THE General Radio EXPERIMENTER

VOLUME XV No. 10 APRIL, 1941

ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

INSTRUMENT SPECIFICATIONS

● OWING TO GOVERNMENTAL RESTRICTIONS on the use of certain materials it has become necessary to use substitutes wherever possible. While the performance specifications of our instruments are not affected, substitute materials are being used. In accepting orders during the present situation brought about by the national defense program, we reserve the right to make any necessary substitutions in the constructional features.

NEW TERMINALS FOR USE WITH COAXIAL TRANSMISSION LINES

● AT HIGH AND ULTRA-HIGH FREQUENCIES the desirability of constraining electro-magnetic fields within very definite confines has led largely to the adoption of coaxial transmission lines for the transference of power from one point to another. Ideal transmission lines of this type, having inner and outer conductors of zero resistance and an intervening medium of zero power factor, are theoretically capable of transferring power with zero energy loss and with zero external field, and the properties of actual lines approach those of the ideal very closely.

(Continued on page 2)

ALSO IN THIS ISSUE:

For measuring circuits, in particular, coaxial lines have been found almost indispensable. Because of the uniform distribution of inductance and capacitance along their lengths and the absence of appreciable losses from radiation, they generally follow the conventional "engineering solution" of the long line with great accuracy at frequencies extending into the hundreds of megacycles. To the properties of low losses and of low external field must therefore be added the further virtue of accurate predictability.

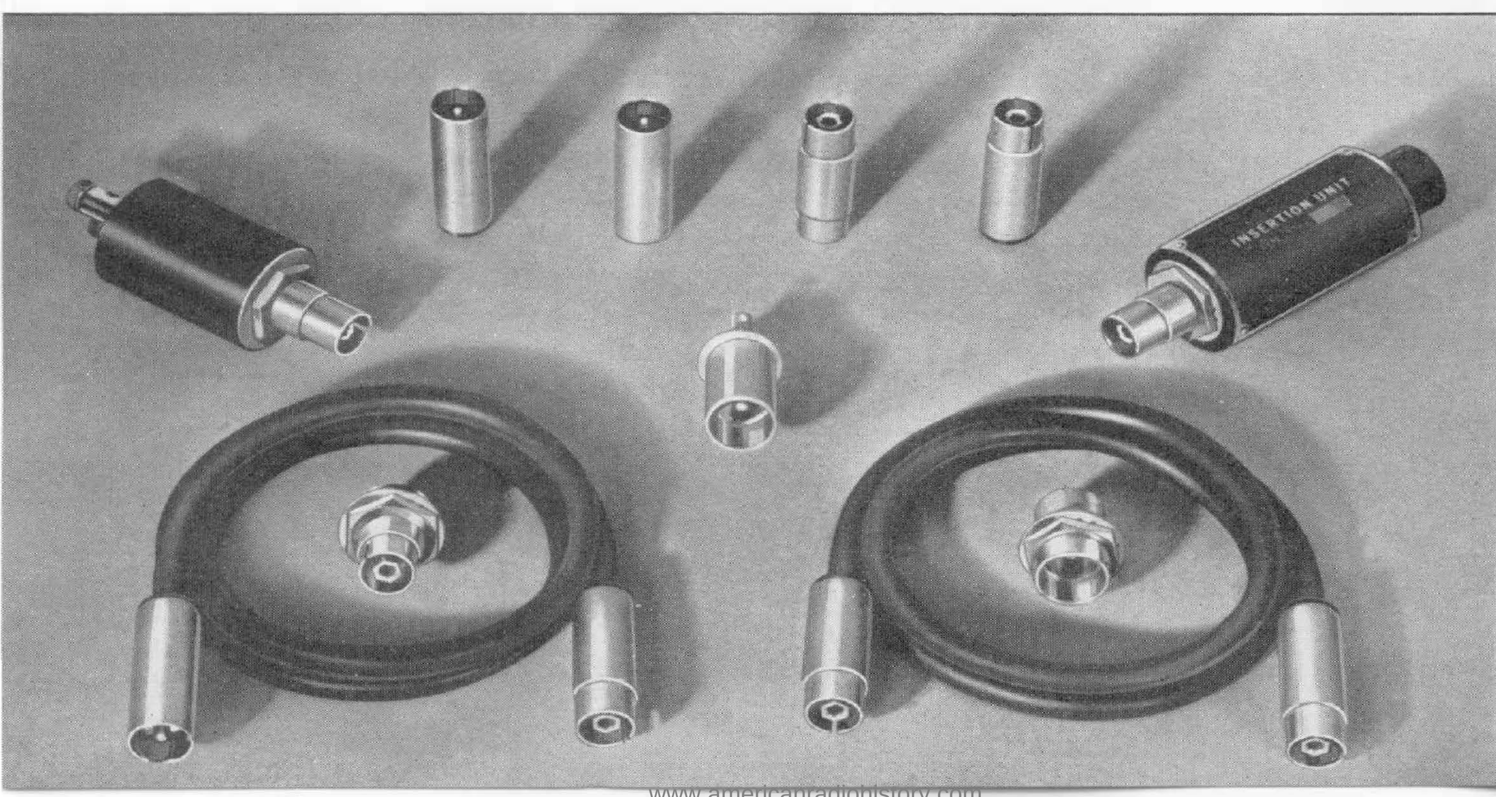
To obtain maximum benefit from coaxial lines, however, it is of great importance to use proper terminal equipment. For convenience, a plug and jack system is often highly desirable for use in setting up measuring systems. The plugs and jacks used should have two very definite properties, namely, (1) they should be as short as possible and have a characteristic impedance differing from that of the line as little as possible, in order to minimize reflections resulting from impedance mismatch, and (2) they should have as continuous an external shield as possible, in order to minimize external fields.

