precision measurements must have many features not usually found in ordinary laboratory condensers. For variable standards it is essential that the plates be sufficiently rigid and well spaced so that handling the condenser will not cause a change in capacitance. It is not alone sufficient that the power factor be low, but it is also important that the dielectric losses be substantially constant throughout the entire range of the condenser.

The General Radio Type 222 Precision Condenser is intended for those places where precision is essential, rather than for use as an ordinary laboratory experimental condenser. In its design, the mechanical as well as the electrical features have received special attention.

MECHANICAL. The plates are of heavy aluminum, widely separated by accurately turned spacers, and firmly clamped between

substantial cast metal end-plates. A steel shaft, carrying the rotating plates, turns in cone-shaped bronze bearings. The adjustment is locked after the condenser has been subjected to a rotation test to insure the proper fit of the bearings.



The rotary plates are turned by a worm and gear, thus permitting fine control. The worm is held by spring tension in position against the gear to prevent backlash. This is the same method used in accurate dividing engines. The worm is lapped in to insure perfect fit, and the condenser then tested for backlash in the laboratory.

ELECTRICAL. The stator plate assembly is insulated from the rigid end-plates, carrying the rotar assembly, by Isulantite blocks. As these blocks are small in volume, and placed in a weak, non-varying electrostatic field, the condenser has a very low power factor, .007% at 1000 MMF.

When using this condenser in measuring the power factor of absorbing condensers the fact that the field, where the Isulantite supports are located, does not vary with condenser setting is of importance. because it permits the assumption that the precision condenser is the equivalent of two condensers in parallel, one being a perfect condenser of variable capacity, the other a small fixed condenser with which is associated all the dielectric losses.

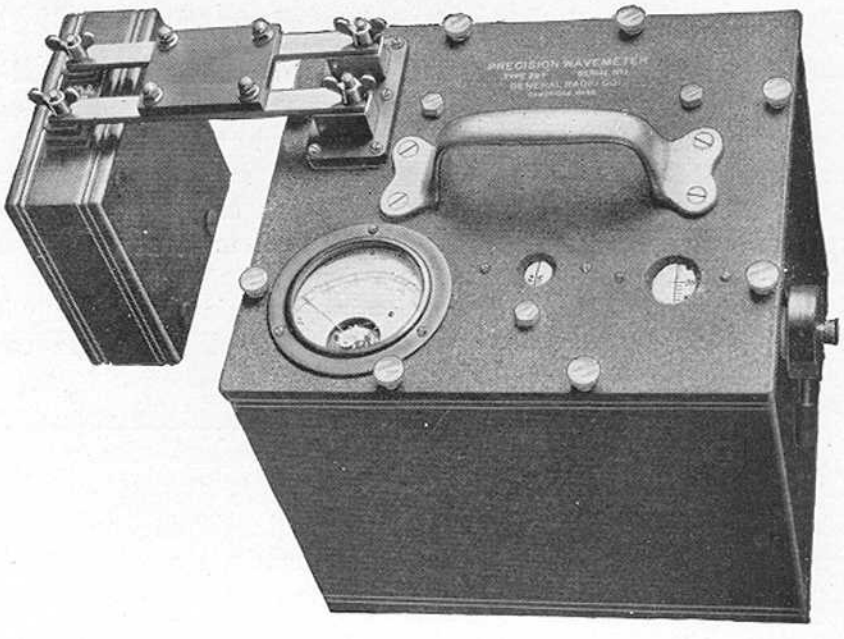
The temperature coefficient of this condenser is practically nil, and there is no change in capacity with frequency. The equivalent series resistance at 1000 cycles and 1000 MMF. is approximately 11 ohms. The breakdown potential is about 1000 volts.

SCALES AND CALIBRATION. Attached to the main shaft is a scale, divided into 25 equal parts, while on the worm shaft is a second scale, the circumference of which is divided into 100 equal parts. Since one complete turn of the worm shaft moves the main scale through one division, the position of the rotary plates may be read directly to 1 part in 2500—equivalent to about 0.6 MMF. Since these sub-scale divisions are $\frac{1}{16}$ of an inch apart, it is easy to estimate to one-fifth of a division. Each condenser is supplied with a chart giving, with an accuracy of 1 MMF., the condenser calibration at 26 points.

