THE General Radio EXPERIMENTER

ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

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THE TYPE 1803-A VACUUM-TUBE VOLTMETER A QUALITY PRODUCT AT A MODERATE PRICE

Also
IN THIS ISSUE

● **DURING AND SINCE** the war years, there has been a tendency for engineers when designing test equipment to strive for the ultimate in performance and adaptability, regardless of price. There is still, however, a need for simple, straightforward instruments of adequate scope that will give accurate results at a price within a modest laboratory budget.

The TYPE 1803-A Vacuum-Tube Voltmeter substantially duplicates the performance of our older TYPE 726-A. It is just an a-c voltmeter, with no d-c scales, no ohm scales, and no other frills, but in many respects it is a better instrument. Nevertheless, through advances in circuit design and manufacturing techniques, the new instrument sells for $20 less than its predecessor did over ten years ago. Obviously, such a low price was not achieved without careful attention to the cost of every detail of electrical and mechanical design, and a firm resistance to the temptation to add just one little feature here and there, the combined cost of which would increase the selling price by a substantial amount.

Figure 1. Panel view of the Type 1803-A Vacuum-Tube Voltmeter, showing how probe can be stored on side of cabinet.

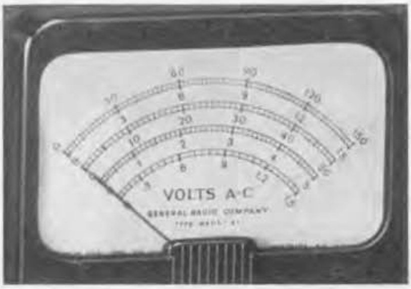


Figure 2. Close-up of the meter scales.

Although the over-all range of the voltmeter corresponds to that of the TYPE 726-A, the new instrument is improved over the old in several respects. In particular, (1) it is smaller and lighter, (2) the probe is smaller and completely shielded, (3) a single zero adjustment takes care of all ranges, and (4) the power supply is not limited to operation at a single supply frequency.

RANGE AND ACCURACY

The face of the meter, shown in Figure 2, has four scales to cover the five ranges of 0 to 1.5, 0 to 5, 0 to 15, 0 to 50, and 0 to 150 volts, a-c. There are separate, non-linear scales for the 1.5-volt and 5-volt ranges. Voltages from 5 to 50 volts are read on the 0 to 50 linear scale, and voltages from 5 to 15 volts or 5 to 150 volts are read on the 0 to 150 linear scale. A voltage below 5 volts should always be read on the appropriate non-linear scale in order to obtain the best accuracy.

The scales are calibrated to read the r-m-s value of a sine-wave voltage. The accuracy on all ranges is ±3% of the full-scale value.

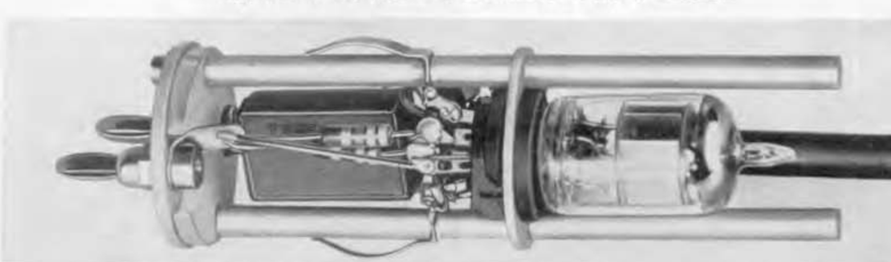
As on the TYPE 1800-A, the meter pointer is broad over the two inner scales in order to be visible at a distance, and the upper portion is knife-edged in order to make it easier to read small differences and to reproduce voltage readings or settings more accurately.

GENERAL CONSTRUCTIONS

The voltage input terminals are on the probe. Provision is made, as shown in Figure 1, for storing the probe by attaching it to the side of the cabinet, and in this position it provides a convenient pair of fixed input terminals, to which test leads can be connected. To facilitate connections there are also furnished a TYPE 274-MB Double Plug; a pair of 30-inch test leads, one red and one black, for attachment to the plug; a pair of test prods, one red, one black, that plug into the test leads; and two alligator clips into which either the leads or the prods can be plugged.

