The Aerovox Research Worker

The Aerovox Research Worker is a monthly house organ of the Aerovox Corporation. It is published to bring the Radio Experimenter and Engineer authoritative, first hand information on capacitors and resistances for radio work.

VOL. 18, NO. 12 DECEMBER, 1946

50c per year in U.S.A.
60c per year in Canada

THE RECTIFIER-AMPLIFIER V. T. VOLTMETER

By the Engineering Department, Aerovox Corporation

The vacuum-tube voltmeter is an extremely useful laboratory instrument, the full utility of which has been exploited by modern designs. Both a. c. and d. c. types are in wide use in many phases of electrical measurement practice. A variety of v. t. voltmeter circuits is available for the measurement of direct voltages and of alternating voltages from power frequencies to super-high frequencies.

Modern v. t. voltmeters may be classified into two main groups; (1) direct current and (2) alternating current. And the a. c. group may be subdivided further into untuned and tuned cataegories which then are subdivided still further according to functions and the specific types of circuits employed. As a consequence of the large number of practical circuits developed to meet the requirements of every type of radio work, the literature is rich in vacuum-type voltmeter data. At least one textbook covering this subject entirely has been issued comparatively recently.[1]

Of the numerous v. t. voltmeter circuit arrangements developed within the last ten years, the one most widely used at present and perhaps the most satisfactory for all types of a. c. service is the *rectifier-amplifier* circuit. This circuit has been discussed only lightly in previous issues of the *Research Worker.*[2, 3] In this circuit, the a. c. test voltage is rectified by a shunt-connected diode tube, and the resulting d. c. output voltage (which is very nearly equal to the peak a. c. voltage value) is presented to the control grid of a triode tube operated as a degenerative d. c. amplifier. The indicating meter is included in the triode plate or cathode circuit. Essentially, the rectifier-amplifier v. t. voltmeter thus is a peak type instrument, although the meter scale is graduated in R. M. S. volts in most commercial models.

Rectifier-amplifier instruments are useful over a wide frequency range. The General Radio Type 726-A vacuum-tube voltmeter, which uses this circuit arrangement, has a frequency error of less than 1 percent between 20 cycles and 50 megacycles.[4] The error at 100 megacycles is approximately +3% when the probe tips are removed.

Input impedance of the rectifier-amplifier type instrument is high, being of the order of several megohms at the lower end of the audio-frequency spectrum and somewhat lower at the high radio frequencies. This is a desirable characteristic, since v. t. voltmeters often are used for measurements in circuits where the loading effect of the instrument must be negligible. The input capacitance is

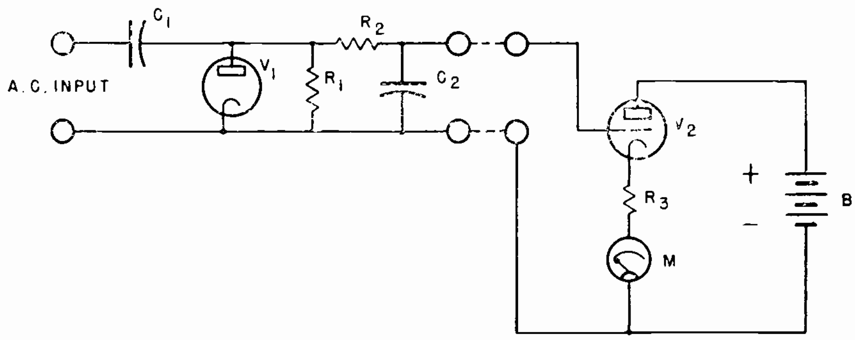


FIG. I

reduced by employing a low-capacitance diode, such as an acorn type. The resonant frequency of the input circuit may be increased so that it is out of the normal range of measurements by employing a special ultra-high-frequency diode with a resonant frequency of 1000 megacycles or higher.

The entire diode rectifier circuit of the instrument usually is built into a relatively small probe mounted on the end of a four-wire cable connected to the amplifier circuit. This enables the rectifier to be placed close to the circuit under test, thereby obviating long leads.

