THE General Radio EXPERIMENTER

VOLUME XXII No. 4 SEPTEMBER, 1946

ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

Also IN THIS ISSUE

A NEW VACUUM-TUBE VOLTMETER

● **THE TYPE** of peak-reading vacuum-tube voltmeter now considered standard in the communications industry was first introduced by the General Radio Company some ten years ago when the Type 726-A Vacuum-Tube Voltmeter was announced.[1] The novel design and excellent performance of this voltmeter has maintained its popularity over the intervening years considerably beyond the time when advances in the art would normally necessitate a new design. The development, during this period, of new tubes, circuits, and construction techniques has, however, progressed continuously, and these now make it possible to design a completely new instrument having even better performance.

In the design of the new Type 1800-A Vacuum-Tube Voltmeter, which replaces the Type 726-A, effort has been directed to correcting the minor disadvantages that have been found in the older voltmeter as well as to incorporating desirable new features that make the instrument more flexible and convenient.

[1] W. N. Tuttle, "Type 726-A Vacuum-Tube Voltmeter," General Radio *Experimenter*, Vol. XI, No. 12, May 1937, pp. 1–6.

Figure 1. Panel view of the Type 1800-A Vacuum-Tube Voltmeter.

Some of these disadvantages were:

1. The shielding of the probe of the Type 726-A was not complete, and trouble with pickup from strong fields at frequencies over about 50 Mc was sometimes encountered.

2. Individual zero adjustments for each range were used in the Type 726-A, and these sometimes drifted from their correct setting, so that readjustment of the zero when switching from range to range was necessary.

3. The voltage-regulating transformer in the Type 726-A was explicitly designed for one line frequency. In addition, the transformer radiated an appreciable 60-cycle field.

4. The Type 726-A probe was relatively bulky and difficult to get into confined spaces.

5. The Type 726-A meter was somewhat difficult to read at a distance because of the knife-edge pointer and was confusing because of the arrangement of the scales. Reflections from the glass were often bothersome, and the light from the pilot light distracting.

6. The cabinet of the Type 726-A, while convenient for ordinary bench use, was rather large and could not readily be used in other positions than the normal one in which the panel was at a 15° angle to the horizontal.

These disadvantages, with others of a more minor nature, have all been eliminated in the Type 1800-A, and many new features have been added. These include:

1. The natural frequency of the probe has been increased by nearly 3:1, and the gain in high-frequency performance because of the complete shielding is even greater.

2. The input capacitance has been reduced by a factor of 2, and the parallel resistance component increased fourfold at low frequencies.

3. An additional 0-0.5 volt scale has been added that extends the sensitivity by a factor of 3.

4. A complete set of d-c scales has been added, covering the same ranges as the a-c scales.

5. A set of terminal parts has been provided that makes it possible to assemble, on the end of the probe, connectors that will fit all standard General Radio Type 138, 274, and 774 terminals.

6. The new instrument is smaller, lighter, and easier to use.

7. It can be operated with the panel horizontal, vertical, or inclined.

METER

Figure 2 shows the arrangement of the five scales on the face of the meter. The two outer scales, 0 to 15 and 0 to 5, are linear. On these two scales are read all d-c voltages and all a-c voltages above 5 volts. The non-linear inner scales, 0 to 0.5, 0 to 1.5, and 0 to 5, are used only for a-c voltage measurements of 5 volts or less. The a-c scales are calibrated to read the r-m-s value of a sine-wave voltage or 0.707 times the peak value of a voltage of complex wave shape. The accuracy of all d-c ranges and all a-c ranges at low frequencies is $\pm$ 2% of full scale.

A mirror has been located between the inner and outer groups of scales. The mirror, of course, does not increase the accuracy of the voltmeter, but it does make it possible to read a voltage more precisely than when no mirror is present. The extra precision of reading or setting is most important when small differences must be observed. Without a mirror, parallax makes it very difficult to observe small movements of the pointer, especially when the attention of the observer must be removed momentarily from the meter to some part of the circuit under test. With a mirror, the eye can be placed precisely over the pointer for every reading. The upper portion of the pointer has been made knife-edged to facilitate further the precise observation of small differences. The lower portion has been made broad so that the approximate position of the pointer can be seen from some distance away.

Quite often small differences must be observed in an a-c voltage that is not properly read on one of the linear scales under the knife-edged portion of the pointer. If the voltage is above approximately 0.5 volt, the difference can be observed on the corresponding linear scale with only a small error. If the voltage is less than approximately 0.5 volt, the difference read on the linear scale must be corrected for the non-linearity of the a-c scale. Of course, the actual voltage level, if it must be known, should be read on the correct a-c scale.

The meter face is illuminated by two lamps inside the meter case. The illumination makes a pilot light unnecessary and eliminates bothersome reflections from the glass over the meter face.

PANEL

On the panel, in addition to the meter, are input terminals for a-c and d-c voltage measurements, and three operating controls. The panel is shown in Figure 1. The d-c terminals, at the upper left, provide two different input impedances. The input resistance at the vertical pair is 10 megohms, while the horizontal pair apply the voltage directly to the grid of the d-c amplifier tube. A link is provided to short-circuit the pair of terminals not being used. The a-c terminals, which can be used only when the probe is plugged into its position behind the panel, are at the upper right. The LOW terminal is not grounded directly to panel but is isolated by a blocking condenser. A short-circuiting link is provided to ground the LOW terminal if it is desired to do so. Internal connections for a-c or d-c voltage measurement are made by the combined power and selector switch located at the left under the meter.

The center knob operates the VOLTAGE RANGE selector switch, which is used to select the appropriate voltage range for either a-c or d-c measurements. The zero control is operated by the knob at the right. The zero setting is not changed by operation of the VOLTAGE RANGE switch, although slight readjustment may be required when the A-C — D-C switch is operated. The line fuses, located at the bottom of the panel, can be replaced with the aid of a screwdriver without removing the instrument from its cabinet.