The welded, heavy-gauge aluminum cabinet is finished in black wrinkle, and is painted black on the inside to aid heat dissipation. Rubber feet are provided to support the voltmeter with the panel either vertical or horizontal, and a simple carrying handle is located on the top.

Figure 3. View of probe with case removed to show construction.



Both the power cord and the probe cable are permanently attached to the chassis and are led out through notches in the cabinet edges. The probe cable is completely shielded.

The photograph in Figure 3 shows the construction of the probe. Standard parts are used wherever possible, and expensive machine work is eliminated. The rectifier is a Type 6AL5 twin-diode, one diode of which is used to rectify the a-c voltage to be measured. The other, or inactive, diode is connected to the d-c amplifier to balance the effect of the contact potential of the active diode on the indicating meter.

FREQUENCY CHARACTERISTICS

The resonant frequency of the probe input circuit, with the Type 274 Plugs removed, is 410 Mc. Correction curves for several values of indicated voltage are shown in Figure 4. From these it is evident that the voltmeter can be used, without correction, up to 120 megacycles with a maximum error of 10%. The rise of the curves for low indicated voltages is the result of the transit-time error being larger than the resonance error and in the opposite direction. In order to approach the high-frequency performance indicated by the curves, it is important that short leads be used to connect the voltage source to the probe.

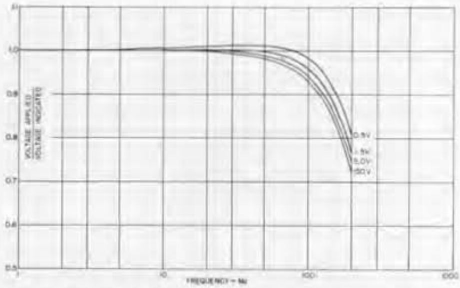


Figure 4. Plot of frequency response for different voltage levels.

The equivalent parallel input capacitance of the probe input circuit is 11.5 $\mu\mu$f without the connecting plugs which add about 0.5 $\mu\mu$f. The equivalent parallel input resistance is 7.7 megohms at low frequencies and falls off with frequency as shown by the curves of input impedance in Figure 5.

CIRCUIT

A simplified schematic of the d-c amplifier and probe is shown in Figure 6. The amplifier is a simplified version of that used in the Type 1800-A and consists of a twin-triode tube, V-2, used in a balanced circuit. The inactive section of the twin-diode in the probe is connected to the grid of one triode while the active section is connected to the grid of the other triode.

Degeneration of the amplifier is obtained by a resistance of approximately

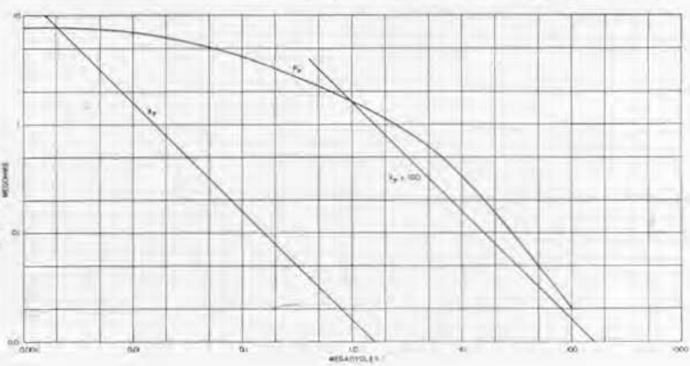


Figure 5. Plot of effective parallel reactance and resistance at the input terminals.

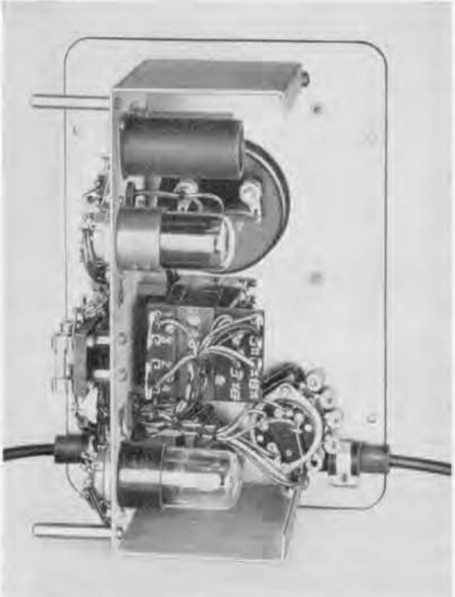


Figure 6. Rear view of the voltmeter panel and chassis.