MOUNTING. The condenser is mounted on a ¼ inch aluminum plate, finished in permanent crystalline black. This plate forms the top of the case, which is of polished walnut and lined with a copper shield. In order that the condenser may be kept free from dust the two scales are read through glass windows set into the aluminum top. A hard rubber rotating handle extends into the box and engages the worm shaft. The carrying handle and other metal parts are finished in polished nickel.

A substantial whitewood carrying case, provided with lock and carrying handle, is furnished with each instrument.

Type 222L Precision Condenser.....$80.00
Dimensions 8¼" x 8¾" x 9". Weight 16 lbs.
Code Word "COPAL."



Type 224
PRECISION WAVEMETER
Range 75-24,000 meters (4,000-12.5 kilocycles)

This wavemeter is designed to provide an accurate instrument for laboratory service, yet sufficiently portable for general measurement work where precision is essential.

MECHANICAL. Since the condenser is the Type 222 described above, it is not necessary to repeat its description here. The coil mounting is rugged, and particular care has been taken to lock or pin all parts to keep them secure. The coils are wound and mounted in such a manner that the turns cannot become loose.

ELECTRICAL. A standard wavemeter must be sharp tuning. This has been accomplished in the Type 224 wavemeter by the use of a low loss condenser and by proper inductance design. In the design of these inductances, of which there are five, attention also has been given to the necessity for low dielectric losses, low distributed capacity, good form factor, and a reasonable amount of overlap in wave length.

To insure accuracy under all conditions no extra circuits such as a buzzer or detector are incorporated in the wavemeter. There is but one circuit, the calibrated oscillating circuit, which consists of the condenser, an inductance and a Weston thermo galvanometer for indicating resonance. This circuit is so connected that the condenser rotor plates, the condenser shield, the thermo galvanometer and the outside of the inductance coil are at low potential. This prevents disturbances due to variation in stray capacities.

SCALES AND CALIBRATION. The scale arrangement is the same as is used on the Precision Condenser. Mounted calibration curves are furnished for each coil. The standards used in calibrating are checked by means of a series of quartz plates, used as described in Bulletin 718. Harmonics of the plates were checked at low frequency against a standard clock.

The accuracy of calibration of the Type 224 is 0.25%.

MOUNTING. The condenser is mounted in a polished walnut case similar to that of the Precision Condenser. Each inductance coil is enclosed in a walnut box with an engraved hard rubber panel stating the wavelength range. The terminal blocks are so shaped that they will fit on to the connecting bars in one way only, thus insuring that each coil will always be connected in the same manner in which it was calibrated.

A strongly built whitewood shipping case is furnished with each wavemeter. Separate compartments are provided for the condenser and coils. This case is fitted with a carrying handle and lock.

Type 224 Precision Wavemeter.....$190.00
Dimensions 18″ x 11″ x 11″. Weight 34 lbs.
Code Word "WAGER"

The Type 224L Precision Wavemeter is similar in general construction to the Type 224, with such modifications as proved necessary for short wave work.

Type 224L. 15—600 meters.....Price $200.00
Dimensions 18¼″ x 12¼″ x 13″. Weight 41½ lbs.
Code Word "UNDER."

(This Bulletin replaces Bulletin 719)

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 7100 **JULY 1927**

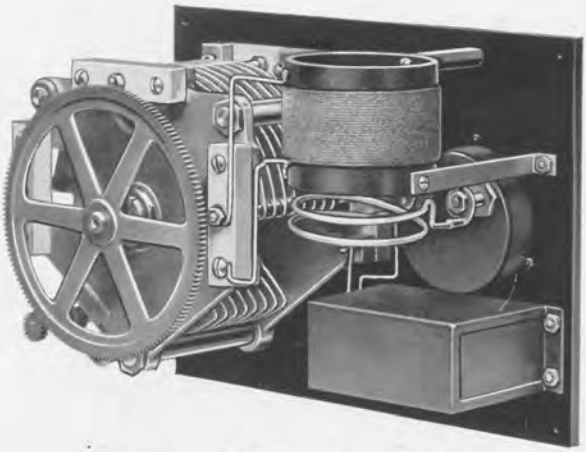
TYPE 332

STATION FREQUENCY METER

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

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

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



Inside view of Station Frequency Meter

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

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

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

USES

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

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

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

Type 332 Station Frequency Meter $90.00

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

Code Word "SENNA."