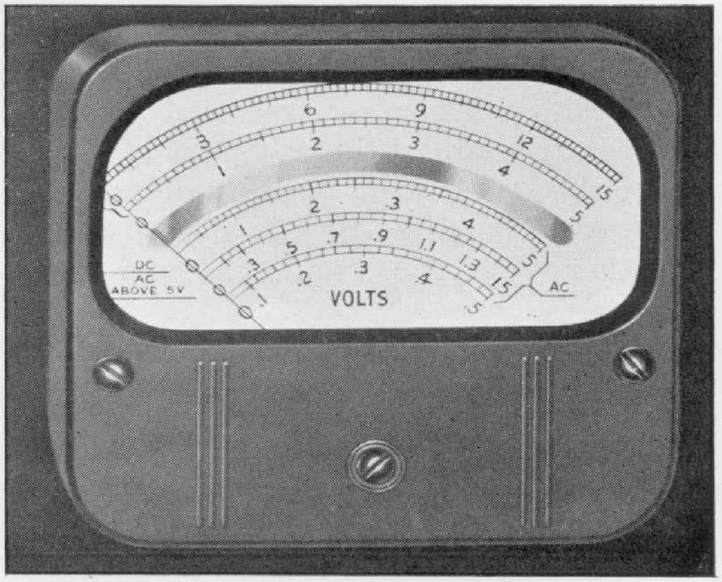


Figure 2. Close-up of the meter scales. The legend at the left is carried to the top two scales by a line that, in this view, is hidden by the meter case.

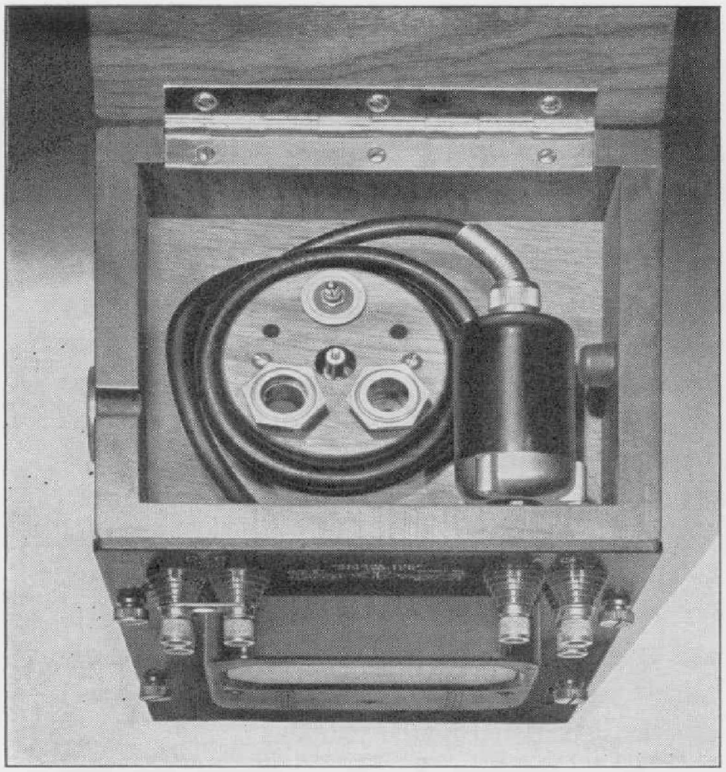


Figure 3. View of the storage compartment at the top of the cabinet. The probe fittings are stored here. The preliminary model used for this photograph has only one slot for the probe cable. Final models have a slot on each side of the cabinet.

CABINET

The shielded walnut cabinet is provided with a storage compartment at the top for the probe and the various terminals supplied. Figure 3 is a view of the compartment with the probe plugged into position to allow use of the panel a-c input terminals. There is a slot in each side of the cabinet for passage of the probe cable when the probe is used externally and the compartment cover is closed. The two slots have proved to be very convenient when the probe must be used at some distance from either side of the instrument.

The voltmeter can be used without separate support in any one of three positions: vertical, horizontal, and inclined. The three positions of use, together with the small size and light weight, make the instrument easy to use in practically any set-up.

In an inclined position, the instrument is supported by the metal carrying handle at an angle of approximately 30 degrees from the horizontal. The handle locks automatically either in the vertical position, i.e., parallel to the panel, or in the horizontal position. It is released merely by pressing in on the handle near each hub.

PROBE CIRCUIT

The a-c input voltage is rectified by a diode, which, at input voltages over 5 volts or so, gives a linear d-c voltage output very nearly equal to the peak value of the a-c input voltage. At lower voltages, the d-c voltage output tends to vary as the square of the a-c input voltage. Therefore, non-linear scales are needed for measurement of a-c voltages up to 5 volts.

The tube chosen for use as the diode rectifier is the Type 9005 acorn tube. The 9005 was chosen because its natural frequency of 1500 megacycles is the highest of any diode commercially avail-

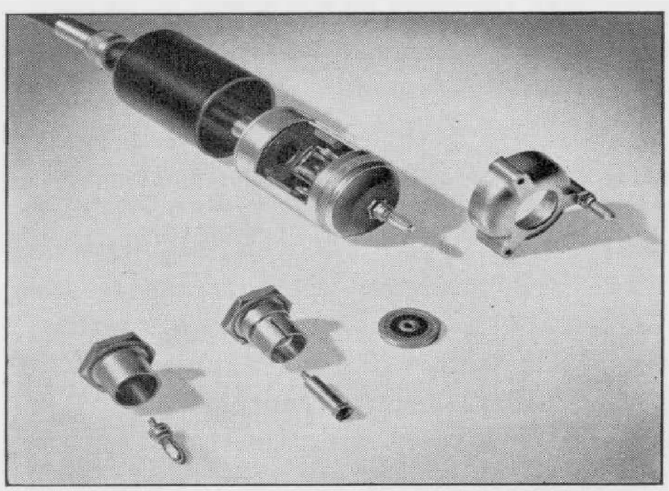


Figure 4. Exploded view of the probe and the various terminal fittings.