The TYPE 774 Coaxial Terminals, shown in Figure 1, have been designed with these two properties in mind. In order to reduce impedance mismatch in lines having different characteristic impedances they have been made with as short internal conductors as possible and with as low capacitance as possible. In order to provide as continuous an external shield as possible, lugs have been provided for four connections to the outer shell from the cable sheath at points uniformly distributed around the circumference.

The solid dielectric is polystyrene, which has both a low dielectric constant and a low power factor. These properties make possible the low capacitance and low losses of TYPE 774 Coaxial Terminals.

A plug unit and a jack unit are available for mounting on panels, and a similar pair of units for terminating coaxial cables. The plug connector and the jack connector make it possible to join two cables having identical terminations, that is, two plugs or two jacks.

FIGURE 1. A group of TYPE 774 Coaxial Terminals.



For many applications the capacitance of these units is the factor to be considered in determining their suitability. The capacitance for each Type 774 Unit is listed in Table I. In addition to the total capacitance listed in the first column, there is given, for many units, a figure called "insertion capacitance," which is the capacitance added to a circuit when that particular unit is plugged in. This is lower than the total capacitance because of the overlapping when a plug unit is plugged into a jack.

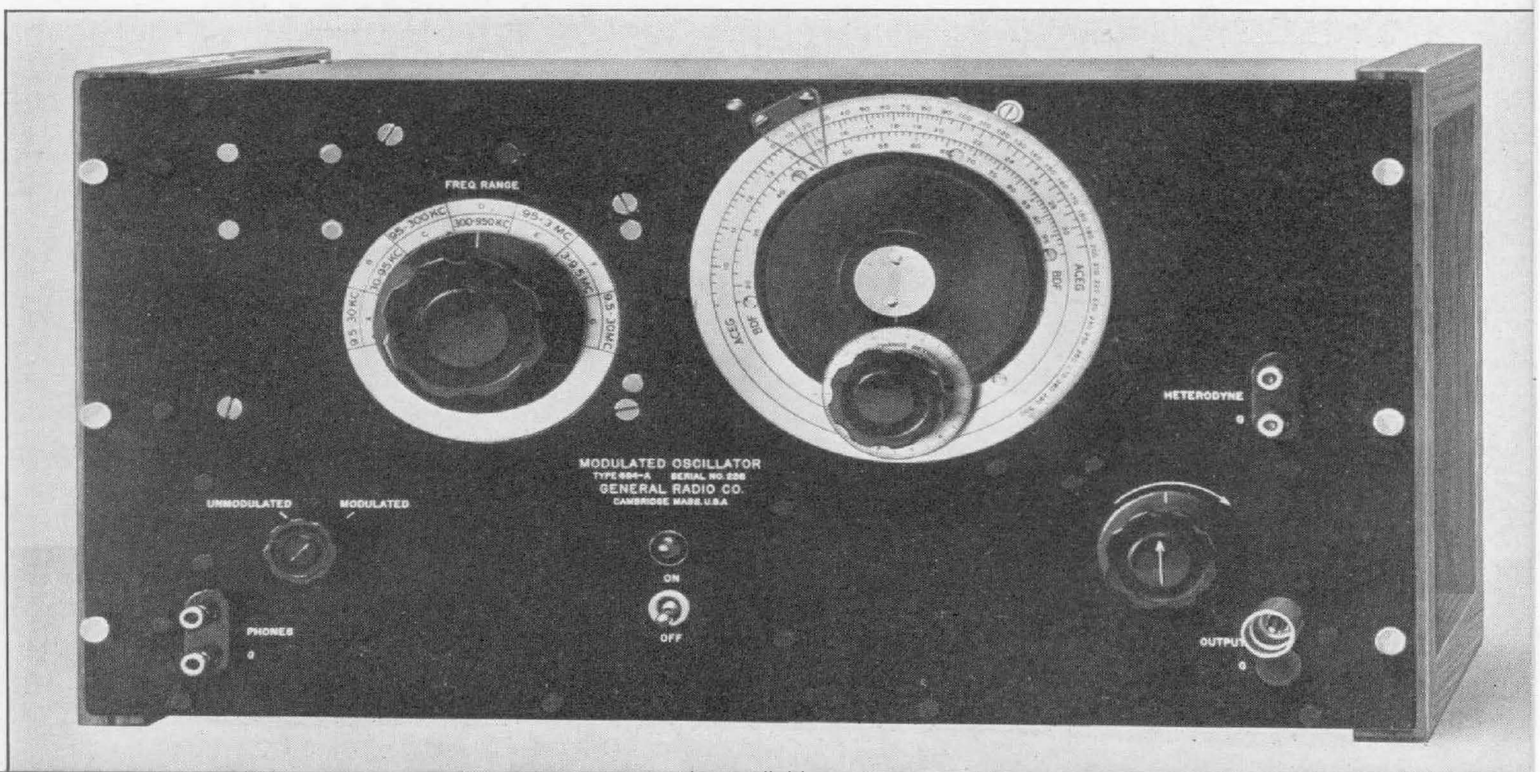
In addition to the connectors listed in Table I, another unit, for use with Type 684-A Modulated Oscillator, is available. This adapter can be installed in place of the output binding posts provided on the oscillator. This type of output terminal is necessary when the oscillator is used as a power source for impedance measurements at frequencies above a few megacycles, as for instance with the Type 821-A Twin-T.

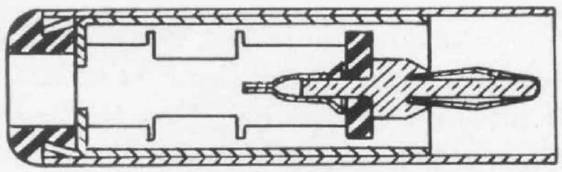
The importance of maintaining the continuity of the external conductor in

TABLE 1

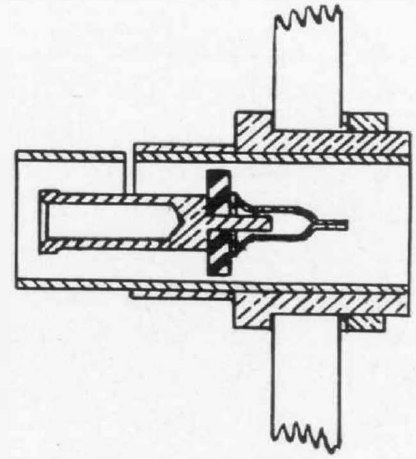
Type		*Total Capacitance*	*Insertion Capacitance*
774-P	Panel Jack	2.8 $\mu\mu$f	1.7 $\mu\mu$f
774-G	Panel Plug	2.4	1.3
774-M	Cable Jack	2.8	1.7
774-E	Cable Plug	2.5	1.4
774-F	Plug Connector	3.6	1.3
774-N	Jack Connector	4.2	2.0
774-X	Terminal Unit	6.0	4.9
774-M and 774-G	Cable Jack and Panel Plug	4.1	....
774-P and 774-E	Cable Plug and Panel Jack	4.1	....