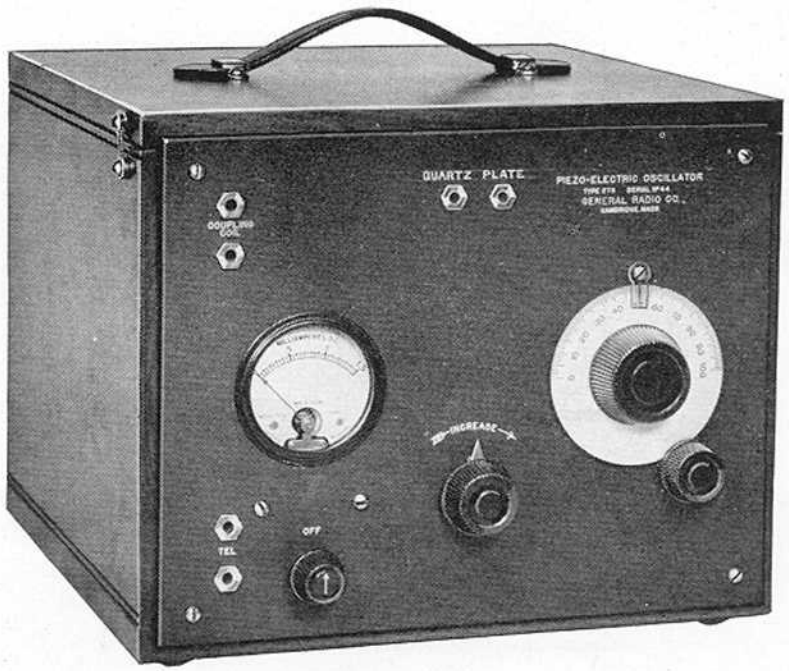
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 7200 **JULY 1927**

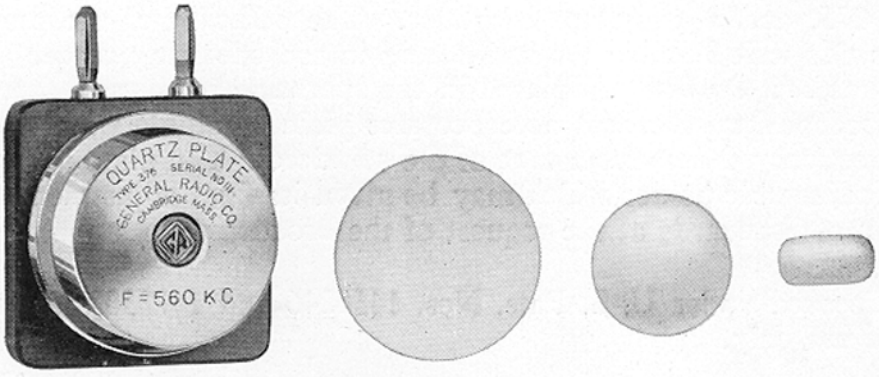


Type 275
PIEZO ELECTRIC OSCILLATOR

The piezo electric properties of crystalline quartz make it particularly well adapted for use as a frequency standard. Plates of this material when properly prepared, and placed in the circuit shown on page 804, will hold the frequency within very narrow limits. The oscillating frequency is nearly independent of the electrical constants of the circuit. The frequency is entirely dependent on the physical dimensions of the quartz plate which may be ground very closely to specifications. The frequency is practically unvarying with temperature and is not affected by any mechanical shock which does not fracture the plate.

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

each oscillator, harmonics as high as the 300th may be utilized. Lower frequencies than the fundamental may also be obtained by means of of the auxiliary tube. The auxiliary tube is adjusted to the lower frequency by tuning it for zero beat between its harmonic of the desired order and the quartz-controlled oscillator. By means of this device, a single plate may be used to obtain a great number of frequencies.



QUARTZ PLATES

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

USES

In the General Radio Type 275 Oscillator the principle of frequency control by the use of quartz crystals has been made available for general experimental use. The 275 Oscillator is intended primarily as a frequency standard. As such it offers numerous advantages over the ordinary standard wavemeter as a primary standard. The entire equipment is considerably less bulky than the wavemeter, and the essential standard of frequency, the quartz plate, is of vest-pocket dimensions. The frequency is affected only by some change in the physical dimensions of

the plate or in the holder clearances. The development of a small, reliable frequency standard suggests the possibility of uniform frequency standards, provided by a central laboratory.