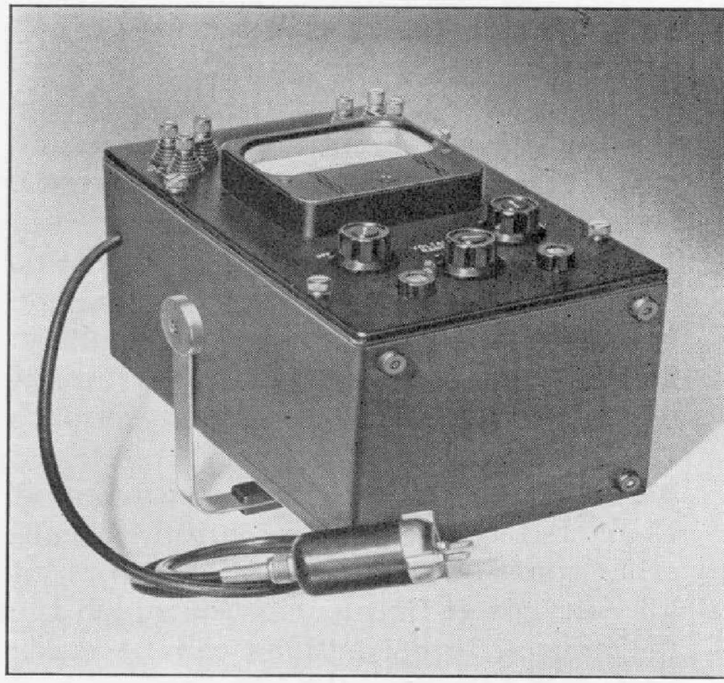


Figure 6. As shown here, the voltmeter can be used with the panel inclined, support being provided by the handle, which locks into position.

able. Because of great care taken in the design of the probe containing the diode and the associated circuit elements (Figure 4), the resonant frequency of the probe input circuit has been kept at 1050 megacycles — two-thirds as high as the resonant frequency of the tube itself. The high resonant frequency was obtained by making the probe small and compact and by minimizing the length of all input connections. The plate of the diode is coupled directly to the high input terminal by a button-type condenser, and the cathode of the diode is connected to the probe shell by a very short connecting strip.

The resonant frequency of 1050 megacycles makes it possible to measure voltages over a wide frequency range without applying corrections. Up to 300 Mc, for instance, the maximum error is ±12% when the indicated voltage is 0.5 volt or more. If the indicated voltage is less than 0.5 volt, the error will be larger because of the increase of the transit-time error of the diode. In Figure 5 are shown curves from which corrections for frequency error can be obtained. The curves show that the frequency error caused by input circuit resonance is in the opposite direction from the transit-time frequency error. For instance, at 0.5 volt indicated, the correction for transit-time balances the correction for resonance at 500 Mc and the net error is zero. When accurate measurements are not necessary, the instrument can be used as a voltage indicator up to 2500 Mc.

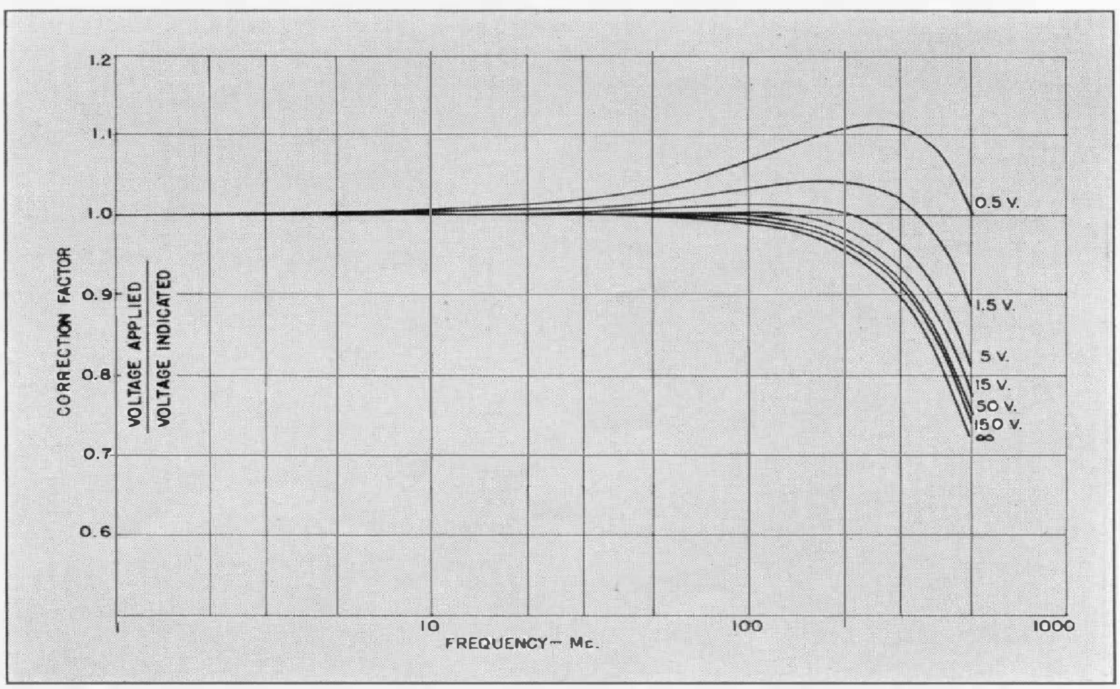


Figure 5. Frequency correction for a number of different indicated voltages. The curve marked ∞ is included to show the complete resonance effect.

