GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 2101 **APRIL 1928**

Type 210
RATIO ARM BOX

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

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

Type 210 Ratio Arm Box $28.00

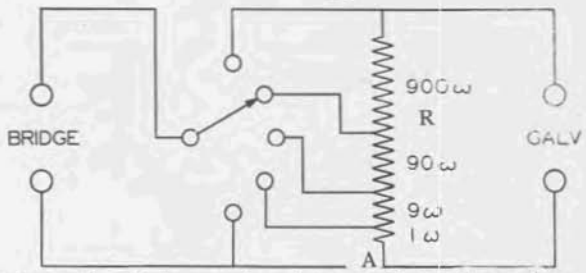
Dimensions 7½"x5"x4". Weight 2¼ lbs.

Code Word "RABID."

Type 229
GALVANOMETER SHUNT

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

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



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

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

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

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

Type 229 Universal Galvanometer Shunt $15.00

Dimensions 5"x3½"x3"½. Weight 1 lb.

Code Word "GAVOT."

Type 125

PHANTOM ANTENNA RESISTOR

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

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

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

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

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

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

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

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

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

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

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

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 2151 **APRIL 1928**

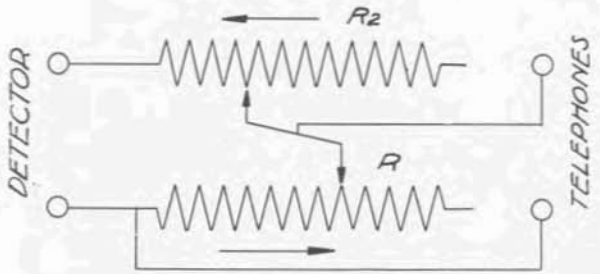
Type 164

AUDIBILITY METER

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

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

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



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

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

Type 164 Audibility Meter..... $32.00

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

Code Word "AWAKE."

Type 371

POTENTIOMETER

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

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

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

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

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

The Type 371 Potentiometer is made in the following ratings:

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

Type 371 Potentiometer ..... Price $5.00

Dimensions 3½" x 3½". Weight 4¼ oz.

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

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

Quotations will be gladly submitted for special units.

In ordering be sure to specify the resistance required.

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

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

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

(This Bulletin replaces Bulletin 2150)

GENERAL RADIO COMPANY

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ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 4151 **APRIL 1928**

Type 240

DIRECT READING CAPACITY METER

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

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

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 4201 **MARCH 1928**

Type 361B

VACUUM TUBE BRIDGE

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

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

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

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

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

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

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

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

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

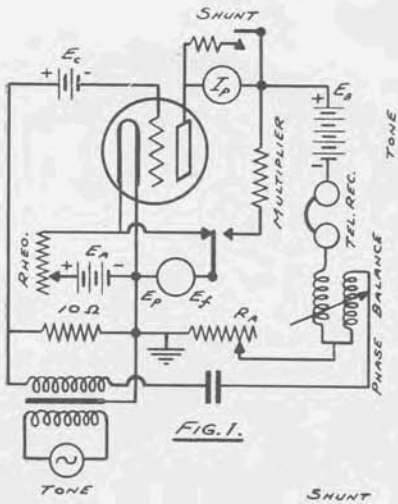

FIG. 1.

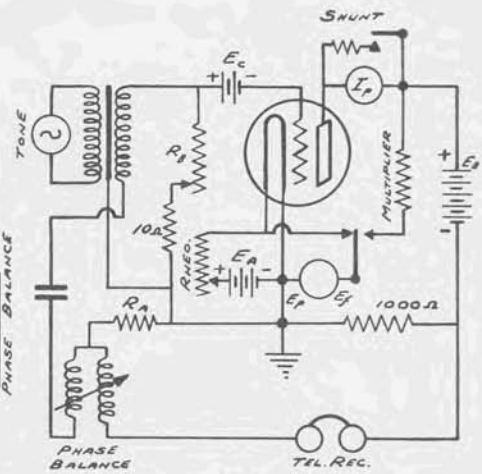

FIG. 2.