Type 375
STATION PIEZO OSCILLATOR

For broadcast station use there has been developed the Type 375 Oscillator. This instrument incorporates an oscillator, similar to the Type 275, and a two-stage amplifier. The addition of the amplifier makes this unit suitable for monitoring in the operating room. When the Type 375 Oscillator is placed in the operating room, and connected to a loudspeaker, the beat note becomes plainly audible when the station frequency differs from that of the standard. The plate is supplied in an adjustable holder which may be given its final adjustment at the Bureau of Standards at the request of the broadcast station.

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

Type 275 Oscillator

Dimensions 10″x11″x8″. Weight 16 pounds.

Price $60.00 Code Word "LABEL."

Type 375 Station Piezo Oscillator, including two-stage Amplifier.

Dimensions 13½″x13″x8″. Weight 19 pounds.

Price, without plate, $100.00 Code Word "LATIN."

Type 276A Plates, unmounted, for amateur use, 150-170 meters.

Price $15.00 Code Word "LABOR."

Type 376B Plates, mounted 25%.

Price $25.00 Code Word "LAGER."

Type 376C Plates, mounted, ground to ± 5% of specified frequency.

Price $35.00 Code Word "LAPEL."

Type 376D Plates, mounted, ground to ± 0.1% of specified frequency.

Price $50.00 Code Word "LARVA."

Type 356 Plate Holder, for use only with Type 276A Plate.

Price $1.00 Code Word "LASSO."

This Bulletin replaces Bulletin No. 724.

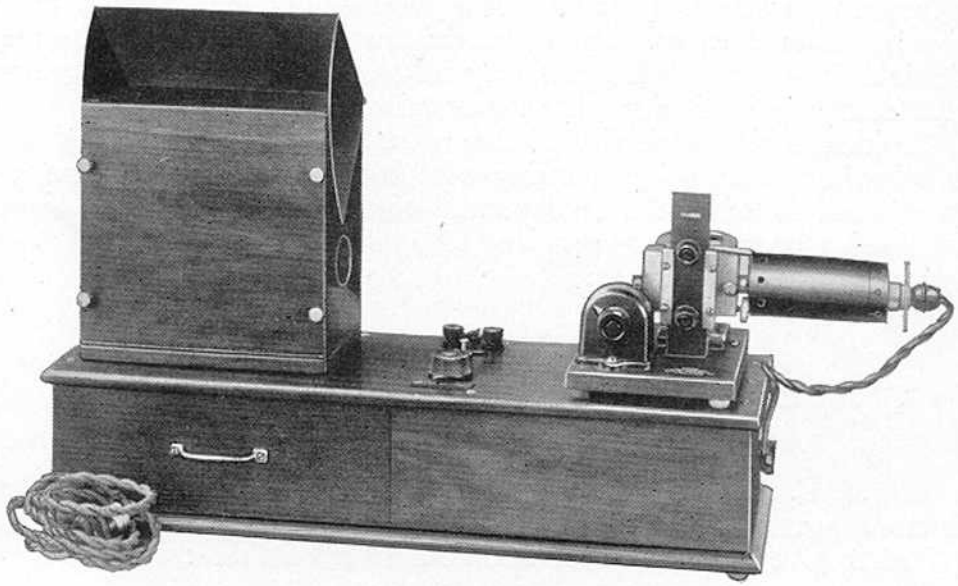
GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 8100 **JULY 1927**



Type 338
STRING OSCILLOGRAPH

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

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

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

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

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

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

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

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

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

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

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

The appearance of the instrument may be seen from the photo-

graph. A walnut base cabinet serves to support and properly align the parts. In the left portion of this is a drawer for holding spare string mountings and other equipment.