The transit-time (or premature-cutoff) error varies directly with the interelectrode spacing and would, therefore, be less with a tube having more closely spaced elements. The spacing, however, is only a few thousandths of an inch, and it seems impractical to decrease this spacing without lowering the voltage rating to a point where the high-voltage limit would be too low for an instrument designed to respond to voltages up to 150 volts.

An inspection of the curves makes it clear that the premature cutoff, in general, contributes substantial errors at all voltages at frequencies for which the resonance-rise corrections can be made with fair accuracy. The performance of the instrument is therefore rather considerably determined by the limitations of the tube itself, and further improvement in resonance-rise conditions would lead to only a minor increase in the useful frequency range. For this type of voltmeter, then, it would seem that the practical high-frequency limit with existing tubes had been approached closely.

The user must remember that in order to obtain the frequency characteristics given in Figure 5, he must be very careful when making connection to the probe. The relationship between the voltage at the probe terminals and the voltage that it is desired to measure at some point in a circuit depends upon the connections used. The voltage applied to the probe is that at its terminals, which is not necessarily the same as that at the far end of the connecting leads. At high frequencies the connection must be as short and direct as possible.

The three types of terminals supplied for use with the probe are shown in Figure 4. They include a Type 274 plug terminal and Type 774 male and female coaxial terminals. A 50-ohm disc-type resistor is supplied for use with the coaxial terminals. The metal cap shown directly in front of the probe is used to attach all terminals to the probe. There are three threaded holes around the edge of the cap instead of only the one which is necessary for attachment of the Type 274 plug low terminal. The three holes are provided so that the cap can be fastened to a metal sheet or other flat metal surface when a minimum ground-connection inductance is desired. A hole in the metal sheet or surface makes the high probe input terminal accessible.

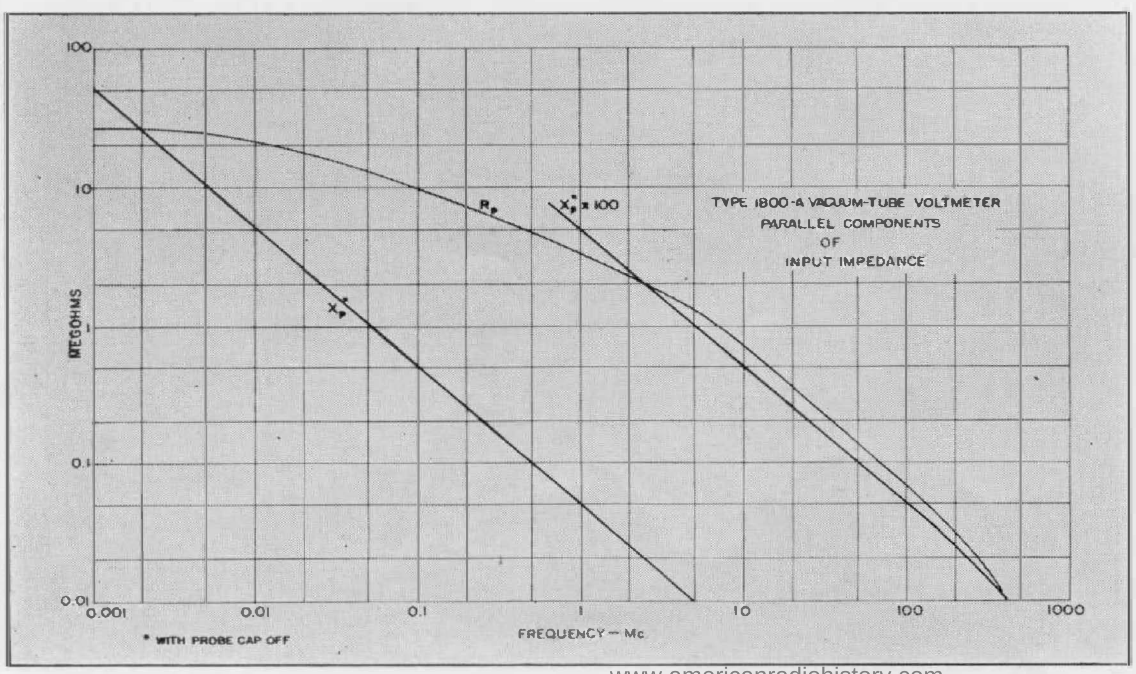


Figure 7. Plot of impedance vs. frequency for the parallel components of input impedance. The equivalent parallel capacitance is 3.1 $\mu\mu f$.

At frequencies low enough so that higher input capacitance and lower input natural frequency are not important, the probe can be plugged into position in the storage compartment and the a-c voltage applied to the panel a-c input terminals.

The probe shell is equipped with a cylindrical shield that has an aperture through which the diode is accessible. When the shield is rotated until the aperture into the probe is closed, the probe is completely shielded. A molded bakelite shell slips over the probe and is held in place by an insulated nut. The exposed metal at the front end of the probe is the only exposed part of the probe that can be at a d-c potential to ground. Connection to the d-c amplifier is made with a three-wire, shielded cable about three feet long.