Figure 2. Panel view of a Type 684-A Modulated Oscillator with Type 774-V Coaxial Adapter installed. The adapter fits one of the mounting holes for the standard binding post terminals supplied with the instrument. A metal button to cover the other hole is furnished.

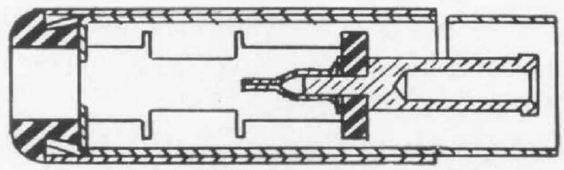




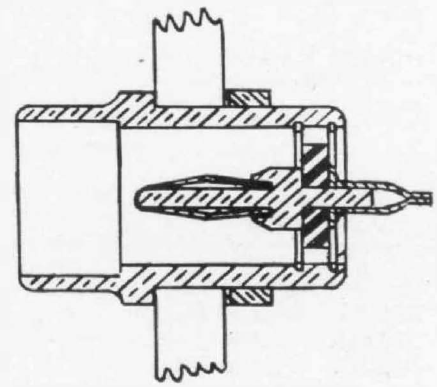
Type 774-E Cable Plug.



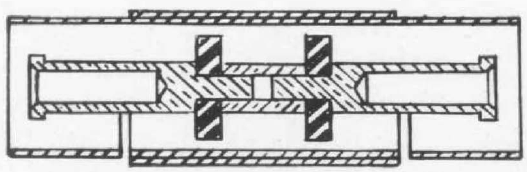
Type 774-P Panel Jack.



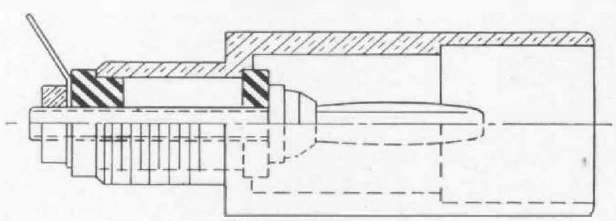
Type 774-M Cable Jack.



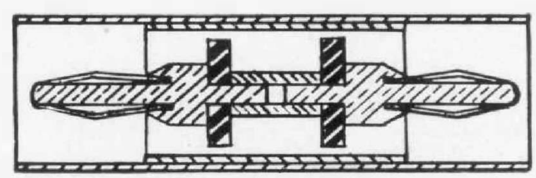
Type 774-G Panel Plug.



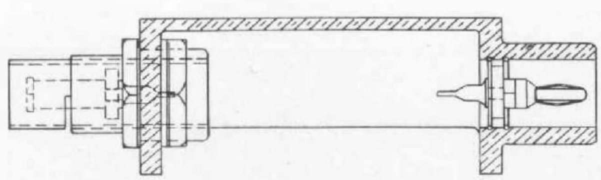
Type 774-N Jack Connector.



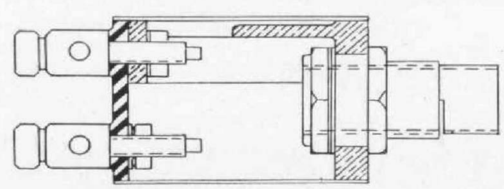
Type 774-V Adapter.



Type 774-F Plug Connector.



Type 774-X Insertion Unit.
(One-half actual size.)



Type 774-YB Terminal Unit.
(One-half actual size.)