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

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

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

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

by varying the voltage impressed on the energizing coil. This is done by means of a potentiometer, the knob of which is seen in the center of the cabinet. A very constant speed of any desired value may be maintained in this manner, which makes it easy to synchronize the motor to any frequency impressed on the string, producing thereby a stationary wave pattern. For observing transient phenomena of some duration, it is desirable to have the mirror run quite slowly, while the maximum speed of the motor is necessary to separate the individual wave forms at the higher frequencies. The 60-cycle wavelength at maximum speed is from 2½ to 3 inches, giving a wavelength of about $\frac{1}{16}$ inch at 3000 cycles.

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

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

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

Type 338 Oscillograph, with Carrying-Case.....200.00

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

Code Word: "OFFER"

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

Type 338-20 Vibration Galvanometer Complete, with Carrying-Case.....$140.00

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

Code Word: "OFTEN"

Rheostat, Type 340 .....$16.00

Transformer, Type 285-N..... 8.00

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 8150 **JULY 1927**

Type 355
AMPLIFIER TEST SET

The widespread interest in audio amplifier characteristics makes the development of a standard and reliable method of taking them highly desirable. The test method should reproduce as nearly as possible the working conditions of the amplifier. It should neither omit any factor tending to affect the characteristic, nor introduce any effects not present in the amplifier.

The coupling device of the audio amplifier is always used in the plate circuit of a vacuum tube whose impedance affects the action of the amplifier very greatly. It is therefore necessary that the test instrument either be so arranged that the coupling device is connected in the plate circuit of a vacuum tube, or that the effect of the plate impedance be reproduced in some manner. It is also important that no current be allowed to flow in the transformer secondary, as even a very slight secondary current will entirely alter the characteristic.

In the Type 355 Test Set all the necessary elements of a reliable test set are assembled in a compact unit. All changes in connections are made with quick throw switches. The cabinet also contains the vacuum tube voltmeter and its plate and grid batteries. The whole unit is assembled in a walnut case with bakelite panel.

The circuit used in the Type 355 Test Set was chosen after an examination of the test methods used in a number of leading laboratories. A resistance (Rp in the diagram) is used to simulate the impedance in series with the transformer primary. This resistance is variable in 5000 ohm steps and covers the usual range of tube impedances. A vacuum tube voltmeter is used as a measuring device. The constants of the voltmeter are so adjusted that the grid of the voltmeter tube cannot take current while the galvanometer is on scale.

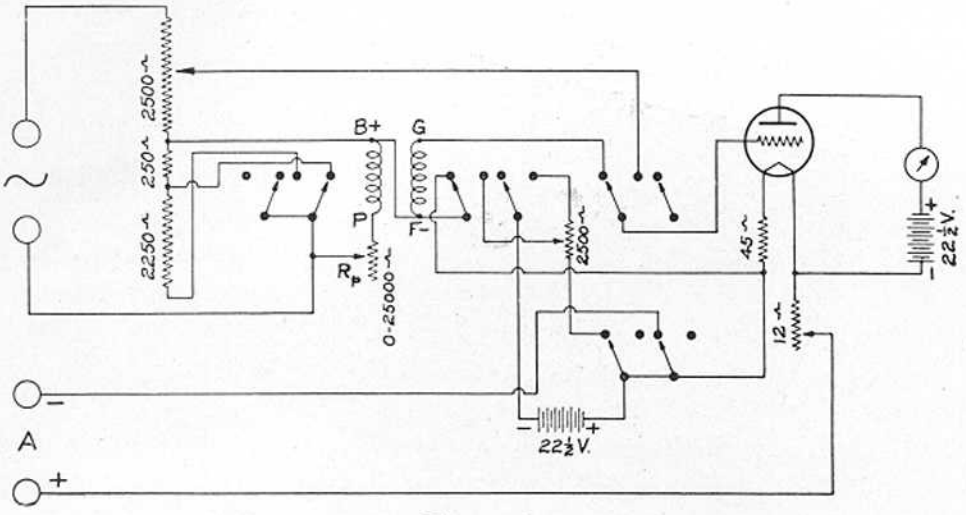


Figure 1

The input voltage to the transformer under test is taken off across a portion of the high resistance across which the oscillator output is impressed. The remainder of this resistance is used for checking the secondary voltage of the transformer. The voltmeter is used only as a transfer instrument.

In order that the effect of winding capacitances may be reproduced correctly it is desirable that the F minus terminals are connected together, both will be at ground A. C. potential, as under working conditions.

The vacuum tube voltmeter is also used to check input voltage, a transfer switch being provided.