CIRCUITS

The basic arrangement of the rectifier-amplifier v. t. voltmeter is shown in Figure 1. The two portions of the circuit have been partially separated for easy recognition. Diode tube V_1, input capacitor C_1, load resistor R_1, filter resistor R_2, and filter capacitor C_2, comprise the rectifier circuit. Triode tube V_2, cathode resistor R_3, and plate voltage source B comprise the d. c. amplifier which, with the indicating milliammeter or microammeter, M, constitutes a d. c. vacuum-tube voltmeter with high input resistance capable of measuring the voltage output of the diode circuit. The rectifier-amplifier instrument accordingly is a combination of two well-known v. t. voltmeter circuits —the diode peak a. c. voltmeter and the high-resistance triode d. c. vacuum-tube voltmeter.

Operation of the circuit may be explained in the following manner: When an a. c. voltage is applied to the A. C. INPUT terminals (See Figure 1), capacitor C_1 is charged to a voltage equal to the a. c. peak value minus the voltage drop in diode V_1. The reactance of C_1 is chosen low enough to prevent the development of an appreciable alternating potential across this capacitor. C_1 has a capacitance value of 0.02 μfd. in most commercial instruments. Capacitor C_2 and resistor R_2 remove any a. c. component, so that only the d. c. component resulting from diode action is present at the rectifier circuit output. The diode plate side of the circuit is negative, while the cathode side is positive. Resistor R_1 discharges capacitors C_1 and C_2 when the applied a. c. voltage is lowered. R_1 and R_2 each have resistance values of many megohms.

The d. c. output voltage of the rectifier circuit is applied directly to the grid-cathode circuit of the triode. In the General Radio v. t. voltmeter,[4] use is made of a large cathode resistor (such as R_3 in Figure 1) in order to obtain certain improvements in the operation of the triode circuit. These include (1) proportionality of the meter deflection to the rectifier output voltage, (2) almost complete divorcement of instrument sensitivity from such tube constants as transconductance, and (3) elimination of a voltage divider (range switching potentiometer) in the triode grid-cathode circuit. The input voltage ranges of the triode section of the instrument may be changed by switching in new values of R_3.

The resistance value of R_3 is made large enough to insure that a *small* increase in triode plate current, resulting from application of the rectifier circuit output voltage, will cause a voltage drop to appear across R_3 equal very closely to the applied grid voltage. Under this condition, the deflection of the cathode current meter, M, will be directly proportional to the applied grid-cathode