Figure 3. Sectional drawings showing construction of Type 774 Coaxial Terminals. Drawings are full size except where indicated.

measurements with this instrument can be seen from the following example:

A measuring system comprising a Type 684-A Modulated Oscillator, a Type 821-A Twin-T Impedance-Measuring Circuit, and a radio receiver are connected as shown in Figure 4.

A small amount of series inductance in the ground side of the generator cable is designated as L_G, a similar inductance in the receiver cable as L_R, and the common ground lead as L_M. The voltage

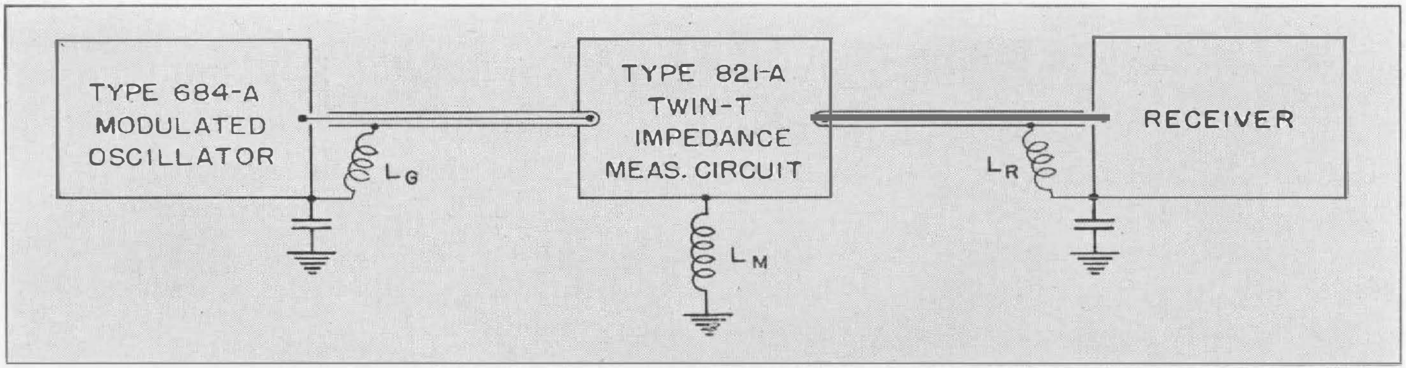


FIGURE 4. Block diagram illustrating the effect of series inductance in the generator and detector leads.

drop in L_G produces a flow of current around the loop consisting of the cable sheath, the ground lead, L_M, and the ground capacitance of the oscillator. Similarly, current flows in the right-hand loop that includes L_R.

The voltage applied to the receiver has, therefore, two components, one from the Twin-T, the other from the drop across L_R. When a null point is reached, therefore, the Twin-T is out of balance by an amount necessary to cancel the effect of the extraneous voltage from L_R, that is, to make the vector sum of the Twin-T output voltage and the extraneous voltage equal to zero.

The error in measurement caused by this series inductance is one of the most serious encountered in null measurements at radio frequencies, and, in order to avoid it, coaxial terminals should be used on both generator and receiver.

TYPE 774 Coaxial Terminals can also be supplied already assembled as patch cords with 3-foot lengths of concentric cable, for use in measuring circuits. Two assemblies are available: TYPE 774-R1, which has a plug at each end; and TYPE 774-R2, which has one plug and one jack.

The cable is made to our specifications by Simplex Wire and Cable Company and consists of a stranded beryllium-copper conductor separated from a braided tinned-copper shield by Anhydrex A insulation, with an over-all covering of abrasion-resistant rubber. The nominal characteristic impedance of the cable is 72* ohms; the nominal capacitance is 26 $\mu\mu$f per foot; and the power factor is 2% or less at 1000 cycles.

*This is subject to a variation of ±10%.