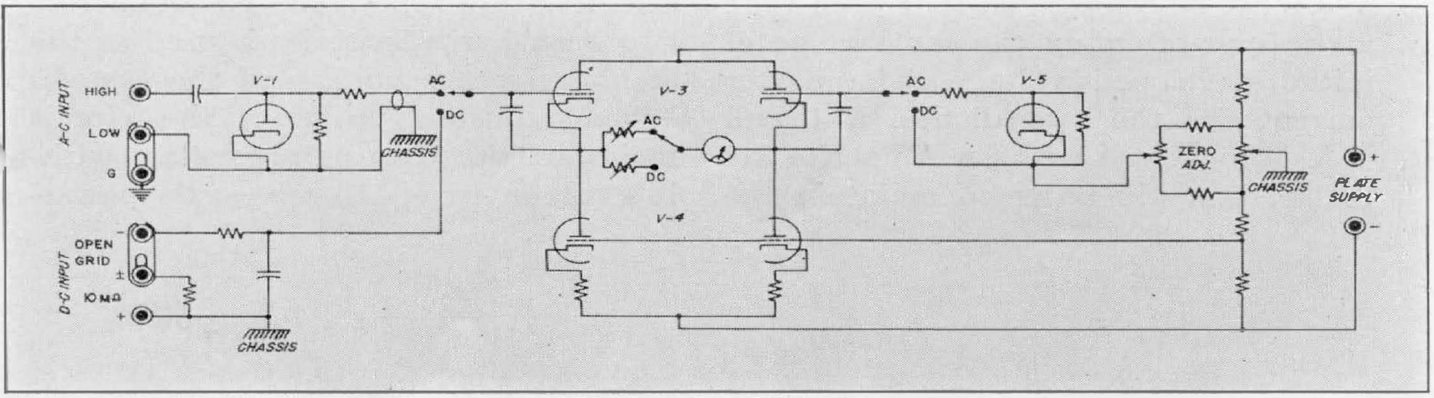
When voltage measurements are made on electronic circuits, or, for that matter, on circuits of any kind, the measuring device should disturb the circuit as little as possible. That is, the input impedance of the measuring device should be as high as possible. A 100-megohm resistor is shunted across the diode rectifier and another 100-megohm resistor is connected in series with the lead from the diode plate to the grid of the d-c amplifier tube. These resistance values give an effective parallel input resistance of 25 megohms at low frequencies. At high frequencies the input resistance is reduced by the Boella effect[2] in the resistors and by increased losses in the dielectrics. The input capacitance to the probe proper is about 3.1 micromicrofarads of which 0.8 micromicrofarad is the plate-to-cathode capacitance of the diode. When the cap used for attaching the terminals is screwed on the probe and the Type 274 plugs are used, the input capacitance is increased about 1 micromicrofarad. Figure 6 shows curves of probe input resistance and input reactance versus frequency. The input reactance curve is calculated for an input capacitance of 3.1 micromicrofarads.

Amplifier

The bridge-type amplifier is shown in simplified form in Figure 8. The indicating meter is connected in series with the appropriate precision wire-wound resistor between the cathodes of the twin-triode voltmeter tube, V-3. The cathodes of V-3 are connected directly to the plates of V-4, another twin triode. The latter tube is used to provide high degeneration without using high values of resistance from the cathodes of V-3 to ground and, consequently, a high plate-supply voltage. Each triode section of V-4, together with its cathode resistor, has the effect of a 7-megohm incremental resistance to voltage changes from the cathode of V-3 to B-; yet the plate-supply voltage need be only 450 volts because of the low d-c drop in the

[2] Boella, M., "Sul comportamento alle alta frequenze di alcuni tipi di resistenze elevate usate nei radio-circuiti," *Alta Frequenza*, Vol. 3, p. 132, April 1934.

Figure 8. Elementary schematic circuit diagram of the Type 1800-A Vacuum-Tube Voltmeter.



tube. Since the incremental resistance from the V-3 cathodes to B- is high compared to the resistance of the meter circuit, the amount of degeneration is determined almost completely by the meter-circuit resistance. At voltage ranges of 15 volts full scale and higher, the degeneration is sufficient to prevent tube changes from affecting the calibration of the instrument. Controls are provided for adjusting the calibration of the 0.5, 1.5, and 5-volt a-c and d-c ranges in case it is ever necessary to change V-3. Change of any other tube except V-1, the diode rectifier, has no effect on the calibration. Changing V-1 may require readjustment on the low a-c ranges.

Input to the voltmeter tube, V-3, for a-c or d-c measurements is selected by the combined power and selector switch mentioned previously. The d-c input system provides an R-C filter to prevent any ripple voltage from reaching V-3. The desired input resistance is obtained by proper connection of the short-circuiting link at the panel D-C input terminals. The input resistance of the OPEN GRID circuit is determined by the insulation resistance and the grid current which flows from V-3 through the voltage source. When the a-c input is selected, a diode, V-5, and circuit identical to that in the probe is connected to the grid of the inactive triode of V-3. The purpose of this diode is solely to balance the voltage developed at the other grid of V-3 from contact potentials and initial velocity of electrons in the probe diode. V-1 and V-5 must be selected so that each tube gives approximately the same value of initial developed voltage. The heater current for the two diodes, V-1 and V-5, is regulated with an Amperite 3-4 ballast lamp in order to maintain the zero of the low voltage a-c ranges as stable as possible.

Zero adjustment of the indicating meter is accomplished by adjusting the grid biases of V-3 very slightly. Bias adjustment is made on one grid to take care of large zero shifts such as may be encountered when V-3 is changed. Bias adjustment on the other grid, which should be sufficient for all normal adjustment necessary during actual use of the instrument, is made with the panel ZERO control. A third zero control is provided to adjust the a-c zero into coincidence with the d-c zero. The control varies the division of heater current between the two diodes, V-1 and V-5, and so changes the initial voltage developed by each diode. Coincidence of the two zeros is of interest only for the sake of convenience. Lack of coincidence has no effect on the accuracy of measurement. A change of resistance in series with the indicating meter, which happens whenever the VOLTAGE RANGE switch is rotated, has no effect on the zero reading.