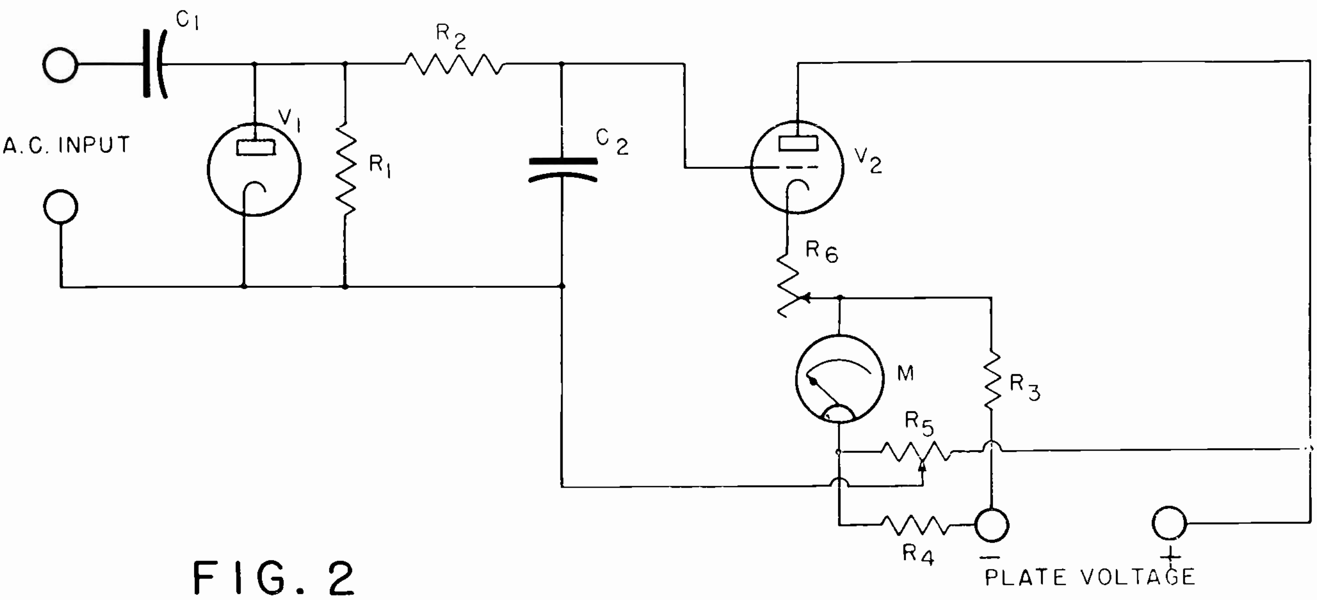


FIG. 2

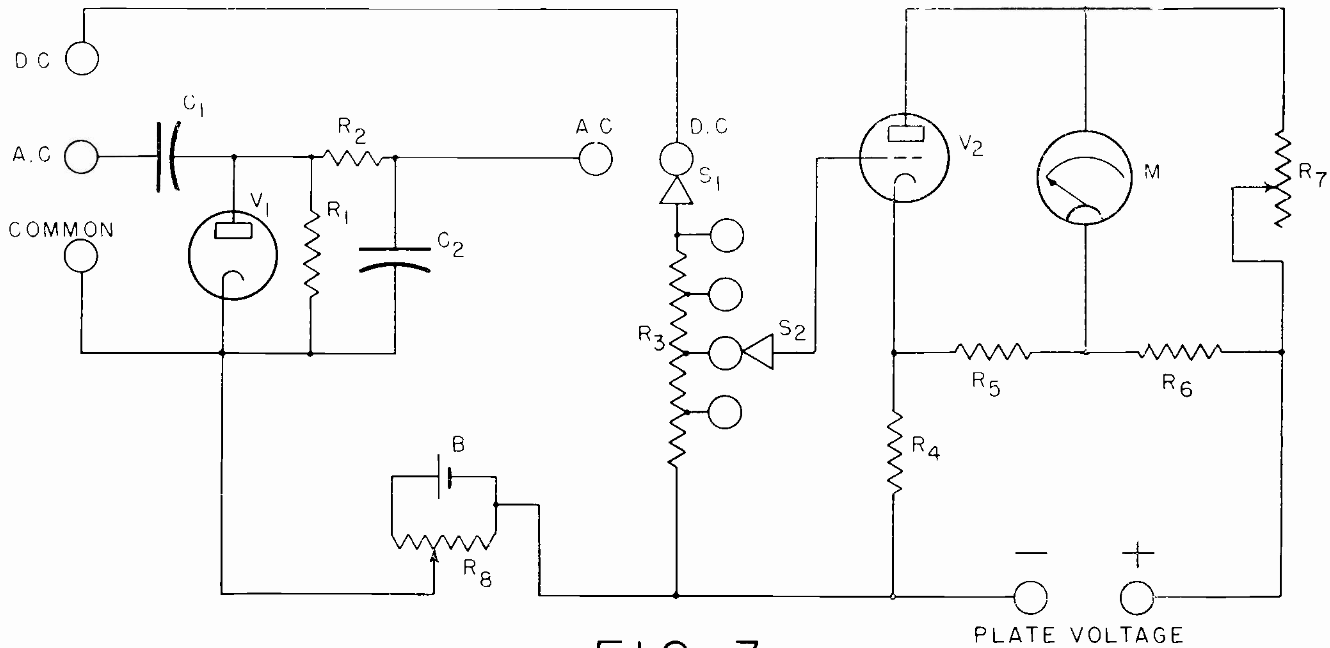


FIG. 3

voltage and will be reasonably independent of tube characteristics.

Further refinements of the circuit provides resistors R_3 and R_4 (See Figure 2) for setting meter **M** initially to zero against the deflecting effect of the static plate current of the triode. Also, since the contact potential of diode V_1 will cause a steady d. c. voltage to be applied to the triode grid even when no a. c. test voltage is present, some means must be provided for balancing out this voltage which otherwise would produce an erroneous initial meter deflection amounting to about 1 volt. A suitable bucking voltage is obtained by returning the diode circuit to the slider arm of potentiometer R_5 (See Figure 2) which is set initially to eliminate the undesired effect of contact potential and usually requires no further adjustment until tubes are changed.