— D. B. SINCLAIR

Type	*Description*	*Code Word*	*Price*
774-E	Cable Plug	ACCESSOEYE	$1.50
774-M	Cable Jack	ACCESSOMUD	1.50
774-G	Panel Plug	ACCESSOGOD	1.00
774-P	Panel Jack	ACCESSOPOP	1.00
774-F	Plug Connector	ACCESSOFIG	1.00
774-N	Jack Connector	ACCESSONUT	1.00
774-R1	Patch Cord	ACCESSORIM	4.00
774-R2	Patch Cord	ACCESSORAT	4.00
774-X	Insertion Unit	ACCESSOXEB	4.50
774-YB	Terminal Unit	ACCESSOYAM	3.50
774-V	Adapter for TYPE 684-A Modulated Oscillator	ACCESSOVAN	1.75
774-A	Concentric Shielded Cable (3 feet)	ACCESSOAPE	1.00

A NEW AUDIO-FREQUENCY MICROVOLTER*

● **IN MANY TYPES OF WORK,** such as the measurement of amplifier gain, hum level, overload points, and transformer characteristics, the Type 546-B Audio-Frequency Microvolter is an extremely useful accessory for obtaining accurate answers rapidly, for by using the microvolter with an audio oscillator an accurately known source of continuously variable voltage is made available over the range from 1.0 microvolt to 1.0 volt.

The microvolter consists of an adjustable attenuator, the input to which is standardized by means of the voltmeter on the panel of the instrument. The attenuator settings are made by means of two panel controls, one a six-step decade multiplier and the other an individually calibrated dial which gives continuous variation over each decade. This dial has a scale which is essentially logarithmic and is calibrated in decibels as well as voltage. The voltmeter is of the copper-oxide rectifier type and is so designed that it has negligible frequency error over the range from 50 to 40,000 cycles. The meters are standardized at 77° F., and a slight correction is necessary if ambients differing widely from this value are encountered. A curve of this correction is given in Figure 2.

Several features of the new microvolter are outstanding. By the elimination of the input transformer and by careful design of the attenuator, the leakage and extraneous pickup are reduced to less than 0.1 microvolt. Therefore excellent voltage accuracy is obtained even at levels as low as 1.0 microvolt, and so gain and overload characteristics of high-gain amplifiers can be measured accurately with only a few microvolts on the input. Furthermore, the decibel calibration makes it possible to obtain gain or loss values, in decibels, for amplifiers, transformers, lines, and other networks, without the necessity of manipulating voltage ratios and then converting them.