Power Supply

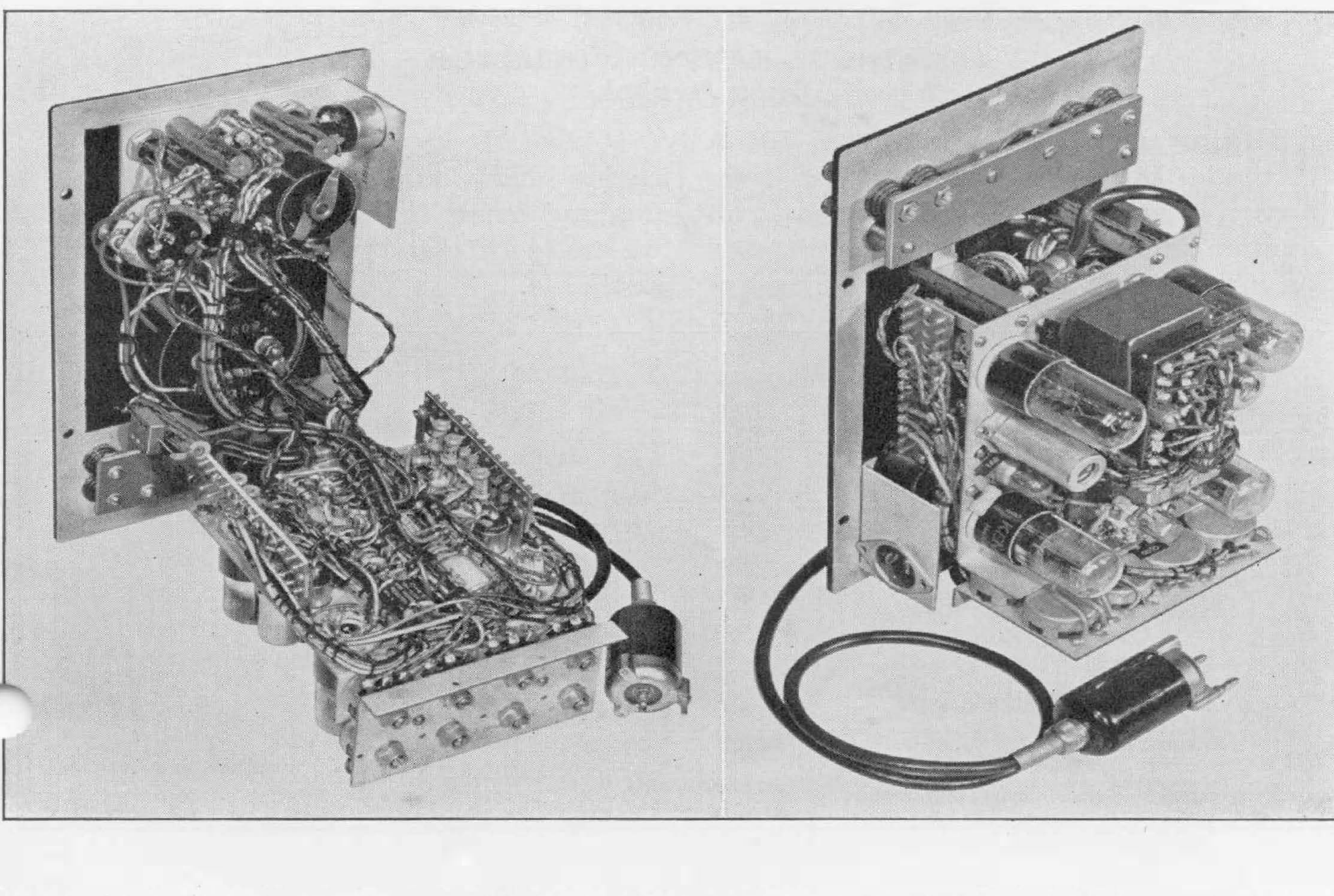
In order to maintain an accurate, stable meter reading on the low-voltage ranges, the plate supply voltage must be held constant regardless of power-line voltage fluctuations. Stabilization of the plate-supply voltage is obtained by use of an electronic voltage-stabilizing circuit, consisting of two vacuum tubes and two neon lamps. Both the shunt amplifier tube of the stabilizing circuit and the variable-resistance series tube are miniature types. The voltage across two neon lamps in series is used as the stable reference voltage of the system. When adjusted properly, the circuit maintains the plate-supply voltage within a volt or two of 450 volts as the power-line voltage is varied from 105 to 125 volts. Heater voltage changes in all tubes except the two diodes, V-1 and V-5, have no appreciable effect on the meter reading. The heater current of V-1 and V-5 is, as mentioned above, regulated by a ballast lamp.

The controls used for calibration and circuit adjustment are mounted on a shelf at the bottom of the chassis where they are easily accessible when the instrument is removed from its cabinet. All of the circuit elements of the voltmeter except those in the probe are mounted on the panel and a small, compact chassis. The chassis circuit elements and the panel circuit elements are connected together with a flexible cable so arranged that the panel and chassis may be swung apart to allow easy access to all portions of the circuit. Figure 9 shows a view of the complete assembly and a view of the chassis and panel separated to expose all parts of the circuit for servicing. The two sections are separated by removing four screws and unsoldering two direct connections to the grids of the voltmeter tube, V-3.

The Type 1800-A Vacuum-Tube Voltmeter has many advantages over the older Type 726-A. It is smaller, lighter, and easier to use; it can measure d-c voltages; it is more stable against line-voltage changes; its input impedance is higher and its frequency range is substantially greater. Mechanically and electrically, full advantage is taken of modern techniques and new components to produce an outstanding new voltmeter.

C. A. WOODWARD, JR.

Figure 9. Two views of the chassis. At the right is shown the complete assembly, while the view at the left shows how chassis and panel separate for servicing.



SPECIFICATIONS

Voltage Range: 0.1 to 150 volts, a-c, in six ranges (0.5, 1.5, 5, 15, 50, and 150 volts, full scale); 0.01 to 150 volts, d-c, in six ranges (0.5, 1.5, 5, 15, 50, and 150 volts, full scale).

Accuracy: D-C, ±2% of full scale on all six ranges. A-C, ±2% of full scale on all six ranges for sinusoidal voltages.