600 kilohms connected from each cathode to B–. Part of this resistance is a potentiometer that is used as a zero control. The 200-microampere meter is connected between the cathodes of the two triodes in series with a highly stable, composition-type multiplier resistor. When the range is switched, only the multiplier resistor is changed, and, therefore, the zero adjustment is not affected.

A single internal control in the meter circuit adjusts the calibration for the particular tube, V-2, being used. Variations in the transconductance of V-2 are in effect variations in the multiplier resistance and can be compensated by a variable resistance in series with the multiplier resistance.

The balanced amplifier circuit insures very little shift in zero or in calibration when the line voltage varies. Very satisfactory results are obtained with no regulation of the plate-supply voltage or the diode heater voltage. A line shift of 10 volts changes the reading only one division on the 15-volt scale.

—C. A. Woodward, Jr.

SPECIFICATIONS

Voltage Range: 0.1 to 150 volts, a-c, in five ranges (1.5, 5, 15, 50, and 150 volts, full scale).

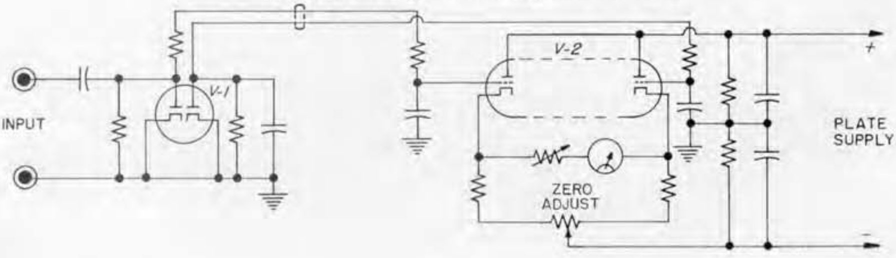
Accuracy: ±3% of full scale on all ranges, for sinusoidal voltages, subject to frequency correction above 50 megacycles. Correction curve supplied in instruction book (see accompanying plot).

Waveform Error: The instrument is peak reading and indicates r-m-s value of a sine wave or peak value of a complex wave. On distorted waveforms the percentage deviation of the reading from the r-m-s value may be as great 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. Figure 4 gives 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. The resonant frequency is about 410 Mc.

At low frequencies the response drops off because of the increasing reactance of the series capacitance of the input circuit. At 20 cycles per second the drop is 2% or less.

Figure 7. Elementary schematic diagram of the circuit.



Input Impedance: The equivalent a-c input circuit is a resistance in parallel with a capacitance. At low frequencies the equivalent parallel resistance is 7.7 megohms. At high frequencies this resistance is reduced by losses in the shunt capacitance. The equivalent parallel capacitance at radio frequencies is 10$\mu\mu$f. At audio frequencies the capacitance increases to 11.5 $\mu\mu$f. The curves of Figure 5 give the variations of R_p and X_p with frequency.

Accessories Supplied: One Type 274-MB Double Plug; 2 test leads; 2 test prods; 2 alligator clips.

Power Supply: 105 to 125 volts or 210 to 250 volts, a-c, 50 to 60 cycles. The power input is about 11 watts.

Tubes: One Type 6AL5, one Type 6SU7-GT, and one Type 6X5-GT/G are used; all are supplied.

Dimensions of Cabinet: (Width) 7¼ x (depth) 6$\frac{7}{16}$ x (height) 11¾ inches, overall. Probe in storage position adds 1 inch to width.

Net Weight: 9¼ pounds.

Type		*Code Word*	*Price*
1803-A	**Vacuum Voltmeter**	ABOOM	**$145.00**

NEW PERSONNEL

ENLARGED QUARTERS FOR OUR NEW YORK ENGINEERING AND SALES OFFICE

To provide more complete engineering and commercial service for our customers in the greater New York area, the staff of our New York office has recently been increased. William R. Thurston and George G. Ross, both from our Engineering Department, now make their headquarters in New York and are available for consultation on the purchase, performance, and use of General Radio equipment. This increase in office personnel will make possible much better service to many friends and customers in New Jersey and eastern Pennsylvania.