The absolute accuracy of the output voltage has been made 3% ±0.1 micro-

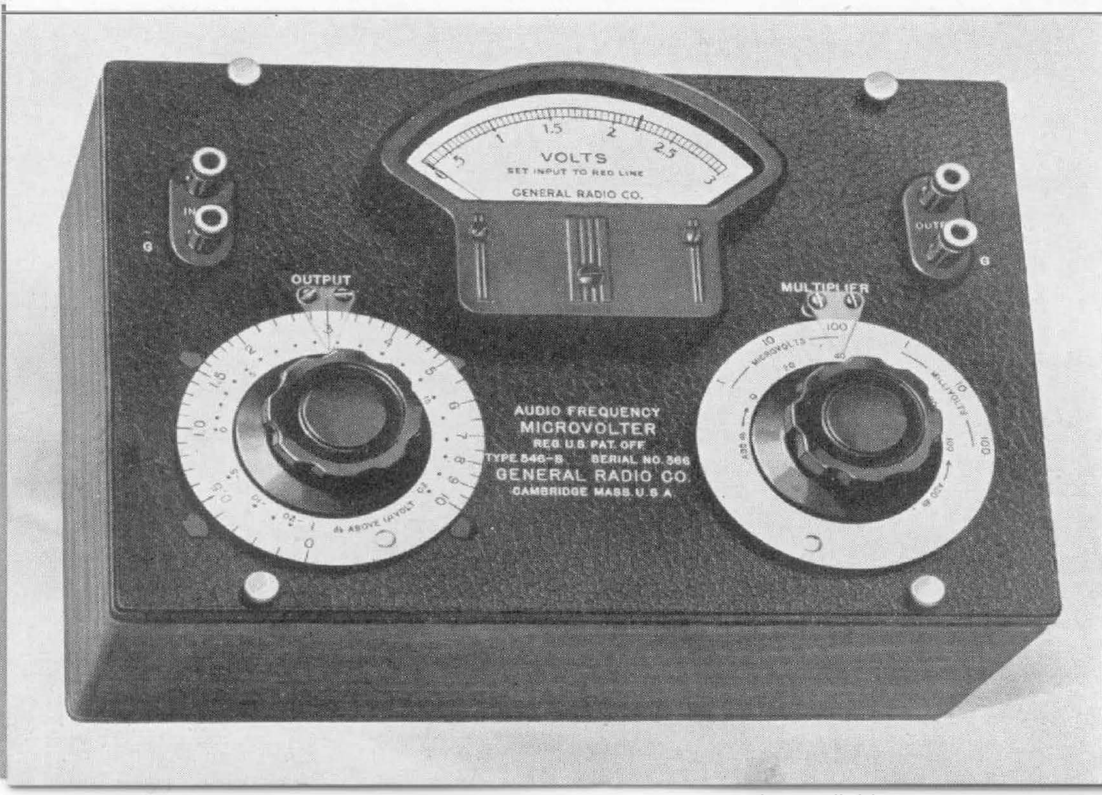


Figure 1. Panel view of Type 546-B Microvolter. The output scale is spread out for precise reading and is approximately logarithmic. The auxiliary decibel scale carries a dot for each decibel between 1 and 20.

* Reg. U. S. Pat. Off.

volt at all voltages above 1.0 microvolt over the entire frequency range from 50 to 40,000 cycles. Because the output impedance is only 200 ohms no corrections for the load impedance are necessary in most measurements. Where voltage ratios are all that are important, or where any error in the input voltmeter can be eliminated, such as by use of an external meter, the accuracy is 2%. The frequency range may be extended to 100,000 cycles with this same accuracy if the output level is greater than 100 microvolts. — Martin A. Gilman

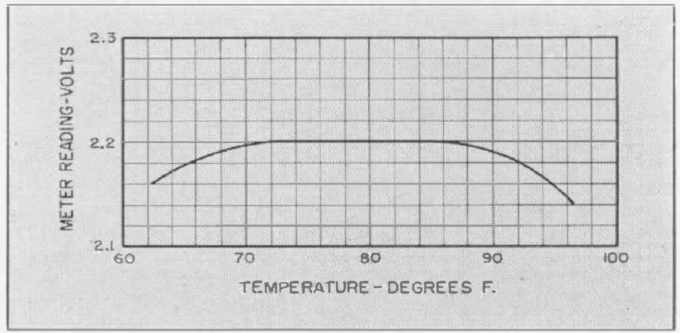


Figure 2. Temperature characteristic of meter used in Type 546-B Microvolter.

SPECIFICATIONS

Output Voltage Range: From 0.1 microvolt to 1.0 volt, open circuit, when the input voltage is set to the standardized reference value.

Accuracy: For open-circuit output voltages the calibration is accurate within ±3% ± 0.1 microvolt for output settings above 1 microvolt and for all frequencies between 50 and 40,000 cycles. This accuracy applies only where waveform and temperature errors are negligible (see below). Below 1 microvolt the error increases owing to crowding of the scale.

For ratios or increments of voltage, at a given frequency, the accuracy of any reading is within ±2% ± 0.1 microvolt, at frequencies up to 100,000 cycles. At the higher frequencies this accuracy applies only at levels above 100 microvolts.

Output Impedance: The output impedance is approximately 200 ohms and is constant with setting within ±5%. This impedance is sufficiently low so that no correction on the output voltage is necessary for load impedances of the order of 50,000 ohms and greater.

Input Impedance: Approximately 430 ohms, substantially independent of output setting on all but the highest multiplier position.

Waveform Error: The accuracy of the microvolter as a calibrated attenuator or voltage divider is independent of waveform. The absolute accuracy of the output voltage calibration depends on the characteristics of the input voltmeter, which has a small waveform error that depends in turn on both the phase and the magnitude of harmonics present in the input. This error in the voltmeter can, in general, be neglected when the microvolter is used with ordinary laboratory oscillators.

Temperature Error: The accuracy of the calibration is independent of temperature when the microvolter is used as an attenuator or voltage divider. The absolute accuracy is affected slightly by temperature because of change in the voltmeter characteristics. The necessary correction for temperatures from 65° to 95° F. are furnished with the instrument.