Waveform Error: On the a-c voltage ranges, the instrument operates as a peak voltmeter calibrated to read r-m-s values of a sine wave, or 0.707 of the peak value of a complex wave. On distorted waveforms the percentage deviation of the reading from the r-m-s value may be as large as the percentage of harmonics present.

Frequency Error: At high frequencies resonance in the input circuit and transit-time effects in the diode rectifier introduce errors in the meter reading. The resonance effect causes the meter to read high and is independent of the applied voltage. The transit-time error is a function of the applied voltage and tends to cause the meter to read low. The curves of Figure 5 give the frequency correction for several different voltage levels. It will be noted that at low voltages the transit-time and resonance effects tend to cancel, while at higher voltages the error is almost entirely due to resonance.

This voltmeter may be used at frequencies as low as 20 cycles with a frequency error of less than 2%.

Input Impedance: At low frequencies the equivalent parallel resistance of the a-c input circuit is 25 megohms. At higher frequencies this resistance is reduced by losses in the shunt capacitance. The equivalent parallel capacitance at radio frequencies is 3.1 $\mu\mu$f with the probe cap and plug removed. At audio frequencies this capacitance increases slightly. The probe cap and plug add approximately 1 $\mu\mu$f. The accompanying plot gives the variation of R_p and X_p with frequency.

On the d-c ranges two values of input resistance are provided, 10 megohms and open grid.

Power Supply: 105 to 125 volts or 210 to 250 volts, a-c, 50 to 60 cycles. The instrument incorporates a voltage regulator to compensate for supply variations over this voltage range. The power input is less than 25 watts.

Tubes: Two Type 9005, two Type 6SL7-GT, one Type 6AT6, one Type 6C4, one Type 6X5-GT, one Type 3-4, and two Type 991 are used; all are supplied.

Accessories Supplied: A seven-foot line connector cord, spare meter lamps and fuses; Type 274 and Type 774 terminations and 50-ohm terminating resistor for probe.

Mounting: Black crackle finish aluminum panel mounted in a shielded walnut cabinet. The carrying handle can be set as a convenient support for the instrument when placed on a bench with the panel tilted back.

Dimensions: (Width) 7⅜″ x (depth) 7½″ x (height) 11⅛″, over-all.

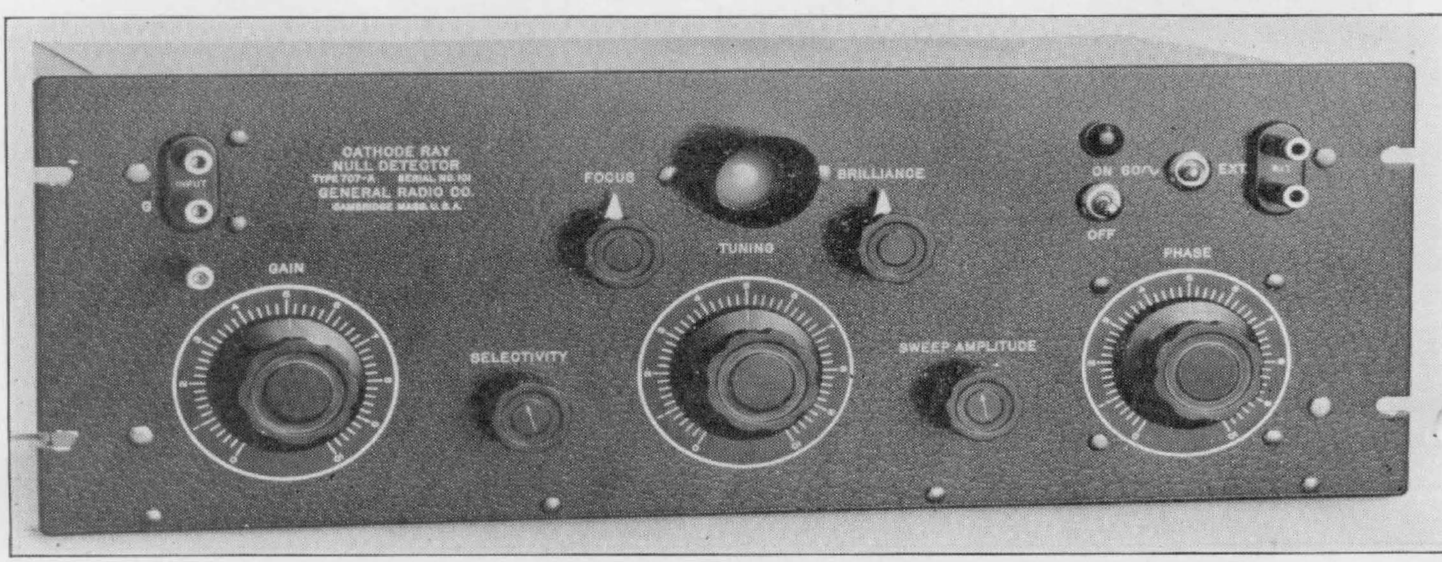
Net Weight: 13 pounds.

Type	*Description*	*Code Word*	*Price*
1800-A	**Vacuum-Tube Voltmeter**	DUCAT	**$305.00**

CATHODE-RAY NULL DETECTOR
Now Available

During the war, the Type 707-A Cathode-Ray Null Detector was temporarily discontinued in order that production facilities might be concentrated on more urgent items.

Repeated inquiries from our customers have made it evident that a demand exists for this instrument, and we are glad to announce that it is again available.



The Type 707-A Cathode-Ray Null Detector was described in the first and second editions of Catalog K. The catalog description is reprinted below.

TYPE 707-A CATHODE-RAY NULL DETECTOR

USES: This visual null indicator is intended for use as a balance detector in bridge and other null-method measurements at power-line and audio frequencies. When calibrated for a given frequency, it can be operated as a limit indicator. It can also be used for comparing frequencies by means of Lissajous figures or, when calibrated, used as an a-c millivoltmeter.