The method of test is as follows: The input voltage is adjusted to the desired value by adjusting the oscillator output. The voltmeter is transferred to the transformer secondary, and the deflection of the galvanometer observed. If the transformer secondary voltage is high enough to send the galvanometer off scale, an additional adjustable bias is switched in and the meter needle brought on scale. The voltmeter is again switched to the oscillator output, and the potentiometer adjusted until the reading is repeated. The voltage amplification of the transformer is then indicated on the scale attached to the potentiometer.

When impedances, or other coupling devices whose ratio is less than unity, are being checked, the multiplier resistance R^3 is connected in circuit.

Amplification factors as high as 1:10 are measurable with this instrument.

Operating Instructions

When the test set is received, the panel should be lifted out by removing the eight thumb nuts and lifting straight out. A UX-199 or C-299 tube should be placed in the socket and the two 22.5 dry batteries connected. The dry cells should be Eveready No. 763 or like size. The red wires are connected to the plus battery terminals. The batteries are not connected together. The batteries are held in place by spring clips.

In making amplification measurements with the Type 355 set, the following procedure should be followed:

The transformer to be measured is connected to the proper terminals, and connections made to the battery supplying the vacuum tube voltmeter. The oscillator is connected and set in operation.

Rp is set at a value corresponding to the plate impedance of the tube which would normally be with the transformer.

In adjusting the input voltage the position of the switch should be as follows: Mult Scale—XI: Bias—Out; Fil—on; amp—amp. and Input Voltage.

The galvanometer is set to zero deflection by adjusting Fil Rheostat while the oscillator is disconnected or inoperative, and the input voltage adjusted as follows: The AMPLIFICATION dial is set to the reciprocal of the desired voltage (0.5 for 2 volts, 1 for 1 volt, 2 for .5 volts, 10 for 0.1 volts, etc.). The oscillator output is adjusted until the voltmeter registers 1 volt.

The voltmeter is switched to the transformer by throwing the fourth switch from the left back. If the meter reads off scale, the bias should be thrown in and adjusted to bring the meter on scale. Observe the meter reading and throw the meter transfer switch forward. Adjust the AMPLIFICATION dial until the meter reading is the same as with the transformer. The figure appearing under the indicator on the AMPLIFICATION scale is the amplication of the transformer.

The process outlined above is repeated for each point on the curve. The input voltage should be checked at each point.

Where impedances or other units where the amplification is less than unit, the X.1 scale multiplier is used. The procedure in measurement is the same as with transformers, except that the reading of the AMPLIFICATION scale in measuring amplification is multiplied by 0.1.

In setting the input voltage the AMPLIFICATION dial should read as follows: For 1 volt read 10, for 2 volts 5, for 5 volts 2, etc.

Impedance coupling units are connected as shown in Fig. 2.

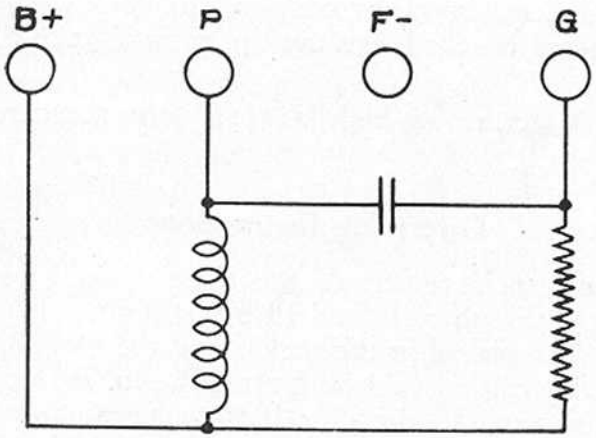


Figure 2

If it is desired to measure the effect of direct current saturation in the transformer primary, a battery and meter may be connected externally, in series with the transformer. If this is done, the battery should be disconnected when checking input voltage.

Type 355 Amplification Test Set.....Price $180.00

Dimensions 9½" x 5¾" x 16. Weight 16 lbs.

Code Word "ABOVE."