Mr. Thurston was graduated from the Massachusetts Institute of Technology with the degrees of S.B. and S.M. in Electrical Engineering. Before graduation he was a cooperative student at our plant. He joined the Development Engineering Staff of the General Radio Company in 1943 and has specialized in the development of high-frequency measuring equipment and techniques. One of the important developments with which he was associated is our new line of Type 874 Coaxial Measuring Equipment. During 1945 he was on leave of absence for work at the M.I.T. Radiation Laboratory. Mr. Thurston transferred to the Sales Engineering Department in 1949.

Mr. Ross was graduated from Northeastern University in 1942 with the degree of B.S. in Electrical Engineering and while an undergraduate was also a cooperative student in our plant. After graduation he served as a degaussing analyst with the Bureau of Ordnance, U. S. Navy, leaving in 1943 to enter the Navy as a Lieutenant, j.g. At the close of the war he joined the staff of our Standardizing Laboratory, later transferring to the Sales Engineering Department.

Ivan G. Easton, who was manager of our New York office from 1946 to 1949, has now returned to the Cambridge office and is working with Dr. D. B. Sinclair, Chief Engineer, on important engineering projects.

Miss Mary Arms continues as our efficient secretary and receptionist.

On March 1 our New York office was moved to larger quarters on the seventh floor of the Brady Building at 90 West Street (no change of address).

The new space provides two private offices, adequate room for exhibiting and demonstrating our equipment, and a storeroom for the maintenance of a stock of smaller instruments and parts including Variacs. Our telephone number continues as WOrth 2-5837. We cordially invite all our friends in the greater New York area to visit our new offices.

LOS ANGELES STAFF INCREASED

The addition of James G. Hussey to our Los Angeles office staff doubles the technical personnel now available to our Western customers and will permit better coverage of the Mountain States.

Mr. Hussey joins General Radio with an A.B. degree in Physics received from the University of California, Los Angeles, and with the benefit of Navy wartime electronic experience. Mr. Hussey's prior years of electronic equipment production-test and quality-control supervision in the Los Angeles area have qualified him with an understanding of regional problems and industrial instrumentation.

The Los Angeles office remains under the direction of Frederick Ireland.

D. B. SINCLAIR BECOMES CHIEF ENGINEER

Dr. Donald B. Sinclair has been appointed Chief Engineer of the General Radio Company, succeeding Melville Eastham who retired from that post on February 15.

Dr. Sinclair was born in Winnipeg, Manitoba, and was educated at the University of Manitoba and the Massachusetts Institute of Technology, receiving the degree of Doctor of Science from M.I.T. in 1935. He was a Research Assistant and later Research Associate at M.I.T. from 1932 to 1935, and he joined the General Radio Engineering Staff in 1936. He has been Assistant Chief Engineer since 1944. During the war he worked in the Countermeasures Division and the Guided Missiles Division of NDRC, receiving the President's Certificate of Merit for outstanding services.

Dr. Sinclair is a Fellow of the Institute of Radio Engineers, a member of the American Institute of Electrical Engineers, and a member of Sigma Xi. He is Treasurer of the Institute of Radio Engineers and has been on the Board of Directors of the Institute since 1944.

George G. Ross — William R. Thurston — James G. Hussey — Donald B. Sinclair

BAYLY ENGINEERING OFFERS REPAIR SERVICE TO CANADIAN CUSTOMERS

Canadian users of General Radio instruments can now have their equipment repaired and recalibrated in Canada, thus avoiding the red tape, expense, and delays that often occur in customs when material is returned to our factory.

Bayly Engineering, Limited, of 5 First Street, Ajax, Ontario, has been appointed Canadian service agency for General Radio products. This firm is equipped to give prompt and competent repair service on all General Radio instruments. Their repairs and calibrations are made to the same specifications and standards as are used at our factory, and we are glad to recommend their service to our friends in Canada.

Bayly Engineering, Limited, is owned and operated by Professor B. de F. Bayly of the University of Toronto. He has had many years of experience in the electrical and electronic industries and is already well known to most of our Canadian customers.

By telephone, Bayly Engineering can be reached through the Toronto exchange, at WAverly 6866.

View of a portion of the laboratory at Bayly Engineering, Limited.

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