DESCRIPTION: The output of the bridge is applied through an 80-db highly selective amplifier,* operating on the degenerative principle, to the vertical deflecting plates of a one-inch cathode-ray tube. The bridge generator voltage is applied through an adjustable phase-shifting network to the horizontal plates. The tilted ellipse so formed is reduced to a horizontal straight line at balance.

FEATURES: Independent indications are given of the effect of balancing either the reactive or the resistive bridge control separately. This adds considerably to the speed and convenience of routine bridge measurements, and permits either bridge control to be balanced accurately without necessitating an accurate balance of the other. Indication is also given of the direction off balance of either one of the bridge controls, chosen at will.

This null indicator cannot be injured by overloading and is instantaneous in response and recovery. External fields do not affect its operation, and it radiates no appreciable field.

For bridge balancing, it is less fatiguing than headphones and can be used in noisy locations.

* U. S. Patent No. 2,173,426

SPECIFICATIONS

Input Impedance: One megohm.

Sensitivity: 150 μv at 60 cycles; 200 to 300 μv at 1000 cycles.

Selectivity: 40 decibels against second harmonic.

Frequency Range: Plug-in units tune the amplifier for any desired operating frequency between 20 and 2000 cycles. Continuous tuning range $\pm 5\%$ for each unit.

Temperature and Humidity Effects: When this instrument is operated under severe conditions of temperature and humidity some decrease in sensitivity and selectivity may be expected. For the low frequency tuning units the sensitivity may be reduced by as much as 6 db, while for all units the selectivity to the second harmonic may be reduced by 5 db. The above figures are for a relative humidity of 80% at 95° Fahrenheit.

Controls: Panel controls are provided for adjusting the focus and brilliance of the cathode-ray pattern, the phase and amplitude of the horizontal sweeping voltage, and the gain, selectivity, and tuning of the amplifier.

Accessories Supplied: A 7-foot line connector cord, spare pilot lamps and fuses, one Type 274-M Plug, and one Type 274-NC Shielded Conductor.

Accessories Required: One plug-in phasing circuit is used at any frequency below 400 cycles; one plug-in tuning unit for each operating frequency used. These are not included in the price of the instrument. (See price list on page 12.)

Power Supply: 105 to 125 volts, 40 to 60 cycles.

Power Input: 20 watts at 60 cycles.

Vacuum Tubes: One 6K7-G pentode, one 6F8-G twin triode, one 6J5-G triode, one 913 cathode-ray tube, and one 6X5 rectifier; all are supplied with the instrument.

Mounting: Standard 19-inch relay-rack panel. Walnut end brackets are supplied for table mounting.

Dimensions: Panel, 19 x 7 inches; depth behind panel, 9 inches.

Net Weight: 29 pounds.

Type		*Code Word*	*Price*
707-A	**Cathode-Ray Null Detector†**	NULTY	$250.00

†Less Phasing Unit and Tuning Unit (see next page).

PLUG-IN UNITS FOR TYPE 707-A CATHODE-RAY NULL DETECTOR

These units are required for use with TYPE 707-A Cathode-Ray Null Detector and are not included in the price of that instrument.

A phasing unit is necessary for operation at any frequency *below* 400 cycles. At 400 cycles and above, none is required. A tuning unit is required for each operating frequency. The tuning range is ±5%.

All units plug into mounting jacks provided inside the null detector.

PHASING UNITS

Type	*Description*	*Code Word*	*Price*
707-P1	**For Frequencies Below 100 cycles**	NULLTECANT	**$8.00**
707-P2	**For Frequencies Between 100 and 400 cycles**	NULLTECBOY	**8.00**

AMPLIFIER TUNING UNITS

Type	*Frequency*	*Code Word*	*Price*
707-P42	**42 cycles**	NULLTECCAT	**$30.00**
707-P50	**50 cycles**	NULLTECDOG	**30.00**
707-P60	**60 cycles**	NULLTECEYE	**30.00**
707-P100	**100 cycles**	NULLTECTAP	**30.00**
707-P400	**400 cycles**	NULLTECFIG	**30.00**
707-P1000	**1000 cycles**	NULLTECGUM	**30.00**
707-P2000	**2000 cycles**	NULLTECHIM	**30.00**

MISCELLANY

We were pleased to welcome recently, as a postwar visitor, Mr. Lewis M. Lyons, a member of the firm of Claude Lyons, Ltd., who have for many years represented the General Radio Company in Great Britain.

Other recent visitors to our plant and laboratories include our representative in Finland, Mr. K. L. Nyman of Helsinki, who was accompanied by Mr. K. S. Sainio, Chief Engineer of the Finnish Broadcasting Company; Dr. Alfred P. De Quervain, Assistant Chief Engineer, Electronics Department, Brown-Boveri Company, Ltd., of Baden, Switzerland, and Mr. Robert C. Habich of Berne, Switzerland, and Port Washington, New York; Dr. Stig Ekelöf, Professor of Theoretical Electricity and Electrical Measurements, Chalmers Tekniska Högskola, Gothenburg, Sweden, and Mr. P. Poppe of Oslo Lysverker, Oslo, Norway; Dr. R. W. Guelke of the South African National Physical Laboratory, Pretoria, South Africa; and Professor F. Dacos, Institute Montefiore, Liege, Belgium.

GENERAL RADIO COMPANY

275 MASSACHUSETTS AVENUE

CAMBRIDGE 39 MASSACHUSETTS

TELEPHONE: TROWBRIDGE 4400

BRANCH ENGINEERING OFFICES

NEW YORK 6, NEW YORK
90 WEST STREET
TEL.—WORTH 2-5837

LOS ANGELES 38, CALIFORNIA
950 NORTH HIGHLAND AVENUE
TEL.—HOLLYWOOD 6201

CHICAGO 5, ILLINOIS
920 SOUTH MICHIGAN AVENUE
TEL.—WABASH 3820

PRINTED IN U.S.A.