Another rectifier-amplifier arrangement is shown in Figure 3. Here, it will be observed that the right-hand side of the circuit is a complete, conventional d. c. vacuum-tube voltmeter with a range-switching input potentiometer, R_3. The left-hand side is the regular diode rectifier circuit already shown in Figures 1 and 2. This arrangement is employed often by technicians who add an external diode probe to an existing d. c. vacuum-tube voltmeter. Battery B and potentiometer R_8 form a balancing circuit for bucking out the contact potential of diode V_1. The indicating meter, **M**, is connected in a bridge circuit (composed of the triode plate-cathode path and resistors R_5, R_6, and R_7), with R_7 as the balancing rheostat used to set the meter initially to zero. For d. c. measurements, switch S_1 is thrown to its D. C. position, connecting the top of the voltage divider (range switch) to the D. C. input terminal. This removes the diode section from the circuit, removing loading effects of V_1 upon the d. c. circuit under test.

The bucking battery, B, (See Figure 3) may be replaced by a second diode (V_2) and potentiometer (R_3) as shown in Figure 4. Arrangements of this type, such as suggested by Silver[5], utilize the contact potential generated by the second diode to buck out that produced by the first. If a duo-diode tube, such as type **6H6**, is employed in the rectifier section, one diode section may be employed as the test voltage rectifier; the other as the bucking voltage source.

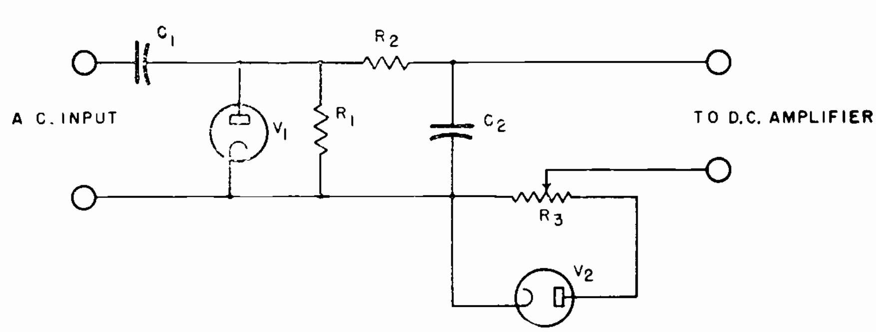


FIG. 4

REFERENCES

[1] Vacuum Tube Voltmeters (a book). John F. Rider. (John F. Rider Publisher, Inc.) New York, N. Y.

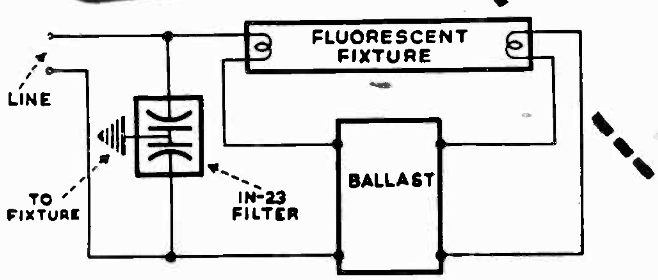
[2] Aerovox Research Worker. August 1938.

[3] Aerovox Research Worker. September-October 1943.

[4] General Radio Experimenter. May 1937.

[5] Silver, McMurdo. *Taming the Vacuum-Tube Voltmeter.* QST. July 1945. p. 17.

KILL Those Fluorescent-Lamp Radio Noises



Here's the low-cost cure — Aerovox Type IN-23 Interference Filter. Just connect it in the circuit with each offending fluorescent fixture, as shown in diagram. It effectively bypasses the high-frequency disturbances to ground. Cuts out radio noises escaping over electric wiring or radiating at large and disturbing nearby radio sets.

One interference filter is used for each fluorescent fixture. Unit is provided with flexible leads and spade lugs for easy connections. Slotted mounting bracket facilitates mounting and grounding on frame of fixture. Anyone can install one of these accessories in a jiffy.

Vital to store demonstrating and selling radios. Equally important in service shops where critical testing and checking are done. And downright essential in any store, office, plant or home where good reception and good fluorescent lighting are both enjoyed.

Ask Your Distributor . . .

Aerovox Type IN-23 is stocked by your local Aerovox distributor. List Price—$1.04.

AEROVOX CORPORATION

New Bedford, Mass.

Sales Offices in All Principal Cities