Power Source: The driving oscillator must be capable of furnishing about 2.2 volts across 430 ohms, or about 11 milliwatts.

Accessories: Two Type 274-M Plugs are supplied.

Terminals: Jack-top binding posts are mounted on standard ¾-inch spacing.

Mounting: The instrument is mounted on an aluminum panel in a shielded walnut cabinet.

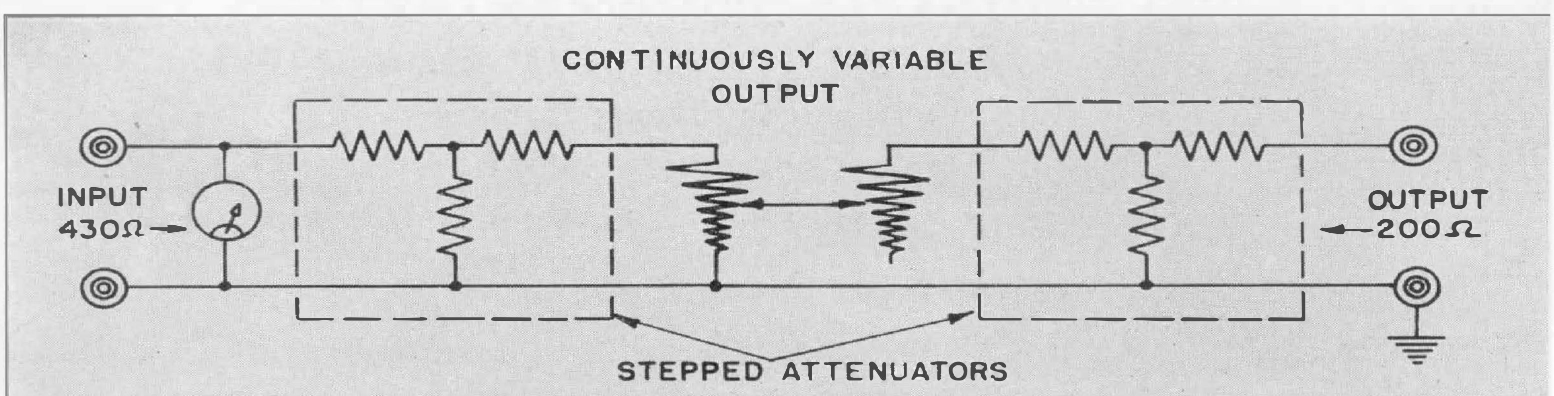
Dimensions: (Length) 10 x (width) 7 x (height) 6⅜ inches, over-all.

Net Weight: 6½ pounds.

Type		*Code Word*	*Price*
546-B	Microvolter	CROWN	$80.00

Type 546-B Microvolter is temporarily out of stock. Deliveries will be resumed in August, 1941.

Figure 3. Schematic circuit diagram of Type 546-B Microvolter.



SOUND-LEVEL METER JOINS POLICE FORCE

● **IN THE CURRENT PHASE** of New York City's anti-noise campaign, renewed on January 4 by Mayor La-Guardia, 10,000 taxicabs are having their horns rated by the General Radio Sound-Level Meter under the supervision of Thomas W. Rochester, chief engineer for the Police Department. The accompanying photograph shows the test arrangement used in preliminary measurements made for the purpose of collecting basic data from which a standard horn rating can be determined. Measurements were made at distances of 100 feet and 20 feet from the sound-level meter. These preliminary measurements indicated that the range of sound levels encountered extended from a maximum of 90 db at 20 feet to a minimum of 75 db at 100 feet. For most horns, a difference of about 5 db in level between the two distances was noted.

MISCELLANY

● **COVER-TO-COVER READERS** must have been somewhat baffled by the following paradoxical statement appearing in Mr. Gilman's article in the March *Experimenter:* "Thus the current through one coil is in phase with the line voltage, while the current is out of phase with the voltage by 90°." This condition is admittedly hard to achieve in practice, and the best way out of the difficulty is to insert the words "in the other coil" after the word "while." In order to fit the last piece into the puzzle, the editor admits that ϕ, in Figure 3, and θ, in the balance of the article, are one and the same angle.

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