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 8151 **MARCH 1928**

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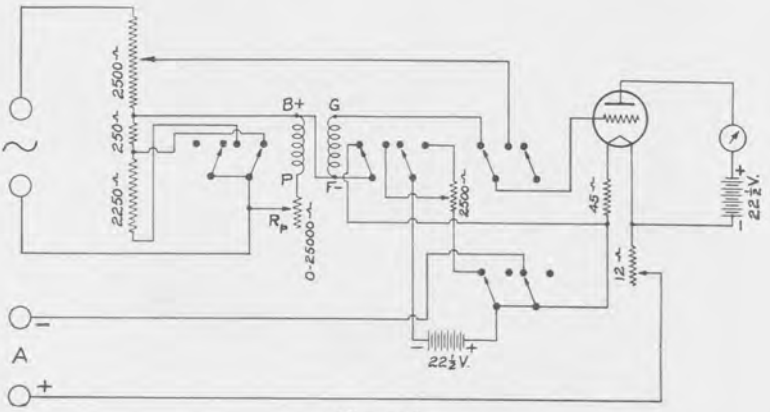

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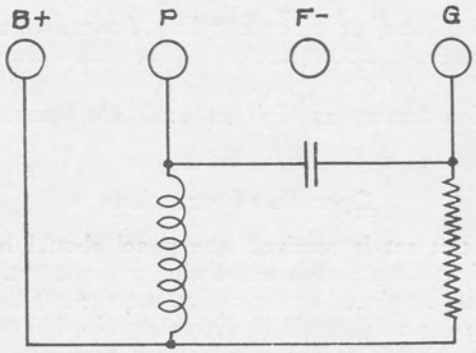

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Type 355 Amplification Test Set.....Price $180.00

Dimensions 9½" x 5¾" x 16. Weight 16 lbs.

Code Word "ABOVE."

(This Bulletin replaces Bulletin 8150)

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 8200 **AUGUST 1927**

MISCELLANEOUS TRANSFORMERS

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

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

VARIABLE RATIO TRANSFORMERS

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

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

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

Type 359A Transformer

Turns ratio (sec. to pri.) 0.025, 0.35, 0.5, 0.7, 1.0, 1.4.

Type 359B Transformer

Turns ratio (sec. to pri.) 0.06, 0.09, 0.13, 0.18, 0.25, 0.35.

Type 359C Auto Transformer

Turns ratio (sec. to pri.) 0.025, 0.35, 0.5, 0.7, 1.0, 1.4.

Type 359D Auto Transformer

Turns ratio (sec. to pri.) 0.06, 0.09, 0.13, 0.18, 0.25, 0.35.

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

Type 359E Transformer

Turns ratio (sec. to pri.) 0.025, 0.35, 0.5, 0.7, 1.0, 1.4.

Type 359F Transformer

Turns ratio (sec. to pri.) 0.06, 0.09, 0.13, 0.18, 0.25, 0.35.

Type 359G Auto Transformer

Turns ratio (sec. to pri.) 0.025, 0.35, 0.5, 0.7, 1.4.

Type 359H Auto Transformer

Turns ratio (sec. to pri.) 0.06, 0.09, 0.13, 0.18, 0.25, 0.35.

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

Direct current (primary) resistance all types 400 ohms.

Type 359 Transformers.....Price $15.00

Dimensions 4¼" x 3⅝" x 4½".

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

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

Turns ratio 1:15.7.

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

Type 284D Plate to Telephone Line Coupling Transformer.

Turns ratio 3.6:1.

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

Type 284E Telephone Line to Grid Coupling Transformer.

Turns ratio 1:7.3.

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

Type 284F Plate to Grid Coupling Transformer.

Turns ratio 1:2.

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

Type 284 Transformers ..... Price $12.00

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

Type 285M Single Microphone to Grid Coupling Transformer.

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

Turns ratio 1:15.7.

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

Type 285M ..... Price $7.00

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

Impedance Ratio 1:1.

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

Type 285T ..... Price $7.00

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

Ratio—Turns 18:1; Impedance 325:1.

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

Type 285N ..... Price $8.00

POWER TRANSFORMERS

A number of other transformers will be found listed in Bulletin No. 927. They include small power transformers, iron cored chokes, coupling transformers, and filters for use between the plate of various types of vacuum tubes and loudspeakers.

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

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

Type 166

TELEPHONE TRANSFORMERS

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

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

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

Type 166 Telephone Transformer $7.00

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

Code Word "TOPIC."