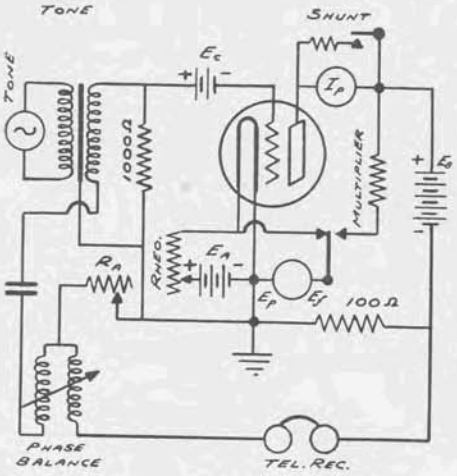

FIG. 3.

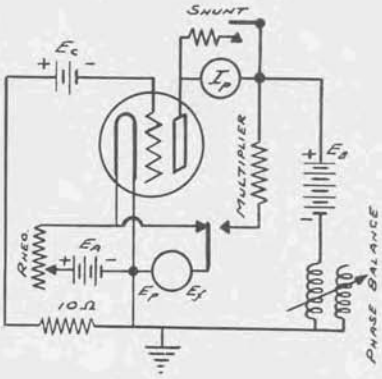

FIG. 4.

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

In order for no current to flow:

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

Where I_T is the current from the tone source

μE_g is opposite in phase to $R_A I_T$

$E_g = 10 I_T$

$\mu = R_A/10$

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

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

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

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

At balance: $R_A I_T = 1000 I_P$

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

$E_g = I_T (R_B + 10)$

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

But: $\mu = R_A / 10$

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

Giving: $R_p = 100 R_B$

R_B is calibrated to read directly in plate resistance.

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

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

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

$E_g = 1000 I_T$

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

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

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

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

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

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

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

A pamphlet of instructions is supplied with the bridge.

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

Code Word "BIBLE."

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

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

Type 361-40 For use with large UV base

Type 361-41 For use with small UV base

Price, either type $3.00

(This Bulletin replaces Bulletin 4200)

GENERAL RADIO COMPANY

MANUFACTURERS OF

ELECTRICAL AND RADIO LABORATORY APPARATUS

CAMBRIDGE, MASSACHUSETTS

BULLETIN 8151 **MARCH 1928**

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.

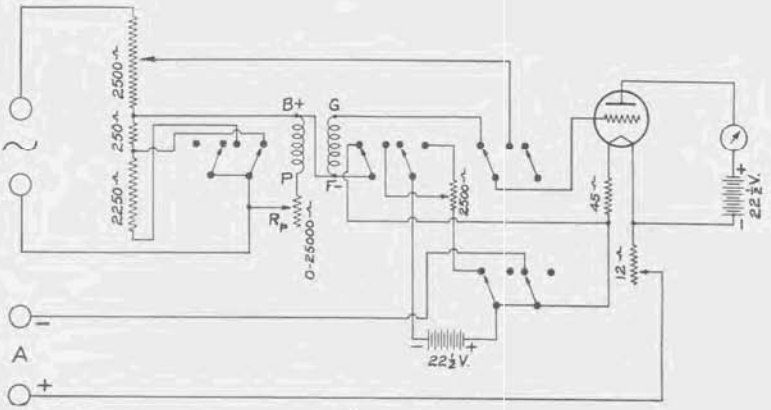

Figure 1

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^a 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.

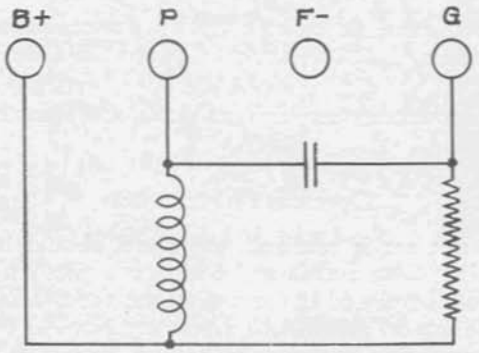

Figure 2

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."

(This Bulletin replaces Bulletin 8150)